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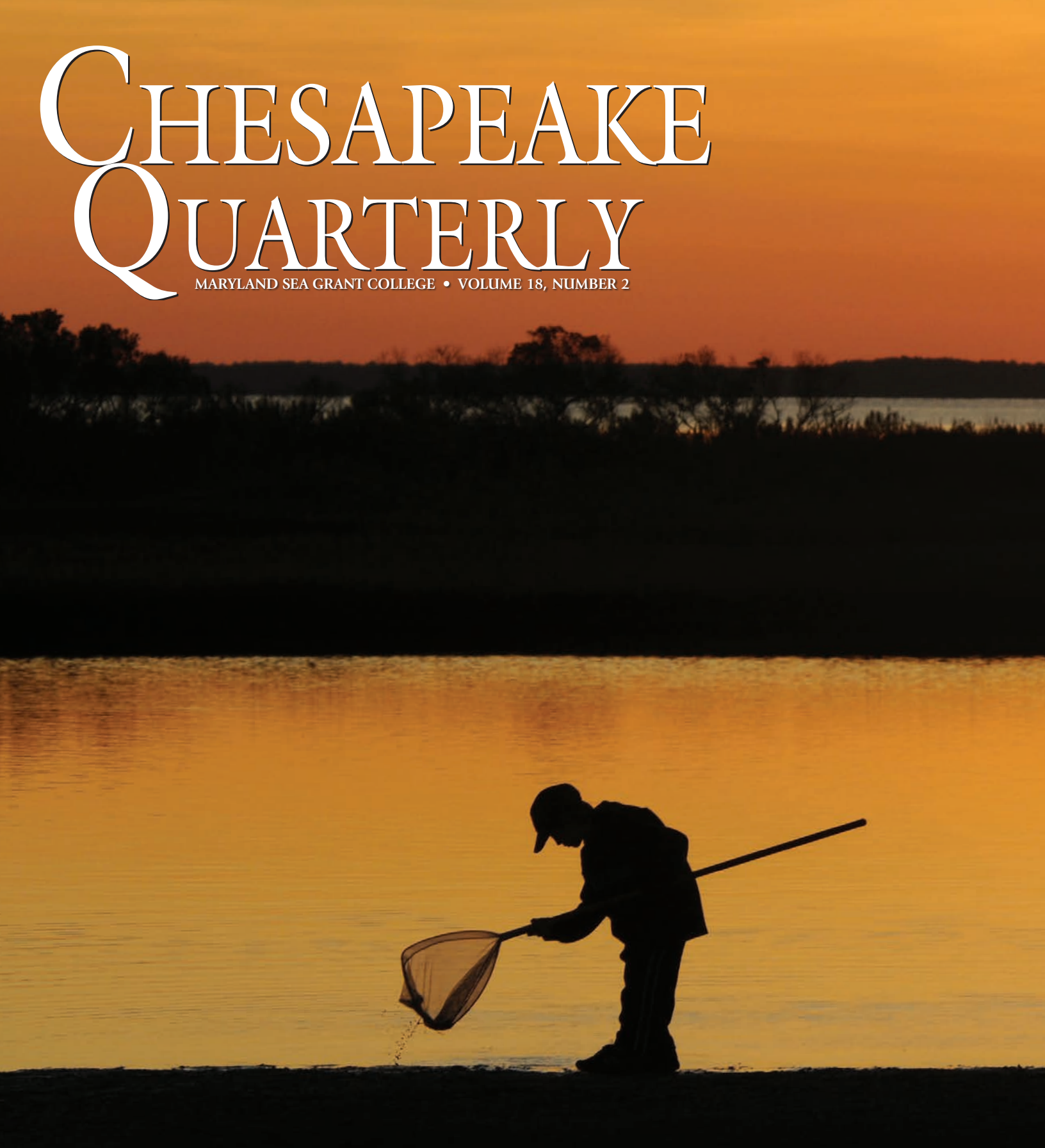

A Closer Look at Our Water

contents

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Cover: *A child explores Sinepuxent Bay on Assateague Island.* PHOTO, LISA TOSSEY

Wading into COMPLEXITIES

Visitors enjoy the beach *at Ocean City, Md. (above top). Rona Kobell (above) paddles Baltimore's Inner Harbor.* PHOTO ABOVE TOP, LISA TOSSEY/MDSG; ABOVE, COURTESY OF RONA KOBELL

Five years ago, I thought I was going to lose my leg. I was on Smith Island, covering a story about sea grass restoration. I climbed out of a waterman's boat, and something bit me. I thought nothing of the tiny blood speck on my skin, and continued working. Hours later, I awoke in the middle of the night with a fever, goosebumps, and a swollen leg.

Could I have contracted one of the infections that occasionally afflict swimmers and boaters through contact with the waters of the Chesapeake Bay? Could it be *Vibrio vulnificus,* a serious bacterial infection? Was it some other flesh-eating bacteria? Or maybe just a bad insect bite?

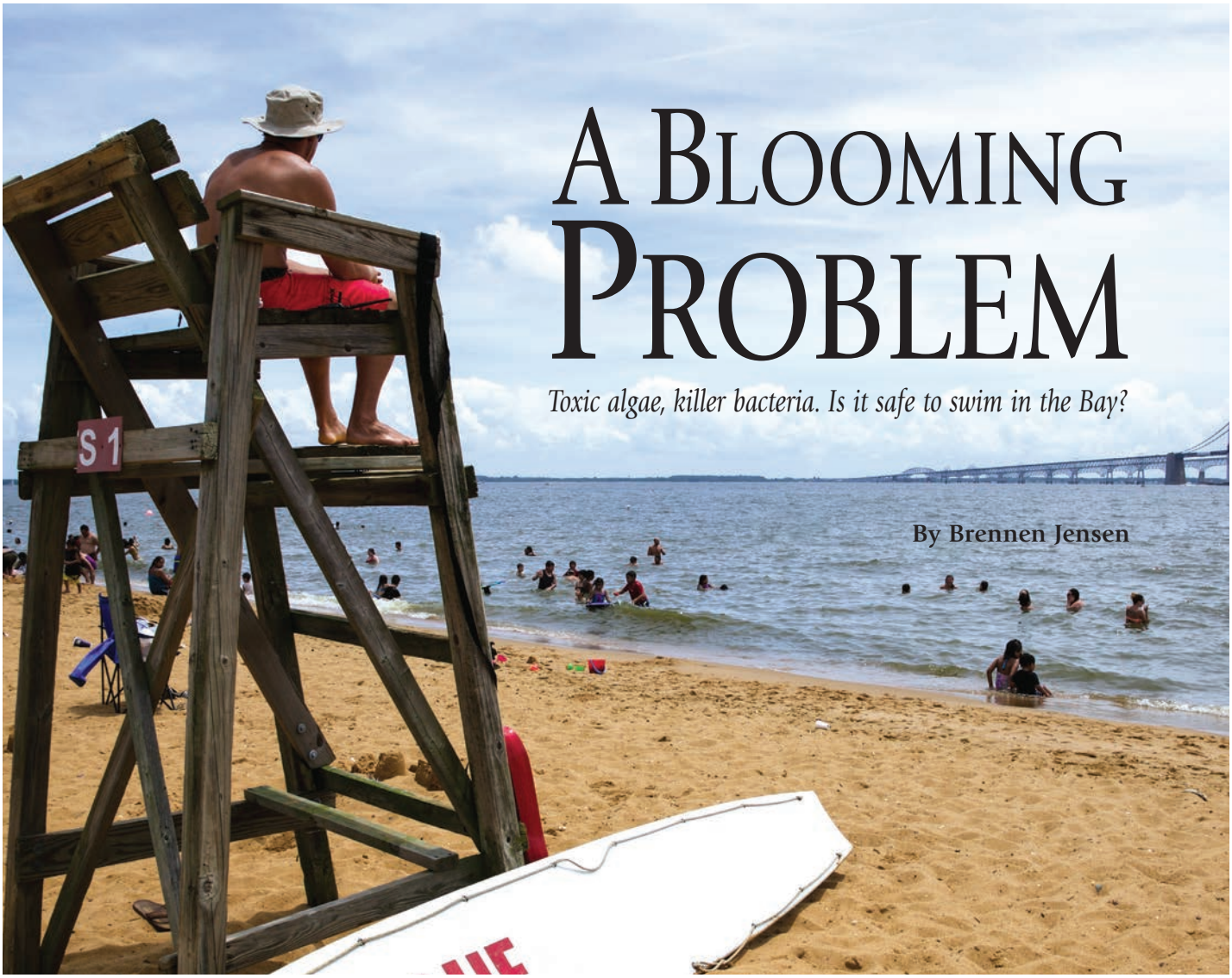
After a long night and what seemed like a never-ending boat ride to Crisfield, I got my diagnosis: cellulitis. It can be attributed to infection from many different bacteria, including *Streptococcus, Staphylococcus,* and the deadly methicillin-resistant *Staphylococcus aureus,* or MRSA. I was lucky—after a course of strong antibiotics and some rest, I was back to my old self within 10 days.

Would I still go in the water? I would, and I do. But I'm more careful now.

In this issue, we will look at what the science says about whether it's safe to swim in the water, when to go in, and how to stay informed about conditions. We'll explore the connection between efforts to introduce residents to Maryland's waterways and citizens' increased interest in stewardship of those waters—while, at the same time, stressing the necessary precautions. We'll talk to open-water Bay swimmers about how they stay safe. We'll examine the rise of harmful algal blooms, and whether the Chesapeake could be susceptible to blooms that have bedeviled Florida. And we'll meet a Bay leader who started a nonprofit to ensure that those who make the decisions about how to clean the water also get out on it. We'll also introduce you to Maryland's Sea Grant new Extension leader and new assistant director for communications and engagement.

We hope you enjoy this issue—and your time out on the water.

—Rona Kobell



A Blooming Problem

Toxic algae, killer bacteria. Is it safe to swim in the Bay?

By Brennen Jensen

It began with cormorants acting drunk on the beach. In early October 2017, concerned residents and visitors started delivering Double-crested Cormorants to an animal rehabilitation center in Sanibel Island, Florida. The water birds, they reported, appeared to be disoriented. Staff at the center quickly determined that it wasn't alcohol that was making them behave this way: it was exposure to *Karenia brevis,* a toxin-creating alga called a dinoflagellate—a single-celled creature possessing the attributes of both plant and animal.

Under the right conditions, these microalgae, or phytoplankton, can experience population explosions called blooms. When the plankton display toxic properties, as do *K. brevis,* scientists classify these events as harmful algal blooms (HABs), which have the potential to disrupt ecosystems and threaten wildlife and humans.

K. brevis blooms are a common occurrence along Florida's Gulf Coast. Almost every year, they cause the ocean surface to turn a deep red, inspiring the nickname "red tide." The cormorants, it turned out, had encountered an algal bloom in the Gulf of Mexico not yet visible from shore. The water birds were the canaries in the coal mine, harbingers of the largest and longest-lasting HAB in more than a decade. By the time the bloom cleared, more than a year later, wildlife casualties included some 150 manatees, 400 sea turtles, and at least a hundred tons of fish.

Florida Sea Grant estimates that the state suffered $20 million in tourism-related losses, as bloom-besieged beaches from Tampa to Fort Myers closed and visitors shunned coastal resorts. Sarasota alone lost an estimated $4 million in one month when dead fish piled up on the city's sandy beaches, patrolled by lifeguards wearing surgical masks. Hits to local fisheries have not yet been tabulated, but HABs in 2015 and 2016 cost the shellfish industry more than $1 million.

Florida reported no human fatalities as a result of exposure to the particular neurotoxins produced by *K. brevis,*

A lifeguard watches swimmers *at Sandy Point State Park in Anne Arundel County, Md.*
PHOTO, STEVE DROTER/CHESAPEAKE BAY PROGRAM

HEALTHY WATERS 411

Many sources collect and analyze information about the health of the Chesapeake Bay, Maryland Coastal Bays, and their tributaries. Here are a few resources focused on water quality.

Chesapeake Data Explorer
bit.ly/ches-data-explorer

This tool stores and shares data from throughout the Chesapeake Bay watershed and features an interactive map where visitors can view a range of water quality measurements for a specific location. The data are collected by a network of monitors working with the Chesapeake Monitoring Cooperative—a partnership of four organizations which includes the University of Maryland Center for Environmental Science.

Eyes on the Bay
bit.ly/eyes-on-the-bay
To report algal blooms, call 410-260-8630 or visit bit.ly/Eyes-on-the-Bay-report-bloom

This site provides access to a comprehensive monitoring system for state waters maintained by Maryland Department of Natural Resources. Interactive maps and specialized pages allow users to access a wide range of data on key measures of water quality, including harmful algal blooms. Information collected by the system is being used to guide the restoration of the Maryland waters by identifying specific problems and evaluating the success of management initiatives.

Maryland Healthy Beaches
bit.ly/MD-healthy-beaches

Administered by Maryland Department of the Environment, this site provides an interactive map to check current water conditions at Maryland's beaches from Memorial Day to Labor Day. The data are also available through a smartphone app or users can sign up for text or email alerts to receive notice of beach advisories or closures.

The Swim Guide
bit.ly/swim-guide

This guide, available both through a website and a smartphone app, delivers free real-time water quality information for over 7,000 beaches, lakes, rivers, and recreational spots around the world. It uses water quality information from affiliates and government agencies and provides the source of data for each location as well as date and time stamps that show when sample results were last verified.

called brevotoxins, but many people were hospitalized after inhaling them. The pounding surf aerosolizes the toxins, launching them into the air, where winds may carry them as far as 10 miles inland—and cause symptoms like painful and difficult breathing, especially for individuals having compromised respiratory systems.

To date *K. brevis* has not appeared in the Chesapeake Bay; however, the Bay has its own resident phytoplankton that could create a harmful algal bloom with the right combination of water temperature, salinity, pH, and nutrients. If a bloom occurred, what would happen? And how could resource managers and scientists control it?

A Bloom Boom

Algal blooms can happen when excessive amounts of nitrogen and phosphorus accumulate in bodies of water. These nutrients come from fertilizers, sewage treatment plants, air pollution, storm water, and other sources. When phytoplankton in the water take up these nutrients, they reproduce, then die off. As the dead organisms sink to the sea bottom and decompose, oxygen in the water is consumed in the process, creating dead zones with little or no oxygen that cause fish kills. This is what happened in 2012, when a toxic bloom of *Prorocentrum minimum* killed an estimated 100,000 fish in Baltimore's Inner Harbor.

A growing phenomenon in both saltwater and fresh, harmful algal blooms pose a challenge to scientists working to control them.

"Globally the algal bloom problem is expanding," says professor Patricia Glibert of the University of Maryland Center for Environmental Science (UMCES) Horn Point Lab. She's a phytoplankton ecologist who spent part of last spring in China researching bloom threats there. "We have new and different species—and new and different toxins appearing throughout the world."

The reason, she says, is the rise of nutrients in the water, particularly nitrogen and phosphorus from fertilizers and human and animal waste. Climate change may be playing a contributing role, expanding the range of HAB species, many of which thrive in warmer waters.

"The Bay has a long list of toxic or potentially toxic or harmful species," Glibert says. "A shopping list of species resides here, some of which are not problematic. They may just be present in low numbers as part of the ecosystem and have never really exploded."

Perhaps the Bay's most infamous bloom occurred in 1997. Maryland made national headlines after the dinoflagellate *Pfiesteria piscicida*—dubbed the "cell from hell"—was blamed for large fish kills in the Pocomoke River. Many affected fish developed ugly, festering lesions. The event cost the seafood industry more than $40 million. More problematic, however, was the fact that approximately 35 people exposed to the bloom suffered a host of health problems, including fatigue, headaches, and temporary short-term memory loss.

Some scientists in the region, including Allen Place, a biochemist based at the UMCES Institute of

Marine and Environmental Technology in Baltimore, believe that another dinoflagellate—*Karlodinium veneficum*—may actually have been the primary cause of the fish kill. What caused the human symptoms, however, remains a medical mystery.

Place believes that *Pfiesteria* was framed during the 1997 fish kills. *P. piscicida,* he says, were simply opportunists that showed up in the bloom to feed on fish killed by *Karlodinium.* He helped isolate a toxin from *K. veneficum,* which kills fish by essentially dissolving their gills, a process he captured in footage of a zebrafish succumbing to it.

Pfiesteria may have different strains, not all of which may produce toxins or which may do so only under specific conditions. Because the organism was rarely detected after 1997, Maryland stopped DNA-based water testing for it in 2010. Organisms resembling *Pfiesteria* do show up occasionally, but only in low numbers, during routine algae counts. Meanwhile fish kills linked to *K. veneficum* have been documented in the Chesapeake eight times since 2005.

"That first cell that gets exposed to *[Karlodinium]* may die, but that's only one of 10 trillion cells in the human body," Place says. "It may cause skin irritation, but it's not going to find its way beyond the local exposure site. Bottom line: we injected it inside mice and it did not kill them. Brevotoxins kill mice."

Science has made great strides in understanding the habits and life cycles of various toxic phytoplankton since "Pfiesteria hysteria" gripped the region. State and local governments have expanded and improved methods for routine monitoring of Bay waters. And new technologies, such as Maryland Healthy Beaches, a free app, can keep the public apprised of rainfall amounts and advisories based on indicator bacteria levels at more than 180 beaches and recreational areas.

In 2014 Maryland Sea Grant and the National Oceanic and Atmospheric Administration's (NOAA) National Centers for Coastal Ocean Science cosponsored a workshop on remote sensing of harmful algal blooms in the Chesapeake and coastal bays that explored available technologies to detect blooms and identify research gaps. That work helped determine what Bay communities need to know regarding human health and environmental impacts, and how quickly officials could identify blooms and warn the public.

A bloom *of* Prorocentrum minimum, *commonly called a mahogany tide, appeared in Spa Creek in Annapolis, Md., on October 28, 2009.* PHOTO, ALICIA PIMENTAL/CHESAPEAKE BAY PROGRAM

Technology may be key in early detection of HABs. NOAA is experimenting with analyzing slight color changes in satellite imagery of the Bay that might indicate the start of a bloom.

Scientists Heidi Sosik, Robert Olson, and Joe Futrelle of the Woods Hole Oceanographic Institution have developed an underwater device called an Imaging FlowCytobot (IFCB) to perform real-time analysis of phytoplankton in coastal waters. The IFCB uses a combination of video and flow technology to capture images of organisms for classification, allowing researchers to determine when levels of potentially toxic ones increase significantly.

But is it enough to predict, or prevent, a bloom of Florida-level disruption?

Good and bad algae

The Chesapeake contains some 700 species of algae. Many are important low-rung components of the food web. Most don't bloom, and the vast majority don't create toxins—fewer than 2 percent, according to the Maryland Department of Natural Resources (DNR).

"The spring usually brings *Prorocentrum,* which some people call the "mahogany tide," in that it turns the water a reddish brown, but it's perfectly fine to swim in and doesn't have any harmful impacts to people," says Cathy Wazniak, DNR's program manager. "It does cause ecosystem issues, because its large biomass can contribute to lowering dissolved oxygen levels and [creating] dead zones."

The state performs a variety of water quality analyses—including monthly algae-specific monitoring at 34 locations in the Bay and 13 locations in coastal bays—to measure algal density in cells per milliliter. A species will be noted as present if as few as two cells per milliliter are detected. Each species has a different density threshold that denotes a bloom; some thresholds exceed hundreds of thousands of cells

A bloom *of* Alexandrium monilatum *just south of the Goodwin Islands in the mouth of the Poquoson River, September 2016. In the far upper right corner is New Point Comfort in Mathews, Virginia, in the southern part of the Chesapeake Bay.* PHOTO, WOLFGANG VOGELBEIN/VIMS

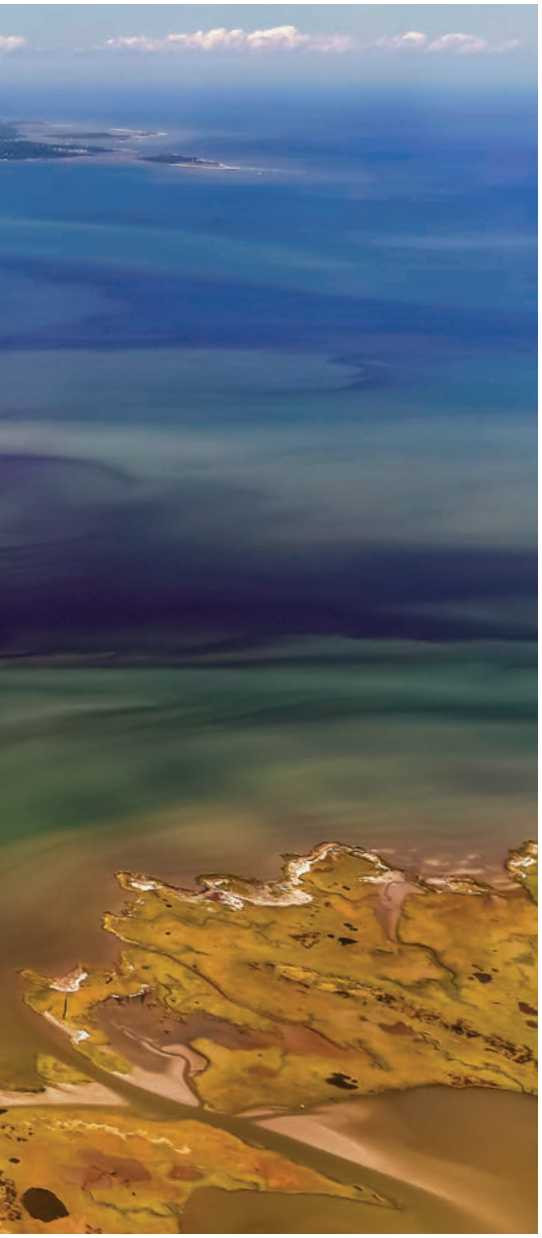
per milliliter. A mahogany tide's *Prorocentrum minimum,* for example, are considered blooming when the density exceeds 3,000 cells per milliliter.

People are encouraged to report discolored water so it can be tested as soon as possible. You can call the Maryland DNR or go online and fill out the Algae Bloom Sighting Report at eyesonthebay.dnr.maryland.gov. (See "Healthy Waters 411," page 4).

Occasionally Chesapeake Bay beaches are impacted by algal blooms, although these are not the only reason for beach closures. Not infrequently the culprit is high fecal coliform counts, often resulting from heavy rains that wash animal waste into waterways or cause sewage and storm water overflows. (See "To Swim or Not to Swim," page 10.)

In 2003 the state issued a no-contact advisory for Kent County's Betterton Beach when a bloom of *Microcystis aeruginosa,* a cyanobacterium, caused some swimmers to report itching and rashes. Commonly referred to as blue-green algae, cyanobacteria actually are not algae but photosynthetic bacteria whose toxins commonly cause skin irritations and can also affect the liver or nervous system. Largely a freshwater menace, cyanobacteria blooms increasingly threaten drinking water supplies around the world. A 2014 bloom in Lake Erie forced the city of Toledo, Ohio, to shut down its water system for three days; in Maryland, blooms have forced the closing of popular recreational lakes. But cyanobacteria have also bloomed in the Bay's brackish waters and tributaries, including the Potomac and Sassafras rivers.

Even if there's no swimming advisory, you probably wouldn't want to dive into the middle of a cyanobacteria bloom. "It's sort of common sense that you shouldn't go swimming if the water is bright green," says Judy



O'Neil, an associate research professor at the UMCES Horn Point Lab. "It's repulsive looking, and it would be like swimming in Shrek's lagoon."

Alas, dogs are not so discriminatory, and several have died from cyanobacteria poisoning, as have water birds.

Compared to cyanobacteria, the Bay's problematic dinoflagellates—*K. veneficum, Pfiesteria*—are complex creatures. They can convert light energy into chemical energy like photosynthetic algae; they can also hunt like an animal with their flagella, the tiny appendages that enable mobility. Some are even bioluminescent, such as *Alexandrium monilatum,* which sometimes blooms, and glows, in the Bay's southern reaches.

"We call them the Venus flytraps of the microbial world," Glibert says of dinoflagellates. "They can capture other phytoplankton and small bacteria, they can capture bits of fish tissue."

They can also create toxins to stun prey as an aid to hunting and eating, to keep competitors at bay, or simply as metabolic byproducts. "They create an array of compounds that have lots of different effects, but metabolically, there are still a lot of questions about how and why they're produced," Glibert adds.

Karenia have not yet been found in the Bay, but they have been detected along the Mid-Atlantic coast and in Delaware Bay. The worry, O'Neil says, is that HAB organisms that prefer warmer water, such as *Karenia* and *Dinophysis,* will thrive as temperatures rise, flourishing in warmer waters during summer months. *Dinophysis,* more common on the West Coast, has bloomed in waters as far north as New York State, and it has been observed in the Chesapeake in moderate salinities. It is possible that both of these dinoflagellates will get into the Gulf Stream and come right up the Atlantic coast.

"Things are warm enough now that, on a seasonal basis, they can come in and potentially cause trouble," O'Neil says. "We're working with Maryland DNR and the National Park Service on a research project going offshore to monitor what's out there. We generally haven't been looking offshore much, so we want to have a baseline so we can detect changes over time."

During a monitoring trip offshore in May, O'Neil and DNR colleagues identified *Dinophysis acuminata,* a dinoflagellate whose toxins can accumulate in shellfish.

Maryland and Virginia's shallow coastal bays, popular destinations for recreational fishing and water sports, are also home to a growing shellfish industry. These bays may be at the greatest risk from these potential invaders.

"The environment selects"

The Bay doesn't have a lot in common with the Gulf of Mexico, but what it does share is the seasonal formation of dead zones. This spring's above average rainfall, following the state's wettest year on record, in 2018, led to blooms of *P. minimum* and other organisms creating one of the largest dead zones in the Chesapeake Bay for the summer of 2019. At its peak, the dead zone in the Maryland portion of the Bay was about two cubic miles, according to Maryland DNR's 2019 Hypoxia Report.

The hypoxia volumes were the third largest since 1985 for the early August time period, and that was after a slight drop in the dead zone from the peak in July. Scientists had predicted the largest dead zones because they were watching the precipitation, particularly in the Susquehanna River watershed, which is responsible for about half of the nutrient loads to the Bay.

"We're just getting record amounts of rainfall persisting throughout the state," says Jeremy Testa, a biological oceanographer with UMCES.

Assessing the increased presence of phytoplankton and photosynthetic bacteria—more blooms in more locations—O'Neil quotes the late Dutch botanist Lourens Baas Becking: "Everything is everywhere, but the environment selects."

As climate change warms waters and higher pollution levels make nutrients more plentiful, these environmental "selections" can be increasingly problematic.

"We've got these oceans with lots of different species of phytoplankton, and the environment selects the ones that can grow well in a particular environment," O'Neil says. "It just so happens that the harmful algal bloom species are the ones that like our sewage and the things that we're polluting the waterways [with], so that's why we have to work on cutting those back."

—mdsg@mdsg.umd.edu

Writer Brennen Jensen lives in Baltimore.

ALGAE

Small size, big impact

Algae are a vital component of aquatic food webs. However, some species can be harmful. Though these potentially damaging algae are often present in the water in small numbers, under certain conditions their populations can increase rapidly. Known as an algal bloom, these events can cause health issues and ecological and economic harm. Here we highlight the impacts of large bloom events in the Chesapeake Bay and beyond.

IN THE BAY

Karlodinium veneficum
Middle River, Maryland, 2015

An unseasonably warm November caused a bloom of this dinoflagellate in popular fishing areas around eastern Baltimore County. Maryland Department of the Environment confirmed the presence of karlotoxins produced by the algae, which cause physical damage to gill tissue. The bloom resulted in the death of more than 200,000 fish in the Upper Middle River and several tributaries, including popular recreational fishing species like largemouth bass, yellow perch, and bluegill.

Prorocentrum minimum
Severn and South Rivers, Anne Arundel County, Maryland, 2018

Maryland Department of the Environment (MDE) reported blooms of this organism, which can block light to underwater grasses and contribute to low-oxygen conditions, creating dead zones. MDE measured more than 100,000 cells per milliliter of water in South River tributaries—10 times the threshold of concern (10,000 cells/ml).

Alexandrium monilatum
James, York, and Rappahannock Rivers, Virginia, 2015

Commonly found in the Gulf Coast's warm waters, this bioluminescent bloom was first detected in the York River in 2007 and was documented throughout the region by 2015. Although the algae has no known health impacts to people, it does release toxins that can be deadly to young oysters, crustaceans, and finfish, making it a concern for local fisheries and aquaculture.

IN THIS ISSUE

Learn more about these organisms in our main story (see page 3).

Prorocentrum minimum
Mahogany tide*

A common dinoflagellate, it is found in a broad range of estuarine and coastal environments around the world.

Public Health Hazards

- Considered potentially toxic if ingested, however no related illnesses have been reported from Maryland waters

Ecosystem Impacts

- Dense blooms can reduce dissolved oxygen in the water, resulting in fish kills and invertebrate die-offs that may impact local food webs and shellfish aquaculture

Karlodinium veneficum
Mahogany tide*

This chlorophyll-containing dinoflagellate is commonly found in the Chesapeake Bay and its tributaries. It relies on both photosynthesis and consuming prey for growth. Commonly called the "fish killer," it produces potent compounds called karlotoxins that cause cell lysis, or breaking down of cell membranes.

Public Health Hazards

- No known human health effects

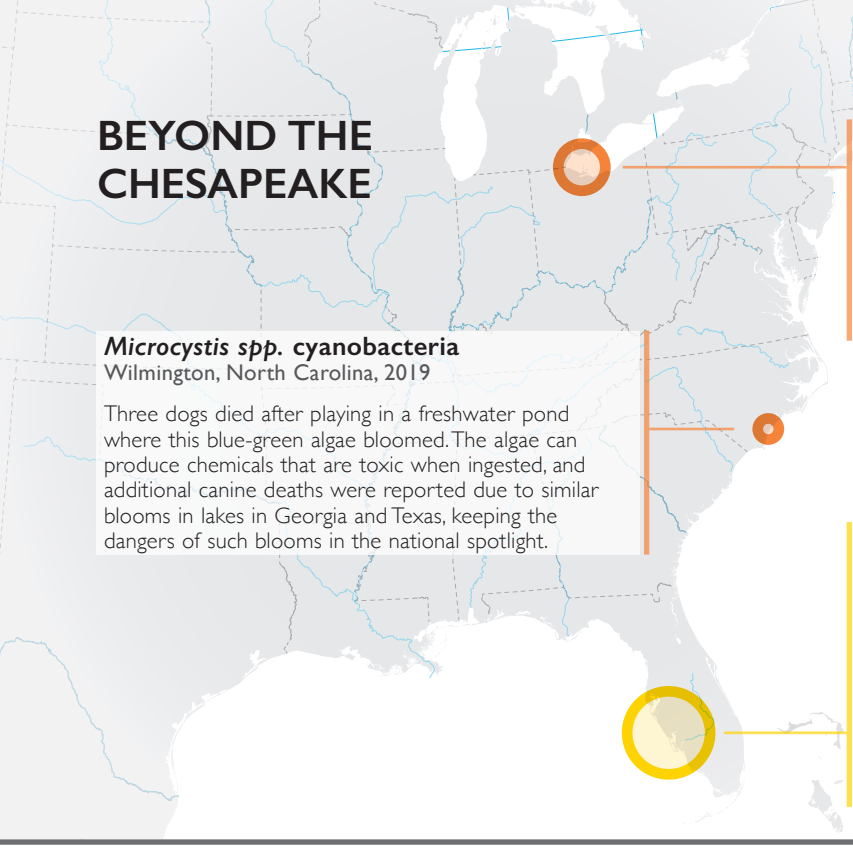
Ecosystem Impacts

- Karlotoxins in intense blooms can cause large fish kills

* Common, or vernacular, names are used by the general public as plain English descriptors for wildlife and elements of the natural world. They are usually simple, descriptive, and can vary by region, which can cause some overlap in the same names being used for different species.

PHOTOS, FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION, UBC DEPARTMENT OF EARTH, OCEAN AND ATMOSPHERIC SCIENCES (DINOPHYSIS ACUMINATA)*; BASE MAPS BY VECTORSTOCK.COM*

BEYOND THE CHESAPEAKE



Microcystis spp. and *Planktothrix spp.* cyanobacteria
Lake Erie, western basin, 2019

This blue-green algal bloom, which NASA estimated at more than 620 square miles, followed many other notable blooms in the area over the past two decades. One of the largest—in Toledo, Ohio, in 2014—impacted drinking water sources, causing officials to shut down the municipal water supply for more than 400,000 residents for three days.

Microcystis spp. cyanobacteria
Wilmington, North Carolina, 2019

Three dogs died after playing in a freshwater pond where this blue-green algae bloomed. The algae can produce chemicals that are toxic when ingested, and additional canine deaths were reported due to similar blooms in lakes in Georgia and Texas, keeping the dangers of such blooms in the national spotlight.

Karenia brevis
Florida, Gulf Coast from Tampa to Naples, 2017

The bloom, also commonly called a "red tide," lasted over a year, causing millions of dollars in damage to the region's coastal economy. Such blooms begin offshore in nutrient-rich water deep in the Gulf of Mexico. They are brought to the surface through a process called upwelling, then are driven closer to land by winds and currents. The toxin produced by this algae can have devastating ecological effects on marine life and spread through the air, causing respiratory issues and eye irritation in coastal residents.

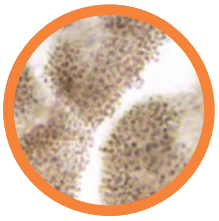
Karenia brevis
Red tide*

This dinoflagellate produces neurotoxins, called brevetoxins, that can seriously impact natural resources and public health. Tasteless and odorless, these toxins are also stable in the presence of heat and acids, making them difficult to detect or remove during food preparation.

Public Health Hazards
- Neurotoxic shellfish poisoning, a gastrointestinal illness, from consumption of contaminated shellfish
- Eye irritation and respiratory issues from contact with aerosolized brevetoxins

Ecosystem Impacts
- Brevetoxins in the food web can cause large fish kills and marine mammal, sea turtle, and seabird deaths

Microcystis aeruginosa
Blue-green algae*



A cyanobacteria that grows quickly in slow-moving, nutrient-rich water, often leaving a greenish film or mat on the surface. It produces several toxins, including microcystin, a potent liver toxin.

Public Health Hazards
- Consuming or inhaling can cause nausea, vomiting, and diarrhea
- Ingestion of microcystins can cause liver damage
- No reported human fatalities, but has caused death in pets, livestock, and wildlife

Ecosystem Impacts
- Can form dense blooms that reduce dissolved oxygen in the water, impacting local food webs
- Severe blooms can form dense mats that limit the amount of light reaching submerged vegetation, affecting benthic communities

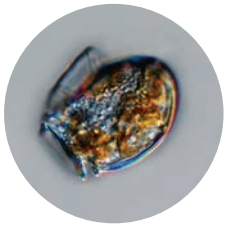
Alexandrium monilatum
Red tide*

An armored dinoflagellate that forms long chains of cells and is bioluminescent at night. First detected in the York River in 2007, its range has expanded throughout the Chesapeake Bay.

Public Health Hazards
- Potential impacts to human health remain largely unknown and are being examined; to date there are no published studies that show this alga to be toxic to humans

Ecosystem Impacts
- Produces toxins associated with the death of finfish and invertebrates, including oyster larvae
- Current research is assessing the impacts of this algae and its toxins on fish and shellfish, including effects on aquaculture stocks

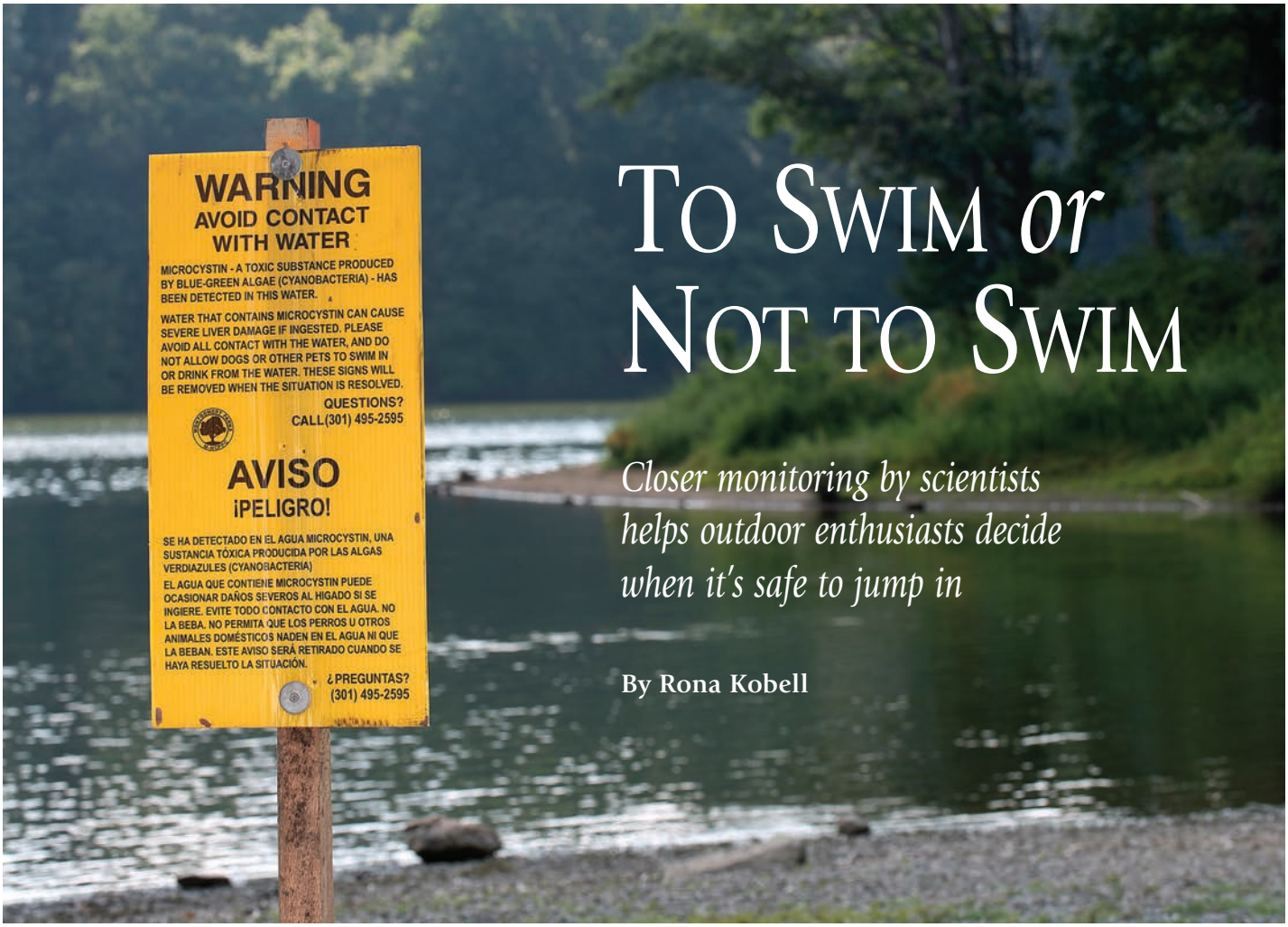
Dinophysis spp.



An armored dinoflagellate that relies on photosynthesis and consuming prey for bloom formation and toxin production. *Dinophysis acuminata* commonly blooms in Maryland's Coastal Bays, but is only seen occasionally in the Chesapeake Bay, where several additional members of this genus have been identified.

Public Health Hazards
- Produces okadaic acid and toxins that can accumulate in filter feeders and cause diarrhetic shellfish poisoning (DSP) if consumed, resulting in nausea, vomiting, diarrhea, and abdominal pain

Ecosystem Impacts
- Can be responsible for substantial economic losses due to the closure of exposed shellfish beds



To Swim *or* Not to Swim

Closer monitoring by scientists helps outdoor enthusiasts decide when it's safe to jump in

By Rona Kobell

The Arundel Breakfast Club is convening its Saturday meeting. And yes, someone remembered to bring the doughnuts. But they are almost beside the point.

This club is about swimming—in the rivers, for miles at a time, hugging a shoreline chock-a-block with piers and powerboats and making way for the occasional otter or dolphin. About two dozen people in this tight-knit swim league have been circumnavigating a four-mile loop on weekend mornings. This morning they launch at a community beach in Arnold under a sherbet sunrise. Some train for the Great Chesapeake Bay Swim, while others have crossed the English Channel, Lake Champlain, or circled the island of Manhattan. They are defense contractors, entrepreneurs, police officers, and government workers from Annapolis to Bowie, Baltimore to Washington. Neither brain tumors nor back surgeries—both of which some breakfast clubbers have experienced—have stopped them from a routine that is part meditation and part exercise, and one that has also made them stewards of the rivers they depend on.

Two years ago, stalwart breakfast clubber Mark Milleker contracted a staph infection that left him hospitalized for five days. Milleker, a 56-year-old technology executive, was cleaning his boat when he scraped his shin, breaking the skin. He cleaned the wound, forgot about it, and swam as usual in the Magothy River near his house a few days later. Shortly afterward, he woke up in the middle of the night in excruciating pain, suffering from a headache, nausea, and a high fever. After a couple of misdiagnoses, he said, doctors concluded that *Staphylococcus* bacteria from the river had entered the cut. They treated him with intravenous antibiotics until he was healthy enough to go home. Unlike some victims of serious bacterial infections, Milleker left the hospital with all his limbs and without having to undergo serious surgery. He was lucky.

Better, and worse

In an average year, about 15 of every 1,000 people who swim or wade recreationally in the United States will become ill from water contact, according to a study published in the journal *Environmental Health* that was led by Environmental Protection

***A sign posted at Lake Needwood** in Rockville, Md. this summer warns visitors to avoid contact with the water because of a dangerous toxic bloom of blue-green algae.*
PHOTO, DAN GROSS/THE FREDERICK NEWS-POST

Agency (EPA) epidemiologist Stephanie DeFlorio-Barker. The researchers also estimated that more than 90 million cases of recreational waterborne illness occur each year, with varying degrees of severity, from skin rashes to serious infections requiring hospitalization.

Bacterial infections like Milleker's are still rare in Maryland, but many summers a bad case or two surfaces. Last year, Frederick County fisherman Al Geisler nearly lost his leg after a spike from a rockfish poked him and *Vibrio* bacteria entered the punctured skin. In 2010, Calvert County crabber Mauro Lanzisera tripped on his dock as he was trying to get to his boat and jumped into the Patuxent River to catch the rope. He had an open wound from his fall when he entered the water. Lanzisera ended up spending a month in the hospital, with an eventual diagnosis of a *Vibrio vulnificus* infection. This summer, a boy contracted a skin infection that was diagnosed as *Vibrio,* according to his mother, after swimming in a bay near Ocean City. It is enough to frighten vacationers and flummox public health officials, who want swimmers and boaters to be safe but don't want to lose the economic benefits that come from outdoor recreation.

Milleker contracted his infection at a time when, by many measures, the water quality in the Chesapeake Bay and many of its rivers is improving. Upgrades to sewage treatment plants, new regulations on fertilizer applied to fields by farmers, and better storm water management practices have pushed the effort along. Also helping are new requirements for denitrifying septic systems in waterfront areas.

But climate change may be turning the tide yet again as it brings warmer water temperatures that bacteria crave, according to recent findings reported by the National Academy of Sciences. Waterborne bacteria, such as *Vibrio, Staphylococcus, Enterococcus,* and *Streptococcus,* can enter the body through open wounds and cause serious infections and even death. Public health officials and scientists have noticed an uptick in bacterial infections over the past 15 years. Meanwhile, officials at the National Oceanic and Atmospheric Administration's Oxford Cooperative Laboratory on the Eastern Shore are using temperature data to map areas in the Chesapeake Bay where the bacteria are likely to thrive, and they are seeing areas of concern becoming more extensive.

In 2016, Rita Colwell, a University of Maryland and Johns Hopkins University researcher, was one of nine scientists from around the world who published a study that linked rising ocean temperatures in Europe to increasing numbers of *Vibrio* species in the water that are potentially harmful for humans. The study, which Colwell believes is the first to explore the connection, examined plankton samples collected over the last half-century and retroactively assessed their *Vibrio* concentrations, then compared those numbers to recent samples in nine areas. In every case but one (Newfoundland), the number of *Vibrio* bacteria had increased, which correlated with an increase in water temperatures of up to 1.5 degrees Celsius over the past several decades.

The number of infections caused by *Vibrio* is also increasing, the researchers found. It's not what Colwell, the former director of the National Science Foundation and Maryland Sea Grant, would call an epidemic. But it is, she said, a concern.

Shorter and more intense rain events due to climate change wash nutrients into local waterways in higher concentrations that help these colonies thrive. Colwell said that both warmer temperatures and more nutrients contribute to favorable conditions for the bacteria.

"It is a bacterium that grows rapidly under optimal conditions in the laboratory," Colwell said, pointing out that longer, hotter summers and shorter winters and optimal salinity could create such conditions in the Chesapeake estuary as its water warms.

The increased number of infections in the Chesapeake Bay region caused by one species, *Vibrio vulnificus,* presents scientists and those working on restoration efforts with a conundrum: how to responsibly encourage people to use local waterways without putting them at risk. It is a delicate balance that swim groups like the Arundel Breakfast Club understand, because environmental stewardship helps ensure clean water for their recreational needs.

A Culture of Swimming

When Tammy Domanski asked a group of teenagers to describe the quality of the water on a recent visit to Spa Creek in Annapolis, she heard the usual answers: "Horrible." "Dirty." "Full of sediment." But Domanski, a microbiologist at Anne Arundel Community College, knows the data tell a different story. She's part of a nearly three-decade effort to collect bacteria counts, post them on a public website, and communicate with county health officials when necessary.

Domanski is the scientific director of Operation Clearwater, a nonprofit connected with the college that runs weekly tests on more than 70 community beaches in Anne Arundel County to determine bacteria levels and also temperature, pH, dissolved oxygen, and salinity. Community associations pay her to do it because residents use the rivers. Many other water quality monitoring organizations and environmental groups throughout the state rely on citizen scientists and research partners to do their own testing. Domanski gets results within 24 hours and uploads them to the Operation Clearwater website as soon as possible (bit.ly/operation-clearwater).

While many counties have mostly private piers and beaches, Anne Arundel has dozens of communities on the Severn, South, and Magothy rivers that share beaches, kayak launches, and piers. The arrangement—which is called "water privileged" instead of "waterfront" because communities share communal property with water access—hearkens back to the days

when the now year-round communities were summer cottages for Baltimoreans. Homes are more affordable because they share the waterfront, and maintenance costs are also shared across community associations. One community, Sherwood Forest, even has a summer camp where children swim in the Severn almost every day.

James Fegley, a longtime, competitive open-river swimmer and professional photographer who lives on the Severn, said he pays attention to Domanski's reports. "I am not driven with a lot of worry," he said. "But if nothing else, it makes you kind of aware."

The communities rely on Domanski to make what are, if not life-and-death decisions, then potentially life-and-limb ones. The Arundel Breakfast Club leader reviews Operation Clearwater data every week and sends an email to the group to determine whether the counts indicate it's safe to swim. In recent years, the answer is almost always yes.

***Tammy Domanski**, a microbiologist at Anne Arundel Community College, uses a secchi disk to test water clarity near the Eastport Yacht Club in Annapolis. Below, biology major Stephanie Vargas looks at a water sample.* PHOTOS, NICOLE LEHMING

Simple question, complicated answer

Domanski said the answer to the "safe to swim" question is always a little complicated. "I'm very leery about giving labels," she said. "This is data. Some parameters are improving, some are not improving. It's really important to dig into what that means."

She generally advises swimmers to stay out of the water for 48 hours after rainfall of half an inch or more, a not-uncommon occurrence in recent years. Her website also advises swimmers and boaters who have a cut or any type of break in the skin not to go in the water.

In the Operation Clearwater lab, biology major Stephanie Vargas analyzes the samples. A safe measurement for swimming is 104 enterococci per 100 milliliters of water, according to the EPA. Enterococci are indicators that show whether fecal matter is present in the water. Often, there is a localized reason for high counts in one spot. Vargas, Domanski, and the team work with Erik Michelsen of the Anne Arundel County Watershed Protection and Restoration program to determine the cause. Sometimes it's a dog beach with lots of pet waste. Sometimes it's a flock of geese.

Residents know what the state of the rivers is at all times, Michelsen said. The rare incidence of alarmingly high counts, such as those last year due to unusual amounts of rain, will make the news and frighten residents.

"It's kind of an ironic situation in that there's a perception that local waters are more dangerous than they have been in the past, when the reality is they are quite a bit less dangerous," said Michelsen, whose children swim in a Severn that is much cleaner now than when he was a kid in the 1980s. "We've been very effective in establishing that there are problems with the Bay. The difficulty then becomes convincing people, as things improve, that things have improved."

Colwell's warning, that the Bay may provide more optimal conditions

for *Vibrio* as the water warms, may come to pass. But for now, community beaches up and down its tributaries, like the Severn and Magothy, are busy with splashing children, romping dogs, and serious swimmers.

As for Milleker, he was back in the water with the Arundel Breakfast Club as soon as his wound healed. Asked if the infection gave him pause, he shrugged and said, "Not for a minute."

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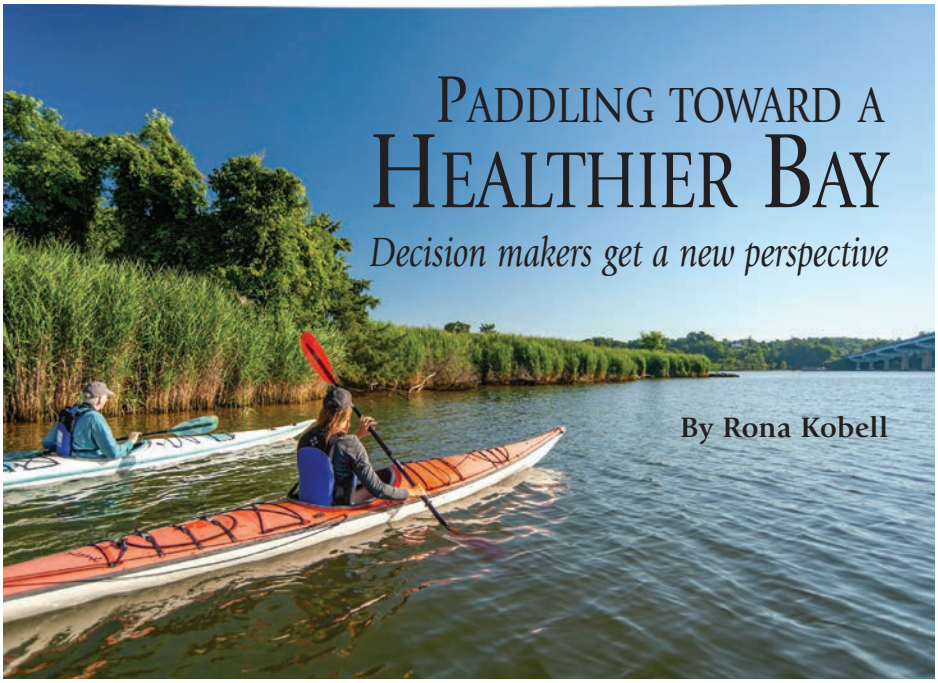

Paddling toward a Healthier Bay

Decision makers get a new perspective

By Rona Kobell

When Don Baugh was vice president of education for the Chesapeake Bay Foundation (CBF), he devoted his days to getting students out on the water in hopes that they would make a meaningful connection with the Bay—and be inspired to preserve it.

His efforts seemed to work. A University of Michigan review of the foundation's education programs reported that students' knowledge of ecology and methods to protect the environment had nearly doubled after those field trips on the water.

Meanwhile, many adults living in the 64,000-square-mile watershed, Baugh learned, lacked that connection. They either were transplants to the area and never had it—or they were locals whose jobs left little time for the outdoors and they'd lost it. Even among those working as professionals to restore the Chesapeake's waterways, many rarely enjoyed them for recreation.

Studies, including those conducted by researcher Louise Chawla at the University of Colorado–Boulder, have shown that individuals who are encouraged to enjoy a positive relationship with the outdoors as children are more likely to become environmental advocates or to choose careers in environmental stewardship.

On that assumption, figuring it's hard to fight for clean water if you don't know what you're trying to preserve, Baugh and his friend Tom Horton, a longtime Chesapeake Bay writer, invited people they identified as key to the cause—local philanthropists, congressional staffers, state water protection agency leaders, and top federal officials—to join them on guided kayak trips. Within a couple of years, Baugh and Horton had garnered a few regulars for a weekend of camping and paddling on the Bay.

Among them was Charlie Stek, projects director for former U.S. Senator Paul Sarbanes (D-MD) and lead on many of the senator's environmental initiatives. His first trip with Baugh, in 2002, was memorable—for the sudden storm that overtook them and the strenuous paddling through it. But Stek returned, again and again, as much for the paddling as for the stimulating discussion with fellow advocates.

"I did environmental policy for years before I met Don," Stek said, "but Don opened my eyes to a world I never knew existed. That gave meaning to the work we did in Congress."

When Stek learned of Baugh's difficulty in finding sites to camp and fish along the Bay, he used his position to push for creation of the Captain John Smith Chesapeake National Historic Trail. The first national water trail in the United States, it follows the Englishman's routes of exploration around the Bay and its tributaries in the early 1600s, and it allowed the National Park Service to create public access points.

After Sarbanes's departure, Stek worked briefly for U.S. Senator Ben Cardin (D-MD) before leaving Capitol Hill to devote himself to conservation. He led the No Child Left Inside Act with a broad coalition of government officials and policymakers that he says coalesced during Baugh's kayak trips.

Ann Swanson, executive director of the Chesapeake Bay Commission, said she has witnessed Baugh transform lawmakers into Bay advocates through his knowledge and enthusiasm for the Bay.

"The paddlers on Don's trips are a tight network that worked together for common causes," she said. "Through the trips, we have developed a deep understanding of the importance of access to Chesapeake Bay and the connections that come with traveling it. There is probably no one that has shown me more of the Bay, and made sure I was aware of the diverse landscapes, than Don."

After retiring from CBF in 2014, Baugh made the informal kayak tours more official. The following year, he founded a nonprofit organization called the Upstream Alliance. His daughter, Erica Baugh, eventually joined the venture. The group has identified hundreds of leaders in the fields of education, restoration, and infrastructure management, introducing them to the natural world of the Chesapeake from the water—where they can glide by old cypress trees, spot runoff from a

***Don Baugh** (left) and Erica Baugh paddle along the Severn River, near Don's home in Annapolis.* PHOTO, NICOLE LEHMING

Don Baugh *(left) with his daughter, Erica. He kayaked to work nearly every day while working for the Chesapeake Bay Foundation.* PHOTO, NICOLE LEHMING.

sand and gravel mine, observe schools of menhaden, or note the clarity of the water above oyster beds. Participants have paddled by the ghost forests of Maryland's Blackwater National Wildlife Refuge to learn about the impacts of sea level rise, and along the Nanticoke to view the large preserves along the river's banks set aside for protection of wildlife and safeguarding of property.

The elder and younger Baughs represent two generations of leadership in the environmental field today, the one existing and the other emerging. Many of Don Baugh's friends became active just as the Clean Water and Clean Air acts were passed; in contrast, Erica Baugh's peers have not seen these types of sweeping changes in federal laws, she said, and so they don't really know how to make them happen.

"There is a whole group of next-generation leaders, people my age and younger, that really need to be coached," she said. "We have a lot of problems coming up in the foreseeable future, and we need a creative workforce to solve the issues ahead."

Among Upstream's other targets for paddling trips are school superintendents, sewage treatment plant managers, and legislators. The alliance has partnered with nonprofits and universities for their access to connect participants with both impaired and relatively pristine waterways. The trips help decision makers focus on real implications of water quality, pollution and regulations to control it, and increasing public access.

"The magic mix is, we're trying to take out [on the water] people that make decisions on those issues, but we're also taking out people who will soon make decisions on those issues," Don Baugh said.

Pennsylvania representative Keith Gillespie, a Republican from York, was already concerned about the Chesapeake Bay's health and his state's contribution to nutrient pollution. But after several trips with Baugh, Gillespie said, he feels even more motivated to push for additional funding for measures to keep runoff out of the Chesapeake, including livestock stream exclusion and riparian buffers. The trips, he said, "keep the fires stoked." He shares photos of Upstream Alliance trips with his Republican colleagues, hoping to inspire them to action even if their state has no Chesapeake frontage.

"Because a lot of my colleagues have never had the chance to see it, they don't consider it a priority. I look upon it as my job to spread that word," he said. He is considering introducing legislation to tax bottled water to raise more funding for pollution prevention. "We have not been fully carrying our end of the log," he said.

Jan-Michael Archer, a University of Maryland doctoral student focusing on environmental health science and environmental justice, described his first Upstream trip in 2016, taken before he enrolled in the doctoral program, It was "kind of a bridge," he said. "It put things into perspective." The Georgia native's experience on the Nanticoke opened his eyes to the challenges facing the Eastern Shore, where low-lying land is giving way to rising water levels.

Through his graduate research, Archer is investigating the motivators needed to increase citizen science participation on climate change issues. He wants residents of these Eastern Shore communities to know how to document the changes that are happening around them. Archer, who studies with Sacoby Wilson in the School of Public Health, is also working to educate environmental advocacy groups, whose membership tends to be predominantly white, on issues of environmental justice and resource equity in adapting to climate change.

The Baughs, he said, were "very interested in my insights as a person of color on the trip."

Upstream Alliance outings always include naturalists, who point out wildlife and plants along the route, and scientists, who inform participants about coastal resiliency, climate change, and other topics. After each excursion, participants gather around a campfire to discuss ecology and policy.

"What we're bringing to the equation is something we feel is critically needed, that is increasingly difficult for people to get. It never was too easy, but it's becoming much harder. People are walled in by their cubicles and their institutions. And when we're able to get them out in a short amount of time—a day, three days—people are having their 'Aha' moments that ignite them for a career," Don Baugh said. "We're feeling positive that we've landed on the right space."

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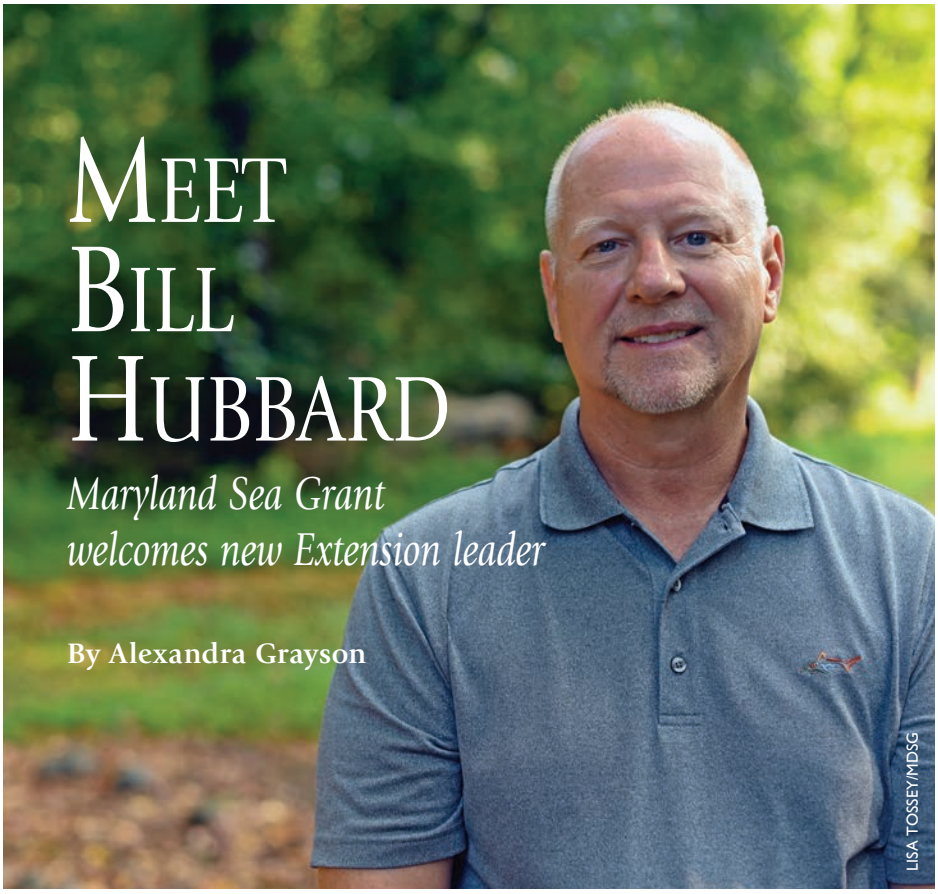

Meet Bill Hubbard

Maryland Sea Grant welcomes new Extension leader

By Alexandra Grayson

Most people will never find themselves in the middle of a Florida forest wrestling with a chainsaw and a colony of fire ants. But William "Bill" Hubbard did. He was 20 years old and an undergraduate studying forest management. Standing around a tree with his fellow forestry students, Hubbard recalls he had no warning when the ants attacked.

"I kneeled down to get the chainsaw going. I felt the sting and the burn. I threw the chainsaw down—luckily, no one got hurt," he said.

Hubbard said the forestry students got to know each other pretty well that year. And soon, we will get to know him, too. He is the new program leader for Maryland Sea Grant Extension and an assistant director for the University of Maryland Extension in the College of Agriculture and Natural Resources, taking over for Robert Tjaden.

Well equipped for the job, Hubbard brings 30 years of experience in forestry, education, and extension service. He held several leadership roles in Georgia and Florida before moving to Maryland in 2018. When he traveled here in June to interview for the position, Hubbard says he remembers thinking that Maryland would be "a great new place to live and work" for him and his family of six.

Hubbard attributes his leadership style to his experiences as a Boy Scout growing up outside Chicago, and later as a Scout leader for his sons. The Scouts, he says, taught him to "lead from behind, not command and control." He also says that starting his doctoral work when the oldest of his four sons was in kindergarten—and finally finishing his degree when that son was in high school—taught him patience. These skills are important in extension work, he says, where "we connect people with solutions, with answers. We try to do that in as many different ways that we can, given the constraints that we have."

Sea Grant's 12 Extension agents function as a link between scientists who conduct marine research and citizens whose actions help to improve coastal habitats and environments. Five of these agents work in fisheries restoring oysters, supporting aquaculture, ensuring the safety of seafood, and advising regulators on the latest research to inform policy. Five are watershed specialists helping communities to obtain funding for and install rain gardens, porous surfaces, and living shorelines. Of the remaining two agents, one works as a coastal climate specialist and the other coordinates the watershed team's efforts.

Hubbard's job is to make sure that researchers have the support they need to do their work. Passionate about expanding the program to enable them to conduct more studies, he sees the need to focus on protecting the Bay, bolstering rural economies, and helping communities. He would also like to improve programming areas, such as oyster restoration and aquaculture.

After spending most of his academic and professional career in north Florida and Georgia, where encounters with rattlesnakes and fire ants are commonplace, Hubbard admits to experiencing some culture shock in Maryland, where the natural environment is somewhat tamer. But the transition from a job where he had 13 bosses, with as many different opinions, to one where team members are all on the same page has been easy.

It's not likely we'll see Hubbard toting a chainsaw around Maryland, but he'll surely find his way to the state's forests as he explores the diverse environments of his new home.

"Everyone always says, when they take a job like this one, 'I want this to be the best environmental and natural resources program in the country,'" he said. "I think we really can have an impact here in a positive way."

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Alexandra Grayson, a rising sophomore at Howard University in Washington, D.C., was a Maryland Sea Grant intern in 2018–2019.

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Sea Grant Welcomes New Communications Manager

Lisa Tossey has always been drawn to the water. After her family moved to Maryland's Eastern Shore when she was five years old, she grew up exploring the sandy barrier islands of the Atlantic coast and the rich marshes of the Chesapeake Bay and its tributaries.

As an adult, Tossey's appreciation for these diverse ecosystems kept bringing her back to the coast—to study, film, and write about the water. This summer she joined Maryland Sea Grant as the new assistant director for communications and engagement. She will lead the four-person team—writers, editors, and designer—who produce *Chesapeake Quarterly,* along with research compilations, videos, fact sheets, and scientific books.

"Maryland Sea Grant is thrilled to have Lisa join our team," said Maryland Sea Grant director Fredrika Moser, "and we are excited to work with her on new innovations in communications to reach our diverse audiences and increase understanding of Maryland's coastal waters."

She worked previously as a research multimedia specialist at the University of Delaware. For Delaware Sea Grant, she produced the award-winning video series, *15 Second Science,* and managed the program's social media presence. Just before joining Maryland Sea Grant, Tossey was one of 12 fellows selected to attend a competitive science filmmaking workshop at the International Wildlife Film Festival.

Tossey also served as communications manager for the National Marine Educators Association, which operates out of Maryland Sea Grant's College Park office. As an educator in the Environmental Studies Department at Salisbury University, she assisted Chesapeake Bay environmental writer Tom Horton in circumnavigating the Delmarva Peninsula by kayak to explore the region's environmental and cultural history.

"Lisa has been at the cutting edge of digital storytelling for almost two decades, never hesitating from trying some new technology, software, platform, etc.—all in the name of education," said Chris Petrone, director of the Delaware Sea Grant Marine Advisory Service, who collaborated with Tossey on many projects. "She is a master of making local and remote


MATTHEW AMEY

environments accessible and engaging."

She has a BS in biology from Salisbury University and an MA in journalism from the University of Maryland's Philip Merrill College of Journalism. In spring 2020, she expects to complete an EdD, with a focus on education technology in science storytelling, from the University of Delaware.

"Maryland Sea Grant has a long history of excellent community outreach, as well as producing impactful films and beautiful printed pieces, like *Chesapeake Quarterly,* that serve to inform the public about complex scientific topics," Tossey said. "I look forward to continuing this tradition, as well as growing our communications offerings through implementation of emerging technologies to tell the stories of the diverse work being done here in fresh new ways."

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