# TRANSECT

BIGELOW LABORATORY FOR OCEAN SCIENCES / SUMMER 2023

**ON THE COVER**

New research aided by Bigelow Laboratory scientists showed that salps, a widespread gelatinous organism, play an outsized role in the ocean's biological carbon pump. By transporting carbon from the surface to the deep sea, the process helps the ocean remove more carbon dioxide from the atmosphere. Read more at bigelow.org/EOS-salps.

Photo: Paul Caiger

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## Message from the President

Summer is an exciting time at Bigelow Laboratory!

In mid May, our Keller BLOOM program brought 16 students from across the state to learn and live at our laboratory for a week-long, immersive experience doing actual research. The next week, 25 summer interns arrived to begin their 10-week dive into our global ocean science. Professional development courses on maintaining algae, identifying harmful species, and science education will bookend our summer programs, drawing participants from around the country to learn from our scientists.

All of this activity is particularly exciting this year, as we prepare for construction of the new center for ocean education and innovation that we just announced (page 2). Our work and staff have doubled since we moved into our current laboratory a decade ago, and this major addition to our campus — along with the fundraising initiative we launched this summer to support related work — will be an evolutionary leap for the laboratory.

I invite you to explore the growing difference we're making in the world in our 2022 Impact Report, which you'll find on page 10. You'll see a few of our favorite examples of recent work that advanced our major research themes. It's incredibly heartening to review this snapshot of our impact. We're taking on some of the planet's biggest challenges, and we are making progress!

On the pages that follow our Impact Report, you'll find a list of the visionary donors who made that impact possible. I am immensely grateful to each individual and organization you see there. Their generosity — and yours — empowers us to make discoveries, create urgently needed solutions, and inspire our current and future leaders to enact societal changes that are so desperately needed.

It's thrilling to look back and see how far we've come, and even more so to look ahead to the future. At the conclusion of a national search this spring, we selected Dr. Beth Orcutt to shepherd our research portfolio as our new vice president for research. I know the impact of our science will continue to grow with her support.

Beth came to Bigelow Laboratory as a senior research scientist in 2012. She has joined over 30 research expeditions and spent more than 600 days at sea. She is widely recognized as a leader in the study of deep-sea microbes. In the months prior to her appointment, she demonstrated remarkable care for the role and passion for our mission as interim vice president, and I know she's just getting started!

With these major additions to both our facilities and our staff, we are moving into a new era at Bigelow Laboratory. I'm so proud to be part of this team and the important work that your generosity makes possible.

Deborah A. Bronk

**DEBORAH A. BRONK,** Ph.D.

# CONTENTS



**CHAIN-FORMING DIATOMS** from the genus *Thalassiosira* provide an important source of nutrition to the base of marine food webs. *Thalassiosira* was the first single-celled marine algae to have its genome fully sequenced. That work was made possible in part by former Senior Research Scientist Robert Guillard, who isolated the strain that was used in this pioneering work.

Photo: Laura Lubelczyk

# Major Expansion to Advance Ocean Education and Innovation

## A new center will open spring 2025 and bring dedicated spaces for training, collaboration, and solutions development.

On June 8, World Ocean Day, Bigelow Laboratory announced an initiative to create a transformative new center for ocean education and innovation. Embodied by a $30 million, 25,000-square-foot laboratory addition, the center will revolutionize Bigelow Laboratory's education and solutions-focused work.

Dedicated teaching labs and classrooms will enable more students and scientists to get hands-on training with cutting-edge techniques. New laboratories will expand support for green business innovation and enable the addition of four more research groups. Newly endowed funds will provide seed grants for exploring promising, creative ideas. And a large and flexible forum will serve as a hub for international scientific collaboration and facilitate ocean solutions among local communities here in Maine.

"Research to understand the foundation of global ocean health will always be at the core of our work," said Deborah Bronk, president and CEO. "But our staff has doubled since we moved into our current space in 2012, and I'm excited by the growing ways we're sharing what we learn and applying it to pressing societal problems."

Groundbreaking is planned for October, with completion slated for spring 2025. Construction and future maintenance is being supported by an $8 million gift from the Harold Alfond Foundation — as well as more than $9 million from individual and institutional donors, and $12 million in federal funding through the National Institute of Standards and Technology 2023 Construction Grant Program.

**LEFT** A rendering of the front of Bigelow Laboratory shows the planned expansion. **BELOW** Hannah Braslau, left, and Katie Baker undertook research on environmental DNA as interns in 2022.

Fundraising will continue through June 2024 to complete the resources needed for the center and the additional education, fundamental research, and solutions-focused initiatives it will enable. Since 2020, Bigelow Laboratory has raised more than $61 million from a variety of partners and donors to support the initiatives set forth in its 2020 Strategic Plan, of which the new center is a critical component.

"We're incredibly grateful to our federal representatives, donors, and all those who are helping to raise these vital funds," said Bill Burgess, chair of the board of trustees. "As the institute nears its fiftieth anniversary next year, this center for ocean education and innovation points to a bold vision for what Bigelow Laboratory will become during the next 50 years."

**A RENDERING** of the recently announced expansion of Bigelow Laboratory shows the new center in the foreground with the existing facilities behind.

### OCEAN EDUCATION

The new center will be purpose-built for flexibility. At the heart of a suite of teaching labs and classrooms is a two-story dynamic forum that will serve as a gathering space for scientists, students, and professionals alike. Together, these spaces will enable an expanding constellation of educational programs at Bigelow Laboratory. This growth will require focused effort to ensure that the programs' full potential is reached, which is why the funding for the center includes the addition of a new role: marine educator.

"Education and outreach are critical outcomes of our research efforts, as well as an integral component of our mission," said Ben Twining, senior research scientist and vice president for education at Bigelow Laboratory, "The investments in these new facilities and staff, along with the recent addition of our 48-foot research vessel, will allow us to greatly expand access to our hands-on education programs that already inspire hundreds of students each year."

From weeklong experiences for high school students to semester-long experiences for undergraduates, Bigelow Laboratory education programs serve students all the way through their doctoral studies. Twining said that the new center will help enrich existing programs and broaden the student base they serve.

"All of our programs center on giving students authentic experiences doing real science alongside practicing scientists," Twining said. "This has required using

laboratories that are otherwise needed for important research projects and are not always ideal for working with large student groups. The new center will really boost the reach and impact of our education programs."

This expanding reach doesn't stop at students, however, as the new space will also allow for more professional development opportunities for an international community of educators, scientists, and representatives from industry, government, and Indigenous groups. This means the center will have an impact in ways both academic and economic.

Single- and multi-day courses and workshops are held throughout the year at Bigelow Laboratory, but those efforts are constrained by the current facilities. In addition to increasing access to those offerings, the 300-seat forum will enable the institute to host large collaborative events for both science and industry.

"The kind of education and connection that will be happening in this space reaches far beyond the transfer of knowledge," said Mike Lomas, a senior research scientist who runs professional education programs on topics ranging from maintaining algal cultures to identifying harmful algal species. "It will also become a place where we are able to translate foundational science into a sustainable economy — one with local, national, and global reach."

**'This center for ocean education and innovation points to a bold vision for what Bigelow Laboratory will become during the next 50 years.'**

## OCEAN INNOVATION

"I've always said that our science shines brightest when it cross-pollinates with other fields and disciplines," President Bronk said. "The greatest opportunities for discovery and innovation happen at the intersection of different specialities and ways of thinking."

The center for ocean education and innovation is designed to harness this potential and foster the sort of interdisciplinary science that is the hallmark of Bigelow Laboratory. The laboratory expansion will have space for four additional research groups and will be filled with collaborative spaces for solutions-focused science. The strategic fundraising initiative surrounding the new center will also support the science — and people — that it takes to turn foundational discoveries into actionable solutions.

"I'm really looking forward to a dedicated space where teaching and learning can happen between scientists, students, industry, and other community members. It's the kind of collaborative setting that we need to figure out how to navigate our rapidly changing environment," said Nick Record, senior research scientist and director of the Tandy Center for Ocean Forecasting at Bigelow Laboratory.

The last two years have been the hottest on record for the Gulf of Maine. As the ecosystem responds to these changing conditions, opportunities and obstacles abound. New insights and tools are desperately needed. Record's science focuses on using advanced computer algorithms and artificial intelligence to create reliable forecasts about life in the ocean, from alerts for imminent harmful algal blooms to identification of future right whale habitats.

Perhaps the most significant obstacle to early stage research into new solutions — and into creative foundational research approaches — is funding. These projects start with an invigorating spark of inspiration, but data is needed before they're attractive to funders. The fundraising initiative integral to the new center aims to address that issue by creating a permanent seed funding program that would provide financial support for promising, early stage projects.

"Exploring our most creative ideas will not always work out exactly as expected, but they can take us somewhere even more exciting," said Senior Research Scientist Manoj Kamalanathan, who recently received a seed funding grant. "They also represent some of the best opportunities for big leaps forward in our impact and understanding."

Kamalanathan was funded to explore the use of algae as a living fertilizer. His initial results indicated that the right blend of microalgal species might be able to live in the soil, produce the nutrients that will enhance the quality of the soil, and eliminate the environmental harm created by chemical fertilizers. The seed grant will allow him to scale up his experiments and build evidence that it's an idea worth further investment.

"The innovative products and solutions we're working on all hinge on the use of microalgae and seaweeds — living organisms — which makes the science and the solution intertwined and inseparable," Bronk said. "Our insights are vital to businesses working to create sustainable products and processes through ocean life. There's so much promise there, and it's so exciting to think about all the innovative projects this new center will enable in the coming years."

**THE EXPANSION** will support the solutions-focused work of Senior Research Scientist Manoj Kamalanathan and other Bigelow Laboratory researchers.


## Join us for this popular series — virtually or in person at our laboratory!

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**JULY 11**
**Tipping Points**
A Multimedia Performance
*Halcyon String Quartet with intro by Dr. Deborah Bronk*

**JULY 18**
**Science from a Seed**
Growing Bold Science from Big Ideas
*By Dr. Catherine Mitchell & Dr. Manoj Kamalanathan*

**JULY 25**
**Hands-On Inspiration**
The Value of Authentic Research Experiences for Student Scientists
*By Dr. Ben Twining*

**AUGUST 1**
**AI and the Ocean**
How Artificial Intelligence is Mapping our Ocean's Future
*By Dr. Nick Record*

**AUGUST 8**
**Innovation through Collaboration**
The Power of Science and Business Partnerships to Advance the Blue Economy
*By Dr. Mike Lomas*

**AUGUST 15**
**Coast-Cow-Consumer**
Using Algae to Reduce the Dairy Carbon Hoofprint and Build Rural Prosperity
*By Dr. Nichole Price*

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# The Fate of Forever Chemicals

**As the scope and dangers of PFAS pollution come into focus, Bigelow Laboratory scientists are working to expand monitoring and testing capacity in Maine waterways.**


**BIGELOW LABORATORY RESEARCHERS** are working with community groups, such as Friends of Casco Bay, to develop a robust monitoring program to identify PFAS hotspots across Maine.

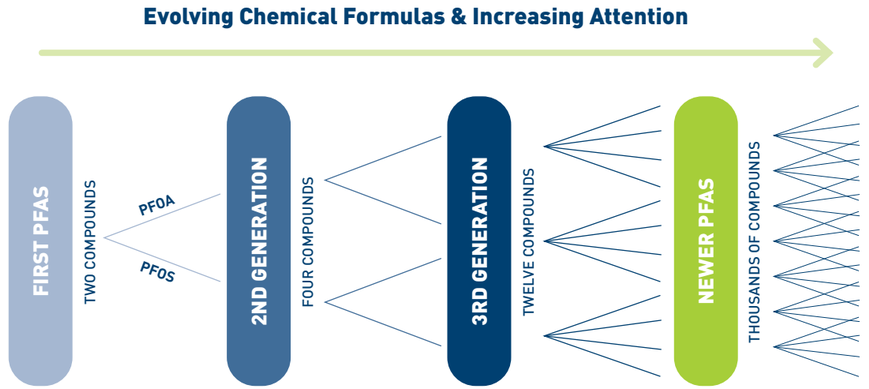
Photo: Robby Lewis-Nash, Friends of Casco Bay

In the late 1930s, a researcher working for the chemical manufacturer DuPont accidently discovered a new compound, polytetrafluorethylene. Within 10 years, DuPont was producing millions of pounds a year of the substance, more commonly known by its trademark name, Teflon. Within a few decades, PTFE and similar chemicals binding together carbon and fluorine were being used in everything from non-stick pans and fast food wrappers to firefighting foam and pesticides. At that time, these chemicals, lauded for their water resistance and durability, were known as "miracle chemicals." Today, they're more commonly — and critically — referred to as "forever chemicals."

Though people now often refer to "PFAS" as a single chemical, in reality, over 9,000 per- and polyfluoroalkyl substances have been developed. Though not all have been widely studied, many of those that have, have been found to increase the risk of cancer. They can also disrupt hormonal and reproductive systems, leading to development issues, increased cholesterol levels, decreased fertility, and even a weakened immune system. The Centers for Disease Control have found traces of four of the most common PFAS in the blood serum of nearly everyone they've tested since 1999. Ironically, many of the thousands of PFAS in circulation today were developed as replacements to avoid the issues of the original compounds. But each iteration showed the same problematic behavior and posed similar risks.

Few areas of Maine have been left untouched by PFAS contamination. Thousands of farms across the state, for example, used to regularly apply PFAS-contaminated sewage sludge to their farms as fertilizer, and the state's Department of Environmental Protection has found that 20% of homes they've sampled close to those sites have levels of PFAS that exceed Maine's interim drinking water standards. In 2021, a National Oceanic and Atmospheric Administration study of mussels in the Gulf of Maine also found PFAS at 40% of their sampling sites.






**THE FIRST PFAS** were designed with eight linked carbon molecules. As people realized the risks of those original compounds, scientists experimented with altered chemical formulas. They created new iterations of chemicals but never solved some of the basic environmental challenges. Most of these new substances are not yet part of the standard testing kit for PFAS.

On the flipside, though, the state is at the forefront of efforts to address this widespread problem. Maine is one of the few states, for example, that has established screening levels for PFAS contamination in agricultural products like milk, and, last year, Maine became the first state to ban the use of sludge on farms. In 2021, the legislature also passed a law banning the sale of most products that contain PFAS after 2030.

"The problem has been around for a while, but I think people are just now realizing the scale of it – like how much is around, how prevalent they are, and how little regulation there was of most of these compounds," said Senior Research Scientist Christoph Aeppli.

For Aeppli, one of the biggest challenges with PFAS is just the lack of understanding of how these complex pollutants are impacting ecosystem health and their long-term fate in the environment. To date, most of his research has focused on oil spills.

"With oil, though, you can look back to 50-plus years of research that has been done," Aeppli said. "With PFAS, the research is all much newer."

There are other chemical differences between PFAS and what Aeppli calls "legacy pollutants" like oil. The latter are hydrophobic, so they don't easily dissolve in water and, instead, build up on sediments and in fatty tissue. PFAS, in contrast, are much more soluble in water and can bind, not just to fat, but also to proteins in blood.

Aeppli highlights several other gaps in our understanding of PFAS at an ecosystem level, everything from how it is getting into the marine ecosystem to how it is transforming as it moves through systems and species. He says we are only starting to develop good models to understand the toxicity of various PFAS and how they move through the food web.

Aeppli is working on a Sea Grant-funded project to start answering those questions. He'll be sampling for PFAS in water, sediments, and mussels at two sites in Casco Bay starting this summer and fall, and then again next spring. Mussels are not only commercially important in Maine, but they also provide a good proxy for the uptake of pollutants in other species. The seasonal sampling, meanwhile, will give them a chance to see how PFAS concentration changes over the course of the year.

As for the sites themselves, Aeppli said they were chosen both to capture a range of potential sources of PFAS, such as Brunswick Naval Air Base, but also to leverage the work that local community groups, like Friends of Casco Bay and Friends of Merrymeeting Bay, have already done. These groups have long-running monitoring programs so they already have a good understanding of the ecosystem and a lot of water quality data. Combining the funding and analytical expertise of Bigelow Laboratory with that deep, local knowledge can help inform the development

**RESEARCH ASSOCIATE ERIN BEIRNE** gathers water samples in Casco Bay for a new project monitoring PFAS in Maine waterways and mussels.

Photo: Christoph Aeppli

**'It's a beneficial relationship, between helping the state address a real problem and contributing to a growing area of research.'**

of robust monitoring programs to identify PFAS hotspots and understand what contamination means for aquatic organisms like shellfish.

Even closer to home, Aeppli and Senior Research Scientist Rachel Sipler, who directs Bigelow Laboratory's Water Health and Humans Initiative, are also working with the Boothbay Region Clean Drinking Water Initiative to assess PFAS in the reservoirs from which the community draws its summer water.

"Our reservoirs are just below the level of threatened ecosystems. We are at a crucial tipping point where we can ignore the issues until they become a significant risk or we can take action to change course and protect this critical resource," Sipler said. "This effort will fill gaps and help us really understand our system so that we can better predict and mediate changes long term."

Working with the Clean Drinking Water Initiative, a collaborative that includes various local stakeholders like the water district, Sipler is trying to develop a better understanding of PFAS contamination locally and how it might be changing. The water district, which last sampled for PFAS several years ago, is partnering to collect water samples this summer that will be processed at Bigelow Laboratory. Sipler hopes that this is the first step to a long-term collaboration to ensure the health and prosperity of our community.

"It's not a required monitoring component, but we can foresee it will be," Sipler said. "We're hoping to help Boothbay get ahead of the curve."

When it comes to being ahead of the curve, Bigelow Laboratory is also one of just two labs recently funded by the state to increase capacity within Maine and get state accreditation to process PFAS samples, which requires a high level of technical expertise and advanced instrumentation. To that end, Aeppli's lab just installed a PFAS-dedicated liquid chromatography-mass spectrometer, the same type of instrument used by Bigelow Laboratory for shellfish toxin testing.

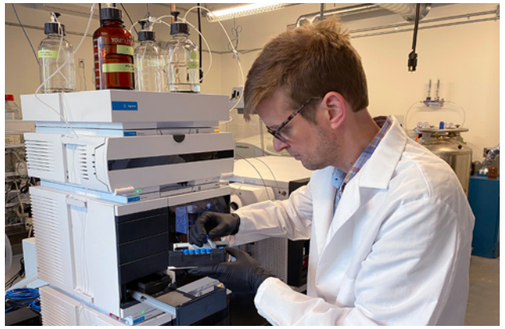
Once the accreditation is official, hopefully by the end of the year, the lab will begin taking samples from the Department of Environmental Protection and other potential clients — from agencies like the Department of Marine Resources to nonprofit groups and private citizens. In the meantime, though, they can process the samples collected for various research projects. Aeppli and Senior Research Scientist Manoj Kamalanathan, for example, will have a student this summer looking at the possibility of using algae to remove PFAS from water.

It's that sort of research expertise that makes Bigelow Laboratory's new testing service so potentially useful.

"For research, we're always pushing the detection limit and expanding the number of compounds we can detect, and that expertise helps us offer a cutting-edge service that keeps up with evolving regulations," Kamalanathan said. "It's a beneficial relationship, between helping the state address a real problem and contributing to a growing area of research."

Sipler agrees about the need for more data regarding the water quality threats facing Maine communities. But she stresses that it's not just to highlight risks but also to develop strategies to address problems before they get out of hand.

"We need to have information to be hopeful and secure the future we want for our communities," she said.



**LEFT** Research Associate Erin Beirne samples sediments as part of a PFAS monitoring program. **RIGHT** Senior Research Scientist Christoph Aeppli examines the new liquid chromatography-mass spectrometer installed in his lab to process PFAS samples.

Photos, left to right: Christoph Aeppli, Collin Sheehan

# FIELD NOTES

## Costa Rica

**BY JULIA BROWN,** Research Scientist

On a local fishing pier in Puntarenas, Costa Rica, I sat among a group of weary scientists, none of whom I'd met before, waiting for the ferry. What showed up was a small covered boat with four long wooden benches blasting '90s pop rock. We hauled on our bags, crowded onto the benches, and began the short ride to the ship that would be our new home for the next six weeks, the R/V Atlantis.

This journey began 10 months earlier when my colleague Maria Pachiadaki, from Woods Hole Oceanographic Institute, approached me about joining a research expedition to the tropical Pacific Ocean. She was leading a project aimed at examining microbe-driven biogeochemical processes within the Eastern North Tropical Pacific Oxygen Minimum Zone (ENTP-OMZ) and wondering if I would be willing to lead research on viruses for her expedition.

The OMZ off the coast of southwest Mexico is a permanent feature of the ocean. Such zones exist around the world, some occurring naturally and others due to human influences such as agricultural runoff. Important steps in the global cycling of carbon, nitrogen, and sulfur happen within OMZs. Some of these processes generate potent greenhouse gasses. In a warming ocean, these zones will likely expand as the ocean's capacity to hold oxygen decreases.

Oxygen minimum zones are often referred to as "dead zones" because organisms that breathe oxygen, such as fish, cannot live in such areas. But OMZs are not devoid of life. Many microbes thrive without oxygen, and these populations are what drive the cycling of carbon, nitrogen, and sulfur. There are clues that viruses, too, influence the cycling of nutrients, but very little is known about how exactly this happens.

With two girls under four years old at home, my immediate reaction to Maria's inquiry was, "I can't." But after sitting on the idea, and thinking about the science that could be done on such an adventure, "can't" turned into "why not?"

With my expertise in microbial genomics and viral ecology, and the data Maria and her team planned to collect, I saw an opportunity to carry out important research on the activity of viruses in oxygen minimum zones by collecting samples in parallel with those of the larger project.

Viruses are present everywhere in the ocean, and influence the ecology and evolution of the microbes they interact with in a number of ways. Little is known about viruses in oxygen minimum zones, particularly how they interact with and influence host populations. So I wrote a proposal for research funding, gave Maria the green light, and began preparations for the biggest science adventure I'd had in a decade.

One challenge to studying low oxygen systems is that oxygen is often toxic to life that is adapted to living without it. My colleagues on board addressed this challenge by running experiments deep below the surface for 18 hours at a time in a pair of drifting incubators. These long experiments were ideal for my sampling plan. While the incubators drifted, I collected tens of liters of water from the corresponding depth within the OMZ, filtered out larger organisms, and concentrated the remaining viral particles down more than 250-fold — a process that took 9 to 12 hours. Once I secure research funding, I will extract and sequence the genetic material from these samples and use computational techniques to identify viruses, microbes, and interactions between them using clues encoded within their genomes.

Life at sea was in stark contrast to life at home. The regimented "schedule" of my working family was replaced with an other-worldly adult life: meals made by the ship's galley and eaten with other adults, countless conversations with members of the science party and crew, nights spent reading and enjoying the evening sky. My days in the lab were long, but my time off was my own in a way I had not experienced since becoming a mom. I squeezed everything I could out of my time at sea, knowing the value of this opportunity, and the sacrifices my family and I were making to make this research happen.

Photo: J. Alexander

# 2022 IMPACT REPORT

From the surface to the seafloor, from the tropics to the poles, from the tiniest viruses to global processes — Bigelow Laboratory scientists work on systems around the planet to study the foundation of ocean health.

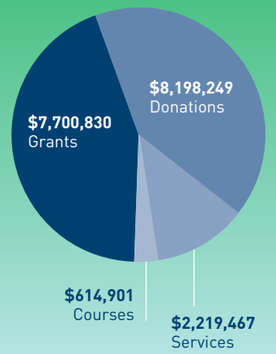
What we're learning builds understanding of some of the greatest challenges society faces, enabling us to unlock the ocean's potential to improve the future for all life on Earth.

We hope you enjoy this look back at some of the ways our work made a difference last year.

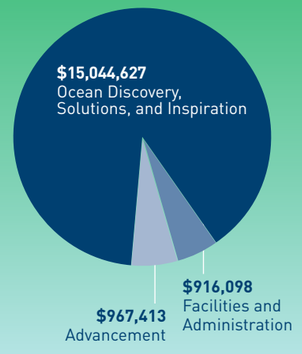
## 2022 FINANCIALS

JULY 1, 2021 – JUNE 30, 2022

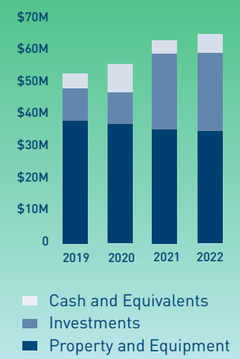
REVENUE **$18,733,447** Total




EXPENSES **$16,928,138** Total




**ASSETS** 2019 – 2022

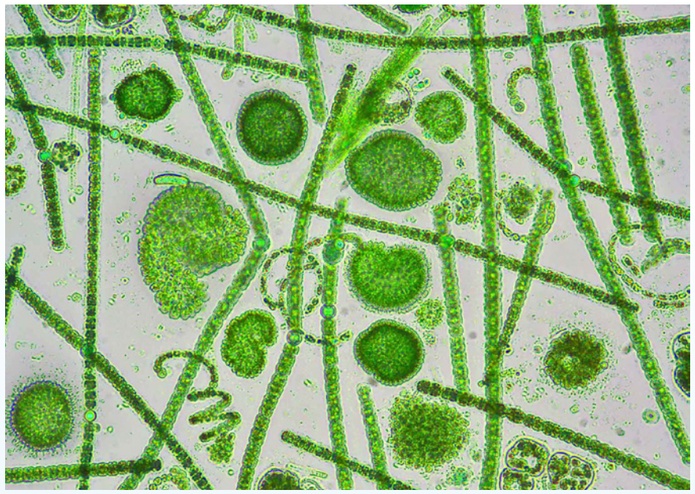



View our audited financial report at bigelow.org/financials.



# Ocean Health and Function

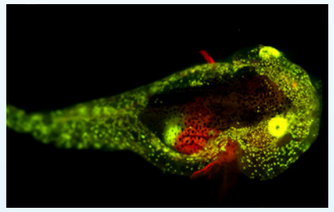
**We reveal how the ocean works and how to better care for our planet.**



**Harmful algal blooms are increasingly common around the world and pose a serious risk to wildlife, fisheries, and communities.** Bigelow Laboratory scientists continue to be at the forefront of efforts to better understand what causes these blooms and how to minimize their impact while also empowering scientists and government officials to monitor and respond to them. **bigelow.org/2022-habs**

**Although rare, there are forms of cancer that are contagious.** Last year, our researchers found that a type of cancer that affects soft-shell clams could be spread through seawater. Understanding the prevalence of the disease and how it is transmitted is essential for minimizing its spread among this valuable species. **bigelow.org/2022-clam-cancer**

**Deep sea mountains are one of the least-understood parts of the planet.** Our researchers continued their work last year to better understand these environments, which are hubs of vast biological diversity — and potential sources of valuable minerals. This work is a first step to illuminating the consequences of human activity, such as mining, on these complex ecosystems. **bigelow.org/2022-deep-sea**



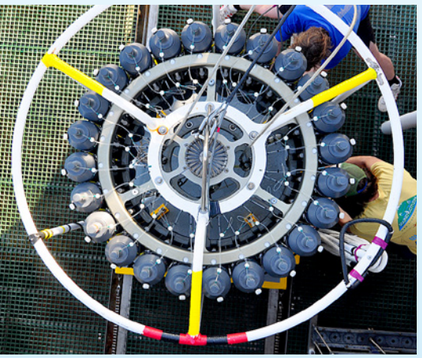
**Species living in polar environments have developed remarkable adaptations to survive in extreme conditions.** Our scientists recently discovered that the variegated snailfish, the only known biofluorescent polar fish, survives by directing significant resources to produce large amounts of antifreeze in its cells. Understanding these evolutionary strategies provides insight into how these species might adapt in our rapidly changing world. **bigelow.org/2022-polar-fish**

Photos, clockwise from top left: Pete Countway; NOAA Ocean Exploration, Ocean Exploration Trust NA134; John Sparks, David Gruber; José Fernández Robledo

# Our Changing Planet

## We focus on key species to predict, combat, and adapt to climate change.

**The Arctic is one of the most vulnerable places to climate change in the world.** As part of the largest-ever Arctic research expedition, our scientists are providing new insights into how the atmosphere, water, and ice interact in this dynamic region. Their efforts set the groundwork for years of research to come on the complex workings and future of the Arctic. **bigelow.org/2022-arctic-future**



**Climate change is altering fundamental processes in the ocean with negative effects on the microscopic life that drives those processes.** Our scientists published research last year suggesting that the ocean surface ecosystem, and the natural carbon dioxide removal it supports, is more resilient to changing conditions than expected, altering how this process is modeled in future forecasts.

**bigelow.org/2022-climate-adaptation**

**Changes in ocean circulation are driving warm, salty water into the Gulf of Maine.** Last year, our researchers analyzed two decades worth of data to elucidate how the Gulf is changing and how fast it's warming. These changes aren't just altering the foundation of the food web locally, but they can also influence ocean processes well beyond our shores.

**bigelow.org/2022-gulf-transformation**

**The number of young lobsters in the Gulf of Maine has decreased in recent years.** Student-led research last year sought to better understand how well lobsters are surviving, and whether they're getting enough food, at this critical stage of development. Their findings illuminate how changing conditions are impacting the region's food web and this important fishery.

**bigelow.org/2022-lost-lobsters**

**Carbon storage is an important strategy for reducing greenhouse gases in the atmosphere and combating climate change.** Our planet has already evolved ways to naturally remove carbon dioxide from the atmosphere and store it in the ocean. Bigelow Laboratory scientists are working with researchers from around the world on solutions to amplify those natural processes.

**bigelow.org/2022-carbon-capture**

**Bigelow Laboratory's National Center for Marine Algae and Microbiota holds one of the world's largest and most diverse collections of algae.** It increased its holdings substantially last year, providing scientists around the globe with access to 1,400 new strains and vast genetic data. This expansion will encourage and enable new research into algae and its applications.

**bigelow.org/2022-seaweed-research**

**New techniques can allow us to better understand how marine organisms control the interactions between the atmosphere and oceans.** Our scientists developed a method for linking the genes and functions of cells, illuminating the relationship between an organism's genetic code and what it does in the environment. Their approach provides unprecedented insight into the role of microbes in ocean carbon cycling. **bigelow.org/2022-carbon-cycling**

**Bioinformatics is an emerging field for leveraging vast amounts of data to understand the microbes that shape life at a previously impossible level of detail.** Our scientists are utilizing cutting-edge computational techniques to analyze the genetic data of the millions of single-celled organisms that form the base of ocean food webs.

**bigelow.org/2022-data-science**

# The Ocean's Potential

## We develop the tools needed to unlock the opportunity of the ocean.



Photos, clockwise from top left: Kevin Posman, Steven Profaizer, Jesica Waller, Andrew Collins

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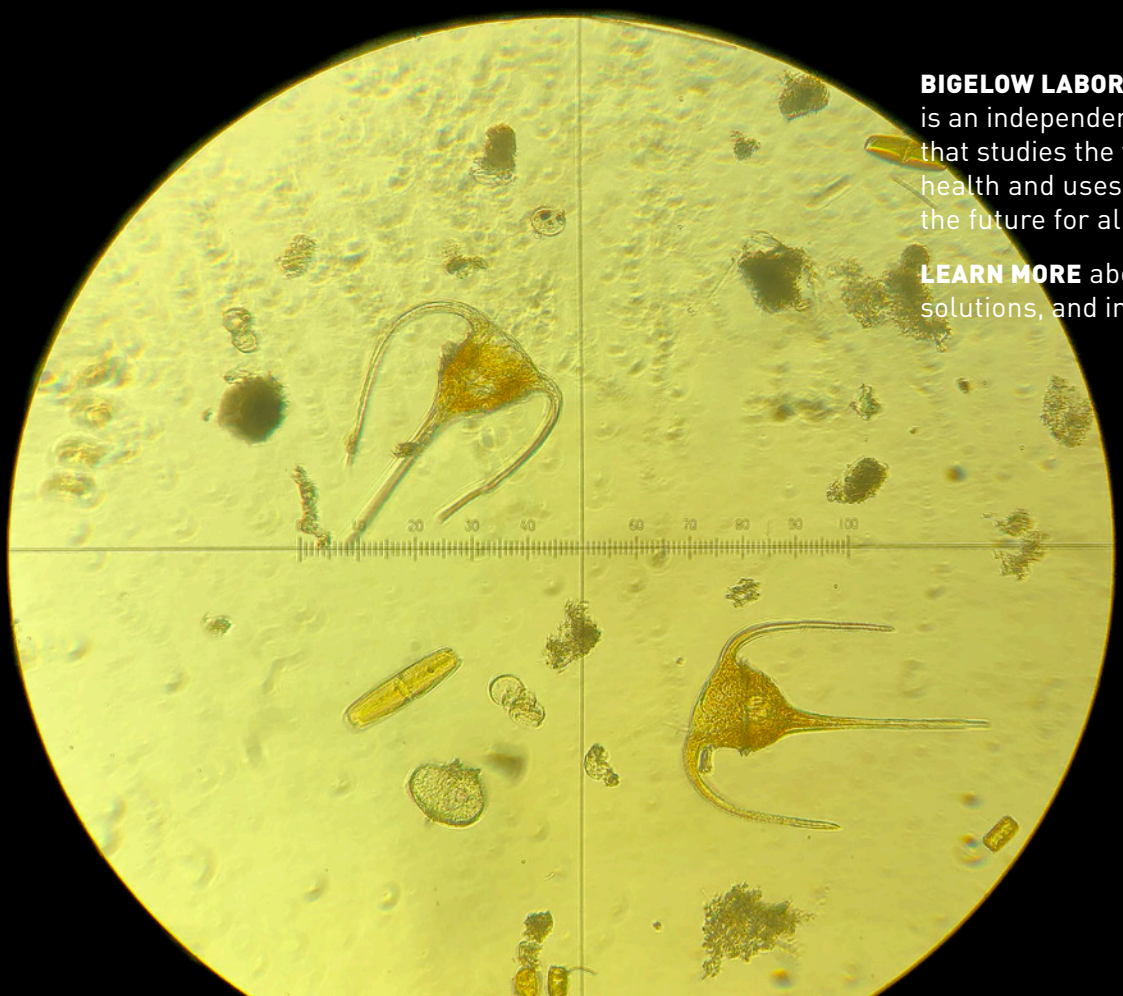

**BIGELOW LABORATORY FOR OCEAN SCIENCES** is an independent, nonprofit research institute that studies the foundation of global ocean health and uses our discoveries to improve the future for all life on the planet.

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Photo: Pete Countway