TRANSECT

BIGELOW LABORATORY FOR OCEAN SCIENCES / SUMMER 2020

ON THE COVER

Aquaculturists tend to kelp stocks in Casco Bay, Maine. Bangs Island Mussels, a long-term research partner with Senior Research Scientist Nichole Price, is among the first farms in Maine growing kelp in order to proactively improve water quality for their mussel stocks. Learn more about our innovative aquaculture work on page 2.

Photo: Joey Conroy, Bangs Island Mussels

The COVID-19 pandemic has changed how we all communicate, live, and think about our future. It has not, however, changed the urgency or importance of the issues we're addressing at Bigelow Laboratory.

Our team has stepped up to the challenge of maintaining our pace of discovery with an inspiring amount of creativity, dedication, and resourcefulness. As an institute, we are designed to be nimble. Our size, structure, and independence have been a real benefit during this crisis — allowing us to make decisions quickly, pivot when needed, and tailor our response to individual scientists and lab groups when necessary.

At the start of the COVID-19 crisis, we developed a robust plan to keep people safe and our science moving forward. Most of our staff have been working remotely since March. Through careful planning and rigorous protocols, some staff members have continued to advance critical work in the laboratory.

One area of our mission immediately impacted by the pandemic was education. We specialize in hands-on, immersive educational experiences that inspire students. Time spent together with our researchers in the lab and in the field is at the heart of most of our programs, and we've had to work quickly to adapt.

We had just completed the selection process for our highly competitive summer internships when the pandemic took hold in the United States. Thirty-seven students from across the country had been chosen to live and work on our campus, gaining first-hand experience with cutting-edge science. When we decided it was no longer safe to hold the program in person, our scientists went to work developing a virtual internship program for those students who preferred not to delay their internships until 2021.

Most of our fieldwork also came to a sudden halt, requiring us to reorganize projects and invent solutions to continue our research. Partnerships, like those with the aquaculture farmers you can read about on page 2 of this issue, have been invaluable to safely continuing sample collection.

While the immediate future holds considerable uncertainty for the world, Bigelow Laboratory remains strong and focused on our mission. This is in no small part thanks to the supporters you'll see in our annual donor listing in the back of this issue. They advise us, inspire us, and provide the critical philanthropic support that powers our work.

I extend my heartfelt thanks to each of them, and to you, for being a part of the ocean discoveries, solutions, and inspiration we generate. Your support is critical to us turning the tide on global challenges and unlocking the full potential of the ocean.

Deborah A. Bronk

DEBORAH BRONK, PhD

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THE RV *POLARSTERN* casts light across the Arctic sea ice during the yearlong MOSAiC expedition. Senior Research Scientist Steve Archer and Senior Research Associate Kevin Posman are researching gas exchange between the ocean and atmosphere as part of this interdisciplinary expedition.

Photo: Stefan Hendricks, Alfred Wegener Institute

THE FUTURE OF

FARMING

Along the coast of Maine, Bigelow Laboratory scientists are helping to grow sustainable aquaculture opportunities for the state — and the world.

ABOVE Kelp farmer Paul Dobbins tends kelp lines growing on his Casco Bay farm.

OPPOSITE, LEFT Research Associate Brittney Honisch assesses water quality while studying the environmental contribution of growing kelp.

OPPOSITE, RIGHT Shellfish aquaculturists tend oyster stocks at Mook Sea Farm on the Damariscotta River estuary.

Photo: Brittney Honisch

Imagine a way of producing food that could help solve some of today's biggest challenges. It would grow without the need for fertilizers or fresh water. It would create jobs and support small businesses, bolstering local economies and strengthening national ones.

Maine is at the leading edge of aquaculture, an industry growing with resourcefulness and ingenuity. Through diverse projects and partnerships, Bigelow Laboratory researchers are making discoveries that support Maine aquaculture — and inform ocean solutions that can be applied around the globe.

"By approaching aquaculture creatively, we can make a real difference to human and environmental health," said Senior Research Scientist Mike Lomas. "We need sustainable food for our growing population, and research can help aquaculture overcome obstacles to address that need."

Lomas is working to make finfish feeds more nutritious and sustainable by tapping into algae as a source of protein, fatty acids, and other naturally beneficial compounds. He is developing a balanced mixture that can improve fish health and aquaculture operations in Maine and beyond.

Shellfish aquaculturists also must contend with environmental factors. Maine's coastal waters are becoming more acidic. Even slight increases in seawater acidity degrade shells and make the animals inside less healthy. This is a major threat — especially to larval and juvenile shellfish.

Senior Research Scientist Nichole Price is partnering with the Rockland-based Island Institute and aquaculturists around Maine to explore how growing kelp can help. Where it flourishes, kelp has an almost magical impact. In protected bays, it improves water quality by removing excess carbon and other nutrients — and it can generate new revenue streams for farmers.

"Kelp aquaculture has the potential to be a key part of fighting climate change on multiple fronts," Price said. "Not only can it help offset Maine's carbon emissions, it can actually improve our coastal waters and develop local jobs."

Kelp soaks up carbon like a sponge, pumping oxygen into the surrounding water while also making it less acidic. Through experiments with Bangs Island Mussels and Atlantic Sea Farms, Price measured a circle of remediated water radiating out from farmed seaweed and its positive impact on mussels cultivated in the area.

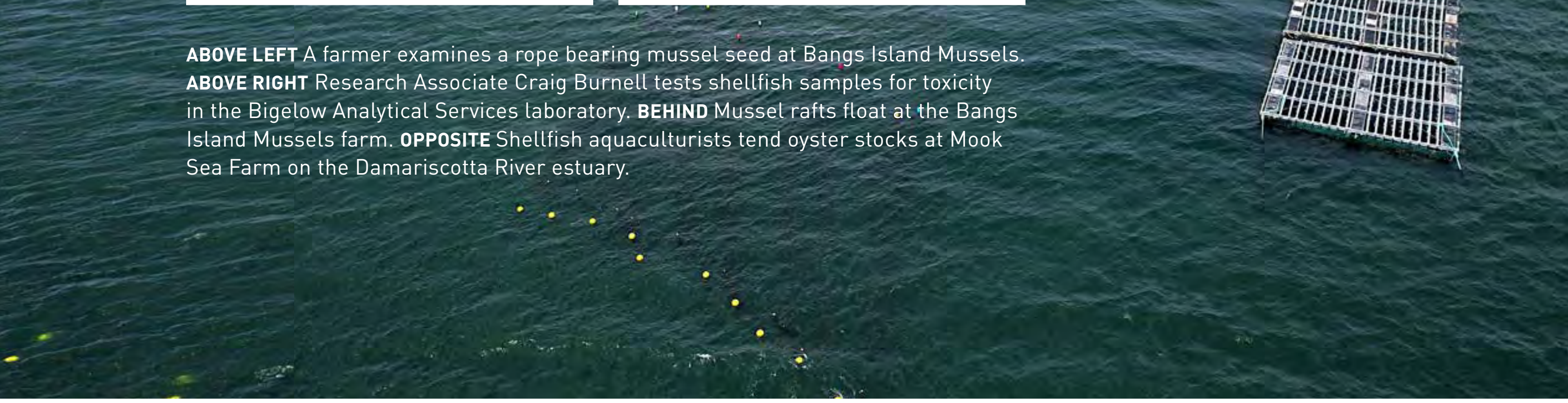
Now, Bangs Island Mussels is among the first to capitalize on this "halo effect" to proactively improve water quality on their farm. During the fall of 2019, they surrounded some mussel rafts with kelp lines, and they are studying the effect.

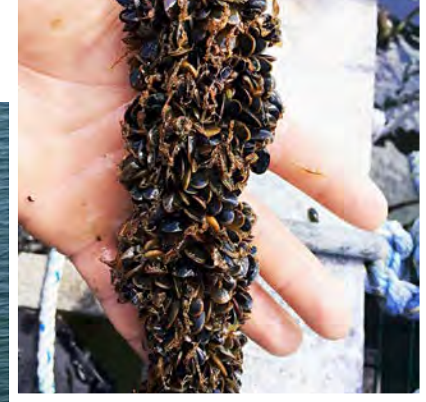
"All farmers are scientists, constantly observing and developing hypotheses about what they see," Price said. "Partnering with aquaculture entrepreneurs has really expanded my understanding of the immediate challenges to sea-farming, and these collaborations are delivering valuable assistance to this promising industry."

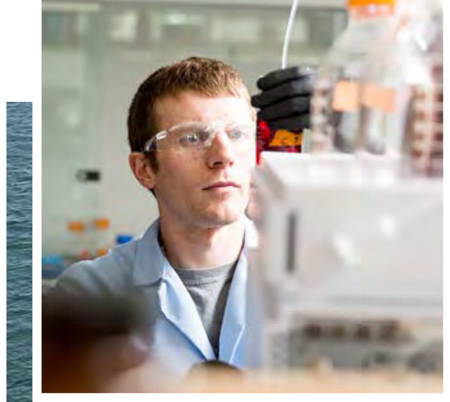
DISCOVERIES FROM MAINE ECOSYSTEMS

The Gulf of Maine is expansive and dynamic, fed by watersheds that flow seaward from Cape Cod to Nova Scotia, and by deep ocean currents from both the north and south. Several Bigelow Laboratory researchers study

Photos: Matthew Wade, left; Robert Mitchell, courtesy of Mook Sea Farm, right







ABOVE LEFT A farmer examines a rope bearing mussel seed at Bangs Island Mussels. **ABOVE RIGHT** Research Associate Craig Burnell tests shellfish samples for toxicity in the Bigelow Analytical Services laboratory. **BEHIND** Mussel rafts float at the Bangs Island Mussels farm. **OPPOSITE** Shellfish aquaculturists tend oyster stocks at Mook Sea Farm on the Damariscotta River estuary.

the physical processes and biological relationships that shape this region, making discoveries that can inform and support Maine aquaculture.

Senior Research Scientist José Antonio Fernández Robledo turns to the Gulf of Maine for his research on marine shellfish and their microscopic parasites. He mines and engineers the genetic code of pathogens for insights into new medicines, biotechnology, and human health — simultaneously uncovering important discoveries for the region's industries and economy.

Oyster aquaculture has been growing steadily in Maine for the last 40 years and rapidly for the last 20, but pathogens always loom as a potentially ruinous threat to any farm on land or sea. Maine farmers saw devastating oyster die-offs in the 1990s, and again in 2010. These events were blamed on the parasite *Haplosporidium nelsoni*, commonly known as MSX.

"Maine's clean, cold waters create excellent conditions for farming, but nowhere is immune to disease," Fernández Robledo said. "In order to be best equipped to grow shellfish, it's important that farmers and managers have early warning about the parasites that could infect them."

Fernández Robledo and several colleagues recently conducted the largest oyster pathogen survey ever undertaken in Maine. They collected oysters from partnering farms along Maine's coast and used genetic techniques to look for any evidence of infection by parasites. Led by Senior Research Scientist Pete Countway, the team also used DNA collected from the environment — called eDNA — to take stock of microscopic organisms in the water near the farms.

Countway specializes in using eDNA to learn about the microbes and algae that thrive in the ocean — including harmful species. He is one of the leaders of a Maine-wide project that is developing eDNA as a revolutionary tool for ocean monitoring. Countway's work with these emerging techniques could fuel early warning systems that would improve managers' and farmers' ability to manage threats.

"Understanding the diversity of microbes in the water could inform us about the sources and timing of shellfish infections, and help us understand this dynamic ecosystem in a new way," Countway said. "Our growing understanding of microbial diversity in the Gulf of Maine has the potential to provide entrepreneurs and resource managers with critical information they can use to enhance the marine economy and ensure the safety of marine resources."

SCIENCE-FUELED SOLUTIONS

A cycle of growth takes place in the Gulf of Maine every year. Each summer, microscopic algae in the upper ocean feed on the newly-available nutrients and sunlight. These phytoplankton grow like plants in a garden, feeding hungry young animals. By fall, the flourishing phytoplankton have consumed all the nutrients, and the sun's rays are waning. As their populations decline, some algae produce dormant kernels called cysts, which fall to the seafloor to await the next spring.

These algae are the foundation of the vibrant Gulf of Maine ecosystem, but a few species are also toxic to animals and people. Farmed shellfish, like those in the wild, eat by filtering seawater — a process that can accumulate toxins if harmful algae are present.

"As scientists work to understand this complex ecosystem, there remains a disconnect in directly relating what is happening with phytoplankton to shellfish toxicity," said Senior Research Scientist Steve Archer. "The Gulf of Maine has such an intricate coastline that we need to know what's happening in all the little bays along the coast where shellfish are grown and harvested."

Understanding the linkage between toxic algae and shellfish would be a real boon to farmers, resource managers, and scientists alike. Eating shellfish tainted by algal toxins can sicken and even kill. Human impacts in Maine are rare, thanks to a thorough harmful algal bloom monitoring program and robust shellfish testing during harvest seasons.

Archer's team conducts regular tests of shellfish samples for the Maine Department of Marine Resources, which evaluates the results and makes decisions on fishery closures. Over time, this work has also spawned a new effort — to predict high levels of toxins before they occur.

"After several seasons of testing, we noticed that certain toxicity patterns arise year after year," Archer said. "We realized our measurements contain hidden information that might be built into the prediction tool that managers and farmers have long desired."

Mandates to stop harvesting shellfish can be costly for farmers and harmful to Maine's economy. Armed with a forecast showing high toxicity on the horizon, a shellfish grower could harvest a week early, and a shellfish wholesaler could better plan their staffing needs.

Led by Senior Research Scientist Nick Record, the researchers have developed a toxicity forecast based on the same technology that powers facial recognition and self-driving cars. Their model utilizes neural networks, a sophisticated machine learning approach that can process huge volumes of data to recognize complex patterns.

As their algorithm churned through more and more toxin data, it became increasingly accurate at predicting toxicity levels two weeks in advance. With funding from NOAA, the team is now testing their model with a pilot group of shellfish growers. The aquaculturists' feedback will help the researchers improve the forecast and optimize its usefulness. In a few years, the team hopes that real-time forecasts will be in place to aid monitoring and shellfish harvests along the Maine coast.

'We realized our measurements contain hidden information that might be built into the prediction tool managers and farmers have long desired.'

"Our research becomes all the more powerful when we use what we learn to solve problems and drive solutions forward," Archer said. "Collaborating with people on the frontlines of the aquaculture industry expedites their access to new tools and provides us with invaluable insights."

INSPIRING ACTION

Though these discoveries and solutions center on Maine aquaculture, their impact does not stop at the state's borders. Bigelow Laboratory researchers are teaming up with regulators, students, and the public to expand the benefits of their science.

Archer and Record are working with resource managers to test how their forecasting model could help in New Hampshire and Massachusetts, and they are collaborating with Canadian colleagues to potentially expand the approach internationally. Fernández Robledo and

Photos: Bangs Island Mussels, top left; Greta Rybus, top right; Joey Conroy, bottom

Photo: Robert Mitchell, courtesy of Mook Sea Farm

SENIOR RESEARCH SCIENTIST Nichole Price teaches high school students about kelp aquaculture during the 2019 Keller BLOOM program.

'The more that people taste the incredible potential of this industry, the more we can work together to capitalize on its environmental and economic opportunities.'

Countway are helping develop fast and affordable tests that could let aquaculturists around the world detect pathogens on oyster farms.

"It's really our partnerships and deep collaborations that makes this research successful," Archer said. "Working with the aquaculture industry, shellfish wholesalers, and managers is essential to creating useful tools and solutions, and we couldn't do our research without them."

In addition to their work in the lab and field, the researchers constantly strive to put their science into action and support Maine's growth. No one does so more than Senior Research Scientist Nichole Price.

Price has discussed aquaculture with members of Congress and presented to the National Organic Standards Board about harvested seaweed. She has connected with individual members of the public and students. She has even broken bread with guests on Maine Food for Thought tours and hosted events catered by Ocean's Balance, a Maine seaweed product company — all in her quest to spread the gospel of kelp and shellfish aquaculture.

"There is no more powerful way to communicate the power of this work than disseminating results right at the dinner table, eating fruits of the sea," Price said. "The more that people taste the incredible potential of this industry, the more we can work together to capitalize on its environmental and economic opportunities."

Price engages people in the scientific process as well. During a pilot project funded by the Casco Bay Estuary Partnership and the EPA, she collaborated with Mook Sea Farm to assess the impact of applying finely ground oyster shells to improve seawater acidity for juvenile oysters — effectively using this "shell hash" as an antacid. Her team shared this work during Shell Hash Day, a citizen science event measuring seawater chemistry along the Maine coast.

Price also advises several groups at the state level. As a member of the Maine Climate Council, she develops strategies to meet the state's goal to achieve carbon neutrality by 2045. Price sits on the Council's Science and Technology Subcommittee and participates in the Coastal and Marine Working Group, assessing the potential for carbon capture by seaweeds. This approach could generate revenue for seaweed farmers, who could sell carbon and nitrogen credits in voluntary markets. Price and collaborators recently received funding from the Department of Energy's ARPA-E program to define the most cost-effective verification protocols for this work.

Bigelow Laboratory research is also a training ground for the next generation of scientists. Several students contributed to these projects through Research Experience for Undergraduates internships, and some have already gone on to professional careers in aquaculture and ocean science.

Now, this work is reaching high school students too. In 2019, Price worked with Research Scientist Nicole Poulton to add a seaweed husbandry component to Bigelow Laboratory's annual Keller BLOOM program.

"There is a lot of momentum behind the aquaculture industry and the research that informs it, and I want to show students an exciting career path that can allow them to stay in Maine," Price said. "There is room for a sustainable, profitable industry here, and Maine can spread the word that aquaculture can be part of the solution for this country and beyond."

Photos: Robert Mitchell, top; José Antonio Fernández Robledo, right

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What Happens as Humanity Seizes the Seafloor?
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JULY 28
A Tale of Two Gulfs
The Return and the Future of Maine's Kelp Forests
Led by Dr. Douglas Rasher

AUGUST 4
A Story in Each Drop
How DNA Can Provide New Vignettes of Our Oceans
Led by Dr. Dave Emerson

AUGUST 11
Burp Busters
A Greener Cattle Industry Through the Power of Algae
Led by Dr. Nichole Price

TUESDAYS, 5 TO 6 P.M.
JULY 7 – AUGUST 11

FROM PANDEMICS TO WHALES:
Insights into Forecasting

The COVID-19 pandemic has rapidly transformed the world. Seemingly overnight, it flipped daily routines upside-down, bent economies, and obscured the future. Doctors, researchers, governments, businesses, and individuals continue to battle this disease on every front, every day.

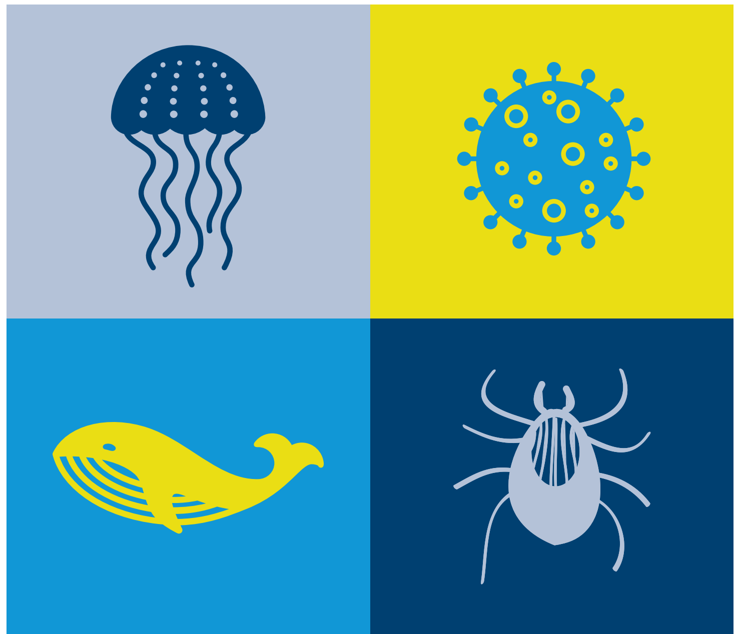
One of the most powerful tools in this fight is data. Total cases, recovery rates, new transmissions — these numbers are the fuel behind mathematical models that elucidate possible versions of our unknown future and help us make progress against the virus.

"Decision-makers and society as a whole are walking a tightrope right now, trying to both save lives and figure out how to keep the economy going," said Senior Research Scientist Nick Record, a mathematician and modeler. "To get the balance right, we need as much data and science as possible."

Just as Record uses environmental data to forecast natural systems, epidemiologists feed data related to the novel coronavirus into predictive algorithms. The resulting forecasts shape our daily lives in unprecedented ways as countries, businesses, and individual people rely on them for long-term and even daily decision-making.

But predicting the path of this virus, or any natural system that involves human behavior, is complicated. The current situation underscores the inherent complexity, valuable opportunities, and deep importance of both data and forecasting — and it highlights broader questions of how scientists and societies can best wield these powerful tools.

SENIOR RESEARCH SCIENTIST Nick Record forecasts natural systems, from jellyfish encounters to whale movements. Similar approaches are being used to forecast the novel coronavirus.



After reflecting on the relationship between his forecasting research and the current situation, Record came up with four key insights about the challenges and opportunities of this rapidly evolving science that he hopes we can all learn from this pandemic.

1 People lack intuition for interpreting biological forecasts

Many people see weather forecasts every day. Over years, we have developed intuition about how to read them and react — a gut feeling for what a 10 percent chance of rain really means, or whether next week will require us to break out a warmer jacket.

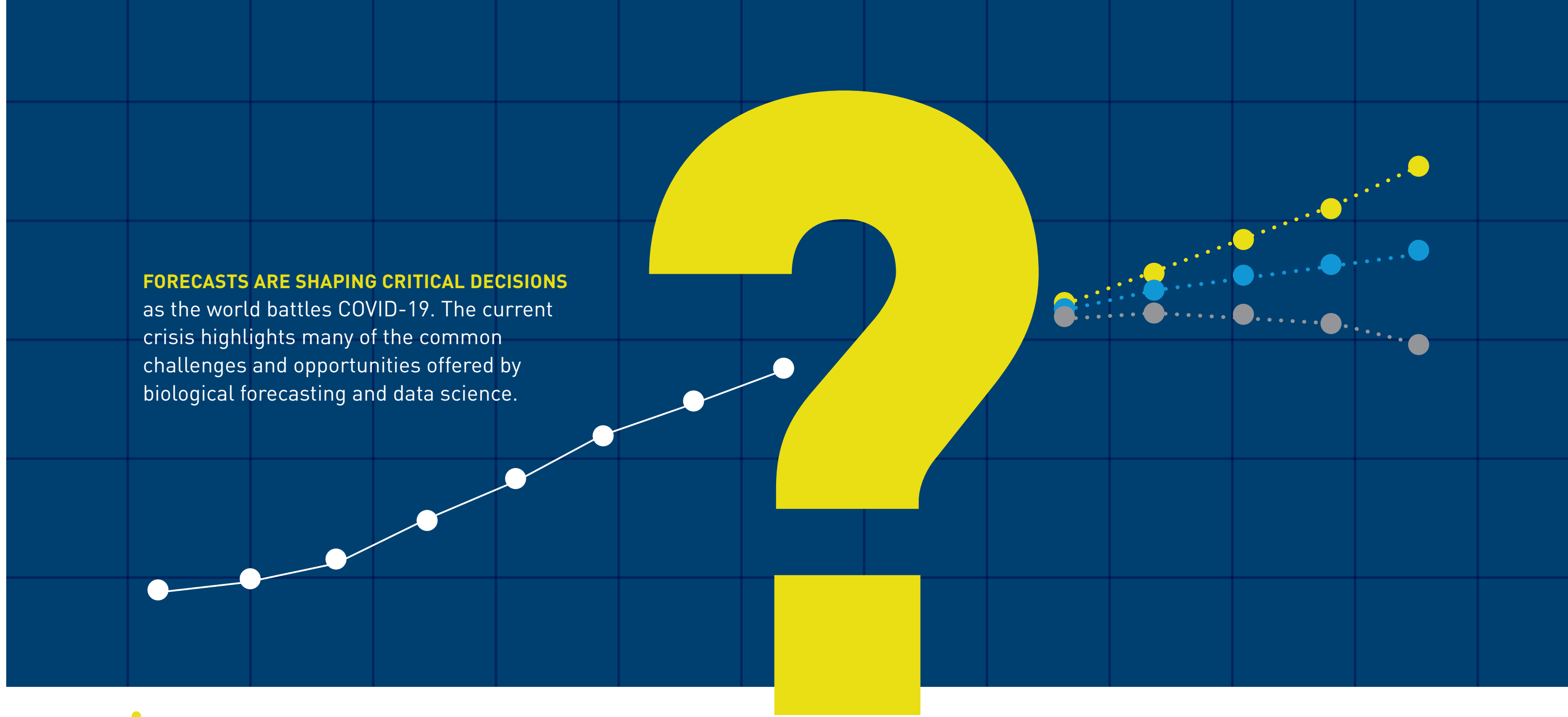
But before the current crisis, no one had seen daily pandemic forecasts. We often can't readily interpret these with a casual glance, and the exponential growth that natural systems like the virus follow is unintuitive. In addition, people tend to disbelieve predictions of threats they haven't personally experienced before.

2 Human behavior is often part of the equation

When Record forecasts the constant ebb and flow of summer jellyfish populations, the way that people act has no bearing on a given day's number. But his forecasts of encounters between jellyfish and humans can be made inaccurate by human action — people may choose to head to the lake on a high-jelly day, or take a hike instead.

Climate scientists navigate this same terrain with climate projections. Global temperatures depend in part on human actions. If a model projects extreme global warming, and humans respond by dramatically cutting carbon emissions, the projection won't match reality anymore. When projections like this serve their purpose, they cease to be accurate predictions of the future.

Faced with the current pandemic, the world is dealing with this paradox in real time. We're making personal decisions and crafting policies based on forecasts that shift in sync with our choices. It's helpful to think of epidemic projections not as absolutes, but as consequences given certain choices that we make.



FORECASTS ARE SHAPING CRITICAL DECISIONS as the world battles COVID-19. The current crisis highlights many of the common challenges and opportunities offered by biological forecasting and data science.

3 Uncertainty with human systems can be trickier

Nature is a math problem. Meteorologists know the equations that describe how the atmosphere moves, how winds gain strength, and how water freezes and thaws. For the most part, they just need to collect the right data to solve those equations and produce weather forecasts.

But with biological systems, like pandemics or red tides, scientists don't always know the right equations. Researchers are accustomed to dealing with typical sources of uncertainty, like measurement error. In uncharted forecasting territory, another realm of uncertainty exists about which processes are important to the equations. That uncertainty can lead to wildly differing predictions about the future.

4 Sharing forecasts can have unintended consequences

Biological forecasts are powerful tools, and they can be used in unexpected ways once made public. For instance, Record works with scientists and resource managers to forecast the locations of North Atlantic right whales, informing strategies to protect this endangered species. Openly sharing these forecasts, however, could lead to whale watching vessels trying to view these remarkable animals, inadvertently increasing the risk of ship strikes.

The same is true of the pandemic. The way that forecasts are presented, interpreted, and used can have complex and unintended consequences. Any public forecast needs thoughtful review from multiple perspectives to understand exactly how it will be used — and how it could be misused.

SCIENTIFIC MOMENTUM

The field of forecasting is expanding rapidly, fueled by new approaches in computer science like artificial intelligence and big data. As scientists generate, respond to, and learn from pandemic forecasts, this momentum can feed back into new methods and discoveries for basic research.

"As computer science becomes more and more powerful, the question is, how can we forecast other aspects of the natural world?" Record said. "Much of my research involves piecing data together into a larger picture of what the ocean and the ecosystem are doing, and that really amounts to a big math problem."

Important questions remain in the nascent field of forecasting, and their answers will help researchers work creatively and capitalize on the trove of ocean science data that already exists. A new computational hub at Bigelow Laboratory, called the Big Data Discovery Initiative, will soon expand researchers' capacity to mine data for discoveries and solutions to global challenges.

Some of Record's ecosystem forecasts rely on crowdsourced data, presenting him with a common big data challenge — a wide range of information quantity and quality. Differences in jellyfish reports from along Maine's coastline, for example, can give Record a lot of high-quality data from one specific location, while sparsely populated areas of the state may have very few reports.

"Integrating two types of data is a really interesting math problem, and finding the solution can help researchers answer a host of new questions," Record said. "We still know so much more about the land and the atmosphere than we do about the ocean. Continuing to build our approach to modeling can allow us to learn new things from data we already have and are collecting every day."

SCIENCE SNAP

POSTDOCTORAL RESEARCHER Thew Suskiewicz prepares to deploy an underwater experiment to help assess sea urchin reproduction in the Gulf of Maine. Despite the collapse of the sea urchin fishery and the decline of large predators like cod, urchin populations have not rebounded as expected. Suskiewicz worked on a survey of urchin larvae with Senior Research Scientist Douglas Rasher, who is leading a study examining why there are currently so few urchins in the Gulf of Maine.

Photo: Rachel Kaplan

PROFILE **Tom Allen** Trustee, Bigelow Laboratory

Progress on national and global issues arrives more like a tide than a tidal wave. Leading that progress takes incredible perseverance and grit, and few can do it for decades with their optimism and warm smile intact.

A self-described "glass-half-full person," Tom Allen has spent much of his life as a public servant. He served on the Portland City Council, including one term as mayor. In 1996, he was elected to represent Maine in the U.S. House of Representatives, where he served for 12 years. Since that time, he's maintained his involvement in national politics as an advocate for ocean conservation.

His experience has taught him a lot about how to make steady progress and maintain optimism when dealing with big issues. He has also learned to rely on some wisdom attributed to Teddy Roosevelt: "Do what you can, with what you have, where you are."

When it comes to serving in Congress, Allen believes there are three things you need to come to terms with if you're going to be successful. The first is the incredible complexity of every issue that comes up. The second is that, if you're honest with yourself, you're going to need a lot of help from subject experts. The third is that it takes more time than you might like to get things done.

"If you can accept those contours, you can keep slogging away toward progress," said Allen, who joined the Bigelow Laboratory Board of Trustees last fall. "Unfortunately, there's almost never a magic answer."

It is perhaps this outlook that has enabled his longstanding dedication to the global challenges of the oceans — overwhelming in size and scope, but critical to our future.

Allen feels like the ocean has generally been an afterthought during much of his lifetime — something to play in or travel across. Most people haven't perceived its complexity and contributions to impact their lives.

"More and more, people are understanding that the health of the ocean is tied to the health of the planet, and that the health of the planet is tied to the health of the people," Allen said. "More and more, we are realizing that we had better get this right."

Allen considers himself part of that group that has come around to the importance of the ocean later in his lifetime. A seventh-generation Mainer who grew up in Portland and still calls it home, Allen has never lived far from the sea. But his ancestral roots lead inland, where his great-grandfather lived, and his cherished family farm still stretches over the gently rolling woodlands.

After joining Congress, however, he was quickly pulled into one of the hot topics of the day — commercial fishing. It was complicated and contentious, with competing interests all trying to control how the country managed the ocean's natural resources. This introduction to the complexity and importance of ocean issues changed his relationship with the sea, now a focus of his work and passion for more than two decades.

'More and more, people are understanding that the health of the ocean is tied to the health of the planet.'

In the late 1990s he co-founded the bipartisan House Oceans Caucus to raise congressional awareness about the need for a coordinated global oceans policy. In 2006, he helped negotiate the reauthorization of the Magnuson-Stevens Act, the primary law governing U.S. marine fisheries management. In 2008, he introduced the first bill in the House of Representatives to address ocean acidification and fund needed research on the topic. After leaving Congress, he joined the board of the Ocean Conservancy, where he has continued to serve and inform ocean advocacy, particularly in regard to climate change.

Allen believes that Bigelow Laboratory holds a critical perspective on the ocean and its role as the lifeblood of the planet — generating everything from the oxygen we breathe to the food we eat.

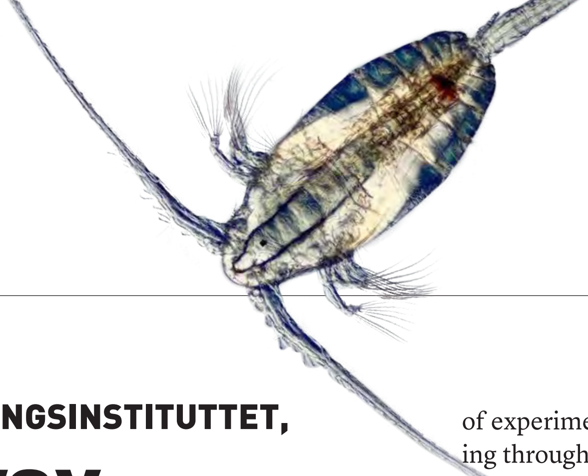
"If we can help people come to grips with how much all our lives are bound up with each other and with this planet," Allen said, "I think we can generate the sort of changes the ocean needs to be as clean as possible, as stable as possible, and as productive as possible."

Allen acknowledges that the scale of the problems and of the changes needed mean that they aren't going to happen overnight. They will require sustained attention over a long period of time, which means that there is no time to waste.

"With the right leadership, I believe that the United States and the rest of the globe can do it," Allen said. "It won't be easy, and it won't be done immediately. But it can happen. It has to, really."

FIELDWORK

Notes from the Field



OFF THE COAST OF
California

BY JOHN BURNS

Trinidad, California, is a small coastal town atop a bluff overlooking the wild, rocky coastline of the Pacific Ocean. It hosts a supermarket, a burger shack, a local museum, and the Humboldt State University Marine Lab. Heading due west from Trinidad is a sampling route that stretches 23 miles out to sea. In 2006, Dr. Eric Bjorkstedt began a time series study in which the research vessel *Coral Sea* travels the "Trinidad Head Line" nearly every month, collecting plankton and physical ocean measurements at five stops. It is a brilliant effort, so far preserving a decade and a half of detailed physical and biological information from the depths of the unseen ocean.

A friend of mine, Roxanne Robertson, oversees the monthly collection trips. Roxanne is intimately familiar with the copepods and other small animals that are a focus of the research mission, but she also has an eye for microscopic bycatch. A few years ago, she caught wind of my interest in radiolarians, single-celled jewels of ocean microorganisms, and she sent me a text message saying "yeah, I see radiolarians in our collection."

I was skeptical. Even though some species can be pretty big, I thought most radiolarians would slip right through the pores in their plankton nets. Roxanne was steadfast in her identification, though, so when I joined Bigelow Laboratory and turned my research focus toward ocean microbes, I jumped at the chance to examine the invaluable plankton collection at Humboldt.

My plan was to fly out to the marine lab and spend a week picking through samples from the collection. But I happened to be in California when the *Coral Sea* was going out, and Roxanne asked whether I'd like to join the 12-hour cruise. Of course, I said yes!

As a molecular biologist, I am used to working independently and in miniature. Tiny tubes, tiny volumes, tiny invisible reactions — work that requires just two hands and can be conducted by a single researcher. I imagined a relaxing boat trip with a couple of stops to drop a net. Clearly, I had no idea what a research cruise was like.

This lab scientist learned quickly that oceanographers work hard. And I don't mean just the long hours — it is physically demanding work. There are giant nets and heavy instruments that need to be dropped hundreds of feet into the cold ocean in a timely manner. Those nets and instruments need to be recovered, their samples collected, and then finally get washed off — all while the boat is motoring on to its next destination. It is cold; things are moving; and everything is wet. What an effort!

The procedures, protocols, and experiments on board were giant-sized versions of the tiny experiments I know in the lab. There was a big difference, though. Work onboard required teamwork, cooperation, and coordination. It required people taking initiative and helping out proactively wherever a hand was needed. It required patience and perseverance to work through seasickness, fatigue, and cold. On top of all that, it required strong leadership.

That leadership came from Roxanne. I learned that not only does she have a keen eye for microbes, but she knows the instrumentation, locations, and procedures of all the research on board. She coordinates the team to ensure that every month the samples are taken the same way, and she manages people to keep them productive and collegiate during those intense trips. I found myself in awe of her skill, dedication, and knowledge.

The trip was a great success. Roxanne was absolutely correct that I would find radiolarians (see back cover image). This new data will help me understand radiolarian population dynamics off the California coast. The experience taught me some of the story behind the smiling images of researchers on ships, and it showed me a shining example of leadership and good science practices under challenging conditions. I can't wait to apply what I learned on the *Coral Sea* to my next ocean research experience.

Photo: Roxanne Robertson

HAVFORSKNINGSINSTITUTTET,
Norway

BY MAURA NIEMISTO

This past October, I was lucky enough to have the opportunity to travel to the Havforskningsinstituttet, one of Norway's prestigious marine institutes. The site is located on Austevoll Island, between a beautiful fjord and the North Sea. The institute is known for studying a wide range of marine species through all their life stages, particularly fish important to aquaculture industries. This made it a prime location to study our species of interest — a parasitic copepod called the salmon louse. Copepods are a diverse group of tiny crustaceans that are found in nearly every body of water around the world, and they are a focus of study by Senior Research Scientist David Fields and his lab group.

Salmon lice are a major issue in Atlantic salmon aquaculture in Europe and North America. They cause reduced growth, loss of quality, and even mortality in farmed fish — resulting in an estimated $500 million in annual losses of profit internationally. As a result, a lot of research has gone into developing methods to combat infestation, from using wrasse cleaner fish to various chemicals as treatment. However, many of these chemicals are toxic to humans, and salmon lice have developed tolerance to some over time.

In collaboration with Senior Research Scientist José Antonio Fernández Robledo, we are interested in novel ways to fight the salmon lice problem for fisheries, without harming the fish. A previous Research Experience for Undergraduates intern at Bigelow Laboratory conducted a preliminary study on a single-celled parasite found in Maine that might offer a promising solution. The student investigated how the presence of this organism can kill invertebrates like copepods, but have no negative impact on vertebrates like humans or fish. The research revealed that the parasite left behind chemicals in the water that killed many copepods within hours of being exposed.

We wondered — if the presence of this parasite could have such a strong effect on copepods in our lab, could it also be used as a treatment against pesky salmon lice? With this hypothesis in mind, one of parasite versus parasite, we traveled to Norway. We collected eggs from adult salmon lice, hatched them, and subjected them and another marine copepod, *Calanus finmarchicus*, to a series of experiments. This process included a lot of time looking through microscopes, counting and picking out millimeter-long organisms, one by one, with a pipette.

Our hypothesis was not supported by this study — the parasite and the chemicals it produces did not seem to harm either of these copepod species. Though this was not the result we were expecting, it gave us some interesting questions to bring back to Bigelow Laboratory and investigate further.

Though this study was lab-based, I luckily wasn't chained to my microscope the entire time. Between counting animals, we could hop on a boat to toodle through the fjord and collect zooplankton samples with glaciers in the distance, or walk along the narrow winding roads between intermittent rain storms. The fall weather in Norway is more fickle than I've ever experienced. But despite the random hail storms and unexpected results, it was a pleasure to be able to work with the Norwegian scientists and in such a beautiful place for a few weeks in October.

Photos: NOAA, top; Steve Shema, right

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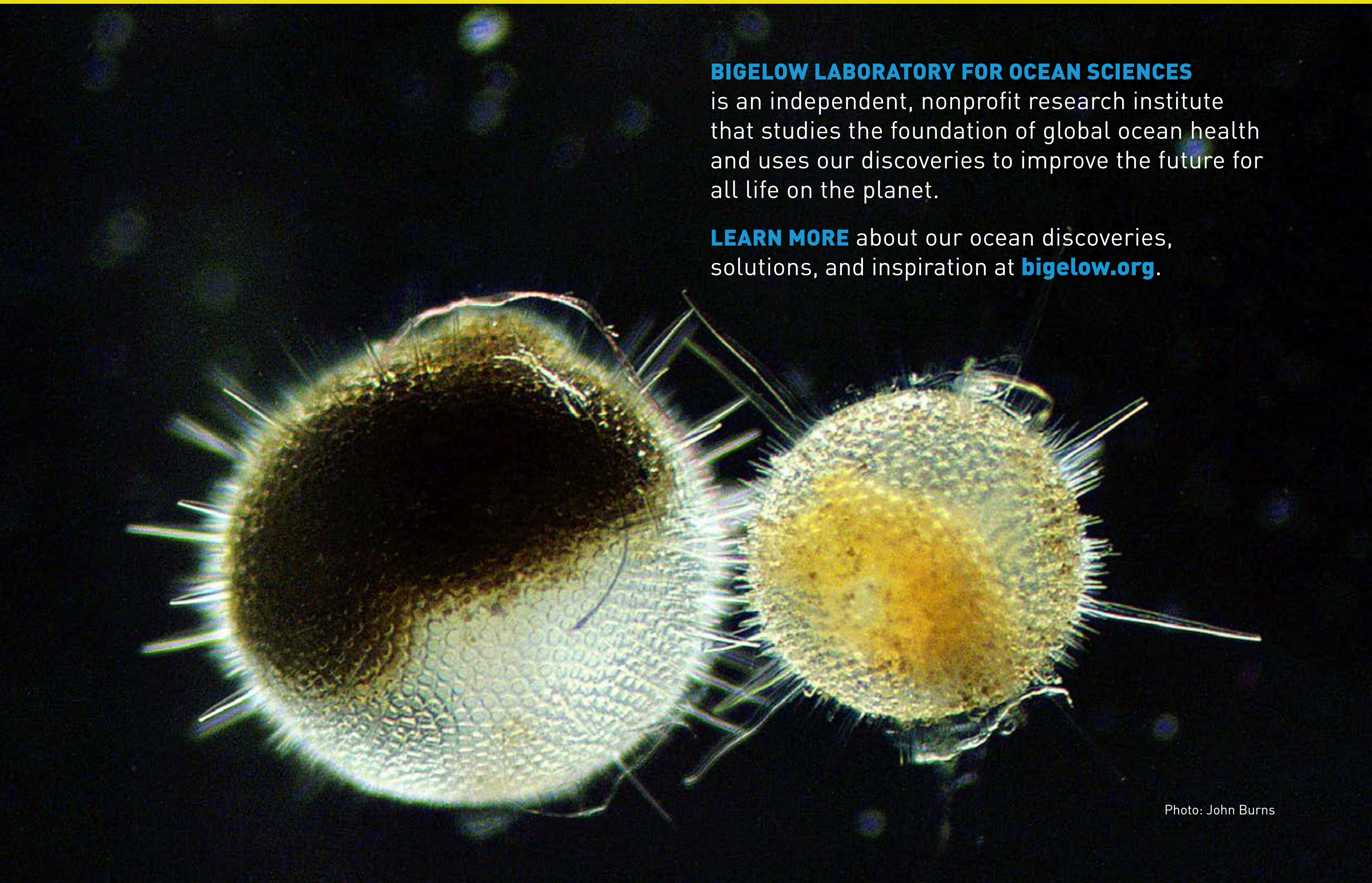

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