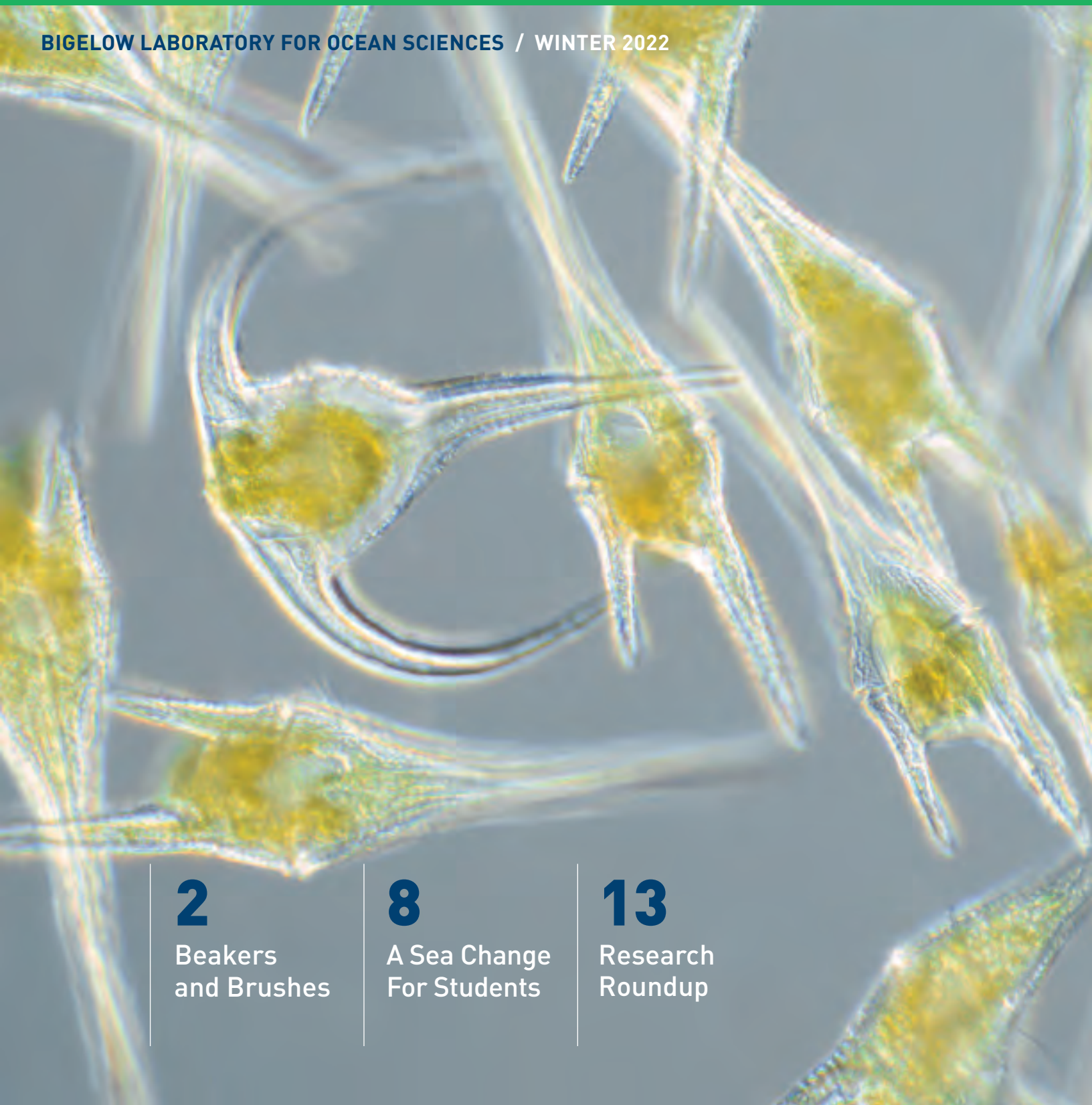
TRANSECT

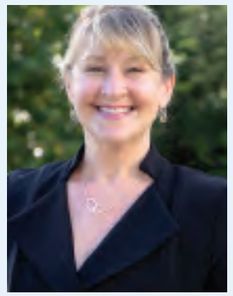
BIGELOW LABORATORY FOR OCEAN SCIENCES / WINTER 2022



Message from the President

Students contribute so much life and energy to our work, and it's been wonderful to have our in-person education programs back to full capacity over the last few months. While their faces remain masked inside the laboratory, their enthusiasm for our research into the foundation of global ocean health fills our halls and hearts.

It also serves as a powerful reminder of one vital impact of our research: inspiration. The discoveries and solutions that flow from our research only truly make a difference if we inspire people to embrace them.



Our experiential education programs are one way we do this. By immersing students in authentic research experiences, we inspire many to become scientists — and all to be better stewards of the ocean.

This year, 47 undergraduate students joined us for internships. Sixteen high school students participated in our Keller BLOOM program. And we now have nine students living and learning on campus as part of our Sea Change Semester. You can read more about this unique program on page 8 and hear directly from students about their transformative experience.

Another exciting and inspirational happening on campus right now is a new two-story art installation! The Gulf of Maine EcoArts exhibit is the latest in a series of collaborations between artists and our scientists that are designed to help share the wonder and opportunities of the ocean with the public.

The changes the planet so desperately needs will only happen with broad support and understanding from our fellow citizens, and our outreach with artists helps us illuminate the importance of the ocean and inspire people to care about all our science reveals. You can read more about some of these partnerships on page 2.

What we're learning is vital to the future of humanity and to charting a path forward. With the rapid warming of our planet, science and the changes it can motivate and inform have never been more important.

I want to extend my heartfelt thanks to each of you who invests in that work through Bigelow Laboratory. It means so much to each of us here, and it truly makes a difference.

Deborah A. Bronk

DEBORAH BRONK, PhD

ON THE COVER

Microscopic *Ceratium* dinoflagellates are common in fresh and saltwater from the Arctic to the tropics. This image is part of Bigelow Laboratory's "Tiny Giants" photographic exhibit, currently on display at the Portland International Jetport. It is one of many efforts by Bigelow Laboratory in recent years to use art to share the incredible influence of marine microbes on planetary health. Read more about our creative collaborations with artists on page 2.

Photo: Peter Countway

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CONTENTS

COLONIES OF *GLOEOTRICHIA* CYANOBACTERIA float in a sample collected from a New Hampshire lake. Scientists at Bigelow Laboratory are utilizing DNA-based techniques to investigate the abundance, distribution, and timing of harmful cyanobacterial blooms. This work is part of the Maine-eDNA project, an effort with partners across the state to use DNA collected from the environment to better understand and manage ecological changes.

Photo: Peter Countway

"MAJESTIC FRAGILITY," a new art installation at Bigelow Laboratory, is the culmination of a three-year project between Bigelow Laboratory scientists and Maine artists. It is the latest in a line of creative collaborations designed to inspire people to embrace the importance of the ocean and the scientific efforts to understand it.

LEFT Pamela Moulton installs her hanging textile sculpture. **TOP RIGHT** Anna Dibble, left, and Senior Research Scientist Nick Record discuss the newest art installation at the laboratory. **BOTTOM RIGHT** Andy Rosen, rear, works with Carter Shappy to install a 24-foot right whale sculpture.

BEAKERS AND BRUSHES

Inspiration Through Creative Collaboration

The microscopic organisms that form the foundation of ocean health are hidden from sight, but the scientific process reveals the life, wonder, and opportunity inside each drop of the sea.

Scientists brim with excitement about what they learn, but their attempts to share it can be obscured by the complexity of the tools and training that guides their insights. When nonscientists hear the information, they rarely feel the emotions behind it.

The artistic process can provide the emotional translation needed to communicate the importance of science and broadly instill the same passion that researchers feel for the natural world. It can connect people with the heart of discovery and inspire them to care, which is vital to building a society that is guided by science.

Bigelow Laboratory researchers regularly collaborate with artists to help share the essence and significance of their work. The newest endeavor is a two-story installation at the laboratory made by Gulf of Maine EcoArts, a collaborative group of Maine artists. "Majestic Fragility" is scheduled to be up through Fall 2022 and is open to the public during the laboratory's normal business hours.

The exhibit presents a cross-section of sky and sea that illuminates the diverse life in the Gulf of Maine — and the challenges it faces from human impacts.

"This exhibition is a communication to the public about what is currently going on with the environmental crisis in the Gulf of Maine ecosystem, and also in oceans all over the planet," said Anna Dibble, founding director of EcoArts and lead for the project.

Dibble's work is driven by the urgency of climate change and humanity's disconnect with the natural world. That inspiration sparked the purpose and themes of the EcoArts' project with Bigelow Laboratory. She organized a decision-making group of artists and worked with educators around the state to engage students with

KRISANNE BAKER looks up at the nearly 100 glass sculptures she created, all inspired by microscopic life in the ocean.

the science, art, and environmental messages behind the project.

"A lot of Bigelow Laboratory's research is studying microorganisms to discover what is happening, and will happen, to life on the planet due to climate change, and then design solutions," Dibble said. "I think art communicates best what this science is trying to do because people respond emotionally to art more than they do to science."

Few animals elicit more emotion than whales. The image of their massive figures gliding through the ocean, majestic and calm, have been an inspiration for writers, filmmakers, and artists of many mediums.

The centerpiece of the new installation at Bigelow Laboratory is a bone-white, 24-foot sculpture of a North Atlantic right whale, one of the world's most endangered species. With a massive root ball and trunk of a tree at its core, it hangs from the ceiling, silently swimming amongst renditions of coastal birds and colorful fabric kelp. The cast of coastal characters make a fantastical rendition of the sea, rooted by the science conducted at the laboratory.

Senior Research Scientist Nick Record is a computational ecologist who served as the coordinating scientist for the installation. He uses computer modeling and data science to understand the changing Gulf of Maine, including the North Atlantic right whale. His findings have helped reveal why right whale movement patterns have shifted, and how they are likely to change in the future as the Gulf of Maine continues to warm.

"Science is important to everyone because it deals with how we're going to live on this changing planet, but scientists often don't communicate in a way that draws people into our work," he said. "It is really important to get people involved from a lot of different directions, so we need to use more effective ways to inspire them."

Despite the general perception, Record said that science and art are not as distant as one might think. Each field shares a sense of discovery and a search for truth, reliant on inspiration from the natural world and the forces around us.

"Both artists and scientists have to look at the world in a way that people haven't looked at before," he said. "You need to see the world through a new lens, and show people the world through a new lens, to really be doing something cutting edge in either."

'Artists can help communicate beauty. They help pull us out of our heads and translate the objective aspects of science into heart and soul.'

Bigelow Laboratory scientists have a rich history of fruitful relationships with artists. Through art installations at the laboratory, traveling exhibitions, and live events, these partnerships have helped connect people to science in new ways.

Carter Shappy played a key role in the EcoArts installation, but he was also the first to participate in Bigelow Laboratory's visiting artist-in-residence program in 2016. He partnered with Senior Research Scientist Steve Archer and his team to create a sculpture for public display.

"I was basically like a sponge," Shappy said. "I came in as an artist and soaked up all the research and ideas I could. I then used abstraction to tell a story, inspire curiosity, and encourage a deeper investigation into the research that influenced it. That process of allowing oneself to be curious and to look closely is at the core of both artistic and scientific pursuits."

Based on Archer's work, Shappy created "Colorcosm," a 21-foot, screen-printed sculpture made of six prismatic cylinders that hung from the ceiling of the laboratory's main hall. The art was initially inspired by research into a gas produced by microorganisms that has far-reaching effects on cloud coverage and how much energy it reflects into space. The sculpture included layers of colorful rings representing the water column, the way light changes at depth, and key processes that happen at the ocean's surface where light, gasses, and microbes interact.

"I really latched onto this kind of ripple effect, which most people don't have the ability or training to see — how a change that humans cause can ripple throughout ecosystems and lead to wildly unforeseen effects," he said.

The critical impacts of unseen organisms represent the heart of the work at Bigelow Laboratory. The ocean is filled with microorganisms that provide half of the oxygen we breathe, form the foundations of food webs, and influence global cycles.

Their importance and intricate beauty have inspired exhibits like, "Tiny Giants." This collection of large photographs reveals microscopic marine life in staggering detail. After travelling the Northeast for several years, the exhibit now resides at the Portland International Jetport.

Krisanne Baker sculpted some of the same microbes from recycled glass while working as visiting artist-in-residence in 2019. She spent six weeks with Senior Research Scientist Mike Lomas and his team learning about phytoplankton and sketching illustrations of them as seen through a microscope. She then created a collection of nearly 100 sculptures based on the experience, which were then hung alongside Shappy's "Colorcosm."

"THALIA," a painting by Michel Droge, reflects the unconventional beauty of the deep-ocean. The artist is creating a series inspired by Senior Research Scientist Beth Orcutt's research into this precious environment and the impact that human activity may have on it.

Baker was fascinated by the beauty of the ocean's tiny organisms and how such small creatures could be so significant. She set out to create representations of phytoplankton to encourage people to think about something they can't see with their naked eyes. She was also driven to effectively communicate how climate change and ocean acidification are threatening these vital organisms.

"I find I get a much stronger reaction from the public when they're drawn in by beauty, and then presented with the concerns," she said. "I think people are frightened by what's going on with climate change because they feel powerless to do anything about it. So, I like to approach them with the positive and try to get them to think, 'This is gorgeous. Let's save this.'"

Like science, art pushes boundaries and explores new horizons. Michel Droge is an abstract artist who aims to create beautiful art inspired by unconventional aesthetics. After a trip to Katahdin Iron Works in Maine, Droge became interested in mining and "the appalling beauty of the way we rip into the earth."

Their path led them to Senior Research Scientist Beth Orcutt, an expert on the deep sea. Orcutt's work focuses on deep sea ecology and the impacts of human activity in ecosystems miles beneath the waves. This includes min-

ing for the rare elements, like nickel and cobalt, needed to make the electronic technology that could curb carbon emissions and energy use.

"I was really inspired by the combination of gorgeous, rich, mysterious parts of our world plus the incredibly violent kind of excavating that we do to survive on this planet," Droge said.

Orcutt and Droge began to foster a relationship around both their work and the deep sea. Orcutt would share images and explain how they related to research about life on the seafloor, answering questions along the way.

"My role was opening the door to the wonder of the deep sea," Orcutt said. "But they took the knowledge and turned it into something totally different that I could never have envisioned."

Droge eventually invited Orcutt to come to their studio to see the first of the paintings and offer critique. It was a new experience for the research scientist.

"I just tried to relate the emotions that the art captured for me," Orcutt said. "We talked about art in terms of color and composition. It brings inspiration. It brings whimsy. I could also see how I could use the paintings as a way to talk about my science in a way that I've never been able to do before."

Droge doesn't want their art to compete with the imagery that exists of billowing underwater volcanoes and alien-like seafloor environments. To them, the competition with nature is too stiff. As an abstract artist, they wanted to capture the emotions around the deep sea and mining. They wanted to create art that connects a mind full of science and a heart full of emotion.

"I didn't want to do anything representational, but I wanted to draw from the richness and ideas of it all and create a platform where people could talk about the impacts of deep-sea mining," Droge said. "I hope that I create a platform where people can spend time enjoying beauty and light, love and mystery, and also think about and learn more about deep sea mining."

Orcutt saw this as an opportunity to engage an audience that may otherwise be left in the dark. Some of the initial paintings from the collaboration were put on display this fall at the Maine Jewish Museum, where Orcutt gave a public talk about her research and her work with Droge.

"A very small fraction of humanity gets the opportunity to see the seafloor, so getting people to care about it enough to protect it is really difficult to do just with words," Orcutt said. "Art can reach people's hearts in a way that they could care about something because they have an emotional attachment to it."

This challenge persists even in the sunlit surface waters where phytoplankton grow. Despite their importance, these microscopic plants remain unseen and unfamiliar to most.

JULIE CRANE works on her large-scale sculpture of a coccolithophore, a common phytoplankton. Her artwork will be displayed outside of Bigelow Laboratory in 2022.

Coccolithophores are one of the most ubiquitous types of phytoplankton on the planet, and you're not likely to find a bigger fan of them than Senior Research Scientist Barney Balch. Balch is enamoured of their role in the ocean and their unique aesthetic. He even published a book of photographs this year that showcased the beauty of coccolithophores. So, when he was approached by Julie Crane about creating a sculpture of one, he jumped on the opportunity.

"Mother Nature, through evolution and selective fitness, has designed these incredibly intricate, amazingly-shaped organisms," Balch said. "Artists can help communicate this beauty. They help pull us out of our heads and translate the objective aspects of science into heart and soul."

Crane is currently working on a five-foot-diameter sculpture made of clay epoxy that will be displayed outside of Bigelow Laboratory in 2022. The piece will be based on *Emiliania huxleyi*, the most common coccolithophore, which plays a key role in food webs and the global carbon cycle. By creating a sculpture at a scale that better reflects their impact, Crane hopes to communicate the importance of these microscopic wonders.

She also hopes viewers will see their own lives reflected in the piece.

"When we are able to encounter something we typically can't see, we can ponder the intricacies of the role each of us contributes to the whole," she said. "The design of this living planet pulses with beauty, function, and purpose, and it requires us to be stewards of what we have been offered. I hope we can learn to appreciate what we have here."

Photo: Stephen N. Crane

NEW HORIZONS

Our senior research scientists guide our global research. This year, we appointed four new people to this leadership role, expanding the depth and breadth of our ocean expertise.

DR. MAYA GRONER, Quantitative Disease Ecologist

Diseases that infect marine organisms have far-reaching implications. Maya studies the impacts and causes of infectious diseases on a range of ocean populations. She is especially interested in understanding how changing climates alter pathogen transmission and organism mortality due to disease. She examines how diseases impact ecologically and economically important species, like American lobsters, and hopes to provide the analyses needed to support evidence-based management that will help people adapt to a changing world.

"I'm most inspired when I'm observing organisms in their natural environment, thinking about how disease impacts populations, and how those changes then ripple through the ecosystem."

DR. CATHERINE MITCHELL, Satellite Oceanographer

Raised on a farm in Scotland, Catherine appreciates solving practical problems. She began her career in physics, and she grew her oceanography skill set at Bigelow Laboratory as a postdoctoral researcher and then as a research scientist. Using satellites and computer algorithms, Catherine can interpret ocean color as a tool to understand critical marine microorganisms, like phytoplankton and copepods, and the ocean processes around them. This work can be used to better understand how microscopic life impacts the entire planet and provide improved tools for supporting our oceans.

"The different parts of oceanography are connected, and I am driven by the idea that the tools I develop could ultimately be used by not only scientists but by environmental decision-makers as well."

DR. RACHEL SIPLER, Ocean Biogeochemist

Rachel grew up on the Chesapeake Bay. She spent so much time on the water she began to ask questions about how the ocean works. As years passed, Sipler didn't lose her inquisitive spirit, she honed it. She has worked across North America and the Arctic on environmental issues from harmful algal blooms to wastewater management. She joins the lab as the director of the Water Health and Humans Initiative, a new effort to identify issues impacting our waters and support economic growth and environmental wellbeing.

"I've done a lot of work observing climate change and identifying problems. I want to stop being a fire alarm and start being a fire extinguisher. I want to focus on solutions for positive change."

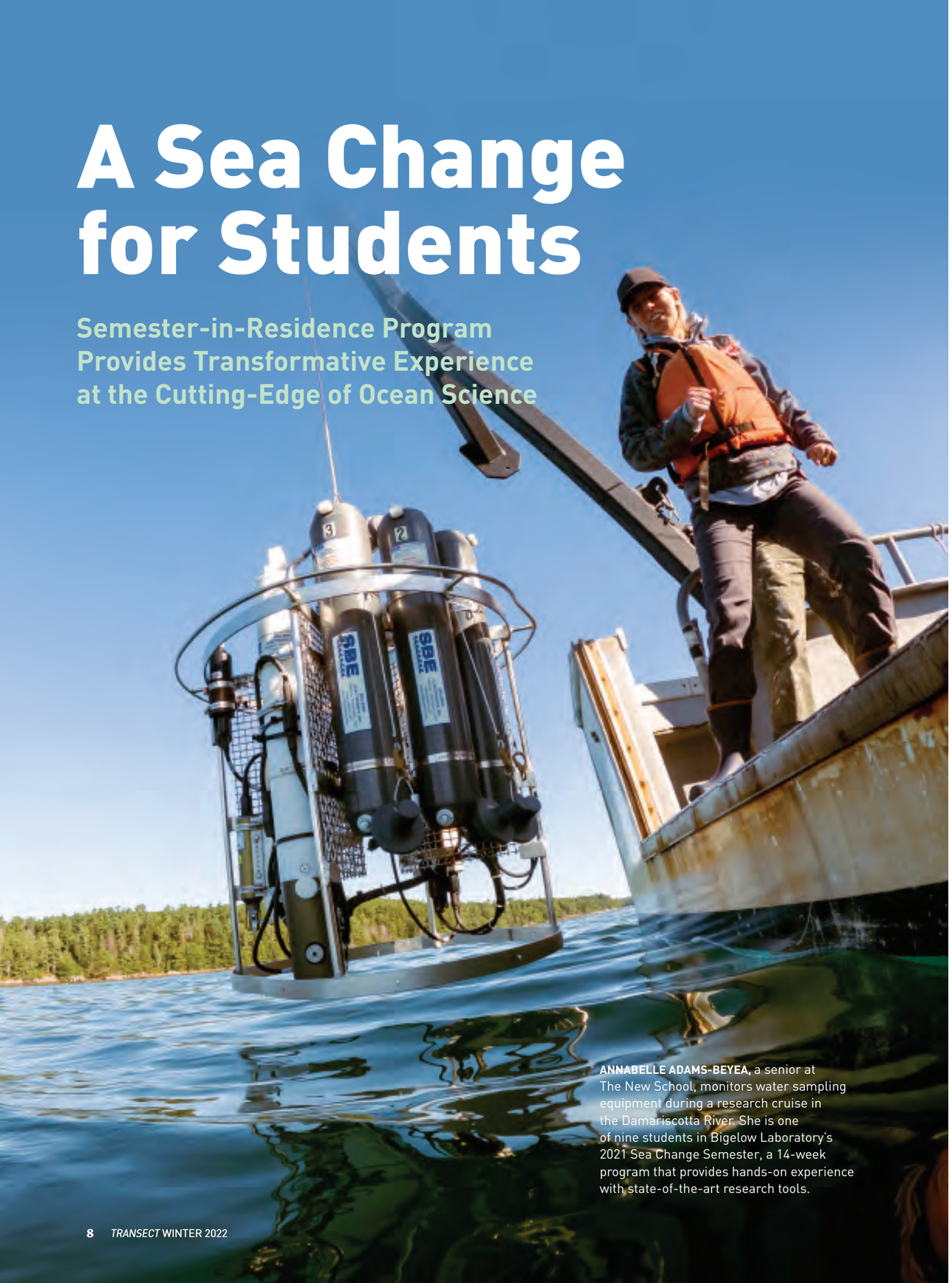
DR. NICOLE POULTON, Phytoplankton Ecologist

Nicole has supported almost every group at the laboratory as a research scientist and the director of the laboratory's Center for Aquatic Cytometry. Her new role positions her to more effectively lead her own research into the distribution of ocean microbes and their role in the global carbon cycle. She also wants to continue to grow her impact on students. Nicole already leads the Keller BLOOM high school program and the BLOOM Educator program, and she plans to integrate more hands-on student experiences into her work.

"My passion has always been to look at how changes are affecting the microbial life in the oceans. They give us a valuable window into what the future of the planet may look like and how to better prepare."

A Sea Change for Students

Semester-in-Residence Program Provides Transformative Experience at the Cutting-Edge of Ocean Science



ANNABELLE ADAMS-BEYEA, a senior at The New School, monitors water sampling equipment during a research cruise in the Damariscotta River. She is one of nine students in Bigelow Laboratory's 2021 Sea Change Semester, a 14-week program that provides hands-on experience with state-of-the-art research tools.

FIELDWORK is a core part of the Sea Change experience. **TOP LEFT:** Research Associate Maura Niemisto, Senior Research Scientist David Fields, and Colby College senior Henry Heck. **TOP RIGHT:** Fields and Colby College junior Kenny Douyon. **BOTTOM LEFT:** Colby College junior Robbie Graham. **BOTTOM RIGHT:** Douyon, University of Hawaii junior Sydney Lewis, and Niemisto.

Like many kids with dreams of becoming an oceanographer, Kenneth Lai's interest in the sea began with whales. But the more he learned, the smaller his focus became. Microbes are now at the center of his curiosity, and he is especially interested in how they can survive in extreme conditions — and the light that sheds on how life may exist on other planets.

"When people say they're interested in whales or multicellular organisms I'm usually just like, 'That's so boring,'" Lai said. "Because a lot of multicellular organisms are really limited as to what kind of conditions they can survive in. Microbes are fascinating because they can really be found anywhere."

Lai is now a student in Bigelow Laboratory's Sea Change Semester. The 14-week program gives students hands-on experience with marine research, equipping them with the tools to answer questions they have about the future of the ocean. Students live in residence and earn college credits through field research, courses, and independent research under the guidance of Bigelow Laboratory scientists.

"We give the students an immersive experience of what it's like to be an oceanographer," said Senior Research Scientist Nick Record, director of the program. "They conduct their own research in a working laboratory. It's really different from a research experience on a college campus or even other hands-on programs. They get to experience exactly what it's like to be a scientist."

The program is a collaborative effort with Colby College, which awards course credits to participants, but it draws students from across the country.

Lai is one of those students. A junior at University of Washington, his semester project is on microbe-driven chemical reactions in the Arctic. He is working with Research Scientist Alex Michaud to investigate bacterial communities associated with iron-rich microbial habitats in Alaska. These habitats are common in the tundra, where bacteria significantly impact nutrient availability and control chemical reactions of iron and methane. Lai is studying the genetics of these microbes, their metabolism, and how they are involved in greenhouse gas emissions.

"I've been really excited to learn how to analyze genetic data found in the environment, and that's exactly what I've been doing this semester," he said. "I really wanted to come to Bigelow Laboratory because undergraduates don't get many opportunities to work with genetic research tools like that."

The Sea Change Semester gives students hands-on experience with the latest molecular, artificial intelligence, and synthetic biology tools. With guidance from their mentors, they choose a research question based on their personal interests to answer through an

SENIOR RESEARCH SCIENTIST Nicole Poulton and University of Southern Maine senior Vincent McDaniel collect samples on the Damariscotta River.

'You're not only learning the material; you're learning how to apply it in all sorts of ways that you'd use as a scientist.'

independent project. They also take part in field research that includes six cruises on the Damariscotta River. For many, the program even leads to their first published scientific paper.

"There is such a different learning experience when you're working on a project in a lab versus learning in a classroom," Record said. "We try to incorporate that not just through their independent research project but as much as we can through the courses they take."

Students complete three intensive, month-long courses that cover the foundations of marine ecology, microbial oceanography, biogeochemistry, biotechnology, and molecular biology. This interdisciplinary tack lies at the heart of Bigelow Laboratory's approach to science, and the Sea Change Semester helps students use this unique environment to focus on solutions to real-world problems.

"If the students want to help address the pressing ocean issues the world is facing, they need to learn how to pull from the expertise of other fields, in addition to their own," Record said. "Solutions to problems of this size and complexity take all of us working together."

This collaborative approach dovetails with Bigelow Laboratory's welcoming culture to integrate the students into life on the campus. They build connections with scientists from a wide variety of disciplines through both research and social events. These relationships provide students with mentors at a pivotal time in their careers, and they enable access to the far-reaching professional network that is fueled by the laboratory's collaborations around the world.

"The scientists at Bigelow Laboratory don't need any encouragement to open up to a student who shows up at their door," said Ben Twining, Henry L. and Grace Doherty Vice President for Education. "I think of students who come here as not just part of the research group they work with, but part of the laboratory community."

Now a University of Maine doctoral student co-advised by Senior Research Scientist Peter Countway, Sydney Greenlee is a familiar face around campus. She has participated in numerous educational opportunities at the laboratory during the last three years, and one of her first was the Sea Change Semester, which she completed as a junior at Colby College.

"The main strength of the program is that you're not just getting foundational courses in oceanography and marine sciences, you're also conducting research," Greenlee said. "You're not only learning the material; you're learning how to apply it in all sorts of ways that you'd use as a scientist."

Greenlee did have a chance to apply the experience as a scientist, perhaps sooner than she expected. Following her participation in the program, she was offered a role as a student researcher on a six-week research cruise to the Southern Ocean with Senior Research Scientist Barney Balch. She now works with Countway using DNA found in the environment to understand harmful algal blooms in Maine's coastal ecosystems.

Those insights can help states support environmental health — and the many people and industries that rely on it. This connection between ocean and human health is a core theme of research at Bigelow Laboratory, and a passion shared by its scientists and students.

Current Sea Change student Kenny Douyon, a junior at Colby College, is working on his independent project with Record using machine learning computer algorithms to forecast harmful algal blooms. The blooms are health and safety hazards around the world and are particularly hard on underdeveloped countries. Douyon immigrated to the United States from Haiti as a child, which has left him with a passion for helping communities with limited resources.

He hopes that the skills he is learning through his Sea Change experience will one day help him provide monitoring techniques and information to help countries like Haiti forecast and plan for environmental challenges.

"Understanding the processes that scientists use to get data helps you understand how the data can be used," he said. "In order to really help developing communities you need to promote science that's essential in that region and unique to that environment and community. It's great to gain experience with some of the techniques now that I might need in the future."

PROFILE Ed and Melanie Hodgdon

Planned giving donors

Ed and Melanie Hodgdon are high school sweethearts. They have been married for almost 50 years, but their relationship with science has lasted almost as long. The couple deeply appreciates the value of the ocean and its health, and they have dedicated their lives to education and science.

"People need to ask themselves if they are creating the type of world they want to live in," Ed said. "We have the capability to change the world, but we first have to understand it. Science is the tool for that understanding."

Ed had an early interest in science and began studying engineering in college. However, that wasn't enough to satisfy his inquisitive mind. He didn't want to just build bridges and dams, he wanted to understand the deeper issues surrounding them. This led him to launch a career in physics and chemistry.

As he worked as a researcher, his curiosity never dimmed, and his passion for sharing it grew. He decided to switch his focus to education, and he spent the rest of his career teaching. At his core, he wants to stimulate others to ask questions about the world around them.

"I am extremely passionate about science, the need for people to understand things, and the need for people to relate knowledge to the real world," Ed said. "The whole emphasis of my life is to get people to understand and want to learn."

Melanie was also drawn toward understanding the world — but through the incredible variety of life on the planet. She remembers a high school biology project where she studied the organisms living in a puddle in her backyard to understand its microcosm.

"I wanted to observe, categorize, and look for patterns, then use that for prediction, which is science," she said. "It's just the way that I'm built. It's a puzzle, and I find puzzles alluring."

She built her career in science education, teaching in Lincoln County, Maine. She loved sharing her passion for inquiry with students and tried to foster their own sense of wonder. Interacting with nature was critical to that process, and she created a field course in the 1980s to study intertidal and wooded areas of Maine.

"You have to engage students to learn," she said. "You can't learn to ride a bicycle by reading a book, and you can't understand the nature of science without engaging in it."

Both Ed and Melanie have lived in Maine most of their lives. Longtime residents of Lincoln County, they have been supportive of Bigelow Laboratory for years. They are excited to be part of research that can be applied to solve real-world problems, and they are especially interested

in the education programs that bring in students and teachers to learn about the ocean in a hands-on research environment.

'We have the capability to change the world, but we first have to understand it.'

"Bigelow Laboratory is working on an international level — doing important research and inventing techniques that have been adopted around the world — but its outreach work is at least as important," Melanie said. "It brings people to live and work and breathe with scientists. That is critical because they are learning from the source."

The couple recently made a lasting investment in that work by including Bigelow Laboratory in their estate plan. They said it's important for them to leave a legacy of support for causes they believe in — for the benefit of Maine and the planet.

"Throughout our lives, we have tried to impart a passion for science in the classroom," Melanie said. "It is with a sense of joy and satisfaction that we plan to enlarge our sphere of influence through Bigelow Laboratory. Giving to ocean research and outreach programs is a no-brainer. Having such a wonderful institute in our backyard is the icing on the cake."

FOR MORE INFORMATION about how you can partner with Bigelow Laboratory to steward your continuing impact through a planned gift, please visit bigelow.org/legacy.

SCIENCE SNAP

RESEARCH TECHNICIAN Gabriella Iacono prepares cultures in the laboratory. Iacono is working on several projects led by Bigelow Laboratory scientists that aim to develop algae-based feed supplements for cattle. The projects aim to reduce greenhouse gas emissions while improving milk production. This work has been supported by the Shelby Cullom Davis Charitable Fund since 2017 and recently received a $10 million grant from the USDA.

Photo: Colby College

CURRENTS

New View of Coastal Seaweed

Maine has 3,500 miles of coastline and much of it is covered in seaweed. Quantifying these plants is challenging, but it is essential to managing their sustainable harvest and understanding the dynamics of nearshore food webs. Senior Research Scientist Catherine Mitchell is using aerial drones to develop better methods for mapping, classifying, and estimating the amount of rockweed and other intertidal seaweeds. The work is part of a project led by Maine Maritime Academy, with collaborators across Maine and New Hampshire.

The team conducted fieldwork around Maine over the summer and fall to collect images. They also conducted laboratory analyses to record the wavelengths of light that different seaweeds reflect under various natural conditions. Mitchell will now create computer algorithms that can use the data to identify and quantify intertidal seaweeds from aerial photos. The researchers hope to apply the technology to satellite images to analyze seaweed over even larger areas.

COURSE EDUCATES ON HARMFUL ALGAE ID

Harmful algal blooms pose a threat to coastal environments, human health, and seafood industries across the world. Managing their impact begins with the identification of harmful algal species in water samples. This summer, Bigelow Laboratory drew in 13 specialists from across the country for a 10-day course on effective collection and microscopic identification of harmful algae.

As climate change redraws the boundaries of where different harmful algae species may appear, traditional methods of visual identification remain essential, supported by molecular monitoring. Participants were led by Senior Research Scientist Mike Lomas through lectures, demonstrations, and hands-on practice using microscopes to identify the subtle differences in algal species. This is the fifth year of the course, the only one of its kind in the country.

Photo: Susan Lang, U. of S.C. / NSF / ROV Jason / 2018 © WHOI

Pioneering A Deep Sea Technique

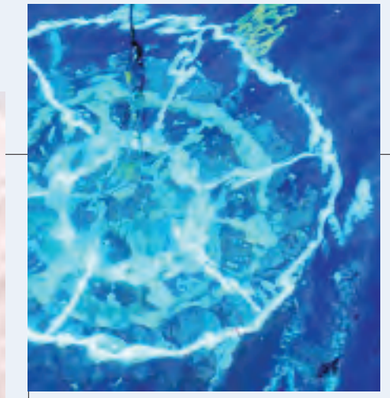
Researchers at Bigelow Laboratory are pioneering a method to understand microbes that could shed light on how life survives in the deep sea — or on other planets.

Senior Research Scientist Beth Orcutt and her team looked at microbes from an underwater mountain region near the middle of the Atlantic Ocean that is thought to be an analog for conditions on other planets. In these rocks, microbes are spread out in low concentrations, making them difficult to study. Working with the Single Cell Genomics Center and the Center for Aquatic Cytometry, both at Bigelow Laboratory, the team developed a method to sort and examine these microbes quickly and accurately. The new approach also enables the study of each cell's genetic information. The method can help study habitats where samples are difficult to collect or microbes are limited, such as in permafrost, the deep sea, or other extreme environments.

CRISPR Research Opens Doors to Fight Oyster Disease

Scientists first published reports on the oyster parasite *Perkinsus marinus* almost 70 years ago. Now, it can be found in most places where eastern oysters are farmed, and it poses a considerable threat to the industry. Researchers still do not entirely understand how the parasite causes disease in oysters or have the means to stop it.

Working to change that, a team of scientists have developed methods that allow them to edit the parasite's genomic sequence. The research was published by Raghavendra Yadavalli, who worked as a postdoctoral scientist at Bigelow Laboratory, as well as Senior Research Scientist José Antonio Fernández Robledo and several undergraduate students. The team adapted CRISPR/Cas9 technology, a revolutionary tool that was awarded the 2020 Nobel Prize in Chemistry, to edit the parasite genome. The new techniques can be used to analyze the biology of the parasite and identify weaknesses that might be exploited to mitigate the threat it poses.



PLANKTON SHED LIGHT ON OCEAN NUTRIENTS

Sweeping changes in marine nutrients seem like an expected consequence of a warming planet. However, new research suggests that processes below the ocean's sunlit surface may control what happens above it.

Plankton are some of the most numerous and important organisms in the ocean. The balance of chemical elements inside them is critical to shaping marine processes such as food webs and the global carbon cycle. Senior Research Scientist Mike Lomas recently led a new study that discovered the ratio of nitrogen and phosphorus introduced from the subsurface ocean, from depths of more than 300 feet, controls the balance of nutrients in these marine microorganisms. The findings can be used to apply realistic parameters to computer models that forecast ocean change.

Photo: Michael Sswat/GEOMAR

Researchers Amplify Natural Carbon Removal Process

Global governments' efforts to decrease greenhouse gas emissions continue to fall short. Scientists around the world are investigating ways to avoid the worst consequences of global warming by accelerating the Earth's natural processes of removing carbon dioxide from the atmosphere. Senior Research Scientist Steve Archer is part of an international project researching the possibility of altering the chemistry of the ocean's water to absorb more carbon dioxide from the atmosphere.

Working with GEOMAR Helmholtz Centre for Ocean Research Kiel, he recently conducted six weeks of field research in the Canary Islands to test this "alkalinization" approach. The technique would also counteract ocean acidification, a negative consequence of increased carbon dioxide that threatens many marine organisms. Inside large test chambers deployed in nearshore waters, the team simulated alkalinization in the first experiment of its scale. Using dissolved minerals to alter the water chemistry, the scientists used the nine chambers to test the effectiveness of different treatments and investigate their impacts on marine life.

MAINE EDUCATORS GET IMMERSED IN RESEARCH

Science teachers from around Maine spent a week gaining hands-on research experience at Bigelow Laboratory this summer as part of the 10th annual BLOOM Educators Program. The workshop trained the educators how to teach the fundamentals of ocean science in a local and global context.

Participants were shown how a curriculum on general science topics, like food chains, can be taught using ocean-based examples. Teachers also participated in a research cruise on the Damariscotta River. They were given scientific tools to collect and study field samples, and they were trained on how to apply the experience to their classrooms. New to participants' take-home toolkits this year was a Foldscope, a paper microscope that can use a smartphone to capture images for online teaching.

Photo: Brennan Phillips, URI

New Method to Collect Fragile Samples

Senior Research Scientist John Burns took part in a research cruise to change the way scientists collect samples of fragile organisms, like jellyfish. The project is developing technology that can collect enough information to scientifically describe a new species, including genetic information, from a single encounter.

The area below the ocean's surface and above the seafloor, is the largest contiguous ecosystem on Earth — but also one of the least explored. Samples can be destroyed by pressure changes as they are brought to the surface. Burns helped test the new technology, a robot with specialized collection and measurement instrumentation, which allows scientists to study delicate organisms and preserve samples. As the biologist on a team of engineers, he studied samples' genetic information to evaluate the new tool's effectiveness.

ROBUST MICROBIAL ACTIVITY DISCOVERED IN ALASKA

The amount of iron in soil controls critical elements through chemical reactions, and those reactions are driven by multitudes of microbes. This summer, Research Scientist Alex Michaud conducted fieldwork in Alaska to measure iron and microbial activity that influence global processes — from greenhouse gases emissions to nutrient availability for plants. In more temperate regions, chemical reactions involving iron happen from the topsoil to water hundreds of feet underground.

In the Arctic, a solid layer of frozen soil, called permafrost, traps iron in soil's top few feet and reactions only occur when the surface thaws during the summer.

Michaud discovered the annual rate of microbial activity in the Arctic is comparable to that of more temperate regions — despite much shorter summers. This means reactions in the Arctic are more intense, and the microbes are resilient to being frozen at negative 50 degrees for months. The findings are important as climate change warms the Arctic, permafrost melts, and soil microbes stay active for longer.

FIELD NOTES

ISLE AU HAUT, Maine

STUART RYAN, Research Technician

"Do we have everything?" I ask my colleagues Dara Yiu and Shane Farrell, two doctoral students from the University of Maine. We are floating in the chilly waters off Isle au Haut with our scuba gear, dry suits, and armfuls of scientific equipment. Between us, we are holding over a dozen one-liter syringes for collecting water samples, three large squares used for marking out plots, a bag of sensors, and a concrete block to affix them to the ocean bottom. We review our checklist before signaling to descend and then sinking into the green-tinged water, expectantly waiting for the bottom to appear below us.

Once on the bottom, we quickly begin to execute what has, by now, become a tightly choreographed routine punctuated by the occasional hand signal. While Shane begins rolling out a 50-meter tape measure, Dara scans the water ahead for fish, counting them and estimating their length. I stay just behind, collecting water samples at designated points along the line. Next, we conduct detailed surveys of the algae and invertebrates that we observe on the seafloor. Within each one-meter square plot, we collect algal samples to bring back to Bigelow Laboratory and record their wet and dry weight.

After two 60-minute dives, it's time to bring all that gear and our samples back up to the surface. The only evidence of our visit is a cluster of digital sensors nestled between boulders, keeping a record of the temperature, light, and wave action until we return.

Exhausted, cold, and hungry, we hand all of that gear to doctoral student Rene Francolini, who loads it into coolers and keeps track of our samples. Senior Research Scientist Doug Rasher starts the engine, pulls the anchor, and charts a course for the laboratory in East Boothbay. We stow gear, eat an entire family-size pack of double-stuffed Oreos, and turn our focus to the journey back to the lab. It's during these moments, daunted by the number of sites left to survey, and anxious about fog, wind, and heavy seas, that I remind myself why we are doing this.

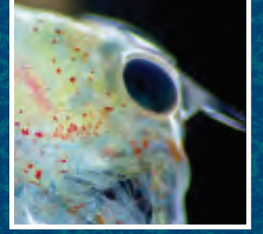
The Gulf of Maine is changing quickly. As this body of water warms, some cold-water species that inhabit the region are being displaced from their native habitat. At the same time, species typically only seen in warmer waters are now appearing. Kelp, once abundant across the entire rocky coastline of Maine, is becoming less common in southern Maine as water temperatures rise.

Surveying 18 sites from Jonesport to the New Hampshire border provides a snapshot of how these underwater forest ecosystems are responding to ocean warming and the arrival of new species. We are looking for these changes not only through underwater visual surveys, but also using environmental DNA, commonly called eDNA. Water samples collected at our sites contain fragments of DNA released into the water by organisms. This eDNA allows us to use genetic tools to ask the question: who is here?

By pairing the results of our visual surveys and eDNA analyses, we hope to understand how this ecosystem is changing and document the arrival of new species before they become abundant. Doing so may enable fisheries managers and policy makers to better anticipate and manage the arrival of these "species on the move."

When we get back to the lab, our coolers need to be unloaded, water samples need to be carefully filtered, and bags of algae need to be sorted and weighed. In between rounds of rinsing dive gear and putting samples in the freezer, I check the forecast. Two days from now the seas are calm and the winds are light. It's time to start prepping our gear for the next site.

Photo: Rene Francolini



Photos, left to right: Madelyn Woods, Joe Tomoleoni, Fritz Freudenberger

GIVING Bold Science For Our Blue Planet

Throughout the Gulf of Maine and around the world, Bigelow Laboratory scientists study the sea life that forms the foundation of global ocean health.

Our research uncovers vital insights about our planet and how to care for it. And we can't do it without your help.

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The need for our creative, cutting-edge science has never been greater. And thanks to the generosity of people like you, we are turning the tide on global challenges and unlocking the incredible opportunity of the ocean.

Photo: Mark Dayel (mark@dayel.com)

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