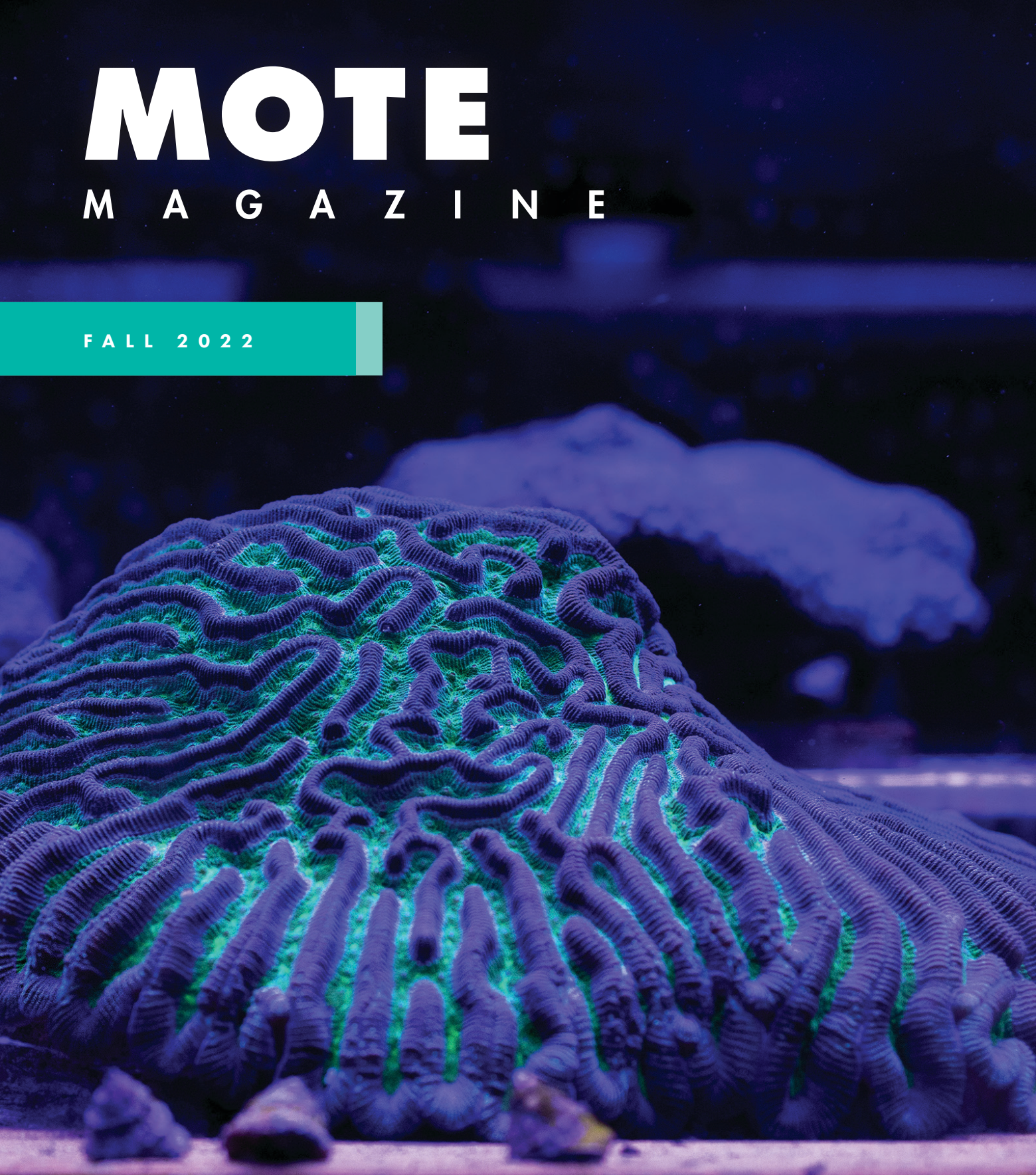
MOTE MAGAZINE

FALL 2022



DIVERSITY IS PRICELESS

At Mote's International Coral Gene Bank

FIN FOCUS

Imperiled sharks in the fin market

NEAT AND TIDE-Y?

The challenge of distilling red tide for forecasts & more

MOTE
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On the cover
Coral in Mote's International Coral Gene Bank.
Story: Page 09

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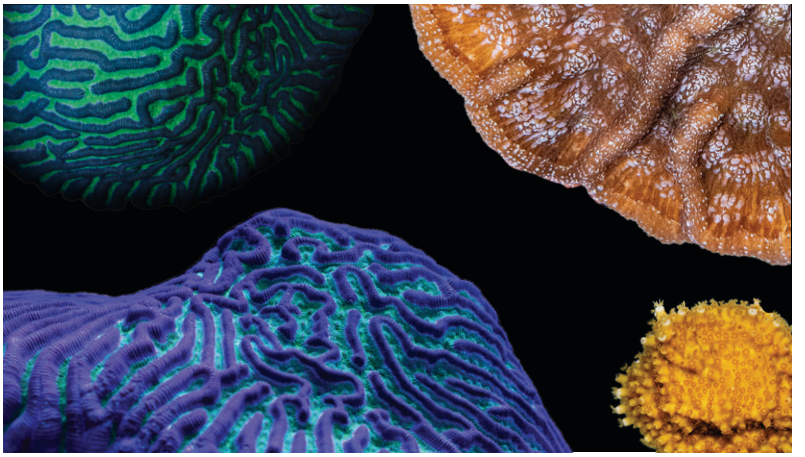


ALL TOGETHER NOW

Collaboration is key for critical research, exciting discoveries, and a path forward for worldwide shark conservation.

New research shows that 70% of species that end up in the global shark fin trade are at risk of extinction. Addressing this challenge will take a team.

BY STEPHANNIE KETTLE

IN 2021, the International Union for Conservation of Nature (IUCN) Red List of Threatened Species assessed sharks and their relatives, rays, skates and chimeras, and found about one-third of all species were threatened with extinction. In that assessment, overfishing represented a universal risk to the populations of all threatened species.

New collaborative research from a team of international scientists dove even further into the interaction between fishing, international trade and shark population status. For nearly a decade, Dr. Demian Chapman—Director of Mote's Sharks & Rays Conservation Research Program—has led the team, which includes researchers from Florida International University, BLOOM Association Hong Kong and Kadoorie Farm & Botanic Garden.

To track and monitor the global shark fin trade, Chapman's team conducted DNA testing on about 10,000 small scraps taken from processed, imported fins sold in markets in Hong Kong and South China. The team's goal was to better understand what species are in the trade and how common they are. By tracking this over time, they are able to inform decision makers about

how well various management measures are working. Their research, published in summer 2022 in the peer-reviewed journal *Conservation Letters*, showed that 70% of species ending up in the global shark fin trade are at risk of extinction. In total, they found 86 different species in the trade. Sixty-one of those, more than two-thirds, are considered threatened with extinction. Results of this new study indicate species in this trade are much more likely to be in threatened categories.

The study found that the species that commonly end up in the fin trade are open-ocean, or pelagic, sharks, such as blue and silky sharks. However, the greatest number of species in the trade— and many of the most commonly sold—live in coastal areas, including blacktip, dusky, spinner and sandbar sharks. The researchers warn that, without management, many coastal species could become extinct.

"A few nations are protecting or sustainably fishing sharks and their relatives, but the majority are not for a variety of reasons," said Chapman. "As a result, multiple sharks we found in the trade—such as smalltail, broadfin and various small hammerhead species—have been listed as Endangered or Critically Endangered. Listings raise awareness, but there are still no regulations protecting these species in significant areas of their range. Unless governments not currently having these regulations take steps to implement such management approaches in those areas, we are likely to experience a wave of extinctions among coastal sharks and rays."

One way to encourage better species management within nations is to list them under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)—an international agreement seeking to protect animals and plants from overexploitation driven by international trade. The 19th meeting of the Conference of the Parties (CoP19) to CITES is taking place in November 2022. This study will provide key evidence for the body's deliberations by bringing the plight of coastal sharks to the attention of governments and showing only a small percentage of the overall trade in shark fins is currently regulated under the Convention.

If proposals to improve shark protections are adopted at CoP19, nations would be obliged to ensure that any export of listed species is legal, traceable and sustainable. "There is a range of management actions that nations can take to get coastal shark fishing under control and avert this extinction crisis," said Chapman. "From changing fishing gear to creating protected areas to limiting catch, the solutions are out there."

"Since our Founding Director, Dr. Eugenie Clark—the Shark Lady—began her work documenting shark populations in southwest Florida and around the world nearly 70 years ago, the core of Mote has been to push the frontiers of science in support of evidence-based, sustainable use of our shared ocean resources," said Mote President & CEO Dr. Michael P. Crosby. "We plan to continue our vital work monitoring species commonly found in the shark trade, through the collaboration of innovative science, community engagement and resource management that together are critical to preventing extinction of these species."

A RARE ENCOUNTER

One shark conservation solution is playing out in Belize, where Chapman and his colleagues have worked extensively to collaborate with local government and the fishing community to protect sharks in ways that are culturally and socio-economically suited to the local community. In 2021, Belize established new management areas totaling about 1,500 square miles of reef habitat that prohibited shark fishing. Now, fisherfolk that would have been targeting sharks to harvest are tagging them for research.

During a tagging expedition looking for tiger sharks in spring 2022, the combined team of local fisherfolk and researchers noticed something strange at the end of the line. It wasn't a tiger shark at all, but rather, something completely unexpected: a Greenland shark!

Greenland sharks are slow-growing species that prefer cold waters, which leads to nearly all sightings of them in the Arctic and North Atlantic oceans. However, so little is known about them that nothing can be definitively ruled out about the species. Many experts believe Greenland sharks could be possibly trolling the oceans worldwide, just at far greater depths.

The sighting was the first of a Greenland shark in the western Caribbean. The edge of the atoll where it was found has a steep slope that drops from 1,600 feet to 9,500 feet deep, meaning there is cold water, which Greenland sharks need to survive.

After taking just a few pictures to confirm the sighting with other experts, the team immediately released the shark. While the team wasn't expecting to ever see a Greenland shark, finding one shows how partnerships can pave the way for unexpected and intriguing new discoveries. ■

PHOTO CREDIT: DEVANSHI KASANA

The first sighting of a Greenland shark in the western Caribbean

Top image: Rendering of a greenland shark. **Inset photo:** Greenland shark found by scientists and fisherfolk in the waters of Glover's Reef Atoll in the western Caribbean

CALLING OUT: EXPERIMENTING WITH MANATEE COMMUNICATION

BY OLIVIA CAMERON

In the shallow salt water of the Gulf of Mexico swims a female manatee and her calf, tooling around and grazing on seagrass. The manatee calls to her calf, but what is she trying to say?

Dr. Beth Brady, a Mote Postdoctoral Research Fellow, strives to answer that question. She and Mote Marine Laboratory's Manatee Research Program study the behavioral ecology, distribution, habitat, genetics, and population status of Florida manatees while providing insights to advance manatee conservation and research.

Brady believes that understanding how manatees communicate reveals what is important to them and how humans may affect them.

One significant form of communication for manatees and other mammals is acoustic—using sound. Florida manatees produce five broadly-defined call types and have a strong sense of hearing, so researchers are curious to know how much they rely on sounds.

After 13 years of studying manatees, Brady continues to focus her research on their acoustic communication and how human activity may influence it, while also studying their vocal anatomy.

Brady conducts "playback experiments," playing recordings of specific sounds that are tonal or atonal (with or without a definite pitch) for manatees underwater to monitor their response, in an effort to determine what is important to them. She works with Hugh and Buffett, Mote Aquarium's resident Florida manatees, and compares results to those from her studies with Antillean manatees in Mexico.

"Every time we played a sound, the Antillean manatees were curious. They would stop, turn around, and go towards the speaker," Brady said. "They were more inquisitive."

Here in Florida, Brady noticed a difference in results.

"Hugh and Buffett don't make any kind of behavioral changes that we can visibly see," she said. "They continue what they've been doing, but what we're finding is they're increasing their own number of vocalizations, which is fascinating."

Mote scientists don't know if Antillean manatees generally respond differently to sounds than Florida manatees, or if the differences in this experiment have more to do with the individual animals or their

Above: Mote's Amanda Foltz and Dr. Beth Brady prepare for an acoustic playback experiment with Mote's resident manatees, Hugh and Buffett.
Below: Closeup shot of Hugh and Buffett.

Q&A

WITH DR. BETH BRADY

What is a manatee's intelligence level?

Their cognitive capabilities have not been heavily investigated, but I think they have excellent memory. They have to remember where their warm water refuges are. We will be looking into vocal learning, similar to research on elephants, their most closely related species on land, which have the ability to mimic and imitate human sounds. So, what about a manatee? Can you train a manatee to voluntarily vocalize when asked and then train it to imitate something? Do they have the cognitive capabilities to do that? We don't know yet.

What are a manatee'a strongest and weakest senses?

A manatee's strongest senses are their hearing and their tactile senses. Their weakest sense is their vision.

Can manatees be right or left flippered?

It looks like sometimes Hugh will use one flipper more when he turns to make circles, so possibly!

environment. Continued research is needed to better understand what these results mean.

"As resident animals at Mote, Hugh and Buffett provide a baseline that we can use to help us understand communication in their wild counterparts."

Brady noted wild manatee sounds are often based on their behavior, too. The structure of their call may be more flat or tonal if they are resting and feeding, while their call may be more varied in pitch when their excitement increases.

"These studies give us an idea of how important communication is to manatees," said Brady. "We have many anthropogenic, or human, impacts such as boat noise that may make it difficult for manatees to hear one another. To support manatee conservation, it would be valuable to know how boat engine noise affects their ability to communicate." It is critical to understand how manatees rely on sounds and how human-induced noise may impact their communication in order to conserve their populations. ■

THE OCEAN'S CURRENCY

Mote's International Coral Gene Bank holds the key to reef restoration work in the Florida Keys

BY OLIVIA CAMERON

The future of Florida's Coral Reef lies in the hands of humans, and with Mote Marine Laboratory's innovative science-based restoration techniques and targeted research comes a brighter future for this massive underwater ecosystem.

Stretching approximately 350 miles from the Dry Tortugas to the St. Lucie Inlet, Florida's Coral Reef is home to dozens of species of reef-building corals that provide shelter, food and breeding sites for millions of plants and animals. The reef also provides a more than $8 billion economic impact, drives tourism and protects coastlines from major storms while supporting diverse life.

However, Florida's Coral Reef is in danger, having lost all but 2–5% of its living coral cover in recent decades while struggling to survive.

Mote scientists are racing against time to rebuild the reef and integrating a suite of strategies critical for success.

That's why Mote Associate Vice President for Research and Senior Scientist Dr. Erinn Muller believes Mote's International Coral Gene Bank is a critical piece of these restoration efforts.

"The Gene Bank is a place that focuses on preserving coral species as well as genetic diversity that exists throughout Florida's Coral Reef," said Muller, who also serves as Program Manager for Mote's Coral

Health & Disease and Coral Reef Restoration research programs.

Located at Mote Aquaculture Research Park in east Sarasota County, Mote's Gene Bank is designed to be a safe haven for corals from Florida's Coral Reef and other targeted Caribbean locations, with plans for expansion to house species from around the world.

Mote's Gene Bank houses corals in multiple recirculating holding systems, each with about 1,500 gallons of water. Each system is monitored and controlled with probes to regulate and change temperature, pH and other conditions.

Mote's Gene Bank is also home to four dedicated ex-situ, or land-based, coral spawning systems. Ex-situ means offsite, away from the reef. The spawning systems are fine-tuned for replicating environmental cues important for corals to undergo sexual reproduction, or spawning events. Using this technology enables Mote to increase genetic diversity of the corals critical for restoration efforts.

"This facility is important because Florida's Coral Reef is experiencing local and global threats that are jeopardizing the existence of most of these coral species," Muller said. "There are a couple species that are functionally extinct out in the ocean and that are primarily only held in human care. These living 'Noah's Arks' of species and genetic diversity are critical for repopulating the reefs."

In order to maintain coral genetic diversity, Mote scientists once relied on capturing coral spawn on the reef. During spawning, multiple species of corals synchronize the release of sperm and eggs over several days following the full moon in August. Orignally, capturing coral spawn to bring to the lab was inefficient and risky.

"Previously, we had to go out on the reef during the nights we thought coral would spawn, when they release the eggs and sperm in the ocean," said Muller. "This all happens at night. It's risky because the weather has to cooperate, your boats have to cooperate and the corals have to spawn while you're out there. Then, we would have to work throughout the night to conduct fertilization back at the lab. That's how it's always been done until now."

Mote scientists are now able to maintain genetic diversity and population by inducing spawning using the ex-situ spawning systems. It's Mote scientists' first year controlling the process on their own time, in their own lab.

"The land-based ex-situ spawning systems allow for us to mimic temperature, sunlight and moonlight to characterize any region of the world you want to work with," said Muller.

Mote scientists have been replicating the environmental conditions of the Florida Keys, where many of their corals originated, to trigger the spawning process.

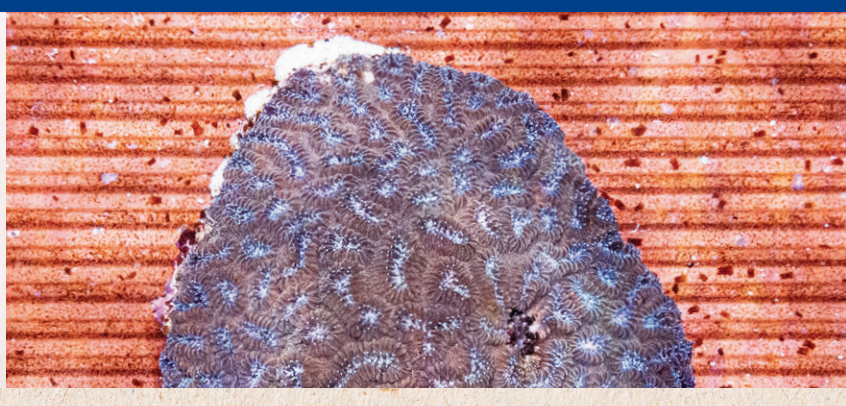
"We can flip the day and night cycle on the corals so they think it's nighttime when it's our morning, which allows us to induce the

Below: Mote's Cody Engelsma takes care of corals in Mote's International Coral Gene Bank at Mote Aquaculture Research Park.

MOTE MARINE LABORATORY
INTERNATIONAL CORAL GENE BANK

PROTECTING CORAL DIVERSITY IN MOTE'S

International Coral Gene Bank



Above from left: Elkhorn (*Acropora palmata*) & elliptical star (*Dichoceonia stokesii*) corals.

Above from left: Flower cup (*Eusmilia fastigiata*) & mountainous star (*Orbicella faveolata)* corals. **Below:** mixed corals.

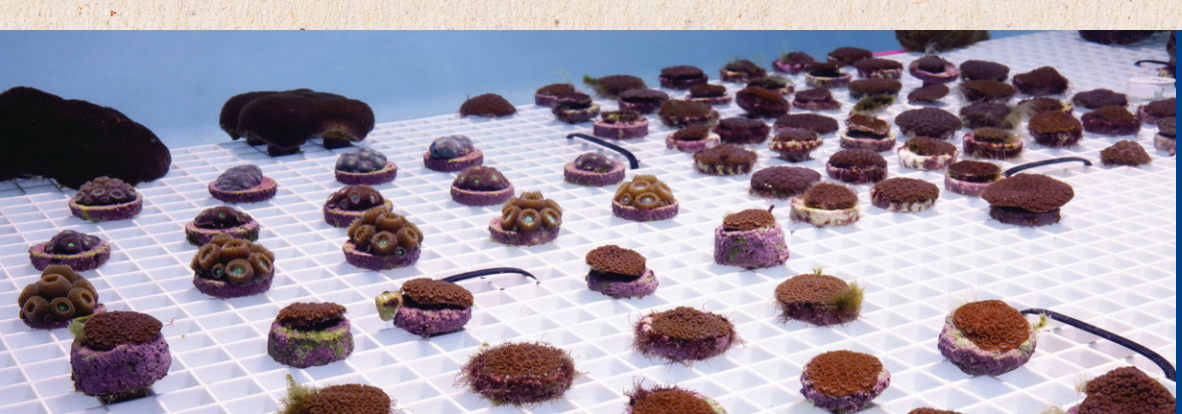


PHOTO CREDITS: CAMERON MCPHAIL, (ELKHORN CORAL, MIXED CORALS), WADE THOMAS (ELLIPTICAL STAR AND FLOWER CUP CORAL), NICK MCMAHON (MOUNTAINOUS STAR CORAL).

Above: Mote staff members Erin Muir and Sarah Hamlyn, Florida Keys National Marine Sanctuary Superintendent Sarah Fangman, Representative Jim Mooney, Ken Reda of Ocean Reef Conservation Association, Mote President & CEO Dr. Michael P. Crosby, Ocean Properties Hotels Resorts & Affiliates Vice President Mark Walsh, Key Largo Chamber of Commerce Chairman-Elect Henry Menendez, Monroe County Commissioners Holly Merrill Raschein and Michelle Coldiron, and Mote Keys Advisory Council Members Margie Smith and Peter Rosasco.

CUTTING THE RIBBON FOR MOTE'S

Key Largo Coral Nursery

coral spawn in the morning and conduct the fertilization processes during the day," she said.

Complementing the continued growth at Mote's Gene Bank in southwest Florida, Mote scientists in the Florida Keys are increasing their restoration efforts with the addition of new coral nurseries.

The Florida Keys are home to Mote's Elizabeth Moore International Center for Coral Reef Research & Restoration (IC2R3) on Summerland Key (Lower Keys), Mote's Islamorada Coral Nursery (Upper Keys) and the latest addition, Mote's Key Largo Coral Nursery, which became fully operational on Aug. 11 to expand restoration in the Upper Keys.

At these facilities, scientists use a method called microfragmentation, cutting coral colonies into 1-centimeter pieces using a diamond-bladed band saw. This encourages the corals to grow 50–60 times faster than it would otherwise. The corals will grow from small fragments to the size of quarters in just a few short months compared to multiple years they would need to grow naturally. Fragments from some species grow in tanks within the land-based nurseries, while other species are transferred to underwater nurseries just offshore. Then scientists outplant them onto damaged areas of coral reefs in circular arrays, which will ultimately fuse together in months to years depending on the species.

As of late 2022, Mote scientists have outplanted close to 175,000 corals, and counting, onto Florida's Coral Reef.

Florida Keys Director of Regional Operations Allison Delashmit sees the expansion of these facilities having a large impact on the future of reef restoration.

"Mote is the world's leading coral restoration practitioner, and the only one in the Florida Keys to create and utilize this on-land and in-water approach to restoration," said Delashmit. "We use our land-based nurseries and field nurseries to complement and enhance the natural growth of multiple coral species with the end goal of getting resilient corals to reproduce on their own."

Muller and other experts look forward to seeing Florida's Coral Reef continue to blossom with the ability to outplant across a larger geographic footprint. "We're simultaneously preserving species and genetic diversity, creating more genotypes and raising more coral for more outplanting in more locations, all at once," Muller said. ■

WHAT'S NEXT FOR RED TIDE?

BY HAYLEY RUTGER

A Florida resident checks her hurricane forecasts all summer long, looking at spaghetti models of where the next storm will go and reading news stories about the outlook for hurricane season and how climate change might be intensifying storms.

But as fall approaches, another phenomenon in the Gulf of Mexico worries her. Red tide is showing up sporadically in local waters, as it typically does at this time of year. How bad will it be, how long will it last, and why is that so much harder to predict for red tides than for hurricanes?

A LIVING STORM

Like a major hurricane, a bad bloom of red tide in Florida involves a perfect storm of environmental conditions. On top of that, red tide is alive—made of microscopic, toxin-producing algae of the species *Karenia brevis*—and its life and death are complicated.

That hasn't stopped a team of scientists led by Mote Marine Laboratory from picking it apart. Their goal: Break down what conditions may intensify, lengthen—or on the flip side, terminate—these red tides, and use that knowledge to build better mathematical simulations, or models, of red tide than we have today. From there, run those models to answer communities' big questions about what is making a given red tide severe or mild, what it might do next, or how a red tide might behave in hypothetical scenarios—for example, with projected increases in water temperature or rainfall due to climate change, altered levels of nutrients released into the water by human activity, or even with mitigation efforts to reduce its impacts.

RED TIDE'S 'KEY PLAYERS'

Gulf Coast residents and visitors might have heard scientists say that "red tide is complex," and there isn't a single reason why a bloom is bad or a single best strategy to fight bloom impacts. That's true, but it can be hard to appreciate when red tide toxins are irritating beachgoers' throats, causing dead fish and wildlife to wash ashore, closing shellfish farms and driving tourists away.

The good news is: By embracing red tide's complexity through decades of research, Mote scientists and their partners are bringing us closer to understanding what features of blooms and their environment are key players—pieces that give us the strongest signals for modeling what drives a bloom and what it might do.

"You have to figure out which organisms and processes are important in a bloom; it's not just *Karenia*," said Dr. Cynthia Heil, Director of the Red Tide Institute at Mote and leader of the ongoing project "Life and Death of *Karenia brevis* Blooms in the Eastern Gulf of Mexico," which is funded by the National Oceanic and Atmospheric Administration (NOAA) Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) program.

Finding the key reasons and signals that a bloom will intensify or weaken, persist or terminate, is a major focus of this project, which includes scientists from Mote, Bigelow Laboratory for Ocean Sciences, the Florida Fish and Wildlife Conservation Commission

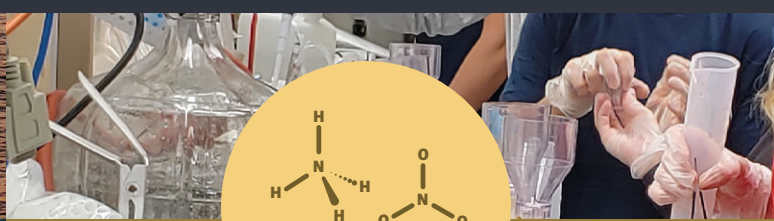
UNCOVERING RED TIDE'S KEY PLAYERS:

PHYSICS

Water movement can help make or break a bloom. It's a key player in existing models made by USF and partners—for example, patterns in the Gulf of Mexico's Loop Current help USF forecast whether offshore environmental conditions will favor red tide formation in a given year. Water movement can also disperse blooms—so it's important for modeling and predicting bloom termination.

Temperature, salinity, oxygen & other physical conditions influence blooms. Notably, we're still learning what temperatures *Karenia brevis* can handle. See Biology.

Physical conditions tell us a lot, but many red tide questions call for modeling physics, chemistry, biology and ecology combined—a longtime goal boosted by the current Mote-led project.



CHEMISTRY

At least 13 nutrient sources can "feed" *K. brevis* blooms, according to studies by Mote, Bigelow, FWC, UMCES and others. Mote and partners are investigating how to represent key sources in models.

Does heavy rain help blooms linger? It depends on timing. Mote scientists reviewed historical records and found that more intense rainy seasons —which could be increasing due to climate change—may coincide with existing red tide events lingering later than normal into summer. More research is needed to determine if a direct causative relationship exists, however.

Fish kills due to red tide are important sources of ammonia that helps sustain blooms, past studies showed. In 2021, scientists at University of Tampa and Mote used new detection tools to better map ammonia in Tampa Bay, finding it was enriched around patches of dead fish.

(FWC), New York University-Abu Dhabi (NYU), University of Maryland Center for Environmental Sciences (UMCES), and University of South Florida (USF). Each partner brings expertise on different components of red tides and the mathematical modeling tools that could help simulate them.

"We already know some of the key players in red tides," Heil said. "For example, we know *Trichodesmium (*a type of saltwater blue-green algae, or cyanobacteria) can fix nitrogen gas from the atmosphere into a nutrient source that *Karenia* can use offshore, where these red tide blooms initially begin, typically in low nutrient waters. We also know some major sources of nutrients for blooms that have moved closer to shore."

"But in some cases, we don't know as much—especially about bloom termination," Heil continued. "For instance, why do most blooms end within five to seven months but some last longer?"

Blooms often start in late summer to early fall, and some last through winter, but few continue past April. Project partners have found four major patterns of bloom termination by

Above: Mote scientists and partners collect chemical and biological samples during a research cruise in December 2021. **Page 13 photo**: Gulf of Mexico waters. **CREDIT BOTH:** JOAQUÍN MARTÍNEZ MARTÍNEZ/ BIGELOW LABORATORY FOR OCEAN SCIENCES

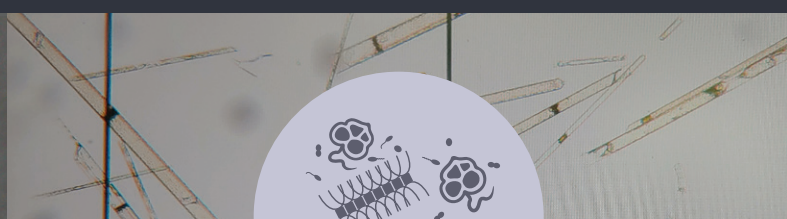
A SAMPLE OF THE SCIENCE TO IMPROVE MODELING & FORECASTS

BIOLOGY

We know the basic biology of *K. brevis* thanks to decades of research by Mote, FWC, NOAA and others on its growth, nutrient uptake, photosynthesis and toxin dynamics, for example—and we need to continue learning. Red tide biology research on land and at sea is in high demand to help build models that represent red tide more realistically.

Red tide algae are monitored regularly through teamwork by FWC, Mote and many others. Supporting red tide detection and sampling will help provide better data for models & forecasts.

Can it take the heat? Past lab studies suggest *K. brevis* becomes stressed as water temperatures approach 86 degrees Fahrenheit, but in summer 2018, Mote scientists reported a bloom persisting at up to 93 degrees! Clarifying red tide's temperature tolerance will support modeling and predictions about how blooms will respond to our changing climate.



ECOLOGY

It's not just *K. brevis*. Scientists know *K. brevis* can use nitrogen nutrients released by *Trichodesmium,* a type of saltwater blue-green algae (cyanobacteria) that can "fix" nitrogen gas from the atmosphere into a form *K. brevis* can use. And that's just one of many living things that can influence red tide—for better or worse.

It's an algae-eat-algae world: *K. brevis* can graze on saltwater blue-green algae called *Synechococcus* as a nutrient source. How that plays into *K. brevis'* life is one of the biggest mysteries that scientists, particularly at Mote and UMD, are working to pin down for realistic red tide modeling.

Red tide has a microbiome. *K. brevis* can be surrounded by bacteria and viruses that can help or harm it, note scientists at Mote, Bigelow and NYU. Representing this in red tide models is a new frontier.

analyzing bloom data from 1998-2021. Understanding what drives these patterns could improve bloom prediction and monitoring.

Some blooms, however, last all the way into the next summer. Certain summer blooms—like the one in 2017–2019—become infamous for their prolonged impacts on coastal communities. What allows these blooms to persist, while others terminate, is one of the biggest questions that Heil and her fellow scientists aim to answer in the NOAA ECOHAB project. By finding out, the team could improve mathematical models to address one of the public's biggest questions, "How long will this bloom last?"

To better understand summer blooms, Mote scientists delved into FWC's historical red tide records and other long-term data—including mid-century records kept by Mote's founding "Shark Lady," Dr. Eugenie Clark. Long term data help the team examine whether warmer winters due to climate change are helping red tide overwinter, and whether rainier summers might be tied to longer red tides—based on the concept that more rain could bring more land-based nutrients to existing coastal blooms. In related research, UMCES scientists are examining whether the concentration of red tide cells varies with the amount of rainwater flowing from Florida's Peace River and with climate variables that affect rain, namely, the repeating patterns of "El Niño" and "La Niña" climate conditions that scientists know as ENSO—El Niño Southern Oscillation.

The jury's still out on these possibilities, but one preliminary finding calls for more investigation: "Non-summer-bloom years experience considerably less rainfall over the wet season compared with summer bloom years by almost an order of magnitude," Heil wrote in a June 2022 project report. "This knowledge will enhance modeling and prediction efforts."

NEVER ENOUGH OBSERVATIONS

"When weather predictions first started in the late 1950s, the results were terrible, but as more and more observations became available, the models got better, and we now, some six decades later, have pretty good weather forecasts," said Dr. Robert Weisberg, Professor Emeritus at USF College of Marine Science and a co-principal investigator on the current project, together with USF Associate Research Professor Dr. Yonggang Liu.

"There are never enough observations to fully specify a complex phenomenon," Weisberg continued. In other words, we can't monitor all of the red tide algae and the conditions around them all the time, so scientists use mathematical models to connect some of the dots between their real-world observations.

"But models are also necessarily incomplete because they require certain assumptions and have errors that grow in time and space," Weisberg said. Just think of a hurricane's cone of uncertainty, which widens as it stretches away from the present time and location.

"So models and observations are best done in a coordinated manner. The observations help to refine and keep the models 'honest,' and the models help to fill in the observational gaps."

USF partners are building upon their current physical ocean modeling for the Mote-led project. USF and FWC already produce four-and-a-half day forecasts of where existing red tide algae may travel, using the physical properties of water movement and real counts of red tide cells provided by FWC, Mote and others. USF has also used a different type of model to make seasonal predictions of whether a bad red tide is likely, based on fluctuations in the Gulf's Loop Current that are believed to change nutrient dynamics offshore. Their model was tested against 29 years of red tide data and it answered correctly—"yes there will be a major bloom," or "no, there won't"—for 24 years.

Such tools are valuable, but physical models alone probably cannot answer some of the biggest questions about red tide—for instance, which blooms will terminate or last through summer. That could require adding biology, ecology, chemistry and geology data to models—and project scientists at Mote, Bigelow, FWC, NYU, UMCES and USF are each working on key pieces.

In the current project, spanning 2019 through 2024, Heil and Mote Postdoctoral Scientist Dr. Tristyn Bercel are leading monthly water sampling and annual "process cruises" where multiple partnering scientists collect many kinds of samples and data from southwest Florida waters and perform certain experiments right on the research vessel.

Bercel said: "Out there we get the whole bloom in context, and in the lab we can use samples and cultures of *Karenia* to investigate specific questions further."

NOAA ECOHAB support has been essential for this group effort. "These ECOHAB multi-year regional projects help you bring in an interdisciplinary team," said Heil, who has participated in all three regional ECOHAB projects about *K. brevis* red tide, first as a post-doctoral scientist in the late 1990s and then twice more as a leader.

"When I first started out, harmful algal bloom science was a backwater, compared to how it is today," Heil said. But through the efforts of research by many scientists and support of programs like NOAA ECOHAB, she said, "We've gained basic knowledge about the system and red tide's role in the system—the cell levels, how they take up nutrients, how they're grazed, and the annual dynamics of the West Florida Shelf (the environment where these red tides occur), including currents and local and offshore inputs of nutrients."

MODEL THIS MESS

Some of the most complicated things to work into a red tide mathematical model are biology and ecology—the life of red tide algae and its relationship to the world around it. Living things are harder to describe with fundamental, mathematical rules than physical forces are, and they come with wider margins of error.

It's hard enough just to keep track of where red tide is—through countless hours collecting and analyzing water samples and comparing them with satellite imagery of the ocean surface. It takes even more time, expertise and expensive instruments to document how and what the algal cells are doing—for example, how fast do they photosynthesize, capturing sunlight to produce energy-rich molecules they need for growth and survival?

Complicating things further, *K. brevis* doesn't behave the same way all the time. It can take up nutrients from its environment and capture energy from the sun (like a plant), but it can also get nutrition and energy by grazing (like an animal) on other microscopic critters. In particular, it seems to graze on saltwater blue-green algae (cyanobacteria) called *Synechococcus*.

That mixed lifestyle is called mixotrophy. "The easiest way to understand microbial mixotrophs is that they are the venus flytraps of the microbial world," said Dr. Pat Glibert, Professor at UMCES Center for Environmental Science and co-principal investigator in the current project.

Glibert and her colleagues at UMCES, along with Bercel and Heil at Mote, are all investigating this "venus flytrap" behavior in *K. brevis* because it could play a role in modeling and forecasting some important red tide processes. For example, what happens to microscopic algae, including red tide, when nutrient-rich wastewater is spilled into the Gulf of Mexico?

Heil, Glibert and others observed that process in spring 2021, after a disastrous spill of nutrient-rich wastewater from the former phosphate processing facility at Piney Point into Tampa Bay. "In response to Piney Point, we had a bloom of diatoms," algae that can compete with *Karenia brevis*, Heil said. "But an already high abundance of *Karenia* was able to continue for the rest of the summer."

Mote scientists collected a limited set of samples from the spill area in April 2021 for experimental studies. Those samples contained abundant *Synechococcus*. When those samples were combined with the *K. brevis* bloom samples in various concentrations in a lab study, the *Synechococcus* disappeared. "It's a strong indication that mixotrophy was likely to have occurred," Heil said.

Knowing *K. brevis* uses mixotrophy, scientists aim to work it into red tide models. Few have done so successfully for coastal algal blooms, but Dr. Ming Li, a co-principal investigator on this project and UMCES Professor, led successful modeling efforts with another species of mixotrophic algae in Chesapeake Bay. "We plan to extend the mixotrophic model to *K. brevis* because the West Florida Shelf has low nitrate (a nutrient source) concentration and *K. brevis* has been shown to feed on *Synechococcus* as an alternative nutrition acquisition strategy."

This is one of many cutting-edge efforts that may lead to better red tide models and predictions through the Mote-led project. Meanwhile, partners at NYU and Bigelow are particularly focused on the bacteria and viruses that can help or harm *K. brevis*. Some of these microbes can terminate red tide cultures in the lab, and scientists are just scratching the surface of what this might mean for blooms in the Gulf. ■

Left: Dr. Pat Glibert of UMCES (front left), project leader Dr. Cynthia Heil of Mote (front right) and other partners in the NOAA ECOHAB-supported project on the Florida Institute of Oceanography's Research Vessel *Weatherbird II.*

CREDIT: JOAQUÍN MARTÍNEZ MARTÍNEZ/ BIGELOW LABORATORY FOR OCEAN SCIENCES

WHAT THE FUTURE HOLDS

With success in this project, Mote and partners aim to:

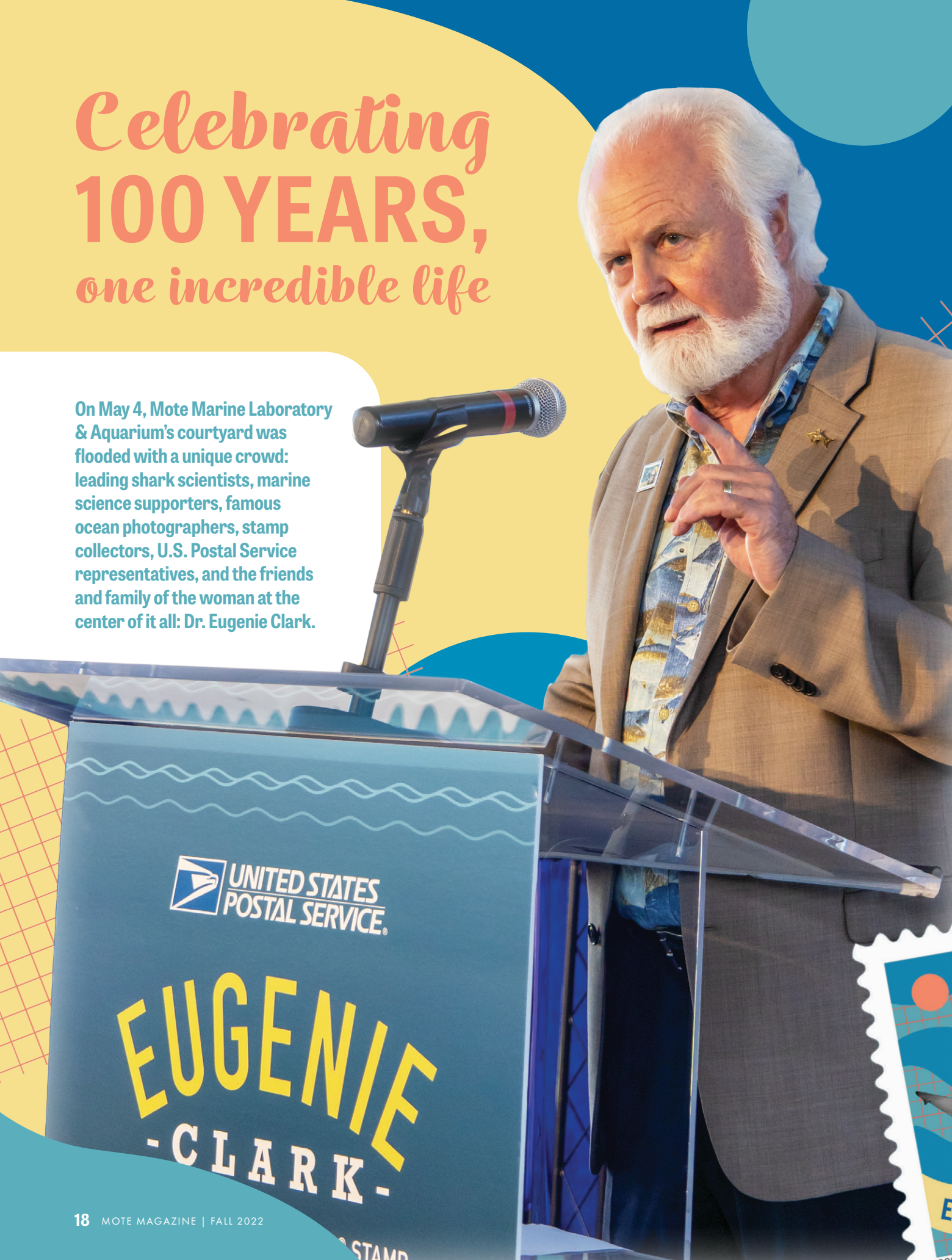
Better anticipate red tide impacts.
This would help communities and industries better prepare. For example, government agencies might heed early warnings by setting aside funding for fish cleanup.

Support safe, effective red tide mitigation.
For example, by helping reveal when blooms are susceptible to mitigation tools, and what impacts mitigation will have. Mitigation science is led by the Mote-FWC Florida Red Tide Mitigation & Technology Development Initiative.

Address key questions our communities are asking. For example: How long a bloom might last, how hurricanes, climate change and releases of land-based nutrients affect blooms, and more.

Celebrating 100 YEARS, one incredible life

On May 4, Mote Marine Laboratory & Aquarium's courtyard was flooded with a unique crowd: leading shark scientists, marine science supporters, famous ocean photographers, stamp collectors, U.S. Postal Service representatives, and the friends and family of the woman at the center of it all: Dr. Eugenie Clark.



Above from left: Tak Konstantinou, son of Dr. Eugenie Clark, Angela Curtis of USPS, Dr. Michael P. Crosby, President & CEO of Mote, Clark's daughter Aya Konstantinou, grandson Eli Weiss, and Mote Board of Trustees Vice Chairman Sandi Stuart applaud after the commemorative stamp is revealed.

BY HAYLEY RUTGER

Clark, the "Shark Lady" who founded Mote in 1955, would have turned 100 that day. To honor her trailblazing impact on marine science, the U.S. Postal Service (USPS) team joined Clark's family and friends to unveil a commemorative Forever® Stamp. The stamp, designed by Amanda Phingbodhipakkiya, features a photo of Clark captured by National Geographic photographer David Doubilet, who attended the ceremony, and a lemon shark.

As the curtain fell to reveal Clark's stamp, applause emanated from the crowd and the stage, where Mote President & CEO Dr. Michael P. Crosby, Mote Board of Trustees Vice Chairman Sandi Stuart, and Angela Curtis of USPS, stood smiling alongside Clark's children, Tak and Aya Konstantinou, and grandson Eli Weiss. Clark passed away in 2015 after a lifetime of studying sharks and other fishes. She was a scientist ahead of her time—back in the 1950s, she'd already caught on that sharks are complex and fascinating rather than mindless and frightening, and that women belong in marine science fields once dominated by men. Her trailblazing mindset has led to many of Mote's greatest impacts today and inspires our progress toward an even brighter tomorrow. ■

Learn about Clark and find out how to order her commemorative stamp:
MOTE.ORG/GENIE100

SHARKS ON A PLANE!

Mote Aquarium's new zebra shark flies to Florida

BY SEAN STOVER

Every year, Florida's population increases by around 5% as more than a million snowbirds travel south from northern U.S. states and Canada. Many of them visit Mote Aquarium in Sarasota, but not every visitor is a snowbird, or even a human. One special, shark-y guest flew down to see us this year, and he's here to stay!

On March 22, 2022, Schnitzel the zebra shark began his long journey from Minnesota Zoo to Mote Marine Laboratory & Aquarium. He flew Delta Air Lines, landing at 5:30 p.m. in sunny Tampa. Matt Seguin, Mote's Registrar and Animal Resource Officer, along with Matt Wade, Curator of Fish and Invertebrates, were waiting to transport Schnitzel for the last 90 minutes of his journey—to his new home at Mote Aquarium!

Currently, Schnitzel is living alongside resident blind green sea turtle Hang Tough in her habitat at Mote Aquarium's Ann & Alfred Goldstein Marine Mammal Center. Mote Aquarium biologists have already begun target training sessions with Schnitzel, teaching him to swim towards a target, touch the target and receive a food reward. This will build trust between the animal and his caregivers, provide enrichment in his everyday life and make any future medical checkups less stressful.

This trust and comfort developed through target training will also ease Schnitzel's second big move: traveling to Mote Science Education Aquarium (Mote SEA) at Nathan Benderson Park in Sarasota County, upon its estimated completion in 2024. Mote SEA, the rebirth of Mote Aquarium, will allow even more visitors to meet Schnitzel and other new resident animals while learning about Mote science that benefits their ocean homes. ■

ABOUT ZEBRA SHARKS

Juvenile zebra sharks are dark brown with zebra-like stripes, but as they mature, their coloration becomes tan with leopard-like spots. Schnitzel is currently between these stages, so Mote Aquarium guests can see both a stripe-like and polka-dot pattern on him. Zebra sharks' natural habitat consists of shallow coral reefs in tropical waters, which is why guests can also spot other tropical species living alongside Schnitzel and his turtle roomate, Hang Tough. These sharks use their barbels, the whisker-like organs at the front of their snouts, to hunt for small invertebrates such as snails, sea urchins and crabs. Many zebra sharks reach a maximum length of about 8 feet, but they're flexible enough to squeeze through tight spaces while hunting.

EXPANDING Diversity

in marine science fields

MarSci-LACE
marscilace.org

Jasmin Graham, first author on Mote's new study on the careers of Black, Indigenous, and People of Color in marine STEM

BY OLIVIA CAMERON

As job opportunities in the field of marine science, technology, engineering and math (STEM) expand, questions regarding the lack of diversity remain.

How can marine STEM careers attract and retain high quality, diverse candidates who are underrepresented in these roles today? Good mentorship can help, according to new peer-reviewed research from Mote Marine Laboratory & Aquarium. "BIPOC voices in ocean sciences: A qualitative exploration of factors impacting career retention," published in the *Journal of Geoscience Education*, explores the recruitment and retention of Black, Indigenous or People of Color's (BIPOC) careers in marine STEM fields based on their early-career research mentorship experience.

Jasmin Graham, the Project Coordinator of the Marine Science Laboratory Alliance Center of Excellence (MarSci-LACE)* and first author on the paper, analyzed the exclusion of BIPOC in STEM. The paper explored the impact of various factors such as BIPOC-focused programs and experiences on senses of belonging, science identity and self-efficacy among BIPOC marine scientists and aspiring marine scientists.

"This study illustrates the issues that have led to a lack of retention of BIPOC students and professionals in the field," said Graham. In turn, the study offers insights for supporting diverse future generations in STEM.

Graham and her co-authors from Mote identified that research and field experiences must be developed intentionally to recruit and retain BIPOC students in marine science.

"With results from this exploration of the sometimes subtle issues, perceptions, and actions that can often unknowingly create challenges for BIPOC students and early career scientists to successfully pursue careers in marine STEM fields, we can facilitate improved opportunities for attracting, mentoring and retaining more diverse future generations of marine scientists," said Dr. Michael P. Crosby, President & CEO of Mote and a co-author on the publication.

Aly Busse, Mote Associate Vice President for Education, Co-Principal Investigator of MarSci-LACE and a co-author on the publication, agreed. "Whether in the marine science field or outside of a research experience, a positive environment can make a difference," she said. ■

**MarSci-LACE, led by nonprofit Mote Marine Laboratory & Aquarium and co-funded by the National Science Foundation (NSF) Louis Stokes Alliance for Minority Participation (LSAMP) and Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science (NSF INCLUDES), opens doors into marine science research, education and careers for underrepresented, minority students.*

Sharing our coral discoveries with the world

BY HAYLEY RUTGER

Six Mote Marine Laboratory scientists and their Mote-affiliated peers presented cutting-edge coral reef research during the 15th International Coral Reef Symposium (ICRS) this July in Bremen, Germany. The ICRS is the primary international conference on coral reef science, conservation and management.

"I'm incredibly proud of our team for presenting such a diversity of new findings to the international community for the benefit of coral reefs," said Mote Associate Vice President for Research Dr. Erinn Muller. "Our team is testing novel coral disease treatments, helping coral reef restoration to be more productive and resilient to environmental change, and revealing the hidden biological and ecological processes that can tip the scales toward coral population decline or recovery."

Read more: **mote.org/icrs**

Women of the Water convene at Mote

BY HAYLEY RUTGER

Mote Marine Laboratory scientists were proud to host the first Women of the Water conference celebrating women and gender minorities who advance sustainable, science-based, inclusive aquaculture—farming animals and plants in water.

The June 14–15 conference was organized by Mote, Florida Department of Agriculture and Consumer Services, and Florida Sea Grant. Speakers highlighted fascinating aquaculture science and riveting stories about women who have fought for inclusion in male-dominated aquaculture fields.

Participants included scientists, commercial seafood farmers, government agency staff, educators and others focused on applying sustainable aquaculture to help feed the world.

The conference was held at Mote in Sarasota and included a tour of Mote Aquaculture Research Park, the 200-acre campus where Mote scientists are advancing sustainable aquaculture, marine aquaponics and cell-cultured seafood.

MOTE THANKS

COMMUNITY FOUNDATION of Sarasota County

Bank of America Client Foundation

Mote and The Haven expand STEM education

BY SEAN STOVER

Thanks to grants from Community Foundation of Sarasota County and Bank of America Client Foundation, Mote's Education Department is partnering with The Haven—a local nonprofit offering programs and services for children and adults with disabilities.

The partnership uses informal science education to create interactive and engaging lessons for high schoolers with disabilities at Haven Academy.

Monthly during the past year, about 35 Haven Academy participants have experienced Mote's specialized marine STEM lessons and engaging educational activities in order to inspire interest in STEM, awareness for the environment and inclusive access to marine science and learning for all abilities.

Mote's work with Haven Academy builds upon our existing partnership with The Haven and Easter Seals to offer virtual programming to about 75 adults a month.

Most recently, through additional support from the Community Foundation, Mote has also been providing quarterly programs for about 25 students at The Haven's Selby Preschool.

Events Calendar

Join us for Mote events where science sparkles, where oceans are for everyone, and where cuisine and curiosity make a delicious combination.

Advance registration required for all.
mote.org/events

OCTOBER 2022

OCT. 29

Oceanic Evening
The Ritz-Carlton in Sarasota, Florida.
Mote's signature black-tie gala shares our mission of groundbreaking ocean science, conservation and education with current and prospective supporters.
mote.org/oceanic

NOVEMBER 2022

NOV. 5

Sensory Saturday
Mote Aquarium in Sarasota, Florida.
Mote Aquarium opens early for those with sensory processing differences, Autism Spectrum Disorders (ASD) and others who would benefit from a calmer sensory experience.
mote.org/sensory

DECEMBER 2022

DEC. 26–30

Winter Break Camp
Mote Aquarium in Sarasota, Florida. Sharks, skates and rays... OH MY! Campers 5–10 years old can enjoy hands-on educational activities focused on Mote's JAW-some research that started with our founder, Dr. Eugenie Clark.
mote.org/winterbreak

JANUARY 2023

JAN. 2–6

Winter Break Camp
mote.org/winterbreak

JAN. 9, 16, 23 & 30

Special Lecture Series
At Mote Marine Laboratory & Aquarium in Sarasota, Florida, & virtual.
Meet our amazing Mote scientists and discover their latest groundbreaking research.
mote.org/lecture

FEBRUARY 2023

FEB. 12

Farm to Fillet
At Mote Aquaculture Research Park in eastern Sarasota County, Florida. Enjoy fine culinary offerings and exclusive, behind-the-scenes tours of the unique research facility where Mote scientists develop new seafood farming technologies to help feed the world.
mote.org/farmtofillet

FEB. 19

A new limited-time exhibit will open in Mote Aquarium! (Mote Member preview Feb. 18)
Stay up to date by following @MoteMarineLab on Instagram, Facebook, Twitter and TikTok.

MULTIPLE MONTHS

OCT. 8, NOV. 26, DEC. 31, JAN. 21 AND FEB. 18

Breakfast with the Sharks
Mote Aquarium in Sarasota, Florida. Sink your teeth into a light continental breakfast while you learn about our favorite finned friends and Mote's breakthrough shark research.
mote.org/breakfast

MOTE MARINE LABORATORY & AQUARIUM

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When you support ocean-saving science at Mote with a monthly gift

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Just click Donate at

MOTE.ORG