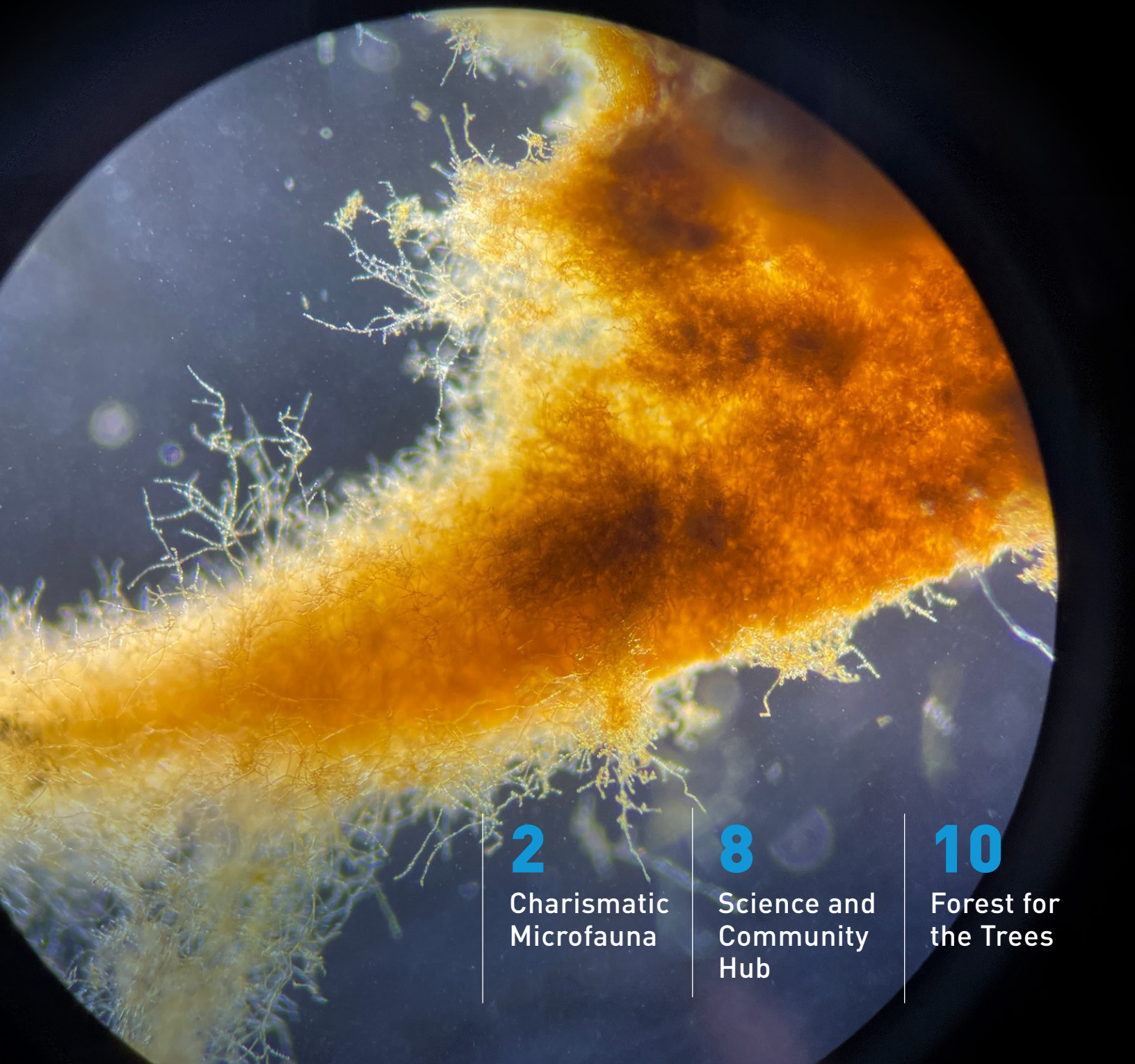
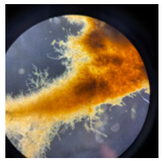
TRANSECT

BIGELOW LABORATORY FOR OCEAN SCIENCES / WINTER 2026





ON THE COVER

Bigelow Laboratory's National Center for Marine Algae and Microbiota houses 1,000 strains of kelp — of different species, life stages, and origins — including this gametophyte of *Saccharina latissima*, or sugar kelp. Our scientists are working with partners across New England to unlock the possibilities of kelp and other forms of algae to develop innovative solutions and commercial products. Learn more on page 13.

Photo: Kerry Dykens

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When we opened the Harold Alfond Center for Ocean Education and Innovation, I moved into a new office. It faces east, and watching the sunrise reminds me that I'm looking forward — to a new day. In these moments, I'm warmed by the sun and filled with energy and optimism.

We've had a lot to celebrate this year, particularly with our new center. Our classrooms have seen their first wave of students, our solutions-focused work has taken a giant leap forward, and our forum has been filled with community members and scientists from around the world who have come to learn, share ideas, and show support for our institution.

But there has been a darkness surrounding all this excitement: namely, the attack on science and science funding at the federal level. It not only threatens our nation's economy, security, and competitiveness, it poses an existential risk to our laboratory, which relies on federal support.

The future isn't as certain as the sunrise, but I see rays of hope everywhere — particularly from our scientists, staff, and supporters. You'll find great examples of each in this issue. Our story on page 10 highlights the efforts of our scientists and students to reveal the consequences of kelp forest collapse in the Gulf of Maine and how we might use what we've learned to help minimize its impacts.

We have researchers unlocking the mysteries of zooplankton, which we lovingly call the "charismatic microfauna" of the sea (on page 2). Our lab also gained three senior research scientists this year — you can read about their work on page 7. Their names may sound familiar because they've already made significant contributions to our lab as research scientists.

You'll also find a profile of Donna and Charles Bagley on page 16. Their generosity makes the work we do here possible, and I ask that as you read their story, you consider making your own gift before the year winds to a close. If you're looking to stay up to date on all the great work that your support enables, check out bigelow.org/currents, which we launched this fall.

Finally, as winter sets in, and the sun begins to rise later and set earlier, I urge you not to focus on the darkness but to do what I've found to be so helpful — celebrate the light when you see it!

Warm regards,

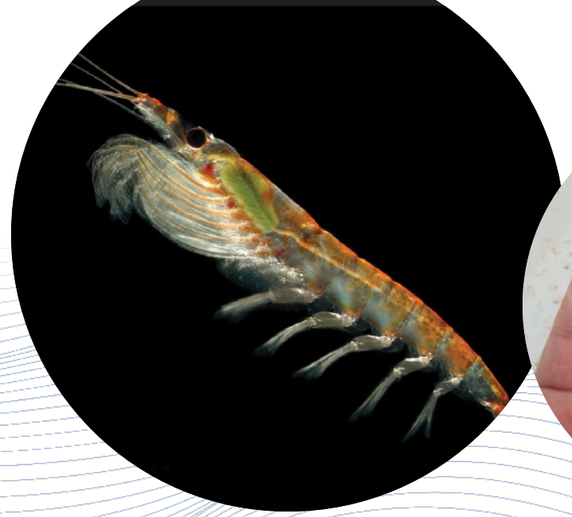
Deborah A. Bronk

DEBORAH A. BRONK, Ph.D.

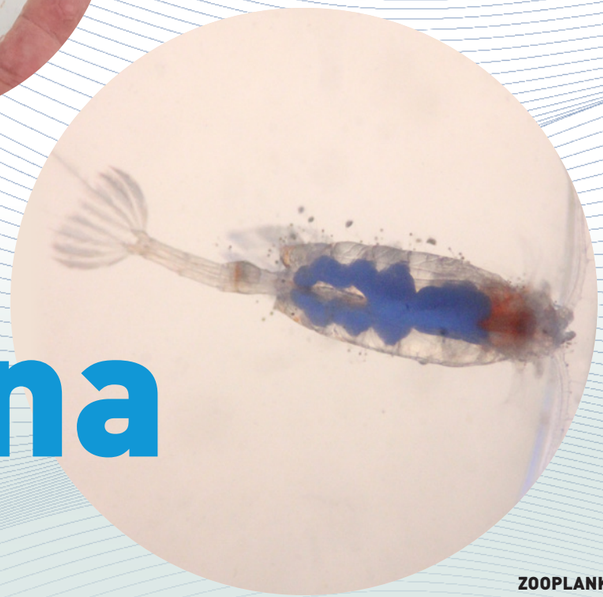
CONTENTS

THE R/V *BOWDITCH*, Bigelow Laboratory's research vessel, sits at the dock before being taken out on an early morning expedition as part of the Gulf of Maine North Atlantic Time Series. Researchers are using the *Bowditch* to collect biological and optical data from across the Gulf of Maine to help validate satellite-based ocean color observations and develop remote sensing tools for studying plankton communities.

Photo: Kim Nutt



LEFT TO RIGHT Micrographs show the unique and complex forms of various zooplankton species, including: a copepod found offshore of Bermuda, an Antarctic krill, various zooplankton collected in the Gulf of Maine, a gravid *Euchaeta* full of blue eggs, a copepod from a freshwater bog that's stained to make its muscles and cells visible, and a zooplankton from the family *Eucalanidae* found in the Gulf of California.



Charismatic Microfauna

Zooplankton are more diverse, more captivating, and more critically important to ocean health than most realize. Bigelow Laboratory researchers are working to unlock the big mysteries of these tiny animals, revealing their fate in a changing world and how it's intertwined with every other creature in the ocean.

What do jellyfish, krill, lobsters, and swordfish have in common? They are different sizes with different life cycles and food sources; yet, at some point in their life, they're all classified as zooplankton.

Zooplankton, Latin for "drifting animal," refers to all animals that float in the upper water column. That includes those that are there for one stage of development, such as lobsters, as well as the vast array of microscopic species that spend their entire existence there. Together, they make up the majority of animal life on the planet and are responsible for the world's largest synchronous migration — billions strong moving up and down the water column every day.

"They're extraordinarily beautiful and extremely important to a healthy ecosystem," explained Senior Research Scientist David Fields. "They really are the true charismatic fauna of the sea."

Most zooplankton species never grow out of their drifting habit. The majority are copepods, a crustacean that is among the most abundant and diverse type of animal on the planet and found in every aquatic habitat, from roadside ditches and ephemeral streams to high alpine lakes.

"Zooplankton are so otherworldly and diverse that one never tires of exploring their planet," remarked Senior Research Scientist Nick Record. "From the ghostly skeleton shrimp haunting the dim waters below docks, to the deep-sea *Phronima*, which inspired the creature in the Alien movies, it's like a never-ending cast of characters from a Halloween universe."

Copepods are also the heart of the marine food web.

"If you take a net tow at the surface at any given time, about 90 percent of what you get are copepods," Fields said. "Almost all of the food at lower trophic levels, at one point, passes through copepods, and then that energy moves up to all of the organisms that feed on them."

Krill, for example, are the most abundant single animal species on the planet, providing the basis of the diet for everything in the Southern Ocean. Meanwhile, in the Northern Hemisphere, *Calanus finmarchicus* accumulates up to 60 percent body fat, creating a thick layer of buttery energy that stretches across the North Atlantic every winter. As they eat, respire, poop, and die, copepods also play an essential role in the cycling of nutrients like carbon from the atmosphere to the deep ocean.

ZOOPLANKTON-FIRST PERSPECTIVE

Despite their importance, though, most models and satellite tools used for studying the ocean focus on the tiny plants, or phytoplankton, that zooplankton feed on — not the animals themselves.

"It's partly because we have so much more data on phytoplankton, but zooplankton are also harder to study in this context," Record explained. "They occupy a lot of different ecological roles throughout their lives, and, for many of them, their life cycle is more complicated than phytoplankton, so the equations we have don't work as well."

Yet, small changes in the zooplankton population can make a big difference in how much carbon dioxide is recycled back into the atmosphere versus how much is pumped down to the seafloor.

"The focus of global carbon cycles has been on net primary production since that's the base of the food web and phytoplankton production is easier to measure," added Senior Research Scientist Karen Stamieszkin. "Assumptions have been made about the fate of carbon

Photos, left to right: John Burns, David Fields, Billy Hickey, Zachary Wagner, John Burns, Amy Maas

‘They’re extraordinarily beautiful and extremely important to a healthy ecosystem. Small disruptions at this level can cascade across the entire marine food web.’

fixed through photosynthesis by these phytoplankton, so research on the fate of carbon has often skipped the nuances of where that carbon goes and how it gets there.”

Stamieszkin is leading an interdisciplinary and multi-institutional team that includes Record to change that.

Funded by the Advanced Research Projects Agency-Energy, they’re examining the relationship between zooplankton physiology and behavior to develop models of how much carbon zooplankton are actively transporting in their daily migrations. The ultimate goal is to incorporate this nuanced information into regional and global models of biogeochemical cycles.

Those improved models will inform efforts to quantify the effectiveness and impact of marine carbon dioxide removal strategies like ocean iron fertilization. They may also be useful for the shipping, seafood, and aquaculture industries who need to better understand the movement of the fishes and mammals that feed on zooplankton.

To that end, Bigelow Laboratory scientists are working on new tools that center zooplankton in larger animal models to aid shipping, conservation, and management efforts. Because, at the end of the day, whales and the like go where their food is.

Earlier this year, Camille Ross, a former research associate with Record and University of Maine PhD student, published a new modeling approach for tracking North Atlantic right whales that incorporates information on *Calanus* and other key copepod prey species. By considering where the whales’ food is concentrated, as well as their daily energy needs, the approach more accurately predicts right whale movements.

In contrast, most existing whale habitat models account for food by using proxies that are easier to measure. For example, chlorophyll concentration is used to estimate, first, the biomass of phytoplankton and, then, the density of zooplankton that feed on those plants. These indirect measures are easier to collect, but are several steps removed from what scientists are actually interested in.

Senior Research Scientist Catherine Mitchell is also trying to develop ways to detect zooplankton directly with satellites. Some species, including *Calanus*, produce a reddish tint visible from space when large numbers swarm together. Mitchell and Postdoctoral Scientist Rebekah Shunmugapandi are exploiting that to develop algorithms that translate ocean color data into maps of zooplankton abundance.

The work is adapting methods developed by Cait McCarry, a former postdoc with Mitchell, and refining them for the Gulf of Maine. The team is still working to fully untangle the relationship between the ocean color signal from satellites, zooplankton abundance, and astaxanthin, the pigment that gives these species their red hue. Yet, the work marks significant progress toward applying remote sensing to study zooplankton.

“There are many more phytoplankton than zooplankton, and maybe there was some thought that zooplankton were too large to influence ocean color. Either way, our existing instruments perpetuate the phytoplankton-sized focus view of the ocean color world,” Mitchell stated. “But there’s so much potential in zooplankton remote sensing, and we’ve really just scratched the surface with the work we’ve done so far!”

ABOVE The right whale nicknamed “Bowtie” is pictured swimming in southern Maine waters in January 2025 during a New England Aquarium survey. **BELOW** Postdoctoral Scientist Rebekah Shunmugapandi presents at a Café Sci lecture this summer on her work with Senior Research Scientist Catherine Mitchell to develop remote sensing tools to monitor zooplankton from space.

Photo, top: New England Aquarium

ABOVE Senior Research Scientist David Fields and Research Associate Maura Niemisto deploy a CTD, a device for collecting water samples, in the Gulf of Maine while aboard the R/V *Bowditch*. **RIGHT** Fields teaches undergraduate students about the ecology and physiology of zooplankton.

A CLIMATE CHANGE BELLWETHER

One major challenge to modeling zooplankton is that, as with most marine life, scientists are already seeing shifts in behavior and physiology in response to ocean warming.

For one, species are already moving poleward in search of more favorable conditions. Fields and his colleagues have also shown that some species, including *Calanus*, are smaller and build up less fat — making them a less nutritious meal — as temperatures rise and their metabolisms ramp up to compensate.

On the behavior front, copepods are known to have a good sense of touch and smell, and many are impressive swimmers.

Former Postdoctoral Scientist Nicole Hellessey worked with Fields and Record to model Antarctic krill’s schooling behavior, an ability that makes them unique among invertebrates. The team showed how krill adapt their swimming in response to the scent of food and predators and even slight changes in their environment, like water temperature and flow rate.

“We often assess damage to ecosystems in terms of whether organisms are dying, but behavior changes — if they can’t find a mate or they’re feeding differently — tell you something about sub-lethal effects of an environmental change,” Fields said. “That gives you a finer picture of when ecosystems are starting to be affected.”

Of particular concern though, Fields explains, is the growing disconnect between the lifecycle of some copepods and the species that depend on them, a phenomenon that ecologists call a phenological mismatch.

Calanus undergoes diapause, a state of suspended development similar to hibernation, in winter. In spring, millions of them emerge, just in time for a copepod buffet for the newly hatched young of all the animals that eat them. In the subsequent months, *Calanus* grow in lock step with their predators, providing a steady food source in those early life stages. The Gulf of Maine ecosystem has developed a biological clock over millennia timed precisely with this pulse.

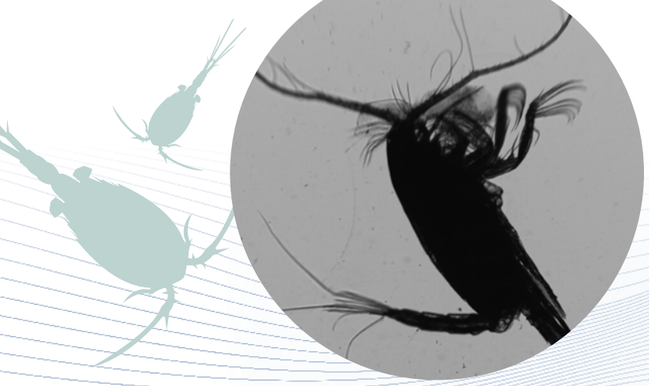
But as waters warm, *Calanus* appears to be coming out of diapause too early.

“When these cycles become uncoupled for one year, the other species that rely on them can get through it,” Fields explains. “But when that uncoupling happens year after year, longer than the organisms that need food for their offspring can survive, entire populations begin to struggle.”

Fields has worked with Senior Research Scientist Peter Countway and Research Scientist Robin Sleith, as well as former University of Maine PhD student Alex Ascher, to understand the impacts of this growing mismatch on lobsters.

Despite incredible numbers of lobsters being born in recent years in the Gulf of Maine, scientists have observed that the number of adolescents has actually declined, suggesting that something is affecting the survival rate of lobsters in their first few weeks of life. Earlier this year, the research team published a novel approach for understanding the diet of these newly hatched lobsters using molecular tools that confirms that larval lobsters rely disproportionately on *Calanus* as a food source. This suggests that the growing mismatch between the *Calanus* hibernation and the lobster life cycle could be partly to blame for why fewer lobsters are making it to the next life stage.

Photos, left to right: Billy Hickey, Gabe Souza



THE FLOWCAM provides an image of a zooplankton, one of thousands of images the instrument quickly takes from a single sample of water, helping speed up the process for identifying and counting animals.

'Zooplankton are so otherworldly and diverse that one never tires of exploring their planet.'

NEW TOOLS FOR NEW QUESTIONS

Understanding these responses to change — and what impact they could have on how the ocean functions — requires sophisticated tools for counting and characterizing these tiny animals.

Typically, scientists tow a net along the surface, sweeping up lots of different, small organisms that get trapped on a filter, which is then used to estimate overall biomass in that sample. But one has to look at those filters under a microscope and visually identify species to say anything about the individuals in that sample.

Recently, however, Fields's lab acquired a FlowCam, with funding from the Maine Coastal and Marine Climate Action Fund of the Maine Community Foundation, which captures high-resolution images of every particle in a sample. With those images, they can quickly determine the ratio of male to female and the general size distribution of the zooplankton population and identify key species in a sample.

The team is still working to optimize the tool for zooplankton applications. That said, it's already proven invaluable for automating a time-consuming process and standardizing measurements to confidently observe changes over time and between different parts of the ocean. The digital images, he says, also provide a better "long-term storage solution" for the data compared to preserving actual animal samples.

"We take the FlowCam out on the boat with us and process samples as we're collecting them, so by the end of a research cruise, you have reliable information that, in the past, would have taken months to process," Fields said.

Right now, Bigelow Laboratory is the only institution in the state that can process and analyze zooplankton samples with a FlowCam, an analytical service his lab is offering to researchers and resource managers around the world and that he hopes will expand the possibilities of this exciting area of research.

"Because of their sheer number, small changes to copepods matter for the whole ocean," Fields emphasized. "There are questions at a population level that are just hard to get at by poking at individual animals under a microscope. Now, we can start answering those questions."

NOTES FROM THE LAB

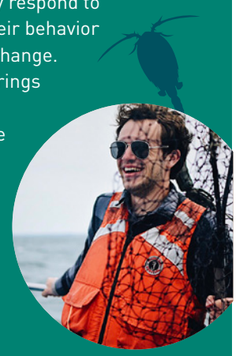
ZACHARY WAGNER, *Georgia Institute of Technology PhD Student*

Copepods have no shortage of amazing traits. They fill every role an animal can in an ecosystem from herbivore to apex predator, and a lot are actually parasites. One of my favorite facts is that they're capable of insane acceleration. An animal less than a millimeter long can move several centimeters in less than a second. That's like a person accelerating to 160 miles per hour in a single kick!

I got into this research as an undergraduate at Roger Williams University where I analyzed the footage of jellyfish that eat copepods. I had to learn how to grow phytoplankton to feed the copepods, sort them to determine age and sex, and handle the very fragile jellyfish. I basically had a whole ecosystem on my workbench, and I loved it.

I'm now a PhD student at Georgia Tech, based at Bigelow Laboratory working with David Fields. The focus of my research is to understand how water temperature and viscosity affect copepod physiology and behavior. Copepods use their antennae to feel vibrations in the water and perceive what's going on in their environment, so they're highly sensitive to water conditions. I'm focused on a kind of copepod called *Euchaeta*, which is a voracious carnivore, filming them in different conditions to see how environmental changes influence their interactions with smaller copepods they eat. From a single interaction within a single video clip, we can analyze the perception distance of both predator and prey, how they respond to each other, and whether their behavior shifts as water conditions change.

It's exciting work that brings together what I love about copepods — their incredible sensory abilities and diversity — to answer important questions about how these amazing animals respond to and shape their changing environment.



Photo, top: David Fields

NEW HORIZONS

Senior research scientists lead our global research efforts, help guide the direction of the institution, and serve as valued mentors to future generations of scientists. In the last year, we have promoted three outstanding research scientists into this important leadership role to advance our ocean science and education efforts.

"Whether through education, informing policy with science, or contributing to the understanding of how this beautiful planet works, my ultimate goal is to provide knowledge and services that equip our society to live well and in harmony as part of the Earth system."

DR. KAREN STAMIESZKIN, Plankton Ecologist

Like many budding ocean scientists, Karen was drawn in by a childhood exploring tidepools at the beach, but it was a biological oceanography class in college that first inspired her love of the ocean's smallest life. She received her PhD in biological oceanography from the University of Maine and first came to Bigelow Laboratory as a postdoctoral researcher in 2017. Throughout her career, she's used a mix of field, lab, and computational methods to answer fundamental questions about how the ocean works, how plankton communities respond to and shape their environment, and how these tiny plants and animals drive global-scale processes.

DR. JULIA BROWN, Microbiologist

Viruses are the most abundant and smallest biological entity on the planet. They're also one of the hardest to study. That hasn't stopped Julia, who received her PhD in microbiology from Cornell University and came to Bigelow Laboratory originally as a bioinformatician at the Single Cell Genomics Center. She uses her combined expertise in bioinformatics and microbiology to uncover novel viral diversity and research the ways viruses and microbes interact and respond to their environment. She also works to make data science and bioinformatics more accessible through coding workshops and undergraduate teaching and mentorship.

"To step into the ocean is to step into a sea of viruses. There is so much that we don't yet understand about the impact of viruses on this planet."

"We must first understand life on Earth to have a chance at finding life elsewhere. The insights we gain at home can help us discover fundamental microbial processes and better understand global biogeochemical cycles."

DR. MELODY LINDSAY, Geomicrobiologist

Melody's interest in scientific research was sparked by an astrobiology program in Hawaii. Her focus has since shifted to extreme environments on our own planet. She studied microbes that thrive in Yellowstone hot springs for her PhD research at Montana State University and first came to Bigelow Laboratory in 2019 as a postdoctoral scientist, expanding her work to encompass marine ecosystems. Her research aims to connect the activity and genetics of microbes living in challenging environments — from sediments along the coast of Maine to the deep ocean floor — with the hope that they might tell us something about life on other ocean worlds.

VISITORS TO THE BURGESS FORUM enjoy some of the numerous events that have been hosted in the space since it opened, including (clockwise from top left): the REU symposium, a presentation by Brian Skerry, a Café Sci talk, and the grand opening celebration of the Alfond Center.

THE ALFOND CENTER provides state-of-the-art facilities to host public events and science talks, such as the annual Café Sci series (top) and the dissertation defenses of graduating PhD students, such as Dara Yiu (bottom).

A HUB FOR COMMUNITY AND SCIENCE IN MAINE

This summer, Bigelow Laboratory marked the grand opening of the new Harold Alfond Center for Ocean Education and Innovation. With modern classrooms, offices, and laboratories, the expansion reflects a 40 percent increase in the institute's physical footprint. But it represents an immeasurable increase in our capacity to advance pioneering research and offer world-class education programs.

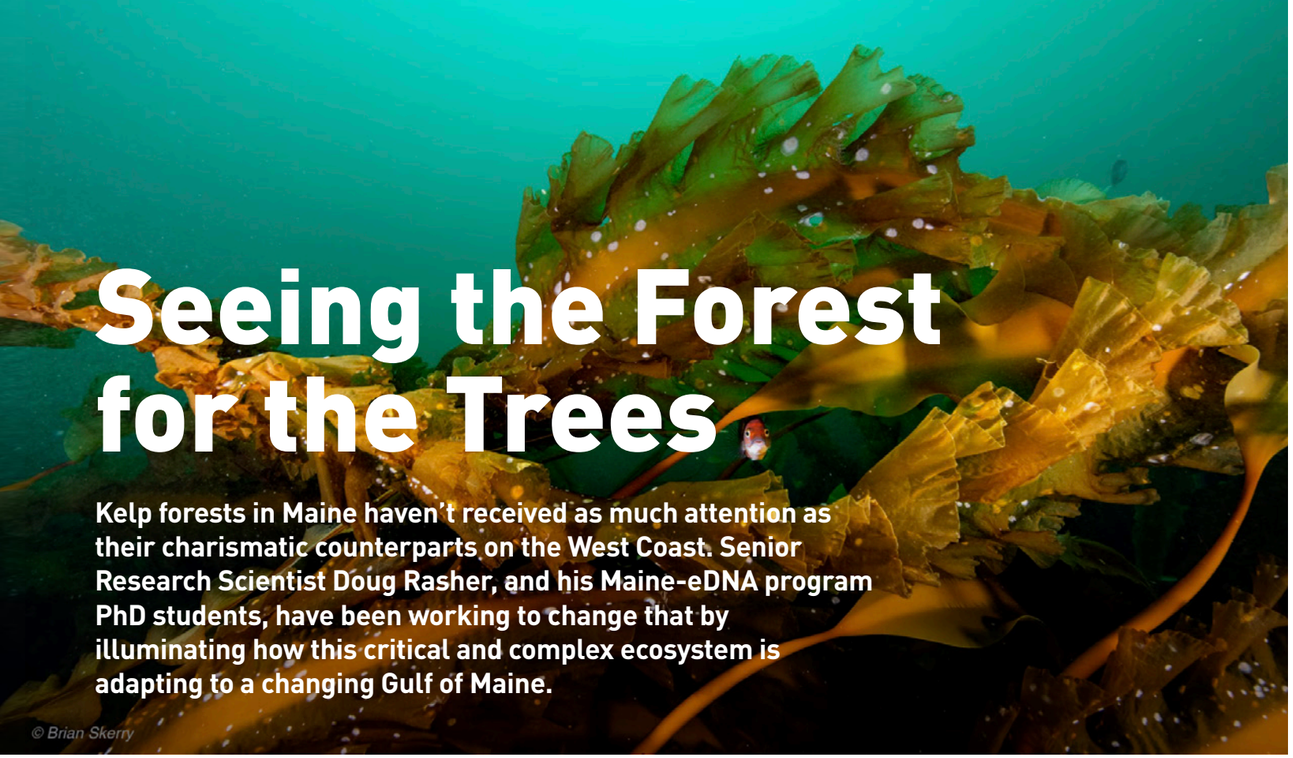
The centerpiece of the expansion is the Burgess Forum, a multi-purpose, versatile gathering space. Fittingly, the first "users" of the forum were participants in Keller BLOOM, a program for Maine high school students getting their first experience with ocean science. At the close of the week-long program, they used the space to share their experience with a presentation for friends and family. The new center was then officially christened with a ribbon-cutting celebration in June that brought together over 250 supporters, community leaders, and scientists.

In the months since, we've welcomed hundreds of visitors to our campus to enjoy the state-of-the-art facility. Our summer research interns closed out their time with a symposium and poster presentation in the forum. Several graduate students defended their dissertations and began the next phase of their careers there. Renowned National Geographic photographer Brian Skerry shared his work on the large screen for our Big Splash fundraiser. Bigelow Laboratory CEO and President Deborah Bronk gave the keynote for our annual open house in the space on the future of science. And Bigelow Laboratory scientists described their research to large audiences during the Café Sci series.

This new space was made possible by the support of donors, the Harold Alfond Foundation, and the joint efforts of Senator Susan Collins, Senator Angus King, and Congresswoman Chellie Pingree. This full lineup of events there in the last months has helped establish it as a community hub and destination for scientific collaboration and education. Going forward, it will continue to play host to workshops, presentations, staff meetings, documentary screenings, and more. As Greg Powell, chair of the Harold Alfond Foundation, said during the grand opening, "This wing is more than a building. It's a bold investment in the future."

Photos, top to bottom: Gabe Souza, Kim Nutt

Photos, clockwise from top left: Alex Seise, Little Heirloom Photography, Gabe Souza, Alex Seise



Seeing the Forest for the Trees

Kelp forests in Maine haven't received as much attention as their charismatic counterparts on the West Coast. Senior Research Scientist Doug Rasher, and his Maine-eDNA program PhD students, have been working to change that by illuminating how this critical and complex ecosystem is adapting to a changing Gulf of Maine.

© Brian Skerry

Imagine a dense, dark forest clear-cut until a vast grassland grows in its place.

That's what ecologists call a state shift — a dramatic, persistent, and large-scale transition of an ecosystem into something new, with devastating consequences for the broader ecosystem and the humans that depend on it.

Bigelow Laboratory Senior Research Scientist Doug Rasher has dedicated his career to understanding the causes and consequences of state shifts on reefs.

"These dramatic state shifts erode the functions and services that natural ecosystems provide," Rasher explained. "My research aims to reveal what's driving these state shifts on reefs, how they reverberate across the broader ecosystem, and how we might prevent or reverse them."

Rasher studies tropical coral reefs, as well as rocky reefs found in the ocean's colder, temperate regions. Instead of coral, the foundational species there are kelps, which thrive in nutrient-rich, cold water and create dense forests that provide habitat, food, and clean water.

Like coral reefs, kelp forests face a multitude of threats, from overfishing and pollution to species invasions, heat waves, and intensifying storms. It was actually in kelp forests where ecologists provided one of the first examples of a trophic cascade, observing how the loss of a key predator, like sea otters, led to the proliferation of herbivorous sea urchins that overgrazed kelp until the reefs were barren.

In many parts of the world, the most acute pressure these days, though, comes from ocean warming, as many kelp forests find themselves in temperatures at the limit of what they can tolerate.

"Since kelps are a foundational species that create this important ecosystem, understanding how they are responding to climate change can aid in understanding a plethora of downstream effects," said Rene Francolini, a recently graduated University of Maine PhD student in Rasher's lab.

The Gulf of Maine's relatively simple food web and rapidly warming conditions make it particularly vulnerable. Yet, when Rasher arrived in Maine over a decade ago, he was surprised to find there was relatively little research happening within its kelp forests.

"The Gulf spans over 1,000 kilometers and is one of the fastest-warming ocean regions in the world, making it both an ideal natural laboratory and a bellwether for kelp forests globally," said Shane Farrell, another University of Maine PhD student in Rasher's lab who is now a postdoctoral scientist at the University of Galway. "Our discoveries about the causes and consequences of change here may help conserve kelp forests worldwide."

A CUNNER FISH swims through a kelp forest around Cashes Ledge, an offshore seamount with a thriving marine ecosystem where Senior Research Scientist Doug Rasher is gaining insight that could help build the resilience of kelp forests on the coast.

Photos, top to bottom: Brian Skerry, Rene Francolini

In 2018, Rasher was funded by Maine Sea Grant to census Maine's kelp forests for the first time in more than a decade. The team, which included partners at the Maine Department of Marine Resources, published their findings last year.

Their work revealed the widespread collapse of kelp forests along Maine's southern coast, driven largely by warming. In their place, small, carpet-like turf algae, which don't provide the same ecosystem benefits, has taken over. But the work also showcased how kelp forests are still thriving in northern Maine, where temperatures are rising more slowly. That motivated Rasher to dig deeper into these regional differences and the consequences of the state shift.

MOVING FROM CAUSE TO CONSEQUENCE

In 2019, Bigelow Laboratory and partner institutions across the state were awarded a significant, five-year grant from the National Science Foundation to advance understanding of Maine's coastal ecosystems using environmental DNA. The DNA that organisms shed into their surrounding environment, eDNA can be used as a powerful tool for tracking species that are hard to see, new to an ecosystem, or just passing through.

Through the Maine-eDNA program, Postdoctoral Scientist Yasmina Shah Esmaeili joined Rasher's lab to compare eDNA and traditional methods, like diver-based visual surveys, for assessing ecosystem biodiversity. Shah Esmaeili, now a visiting assistant professor at Texas A&M University at Galveston, was instrumental in developing the reference libraries that enable scientists to match the DNA they find in the ocean with known, identified species.

The program also enabled Farrell, Francolini, and fellow University of Maine PhD student Dara Yiu, to start their doctoral studies, co-advised by Rasher and University of Maine scientists as part of a cohort of eDNA graduate students around the state.

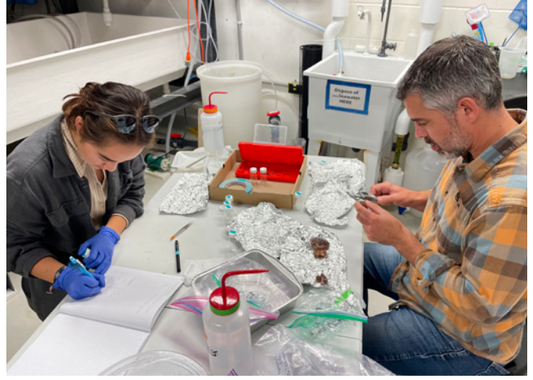
"My vision was to help each student develop a thesis project that leveraged our shared data, but also expanded in a unique direction to explore a particular consequence of the state shift," Rasher said. "Collectively, the students' projects paint a picture of recent and dramatic change in Maine's kelp forests, both with respect to how they look and how they function."

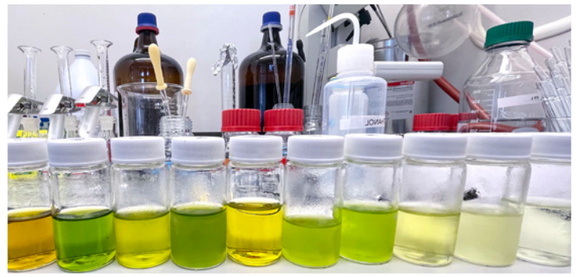
For three years, the supersized Rasher lab studied sites along the entire coast of Maine, in spring and summer, collecting water and kelp samples for genetic sequencing, conducting visual censuses of fish and kelp coverage, and more.

'Since kelps are a foundational species that create this important ecosystem, understanding how they are responding to climate change can aid in understanding a plethora of downstream effects.'

MEMBERS OF THE LAB, including Maine-eDNA students Dara Yiu and Shane Farrell (above) and Rasher (far right), dive to collect ecological data, water samples, and pieces of kelp and turf algae (right) for further study.

Photos, clockwise from top left: Rene Francolini, Brian Skerry, Leah Campbell





ABOVE Farrell examines algae samples in the lab. **TOP RIGHT** Yiu (left) and Rasher catalog samples after a dive survey. **RIGHT** Vials contain the internal chemistry the team extracted from different seaweed tissue.

'Collectively, the students' projects paint a picture of recent and dramatic change in Maine's kelp forests, both with respect to how they look and how they function.'

Each student then took the large dataset to examine kelp forests from a different perspective.

"There is no one right way to study a problem, which is abundantly clear when you see how we used so many different tools and approached questions from multiple points of view," Francolini explained.

"Different tools serve different purposes," Yiu added. "We needed a variety of approaches to look at all these facets of the ecosystem."

Yiu, now a postdoctoral scientist at the University of Nevada, Reno, focused on reef fishes. In addition to applying fish-centric eDNA tools to track the arrival of new species, she also learned stable isotope methods to examine how the loss of kelps is changing the flow of energy through the food web. Her work showed how predator-prey dynamics are fundamentally different on turf-dominated reefs compared to kelp forests and confirmed for the first time that kelp forests provide critical energy to the food web in this region.

Farrell focused on the turf algae itself, trying to understand how this state shift was impacting the chemistry and microbiology of the reef. He developed eDNA tools to understand the makeup of the turf, which can contain a variety of species that are hard to differentiate underwater. He also discovered how turf algae release chemicals that kill young kelp, contributing to a feedback loop where turf algae inhibit forest recovery and lock the system in a degraded state.

Francolini meanwhile worked to identify whether there were distinct genetic populations of kelp along the coast. But like the others, she also focused on new arrivals into the system, using eDNA to track invasive lacy bryozoans. This small organism grows in colonies on kelp fronds, leaving kelps prone to breakage and impeding their ability to reproduce and photosynthesize. Francolini aimed to model how this invasive species might proliferate as the Gulf of Maine continues to warm.

For these students, being part of Rasher's lab and the Maine-eDNA cohort provided technical skills in bioinformatics, molecular biology, science communication, and scientific diving. More than that, though, it allowed them each to grow into curious and capable scientists.

"This experience was life changing. I entered my PhD without a clear direction and left knowing my passion lies in integrating interdisciplinary techniques to study kelp forests," Farrell said. "I started at Bigelow as a 20-year-old intern, and seven years later, I left as a doctor. Along the way, I gained lifelong collaborators, mentors, and friends."

Their varied projects also highlight the value of early-career researchers, such as PhD students, in advancing Bigelow Laboratory's mission.

"Having a large group of PhD students, undergraduate interns, technicians, and postdocs working together on a common project was amazing because it led to multidisciplinary perspectives and approaches," Rasher said. "I learned so much from them as well, and what we were able to achieve by working together was greater than the sum of its parts."

Photos, clockwise from left: Rene Francolini, Leah Campbell, Shane Farrell, Shane Farrell

CURRENTS

Photo: Kerry Dykens

Photo: Sunny Pinkham

Ocean Color Anomaly Explained

Satellites have long observed an unexpected area of bright, turquoise-color water in the Southern Ocean. Scientists have struggled to explain this ocean color anomaly because of difficulties monitoring the remote region due to heavy cloud cover, icebergs, and rough seas.

A team led by Senior Research Scientist Emeritus Barney Balch recently helped answer this long-standing mystery. They undertook a research expedition down to 60 degrees south during which they gathered a novel and valuable combination of optical and biogeochemical data, confirming that this part of the ocean has unusually high concentrations of silica-rich diatoms. They also found evidence of coccolithophores, suggesting that these microalgae, which play a critical role in the global carbon cycle, can survive in colder waters than expected. The findings provide valuable insight into how the plankton community responds to changing seawater conditions and will help improve the remote sensing tools scientists use to study the Southern Ocean.

INSTITUTE HELPS ADVANCE BURGEONING BIOTECH INDUSTRY

With its strong maritime heritage, rich marine ecosystems, and thriving working waterfront, Maine is positioned to be a national leader in the blue economy. Bigelow Laboratory is helping catalyze that economic development by promoting a blue biotechnology sector that drives innovation and enables discovery of novel materials from marine organisms for everything from manufacturing to agriculture.

Beth Orcutt, vice president for research, is serving on the Blue Economy Task Force to provide recommendations on how Maine can grow its blue economy. In service of this, Bigelow Laboratory commissioned an ecosystem map of Maine's leadership potential in blue biotechnology, releasing the resulting report in October. Building on this momentum, the institute was awarded funding from the Maine Technology Institute, in collaboration with Hatch Blue and Ocean House Consulting, to support entrepreneurs with an innovation studio that signals to global investors the state's readiness to support new ventures in this space.

Photo: Catie Cleveland

RESEARCHERS CREATIVELY SHARE DISEASE WORK

Senior Research Scientist Maya Groner and her lab combine field surveys, experiments, and mathematical models to study the pathogens that affect marine species. This year, the team moved forward projects on several species, including sea stars, snow crabs, and eelgrass, to understand what impact warming waters have on diseases and identify opportunities to guide management and conservation strategies.

They also prioritized opportunities to share their work broadly. Groner and Research Scientist Reyn Yoshioka taught a course on infectious marine diseases at Friday Harbor Laboratories this summer. Yoshioka developed an educational board game called Crabdemics that uses crabs to teach epidemiological principles and was shared with schools and agency partners across Alaska. And, here in Maine, the team presented their research to the public during the Café Sci series in which Postdoctoral Scientist Melissa Rocker shared findings from an interdisciplinary project on the spread of epizootic shell disease in Gulf of Maine lobsters.

Photo: Marie-Yasmine Dechraoui Bottein

Helping Build HABs Capacity Worldwide

Harmful algal blooms are a growing challenge for coastal communities around the world. Researchers from Bigelow Laboratory have been working with a global network of partners to share their expertise and help guide communities that want to develop early warning systems to help combat HABs.

Predicting where blooms will emerge and how long they'll last — and getting that information out to people effectively — will ensure managers can make science-informed decisions. To that end, Senior Research Scientist Nick Record and Research Associate Johnathan Evanilla, who were both involved in creating a HAB forecasting tool here in Maine, participated in several UNESCO-funded workshops in Morocco and Namibia. These events brought together stakeholders and scientists from around the world to identify knowledge gaps, build technical capacity, and begin developing early warning systems that are accessible and useful. Following the workshops, Record and Evanilla have been developing virtual content to enable participants to continue building relevant technical skills.

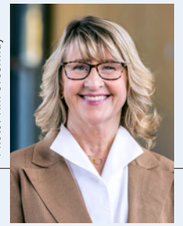


Photo: Tim Greenway

HIGH HONORS FOR BIGELOW LABORATORY

Two Bigelow Laboratory scientists received significant honors this year for their contributions to ocean science and education. President and CEO Deborah Bronk received an award from the Association for the Sciences of Limnology and Oceanography (ASLO) for her efforts to support the scientific society's professional goals and her stewardship broadly of the aquatic sciences community. Bronk was also recognized as a Business Leader of the Year by Mainebiz for her strategic leadership of Bigelow Laboratory, particularly through the opening of the Alfond Center for Ocean Education and Innovation.

Senior Research Scientist Nicole Poulton also received a top honor from ASLO, which recognized her outstanding teaching and mentoring contributions and her dedication to education, which is reflected in her leadership of several Bigelow Laboratory education endeavors. Poulton is also part of the Bio-GO-SHIP team, an international research collaboration that received an Excellence in Partnering Award from the National Oceanographic Partnership Program.

Photo: Sydney Greenlee

Partnerships Power Aquaculture-Focused Research

Collaborations with aquaculture partners are helping advance several threads of Bigelow Laboratory research, resulting in tools and knowledge ocean farmers need. For example, a team is developing cryopreservation and seeding methods for different stages of kelp, which would provide farmers with readily available cultivated spores and help them cope with shocks to wild seaweeds.

Much of the work leverages the power of environmental DNA. This includes molecular assays that can differentiate between kelp species, field-ready tests to quickly detect bacterial pathogens that may affect shellfish operations, and easy-to-use environmental RNA tools to track the larval mussels that farmers need to seed their crop. Researchers are also building tools to accurately and inexpensively quantify kelp-derived biomass in sediments below commercial kelp farms. That work, which confirms that farms have little impact on the bottom communities living below them, is the first step toward quantifying deposition of kelp-derived carbon for "blue carbon" accounting efforts.

Photo: Brennan Phillips

AWARD PROPELS OCEAN DISCOVERY RESEARCH

Last year, a team including Senior Research Scientist John Burns, published a new, multi-disciplinary approach for observing and describing fragile marine animals. The team, now led by Burns, received significant follow-on funding from the Ocean Shot Research Grant Program, an initiative to encourage bold research in ocean discovery and technology.

The innovative approach combines cutting-edge imaging technology and underwater robotics to produce high-resolution 3D images, preserve tissue, and generate reference genomic data. It enables scientists to study even the most fragile animals in their natural environment with unprecedented levels of detail and has the potential to speed up the process for classifying new species in the ocean's vast and understudied midwater region. The team's project was also selected by Schmidt Ocean Institute for a research expedition next year out of Brazil to collect samples and collaborate with another Ocean Shot-funded team focused on species description and neurophysiology of marine animals.

Several Firsts in the World of Single Cells

Bigelow Laboratory and Single Cell Genomics Center microbiologists published new research this year that transforms understanding of the complex and diverse world of marine viruses and microbes. Recent advancements include: the first quantitative analysis across an entire microbiome of the critical evolutionary process of lateral gene transfer; the first environmental application of a new single-cell sequencing tool that vastly improves on the throughput and efficiency of existing methods; and the first use in coastal sediments of an advanced approach for linking the activity of microbes to their genetic code. That latter effort received additional funding to help the team continue unraveling the evolutionary history and function of bacteria they discovered in those sediments.

The institute also recently received a significant award from the National Science Foundation to expand the capabilities of SCGC, which will enable researchers to advance these pioneering projects and aid the institute's broader efforts to unlock the biotech potential of microorganisms.

Photo: Fritz Freudenberger

SCIENTISTS MONITOR BRUNSWICK AREA PFAS SPILL

PFAS are a large group of man-made chemicals known for being durable and long lasting. So, when 50,000 gallons of PFAS-containing firefighting foam was accidently released from the former Brunswick Naval Air Station in August 2024, researchers, organizations, and agencies jumped into action. Led by Senior Research Scientist Christoph Aeppli and funded by the EPA, Bigelow Laboratory researchers have spent the last year monitoring several sites to understand how quickly the chemicals moved through Harpswell Cove into the ocean.

By comparing results to baseline data the team has been collecting across the region since 2023, they revealed that concentrations initially increased along a 10-mile transect downstream from the spill but returned to pre-spill levels within months. This monitoring data, gathered in partnership with Friends of Casco Bay, is providing important context for agencies managing the spill and has vastly improved scientists' understanding of the movement and fate of these chemicals in tidal systems.

Photo: Christoph Aeppli

PROFILE Donna and Charles Bagley Council Members

'You turn over a patch of seaweed or a rock, and there's so much going on there. It was just interesting and wonderful for me as a child to be able to explore all of that.'

Since she was a baby, Donna Bagley has visited the Boothbay region every summer. For years, her parents did the same. Before that, it was her grandparents. Today, Donna and her husband, Charlie, continue to spend their summers in Southport, and it's their children and grandchildren who are visiting. The couple have become fixtures in the Boothbay and Bigelow Laboratory communities.

For Donna, who grew up in Ohio, she says those early experiences in Maine are what inspired her family's love of the ocean. She recalls happy memories fishing and digging for clams with her grandfather, and her house is full of art from her mother, an oil painter who specialized in ocean scenes.

"It all started as a child coming from the Midwest and being able to explore the beaches and the tidal pools," she said. "You turn over a patch of seaweed or a rock, and there's so much going on there. It was just interesting and wonderful for me as a child to be able to explore all of that."

For Charlie, a life-long sailor, his love of the ocean similarly began at a young age exploring the waters of Chesapeake Bay. As with Donna, many of his fondest memories are from his time out on the water.

But, for both of them, that childhood love of the ocean evolved into a passion for protecting it as they traveled widely and saw how degraded much of the world's coastlines are.

"I feel like for so long, the oceans have been viewed as a convenient dumping point for all of the detritus of modern human society with very little concern for the consequences," she said. "We're responsible for a lot of that damage, but we're also the only species that has the ability to say, why does this happen. And we're the only species that has the ability to say, what can we do to change it."

That hope is what eventually led her and Charlie to Bigelow Laboratory. It was at a summer lecture, part of the annual Café Sci series, that they began to appreciate the global reach of the institute's mission. Then, in 2022, they attended the Big Splash fundraiser and have been avid supporters ever since.

Donna says they've been particularly inspired by the institute's focus on educating both the next generation of scientists and life-long learners like themselves. Likewise, they appreciate the interdisciplinarity of the institute's research. As an example, she points to work being done by Bigelow Laboratory scientists to study algae blooms from space. Having spent a lot of time in Florida, she knows well how damaging those blooms can be. That research, she says, illustrates the power of creatively bringing together different areas of science to address a real-world challenge.

"I was blown away when I realized the extent of what's being done all around the world, not just here, but looking toward solutions that can benefit the entire planet," she says.

When they're not in Maine, the Bagleys live on Chesapeake Bay in Gibson Island, Maryland. They regularly champion the lab through a Donor-Advised Fund and have opened their home to other supporters through events like the Council Summer Outing this past August. Last year, Donna joined the Advisory Board, a role in which she'll be able to use her passion and optimism to help guide the future of the institution.

"So much of the news is negative and depressing, and particularly for people who aren't scientists, you begin to think, what can I do." she said. "But the thing that really impressed me about Bigelow was the optimism and sense that these are problems that can be solved and this is something I can support that will make a real difference."

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Photo: Laura Lubelczyk

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