TRANSECT

BIGELOW LABORATORY FOR OCEAN SCIENCES / WINTER 2021

ON THE COVER

Senior Research Associate Kevin Posman measures gas exchange through the sea ice during the MOSAiC expedition. This yearlong study of sea ice dynamics and climate was the largest Arctic research expedition in history, bringing together more than 300 experts from 20 countries. Read more about this historic undertaking on page 2.

Photo: Daiki Nomura

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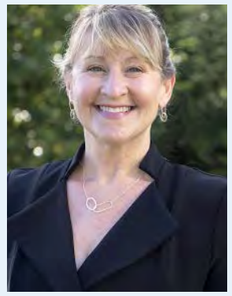
Message from the President

As we look ahead to 2021, I can honestly say that I have never been more grateful to be a part of Bigelow Laboratory. Throughout the last year, our staff showed incredible dedication in the face of global challenges. Our agile institutional model enabled us to maintain our rapid pace of discovery. And through it all, our generous donors have shown unwavering belief that our science is vital to the future.



While 2020 has been filled with many difficult moments, the response of the Bigelow Laboratory community has been an inspiration to me, and I am so excited about where we are headed together!

A few months ago, we launched a new strategic plan that will guide our bold ocean science during the next five years. The ocean is central to so many of the challenges and opportunities facing our planet, and our new strategic plan will help us shape a brighter future for all life on Earth. This plan is now available on the About page of our website, and I'd encourage you to look through it if you want to dig into our specific goals and our strategic approach to maximizing our impact.

One exciting initiative launched by the plan is our new Center for Algal Innovation. This new Impact Center will work with partners around the globe to develop the ways algae can help us build a more sustainable society. You can read more about this exciting development on page 8.

This targeted approach to algal innovation will occur alongside new strategies that bolster our core research and its application to other critical opportunities — including water health and ocean forecasting. It was rewarding to work with the staff and board to target the areas where our expertise can have the greatest impact, and it's been thrilling to watch our new plan come to life in the months that followed. There truly are great things on the horizon for Bigelow Laboratory!

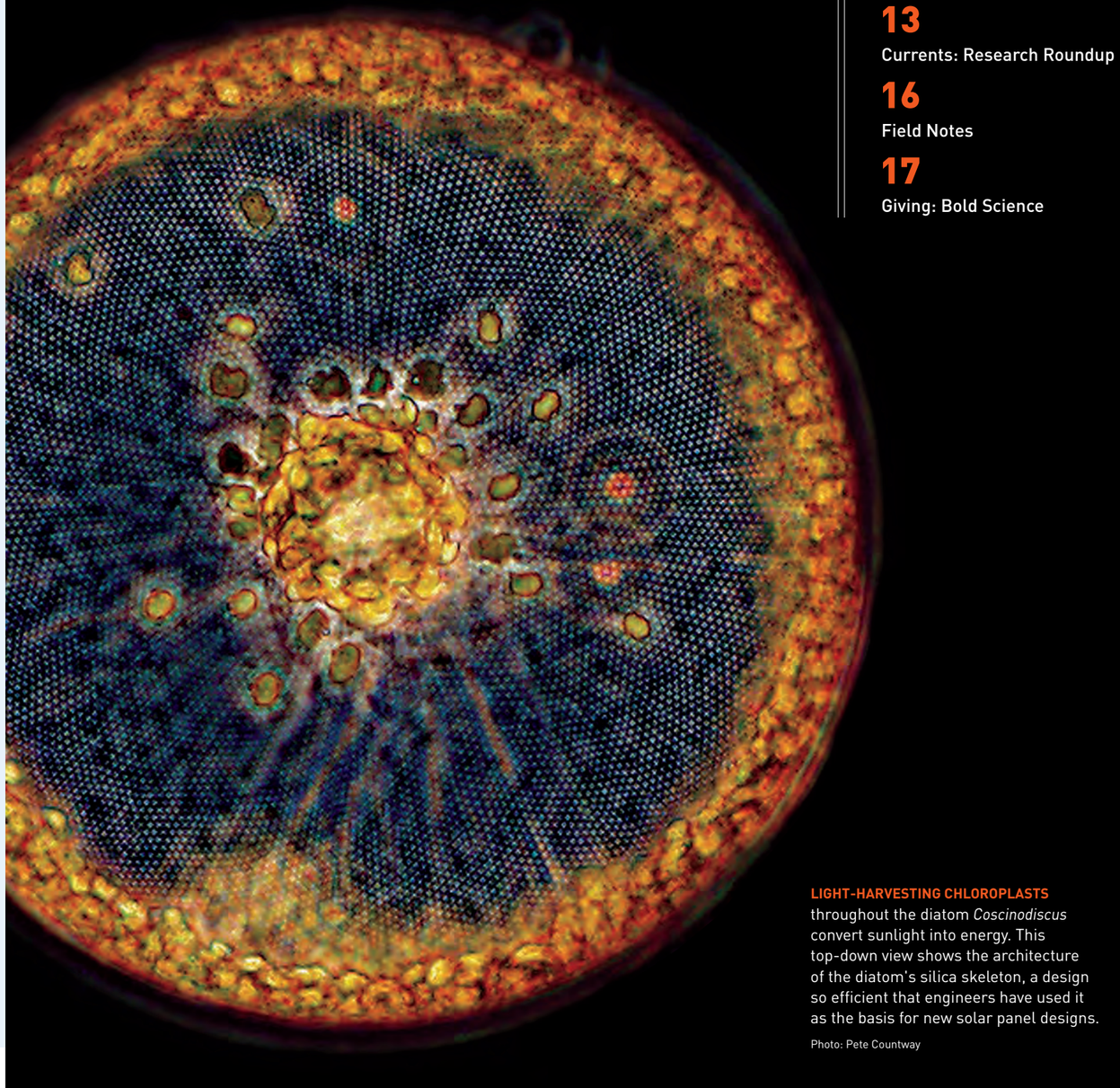
None of this would be possible without your support. The last year has highlighted many worthy and timely causes, but it has not decreased the urgency of the global issues we work to address.

Thank you for continuing to prioritize our shared vision of a better future through ocean science! Together, we will advance the discoveries, solutions, and inspiration needed to turn the tide on global challenges and unlock the incredible opportunity of the ocean.

Deborah A. Bronk

DEBORAH BRONK, PhD

CONTENTS



LIGHT-HARVESTING CHLOROPLASTS throughout the diatom *Coscinodiscus* convert sunlight into energy. This top-down view shows the architecture of the diatom's silica skeleton, a design so efficient that engineers have used it as the basis for new solar panel designs.

Photo: Pete Countway

A YEAR ON ICE

Historic Arctic Expedition Weathers Challenges to Reveal New Look at Global Climate Change

SENIOR RESEARCH SCIENTIST Steve Archer, center, recently led a yearlong study as part of an Arctic expedition that involved more than 300 scientists from around the world.

Photo: Lianna Nixon

LEFT, BOTTOM Archer, at right in both photos, works with fellow researchers during the MOSAiC expedition.

BELOW Polar bears traverse through melting sea ice.

Sounds of cheers, toasts, and a brass band serenaded the scientists aboard the *Polarstern* as the icebreaker left dock in late September 2019. A crowd had gathered onshore in Tromsø, Norway, to celebrate the beginning of the yearlong MOSAiC expedition and wish the researchers luck against the many challenges — both known and unknown — that lie ahead.

"Arctic fieldwork takes an unbelievable amount of preparation, and it was both exciting and a huge relief when we finally set off," said Senior Research Scientist Steve Archer, who lead a study as part of the recently completed expedition. "We faced a lot of obstacles over the year, but dealing with unexpected problems is a big part of research expeditions — especially in the Arctic. Even in this modern age, it's a humbling place to work."

The scope of the MOSAiC expedition was mammoth: a comprehensive, yearlong study of sea ice dynamics and climate. With more than 300 experts from 20 countries, it was the largest Arctic research expedition in history, and its launch was the product of years of logistical fervor, meticulous personnel arrangements, and the careful plotting of plans and back-up plans.

Short for "Multidisciplinary drifting Observatory for the Study of Arctic Climate," MOSAiC's aim was to moor the *Polarstern* to slowly moving Arctic sea ice, where it would drift for a year and serve as the research base for a wide array of measurements and experiments.

As the team neared the North Pole in early October 2019, they selected a site, secured the ship to the ice, and began to assemble their carefully planned field camp in the waning summer sunlight. Before long, a web of power and data cables stretched across the sea ice connecting research sites that spanned a square mile around the ship.

"By the time we got set up, the long months of winter darkness had arrived," Archer said. "It was cold and dark and fantastic to experience. It felt like we were working on the moon."

Over the next three months, Archer lived and worked in the strange lunar landscape. He and his team were there to discover how gases flow between the ice, ocean, and atmosphere. This critical exchange shapes the global climate by controlling the movement of ozone, methane, carbon dioxide, dimethyl sulfide, and other influential gases.

Most of the researchers' time was spent on the ship, where they had set up numerous instruments and could remotely monitor their equipment on the ice. They would make regular trips out into the field camp, but each trip required advance planning — and an armed guard to protect against polar bears.

In January 2020, Archer completed the first stint of his MOSAiC research, and headed home for a few months before he was scheduled to return to the field site in March.

Soon after arriving in Maine, reports of a strange new virus began to emerge and concern began to mount

Photos: Esther Horvath, left; Stefan Hendricks, top right; Lianna Nixon, bottom right

SENIOR RESEARCH ASSOCIATE Kevin Posman, left, collects field data on ocean gas exchange with Hélène Angot, from CU-Boulder.

among the expedition leaders. As the next few weeks passed, the research continued, and the world unraveled. The uncertainty caused by the COVID-19 pandemic engulfed MOSAiC operations and threatened to upend a decade's worth of careful plans and preparations.

THE BEST LAID PLANS

As countries locked down their borders, the personnel exchange that would have brought Archer back to the expedition in March was put on indefinite hold. While the researchers who were about to be relieved from their duties settled in for an extended stay, MOSAiC leaders began to formulate new plans that would protect the research and the safety of all involved. The field camp had effectively already been in quarantine for months, but any exchange of supplies or personnel could put the entire mission at risk.

A resupply date was eventually rescheduled for May; however, the delay had caused a new problem: there were no longer any icebreakers available to bring Archer and the others north to the field site. It soon became clear that the *Polarstern* would have to leave the ice — and break down much of the carefully constructed field camp to do so.

"It was a tough decision, as we knew we'd miss out on several weeks of data," Archer said. "I think it was all pretty confusing for the team in the field as well, as the communication capabilities were pretty limited. They knew there was a pandemic, but they didn't understand the extent to which it had changed things."

In late April, Archer flew to Bremerhaven, Germany, where he and all the incoming team members quarantined in their hotel rooms for two weeks. With a clean bill of health, they sailed to Svalbard, Norway. There they rendezvoused with the *Polarstern*, resupplied the ship, exchanged personnel, and began the return journey to the field site they were forced to leave for several weeks.

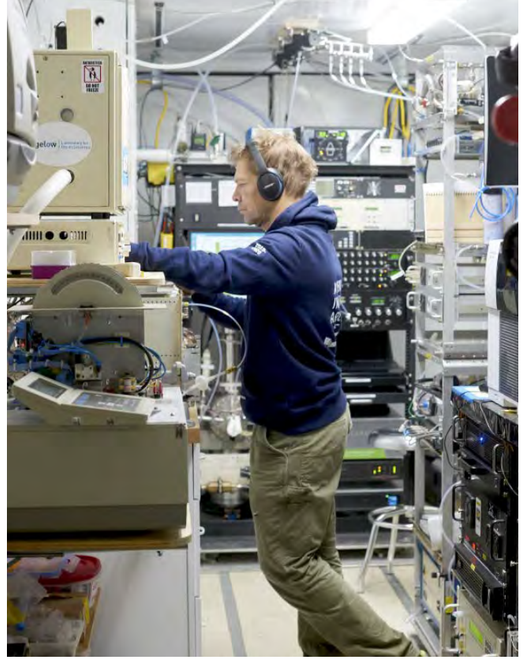
"Returning to the ice floe was a bit like meeting up with an old friend, although I'm not sure I would have recognized it without the instruments and flags that were still scattered over it," Archer said. "When we left after the first leg it had been cold and dark for several months, and now it was light around the clock and the seasonal ice melt was well underway."

The Arctic landscape had changed, and so had the world, but the clock was still ticking on MOSAiC's yearlong mission to build new understanding of the changing Arctic. The role of Archer and his team was to collect continuous measurements that would reveal how the exchange of gases between the ocean and atmosphere varied throughout the annual sea ice cycle. They also investigated how different types of snow and ice cover affected this important process.

"The Arctic influences the entire planet, and it's changing rapidly," Archer said. "As warming temperatures continue to reduce sea ice coverage in the region, we're

Photos: Daiki Nomura, top; Stefan Hendricks, opposite

'The conditions were great for getting to the North Pole, but a sad commentary on the state of the Arctic. This is a historic year for sea ice melting, but historic melting is the new normal.'



LEFT Posman, left, assembles the team's gas flux analyzer during the MOSAiC expedition's final month.

RIGHT Archer runs newly collected samples aboard the RV *Polarstern*.

going to see increasing consequences around the globe. These changes are coming, and the research we're doing can help us prepare."

NEW PERSPECTIVES

As the pandemic progressed, Senior Research Associate Kevin Posman prepared for his own epic journey to reach the expedition and relieve Archer for the last few months of research. His departure was delayed from May, to June, before finally taking place in the middle of July. By the time he arrived on the resupply vessel, the expedition had been transformed once again.

An especially warm summer had ravaged the sea ice, forcing the expedition team to pack up the field camp and prepare to push north into colder waters. There, they would reestablish the camp on stronger ice and spend their final weeks studying the sea ice refreeze that heralds the return of winter.

After a brief reunion with Archer, Posman and the crew of the final MOSAiC leg headed toward the pole through relatively ice-free seas.

"The conditions were great for getting to the North Pole, but a sad commentary on the state of the Arctic," Posman said. "This is a historic year for sea ice melting, but historic melting is the new normal."

After crossing the pole, the expedition team essentially found themselves starting over. The final few weeks played out like an accelerated replay of the year up to that point. They had to again find a suitable ice floe, set up camp, conduct their research, and break everything down.

"We really benefitted from the experience of the team members who had worked on previous legs of the expedition," Posman said. "The month we had on the ice was one of the most intense and successful periods of the expedition. We collected a lot of good data in the short time we had."

As the days began to take on a golden hue, the Arctic summer — and MOSAiC's year on the ice — came to an end. Nearly 13 months after its cheerful sendoff, the *Polarstern* pulled back into port in October 2020. The MOSAiC expedition was completed, but the hard work of scientific discovery was just beginning.

The massive scope of the project was in large part due to its multidisciplinary nature. The hundreds of researchers who participated during the year worked to gain a holistic view of the changing Arctic. They studied the biology, physics, and chemistry of the sea ice. They studied the ocean below it, and the atmosphere above it. By collecting all these measurements at the same location and time, they have gathered the pieces of an enormous puzzle that they now need to assemble.

"MOSAiC scientists collected data from 3,000 feet below the sea surface to 30,000 feet above it," Archer said. "There's a huge opportunity to connect everything, and that's as big of an undertaking as the expedition itself."

This new understanding could revolutionize climate models. Despite the importance of the Arctic, most computer models are currently forced to take a simplistic approach to the complex region. Scientific understanding of the sea ice is largely based on research carried out near the easier-to-access ice edges, and Archer said his team's observations have already made it clear that the central Arctic works very differently.

"We have a good sense for some of the big themes that are going to come out of the research," Posman said. "But there was so much multidisciplinary data collected that I think there are going to be some unanticipated and really exciting discoveries in the coming years."

Photos: Daiki Nomura, left; Byron Blomquist, right

PROFILE

Trustees, Bigelow Laboratory

Bill and Barbara Burgess

Bill and Barbara Burgess have a common passion for the ocean. They share extensive experience with marine nonprofits and have volunteered countless hours in support of their missions. They also approach their service in very different ways.

"I come at my role on the board from a business and governance point of view," said Bill, who became chair of the board of trustees in October 2019. "I want to help create and sustain a foundation that enables Bigelow Laboratory's exceptional, intellectual work to thrive."

"And thank heavens you're interested in that, honey," quipped Barbara, also a Laboratory trustee. "I mostly focus on helping people learn to love the Laboratory's work and become passionate about its importance to the future of the planet."

The Burgesses joined Bigelow Laboratory's Board of Trustees six years ago, shortly after completing a decade on the board of the New England Aquarium. During that time, Barbara also helped found Women Working for Oceans, a nonprofit that works to inform and inspire people about marine issues.

A common thread that connects all the philanthropic causes they champion — from the ocean to equality in education — is a strong desire to protect the under-protected. When it comes to the ocean, they see this need in two different ways.

The first is that the ocean itself has suffered from abuse and a lack of strong allies. The second is concern for the environmental consequences being borne by vulnerable populations around the globe. Sea level rise, overfishing, pollution — it's often island nations and other economically challenged communities who are most impacted and least able to adapt.

"Wealthy countries, like the United States, hold a lot of responsibility for the issues this planet is facing," Barbara said. "And it's heartbreaking that people in the poorest countries are the ones who typically suffer the greatest consequences. We owe it to them to do more, and we have to study the problems to have the opportunity to address them."

Given the global importance of the ocean, Bill and Barbara said they are concerned about how understudied it is. Their work with marine nonprofits has highlighted the importance of understanding the ocean in order to protect it and harness its potential.

For them, this potential not only represents solutions to pressing issues, but the potential to inspire people to look at the oceans — and the planet — differently.

"The ocean has the power to help humanity thrive in a sustainable fashion," Bill said. "It can help us feed our population, power our planet, and learn greater empathy for all the other species with which we need to coexist."

'The ocean can help us feed our population, power our planet, and learn greater empathy for all the other species with which we need to coexist.'

Bill and Barbara have summered across town from Bigelow Laboratory for most of the last two decades. With their five kids now out of the house, they made the decision last year to live in Maine year round, and now split their time between Boothbay Harbor and Portland.

"We moved to Maine because of what I call the four Cs," Bill said. "It's calmer. It's cooler — in many ways. It's closer to things we love. And it has an amazing community."

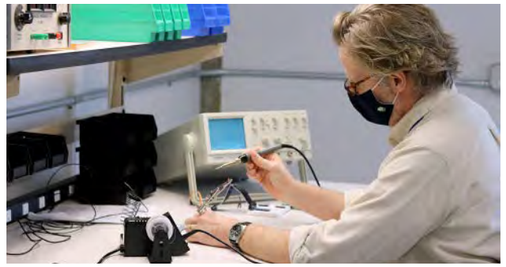
Part of that community has grown from their work at Bigelow Laboratory, and they count many of the scientists and staff as friends. Those friendships have provided valued diversity to their social circle, and gifted them with many fond memories of discussing the latest science over a glass of wine.

Those experiences have informed their understanding of the ocean, and they've helped them be able to share science-based perspectives on global issues with others.

"Our work with Bigelow Laboratory has helped us build meaningful relationships with extremely dedicated people working on some of the biggest issues facing our planet," Barbara said. "It's really enriched our lives in ways we just couldn't have ever imagined."

Sea of Solutions

An increasing number and variety of businesses are venturing into a new frontier in search of sustainable solutions — algae. This year, Bigelow Laboratory launched a new center that will provide the help these pioneers need to turn their ideas into marketable products.



TOP Senior Research Scientist Mike Lomas works as director of the National Center for Marine Algae and Microbiota at Bigelow Laboratory, as well as the new Center for Algal Innovation.

ABOVE Robert Schmedicke, head of technology development for the Center for Algal Innovation, assembles a sensor package in the new fabrication laboratory.

Senior Research Scientist Mike Lomas scans his keycard on the locked double doors. With a beep and a click, he enters the secure laboratory wing and walks past refrigerator-sized incubators that hold rows upon rows of vials.

Inside each vial, most would only see a bit of water and a tint of color. As Mike looks into them, he sees the next cancer medicine, a sustainable protein source, and even the raw materials for new plastics that don't rely on fossil fuels.

"Within 10 years, I think there with be algae or algae-derived products in nearly 75 percent of the things that we interact with on a daily basis," Lomas said. "People are starting to realize that we've barely scratched the surface of algae's potential, and we're seeing a massive surge in interest."

Lomas is director of the National Center for Marine Algae and Microbiota at Bigelow Laboratory, which curates one of the world's largest and most diverse collection of marine algae. Each year, the NCMA team supplies algal samples to researchers and industrial partners around the world, and the volume and diversity of organizations reaching out to them has rapidly grown in recent years.

Lomas attributes much of this increase to a global drive toward sustainability and the inclusion of algae in the USDA's 2018 Farm Bill. This sweeping package of food and agricultural legislation gets renewed about every five years and shapes the system that feeds the nation.

"We've been helping to push for this for much of the last decade, and it's a very, very big deal," Lomas said. "Now, people who grow microalgae or seaweeds can access the opportunities and protections that the country has provided to growers of traditional agricultural crops for the last 100 years."

With new support and recognition for algae, it's attracted the attention of many new companies who are looking at it in new and creative ways. However, they quickly discover that it's a very long road from the tiny vials of algae that they can purchase from NCMA to an actual product. Research, development, training, production, processing — each step represents a significant barrier for companies looking to explore algal applications.

To address these growing needs, Lomas launched the Center for Algal Innovation in 2020. As a core component of Bigelow Laboratory's new strategic plan, the center aims to be a comprehensive resource for the research,

Photos, opposite and top: Greta Rybus

workforce development, and intellectual property development capabilities needed to effectively utilize algae for commercial endeavors.

It's work that the NCMA team has been building experience with on the side for decades, but that team's primary focus has to be on maintaining and distributing their roughly 3,000 strains of algae.

The Center for Algal Innovation now operates alongside NCMA to focus and expand on that expertise, making it possible for a broader array of companies than ever before to explore their ideas for algae and aquatic microbes. The new center is already working with partners that range from tiny startups to Fortune 100 companies, and a new fabrication laboratory is under construction that will allow the team to create algal and microbial innovations for clients, partners, and its own development efforts.

As companies become more willing to explore the unknown, access to the NCMA collection and a knowledgeable guide become extraordinarily valuable assets.

"I think what really makes our approach different is that we are first and foremost research scientists," Lomas said. "We've brought on some new team members to strengthen our business acumen, but we still start with deep knowledge of algae biology and then follow science principles to create solutions. That makes us a very different kind of asset to the industry."

This approach is bolstered by having the NCMA collection in-house and having decades of experience carefully curating and caring for the collection. The team has spent that time exploring algae's incredible range of genetic diversity and potential applications, something that many in the industry are just starting to realize.

Algae first gained major attention in the business world as the promise of biofuels took hold in the early 2000s. Seemingly overnight, countless companies sprung up around the world in a race fueled by more than a billion dollars of venture capital funds. As oil prices climbed and climate change grew in public awareness, the industry rocketed forward.

During the years that followed, the science proved successful, yet the market evaporated. Oil prices dropped, and it's tough to get even the most principled consumers to voluntarily double their fuel costs.

"We have so commoditized fossil fuels that biofuels just can't be price competitive until that changes," Lomas said. "But the industrial knowledge and production capacity that was developed during that decade now represents huge potential that is currently being redirected to less commoditized applications where microalgae-based solutions can compete."

RESEARCH TECHNICIAN Evan Fox monitors a new device designed by the team to harvest valuable compounds from algae.

LEFT Algae grow inside Bigelow Laboratory's research greenhouse as part of a Center for Algal Innovation project.

BELOW Lomas prepares to produce the next batch of algae for a commercial partner.

Biofuels took algae production from small flasks in science labs to massive farms that covered acres. It is this change in scale that would eventually lead the USDA to include algae in the Farm Bill — rejuvenating and reshaping commercial interest in the crop.

Instead of engaging in a singularly focused race toward a common end goal, companies are now being more creative and looking for new applications. Some are starting with specific problems and searching for algae that can solve them, but an increasing number are starting with algae and searching for the solutions they can offer.

"That's a completely different philosophical approach," Lomas said. "And I think it's why the algal industry is increasing exponentially and in a much more diverse way than it did 10 years ago."

This shift in approach is also changing what companies need from Lomas and his team. In the biofuels era, every company was basically doing slightly different versions of the same thing. This meant that a limited range of services and skills could fulfill the needs of most partners.

As the industry diversified, the regional and global need for the Center for Algal Innovation became clear. In addition to meeting a much broader array of companies' needs, the center is also designed to address the more opened-ended questions that the industry has begun to embrace.

While biofuels transformed the scale and technical capabilities of the algal industry, the narrow focus of that revolution constrained the industry's evolution during the following years. Only four or five species of microalgae still represent 99 percent of what is used. This is a tiny fraction of those available in the NCMA collection, let alone the ocean and other aquatic environments. They are, however, some of the algae that were used by biofuel companies.

This is where Lomas sees the largest opportunity for the future of the industry, and where he thinks the Center for Algal Innovation can be the most help. There are microalgae in the NCMA collection that are known to be much better at naturally producing compounds for commercial applications. There are many more that haven't been screened for these compounds. As companies become more willing to explore the unknown, access to the NCMA collection and a knowledgeable guide become extraordinarily valuable assets.

"This new center puts us into position to help the industry embrace the full potential of algae and aquatic microbes," Lomas said. "Companies are going to get more and more creative with these organisms, and they're going to need a lot of help to turn that creativity into actual products that get the sustainable solutions algae offer into the marketplace."

SCIENCE SNAP

SEA CHANGE STUDENT Eliza Goodell, a junior at Oberlin College, completes a solvent extraction to measure organic pollutants on microplastics. The Sea Change Semester program brings a group of students from across the country to live and learn at Bigelow Laboratory for a semester each fall, earning credits from Colby College that are transferred to their home university. Despite the extra challenges presented by the COVID-19 pandemic, extensive testing and safety protocols allowed the program to run in 2020.

CURRENTS

Return to the Southern Ocean

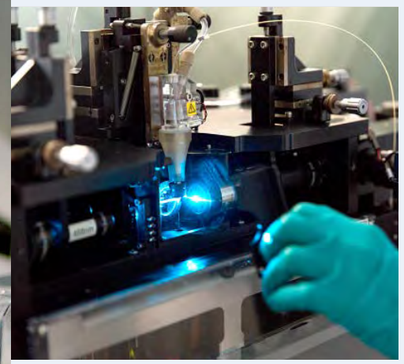
Coccolithophores are a common algae that support ocean food webs and play a significant role in global chemical and carbon cycles. However, they are often scarce in the fertile waters near the equator. This winter, Senior Research Scientist Barney Balch and his team will journey to the Southwest Pacific Ocean on a second research cruise to try to discover why.

The Southern Ocean and equatorial waters are connected by an ocean layer that forms at the surface of the Southern Ocean, sinks, and flows to the equator over a 40-year journey. Balch suspects that booming coccolithophore populations are depleting its supply of an essential nutrient, making the water suboptimal for coccolithophore growth when it reaches the equator. The first cruise of this project was off the coast of South Africa in January 2020, and this expedition will continue the same research from a new location. By measuring water properties and conducting onboard experiments, the researchers hope to uncover how coccolithophores are altering the water before its long journey north.

HIGH SCHOOLERS GET HANDS-ON EXPERIENCE

This year, students at Bigelow Laboratory need more than lab coats and goggles to stay safe, but COVID-19 hasn't lessened the importance of experiential science education. After being delayed from May, 16 high school students from around Maine came to the Bigelow Laboratory campus in August for our 31st Keller BLOOM program. Thanks to thorough safety measures, including testing and social distancing, students still had the opportunity to dive into this inspiring research experience in person.

The annual program provides Maine high school juniors with the opportunity to work alongside researchers to study the local marine environment. Participants in the immersive experience engaged in a range of field sampling and laboratory techniques designed to help them explore a career in science.



Viruses Discovered to be Food Source

When people think of seafood, lobster or fish typically come to mind. But for some creatures, viruses may be on the menu. New research suggests some tiny ocean organisms use viruses as food. This is the first study to report this behavior outside of a laboratory environment. Bioinformatics Scientist Julia Brown and her colleagues found evidence that two groups of protists, single-celled organisms, eat viruses. The research, published in *Frontiers in Microbiology*, was featured in *The New York Times*.

Researchers examined DNA from protist cells. Inside, they found DNA belonging to the protists' genome and a variety of viruses. Similar viral DNA was found in unrelated protists, leading Brown to conclude that ingestion, rather than infection, was the explanation. The lack of bacterial DNA in the cells, a protist's usual meal of choice, supports the finding. This could transform the way we think about the role of viruses in the ocean.

Photos, clockwise from top left: Scripps Institution of Oceanography at UC San Diego, David Fields, Greta Rybus

Research Advances to Reduce Carbon Hoofprint of Cattle

Cows aren't generally known to eat seafood but that may soon change thanks to new research. Senior Research Scientist Nichole Price is leading a team of New England colleagues in an effort to add seaweed to cows' diets and cut methane emissions by cattle — a significant source of this powerful greenhouse gas.

In October, the team moved beyond initial screening of Gulf of Maine seaweeds at Bigelow Laboratory to simulation trials in Vermont and live animal trials in New Hampshire. The team believes feeding nutrient-rich seaweed to cattle may also improve their health and the soil where they pasture. It could also bolster Maine's burgeoning seaweed aquaculture industry, remediate ocean conditions, and help recycle important nutrients. With this in mind, Price recently helped host an international series of virtual workshops to define a research roadmap. They were attended by more than 150 representatives from the scientific community, seaweed and cattle industries, and other major end-users.

NEW AWARD SUPPORTS AMBITIOUS RESEARCH

Senior Research Scientist Douglas Rasher received a national leadership award in October, along with $100,000 in support to freely pursue his research. The Maxwell/Hanrahan Individual Award in Field Biology, launched in 2020, recognizes the quality and creativity of a researcher's dedication to field biology, and the awarding foundation's confidence in recipients' potential for future impact in their field.

Rasher studies coastal areas where humans interact with the ocean in order to understand the ecology of these vital habitats. He has conducted detailed investigations of interactions between macroalgae, herbivores, and top predators to understand how these interactions stabilize or destabilize ecosystems. He plans to use the award funds to begin new collaborations with colleagues around the world and start ambitious field projects in local areas.

Scientists Launch Statewide Environmental DNA Project

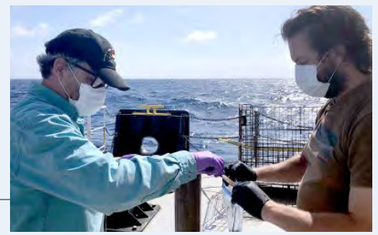
Bigelow Laboratory scientists helped begin fieldwork this summer for a $20 million National Science Foundation initiative to revolutionize the understanding and management of coastal ocean ecosystems. The project leverages developments in environmental DNA — genetic traces left behind by all organisms. This eDNA provides the potential for scientists to recreate a complete snapshot of a local ecosystem by collecting and analyzing small water samples.

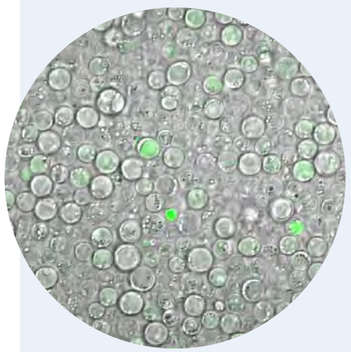
Bigelow Laboratory and the University of Maine are leading the project alongside researchers at other state institutions and collaborators in education, government, industry, and citizens' groups. This summer, our scientists could be found studying harmful algae in lakes, scallop larvae near a developing aquaculture site, and kelp forests along the coast. They also helped launch a statewide effort to regularly sample water in the Gulf of Maine and monitor eDNA over time. The team is now processing samples and analyzing data that will inform next year's fieldwork efforts, and support the research of eight UMaine PhD students who are working on the project at Bigelow Laboratory.

RESEARCH CRUISE STUDIES THE ROLE OF OCEAN SEDIMENTS

Most would assume that sediment just lies on the seafloor, but it actually plays a surprisingly active role in ocean systems. Senior Research Scientist Jim McManus recently completed a research cruise to better understand the chemical exchanges in the deep ocean and how marine sediments release vital elements.

In November, the team completed a 25-day expedition to collect samples from three sites in the central Pacific. These remote and relatively understudied regions of the deep sea contain unusual metal deposits — small "nodules" that form at the sediment surface. Recent studies have highlighted that marine sediments are an important source of elements for modern ocean chemistry, but they also contain a record of the past. McManus' research helps to translate the language of that record, which scientists can then use to interpret Earth's ancient history and climate changes. This research is revealing marine sediments as an essential regulator of long-term ocean chemistry and health.





Searching the Sea for COVID Solutions

As the COVID-19 pandemic swept over the world, several Bigelow Laboratory scientists examined their own expertise to find ways to help. Senior Research Scientist José Antonio Fernández Robledo and his team have spent years developing tools and techniques to use the oyster parasite *Perkinsus marinus* as a model for biomedical research. Based on this work, he believes it may be possible to engineer the parasite for use against SARS-CoV-2.

Within the first week of experiments, his team demonstrated that Perkinsus could incorporate and express part of the virus' genetic material — the first step toward developing a vaccine. Fernández Robledo is leading the only known research using a marine organism as a potential basis for a COVID-19 vaccine. He recently secured a provisional patent and is currently seeking funding to pursue this promising and unique approach.

INTERNSHIP PROGRAM ADAPTS TO PANDEMIC

To safely adapt to the reality of COVID-19, Bigelow Laboratory transformed our internships into a virtual experience this summer. Twenty-five students from across the country spent 10 weeks remotely conducting independent projects. Eighteen of those students were selected as part of the Research Experiences for Undergraduates program, a National Science Foundation-funded effort to help students in STEM fields learn from real-world research.

Each student was paired with a Bigelow Laboratory scientist who helped them identify a research question, develop a proposal, conduct their research, and present their findings. While the experience was quite different this year, our scientist mentors made sure students had an authentic research experience. The projects included such diverse topics as investigating plankton behavior, modeling chemical pollutants, mapping microalgae in the Gulf of Maine, and forecasting right whale populations with machine learning.

Photo, bottom: Raghavendra Yadavalli

Photos: Pete Countway, top; Hans Singh, right

FIELD NOTES

ALONG THE COAST OF Maine

BY SAMUEL TAN

It was September, and my lab-mates and I were perched on the edge of a cliff near Pemaquid Point, Maine, forming a human chain. A storm had rolled through the night before, and we had to collect a water sample in our theoretically sheltered sampling site amidst the ocean surge and swell. We didn't want to risk our delicate electronic instruments to take measurements of the water, but we had other options. Niskin bottles, a plastic device used to collect water samples at depth, are far hardier, and we managed to take the samples we needed with some effort.

As a fresh PhD student on the Maine-eDNA project, this was one of my first sampling experiences in Maine. The project is a state-wide, multi-institutional initiative that aims to develop the emerging technology of environmental DNA (eDNA) for monitoring and management of all the life in Maine's coastal habitats — from microbes to whales. The project has broad goals, among them long-term monitoring of changes at a multitude of field sites across the state.

My role is to do the scientific groundwork — to collect water samples and measure important parameters at our sampling sites, such as temperature, pH, and dissolved oxygen levels. Then I filter the water samples to collect the free-floating DNA present, in preparation for further processing.

Our main priority for this part of the project is to sample extensively and regularly across the state, so we accumulate sufficient data to draw useful inferences from.

While I had worked with eDNA as an undergraduate, I've relished the chance to brush up on my practical skills in sample collection and processing. I've also enjoyed the added bonus of visiting all kinds of interesting places across Maine that I might not have gone to on my own.

As I write this, I have assisted with two rounds of monthly site sampling, and work on the Maine coast has been far from dull. Once, we accidentally dropped a small piece of our filter apparatus into the sea and had to launch a crude rescue mission with improvised tools: a bucket and rope.

Even with the currents in our favor, it was no easy task. We had to hurl the bucket into the water near our target, then maneuver it in the hope that the water filling the bucket would drag our recalcitrant piece with it. After much trial and error, our awkward, bumbling efforts paid off. Thankfully, it was past tourist season, or we would certainly have attracted a lot of unwanted attention with our loud splashing.

I have been sampling at Orr's Island in Harpswell, Fort Popham, Mook Sea Farm, Pemaquid Point, and the docks at the Darling Marine Center and Bigelow Laboratory. I've also spent a frustrating amount of time smacking an uncooperative Niskin bottle with an oar underwater, trying to get it to trigger. And despite our scientific equipment, we have even been mistaken for lobstermen!

Overall, eDNA sampling has been quite an enriching experience for me. I come from Singapore, where eDNA research is still in its relative infancy. Seeing what it can do in Maine, I am excited by the potential of this technology to monitor ecosystem health in species-rich South-East Asia, ideally with extensive community involvement. Both collecting water samples and filtering them in the field and the lab are fairly simple and straightforward. I feel that anyone can get the hang of them with a little training, which provides rich opportunities for citizen scientists to contribute towards eDNA studies.

The Maine-eDNA Program still has a long road ahead of it, but I'm eager to find out what we learn from our monitoring efforts. How does the aquatic life in our coastal ecosystems change seasonally? How are they responding to human impacts? How might it change in the future, and can eDNA provide early warning of these changes? Which species do we have to take special note of? These questions are just the tip of the iceberg.

Photo: Sydney Greenlee

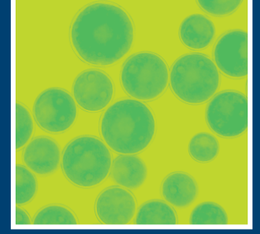


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Photo: Thew Suskiewicz