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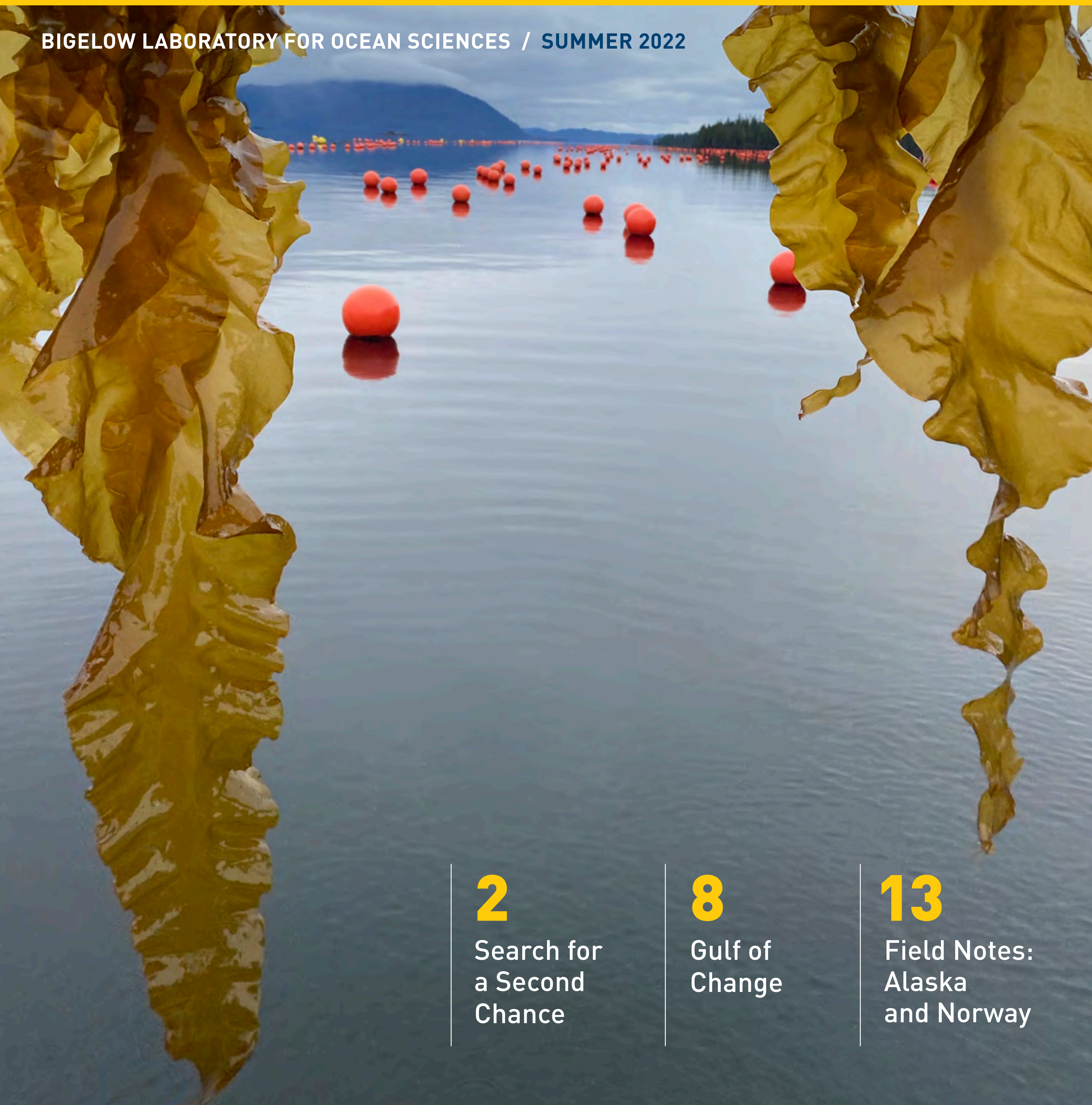

BIGELOW LABORATORY FOR OCEAN SCIENCES / SUMMER 2022

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Message from the President

This is a critical time for our oceans and our future.

A report by the Intergovernmental Panel on Climate Change this spring concluded that we are unlikely to keep global warming under critical thresholds unless we dramatically accelerate reduction of greenhouse gas emissions within the next decade.

We're running behind, but there is still time to act! The ocean and the planet can heal if we give them the chance. Two recent studies by our senior research scientists Mike Lomas and David Fields revealed surprising resilience in foundational plankton species. There is much work to be done, but there is also much reason for hope.

In this issue of Transect, we're taking a look at climate change from a few different perspectives.

Our main story in this issue covers ocean-based strategies that governments and scientists are considering to remove carbon dioxide from the atmosphere (see page 2). At this late hour, it is unlikely that emission reduction will occur at the pace that's needed, and carbon dioxide removal is likely to be used as a supplemental approach. Governments are already planning to utilize these strategies, but research is needed to develop them and decide if they are effective — and safe.

The Gulf of Maine holds a special place in many of our lives and hearts, and this issue also takes a look at the fundamental changes that have occurred there in response to climate change. Senior Research Scientist Barney Balch has led a long-term study of the Gulf and recently published a synthesis of his findings from two decades of data. You can read about some of his key takeaways on page 8.

This summer, we'll be tackling these topics in our Café Sci series as well. I'll be speaking about the state of climate change as outlined by the IPCC report, and we'll cover both our research into potential carbon dioxide removal strategies and our findings about the changing Gulf of Maine in subsequent talks. See page 11 for further details and registration information.

In addition to offering our Café Sci talks virtually this year, we're excited to again be planning to open our doors to the public for the first time since 2019! We'll be kicking things off with a special art and science event on July 12. We hope you come hear about some of our current collaborations with Maine artists to share our science and inspire support for the climate change actions that are so urgently needed!

Deborah A. Bronk

DEBORAH A. BRONK, PhD

ON THE COVER

Kelp hangs in front of the Seagrove Kelp farm in Doyle Bay, Alaska. Bigelow Laboratory scientists are working with partners at the farm — and others around the world — to explore how growing seaweed can improve water conditions for farming shellfish nearby. Read more about this research on page 13.

DESIGN Springtide Studio
PRINTING J.S. McCarthy Printers

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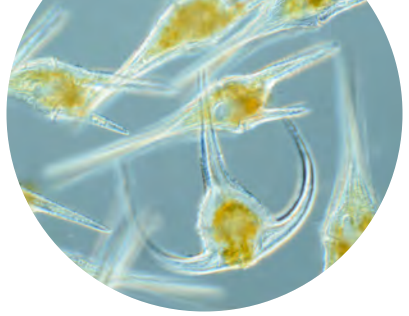
SENIOR RESEARCH SCIENTIST Beth Orcutt recently helped lead two expeditions aboard the E/V Nautilus to explore life on underwater mountains in the Papahānaumokuākea Marine National Monument near Hawaii. The scientists discovered an amazing abundance of diverse life during their two months at sea, and Orcutt collected seafloor samples to study the important microbial communities that live on minerals there.

Photo: Ocean Exploration Trust



SEARCH FOR A SECOND CHANCE

As humanity rockets past critical targets for carbon dioxide reduction, can the ocean help us buy time to avoid the worst consequences?

Society is failing to curb greenhouse gas emissions, and climate change is rapidly altering the planet. Immediate action is needed, but it is likely too late for emission reduction alone to halt the significant consequences of two centuries of pollution. However, ocean science may give us tools to turn back the clock.

Our planet has an amazing variety of ways it removes carbon dioxide from the atmosphere, and Bigelow Laboratory scientists are joining researchers around the world to find ways to amplify those natural processes. From fertilizing marine plant growth to restoring vital ecological communities, the Laboratory's researchers are exploring solutions that might complement emission reduction to keep us below critical thresholds.

"Humans haven't shown the political will to cut their emissions," said Senior Research Scientist Ben Twining. "Even if we were to turn off the spigot of carbon dioxide right now, there's already enough in the atmosphere that warming is baked into the climate system. We need to actually take some carbon dioxide out of the equation."

Removing carbon dioxide from the atmosphere is now essential to meet the Paris Agreement's targets according to an April report from the Intergovernmental Panel on Climate Change. Despite the unknown efficacy or consequences of the yet-to-be determined methods, governments worldwide are counting on them to avert disaster. Research is urgently needed to explore the potential solutions — and prevent uninformed decisions from causing unintended consequences.

Scientists are looking at a suite of approaches that build on natural ocean processes to take carbon out of the atmosphere and store it for long periods of time. Bigelow Laboratory researchers are working around the world to study five leading approaches and build the understanding needed to guide global decision making in the near future.

"I want to help equip society to make the best possible decisions," Twining said. "The earlier we start working on these problems, the more options we'll have. I want to do my part to work on solutions, and we can't afford to wait."

STRATEGY 1: ECOLOGICAL RESTORATION

The ocean removes billions of tons of carbon from the atmosphere annually, where much of it is then stored for hundreds or thousands of years. Despite making up less than two percent of the global ocean, coastal habitats sequester about half of this "blue carbon" by locking it away in sediments.

Coastal development and climate change are putting immense pressure on these precious ecosystems, which are contracting by an average of one to two percent each year. As they shrink, so does their ability to remove and store carbon. And once they've degraded, they release that carbon back into the environment. About a billion tons of carbon dioxide is currently released this way each year.

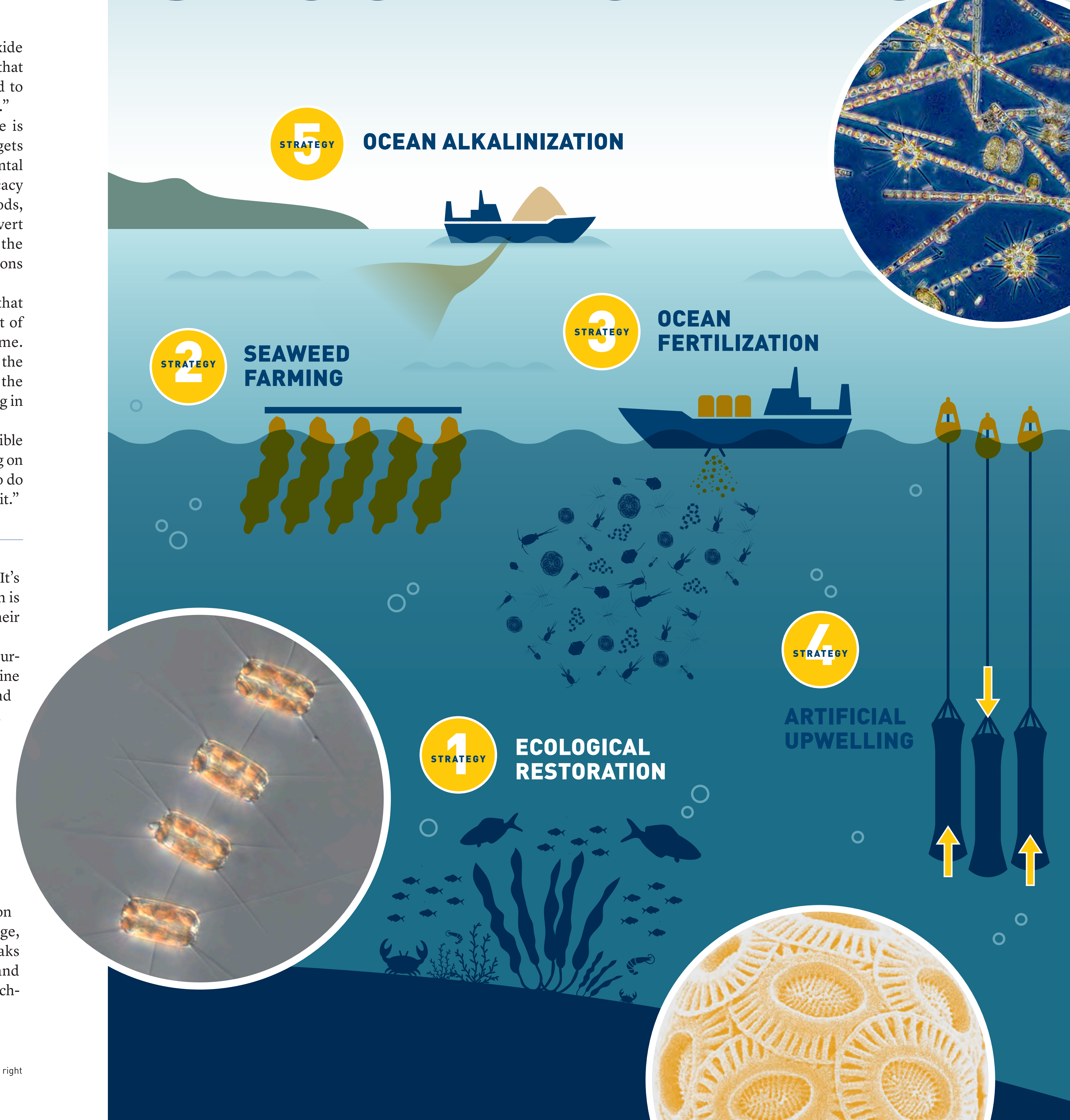
Globally, most of the recognized coastal blue carbon is in mangrove, salt marsh, and seagrass ecosystems. In the Gulf of Maine, seaweed beds, such as kelp forests, may also be a blue carbon sink, but research is needed to determine if managing and conserving them would be an effective way to remove carbon from the atmosphere.

"Kelp forests grow amazingly fast, take up a lot of carbon in the process, and skirt our coast for hundreds of miles," said Senior Research Scientist Doug Rasher. "It's really urgent that we figure out how much blue carbon is produced by Maine's vast kelp forests to understand their potential for carbon removal."

Rasher recently completed a two-year kelp forest survey to evaluate their health in the warming Gulf of Maine — a first step toward determining their current and potential blue carbon contribution. His research revealed lush kelp forests in the cold, northern reaches of Maine, and an almost complete collapse of the forests in the south.

"Maine's kelp forests are changing right before our eyes," Rasher said. "If we're going to manage and conserve wild forests with the aim to remove atmospheric carbon, we first need to understand how these forests are changing, why they are changing, and what these changes mean for blue carbon."

This potential ultimately relies on how much carbon is being locked away in long-term sediment storage, rather than being released when the seaweed breaks down. Tracking its fate is logistically challenging, and Rasher has started by collaborating with other researchers to study the process at seaweed farms.



Photos: Peter Countway, top three; Dolors Blasco, bottom right

STRATEGY 2

SEAWEED FARMING

Seaweed cultivation is a promising approach to carbon dioxide removal with direct benefits for society. Bigelow Laboratory scientists are leading worldwide efforts to support the developing industry while helping the planet.

"Existing seaweed farming practices could be modified to enhance carbon removal and storage, while also generating a nutritious crop in an increasingly food-insecure world," said Senior Research Scientist Nichole Price. "Seaweed farming is a rapidly growing industry with the potential to help combat climate change, while helping working waterfronts adapt."

Kelp absorbs carbon from seawater as it grows at farms. Some of this carbon could be removed from the global carbon cycle when fragments of the kelp fall to the seafloor and get buried in the sediment below.

However, scientists are unsure how much carbon is sequestered through these processes and how long it stays locked away. Price is working with Rasher and Senior Research Scientists David Emerson, Manoj Kamalanathan, and Peter Countway to answer those questions using DNA in the environment.

"If we can identify a unique genetic signal of kelp in the sediment below kelp farms, we could use it to determine kelp's potential for carbon storage," Countway said. "We don't yet know exactly what signal we should be looking for, but that's part of the challenge and excitement of scientific research."

TIFFANY STEPHENS, chief scientist and research director at Seagrove Kelp Co., examines young kelp.

In addition to its potential role in carbon dioxide removal, seaweed has gained interest for use by a wide variety of industries. Price is also working with partners to explore how the energy-efficient crop could be used in animal feed, bioplastics, and fertilizers, thereby avoiding carbon dioxide emissions elsewhere in supply chains.

Farming seaweed at a scale large enough to make a global impact on carbon levels will be challenging, as it would require many millions of acres. However, it will likely prove to be a valuable strategy at smaller scales, providing a resource for carbon credit programs while producing a harvestable product for coastal communities.

STRATEGY 3

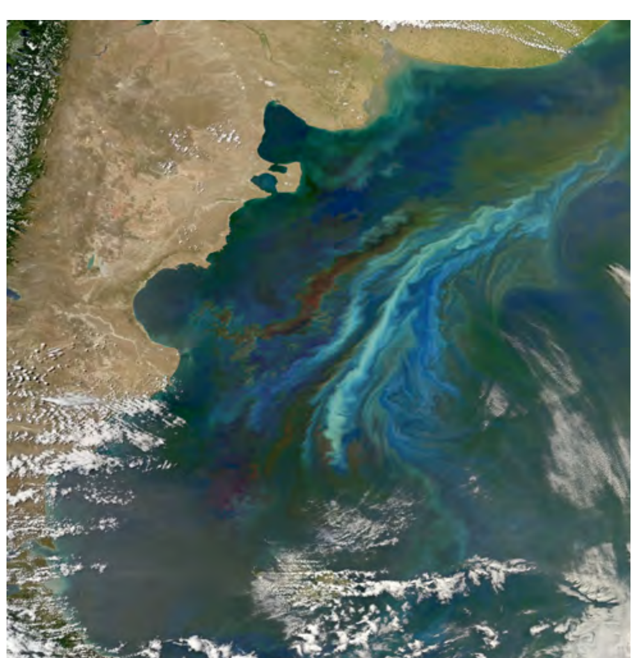
OCEAN FERTILIZATION

Phytoplankton are responsible for most of the transfer of carbon dioxide from the atmosphere to the ocean, together removing as much as plants on land. When they die, some of this carbon sinks and is stored in the deep ocean and sediment.

The number of phytoplankton in the ocean is generally limited by the amount of key nutrients in the water. In the Southern Ocean, the most important region for carbon dioxide removal, iron is the limiting resource. Research has shown that adding small amounts of iron to surface waters triggers phytoplankton growth. If done at large scales, this could enhance the natural process of carbon transport to the deep sea.

"We know nutrient fertilization amplifies carbon dioxide removal, but we don't fully understand its impact," Twining said. "We need to learn how efficient the process is, how long that carbon is removed for, and how adding nutrients might change ocean ecosystems."

Life in the ocean has responded positively to increased nutrients in the past. Almost 20,000 years ago, there was 20 times more nutrient-rich dust going into the Southern Ocean than now, which fertilized a more productive marine community. During the Australian wildfires in 2019 and 2020, nutrients from smoke also fertilized the Southern Ocean — causing phytoplankton blooms that removed billions of pounds of carbon from the atmosphere.



THE ADDITION of scarce nutrients to the ocean has the potential to help remove carbon dioxide from the atmosphere by triggering phytoplankton blooms like the one shown in this satellite image.

Twining is investigating the nutrient compounds that could most efficiently provide iron, as well as how fisheries might be affected. Senior Research Scientist David Emerson is a collaborator on several related projects, including one to calculate the cost of iron fertilization per tons of carbon removed under several possible scenarios. Emerson is also investigating bacteria that produce nanoparticles of iron that could be used in nutrient compounds.

Since the 1990s, scientists have conducted intermittent fertilization experiments but much remains unknown about its scalability and broader impacts. Increasing phytoplankton, a key species in ocean food webs, could lead to greater fisheries productivity or greater whale populations. However, this could also lead to overpopulation of phytoplankton, some of which cause harmful algal blooms.

"I'm trying to use my skills to help us reduce atmospheric carbon in the least harmful way, because the cost of inaction will be worse," Twining said. "I don't think of myself as a champion for ocean fertilization, but I am a champion for science being used to empower smart decisions about our future."

'I'm trying to use my skills to help us reduce atmospheric carbon in the least harmful way, because the cost of inaction will be worse.'

STRATEGY 4

ARTIFICIAL UPWELLING

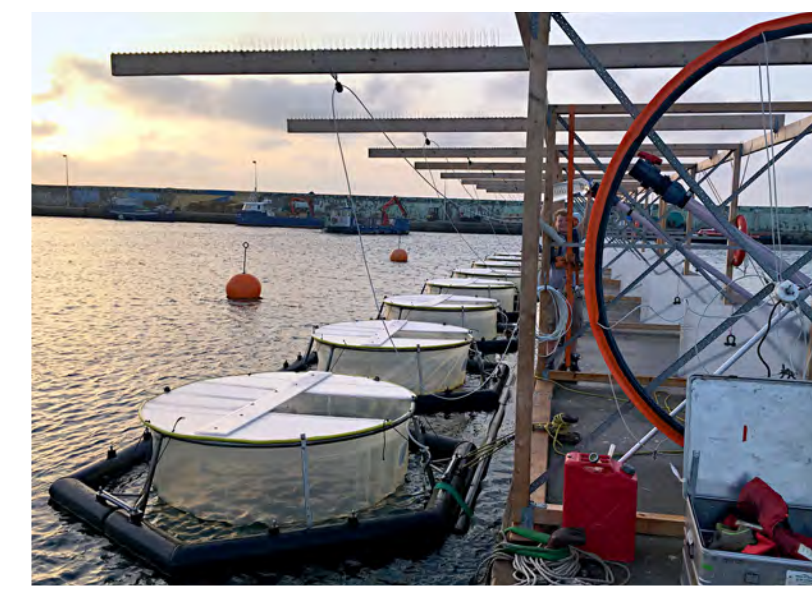
Nutrients may not need to be added to the ocean to spur phytoplankton growth. Water from deeper parts of the ocean is generally richer in nutrients than at the surface. Vertical movement of water, called upwelling and downwelling, naturally transfers them between the environments.

As a carbon dioxide removal approach, upwelling could be artificially enhanced to increase the supply of nutrients to the surface ocean. This would increase phytoplankton growth and thereby carbon removal from the atmosphere, similar to the strategy of ocean fertilization. However, there is one important caveat: deep water also has high amounts of carbon dioxide.

"So, while you are pumping up nutrient-rich water, you are also pumping up carbon dioxide," Senior Research Scientist Steve Archer said. "This has the potential to significantly reduce or cancel out the benefit of more phytoplankton, so finding the balance is key."

Since the 1950s, researchers have sought to artificially enhance upwelling using pumps and other approaches. Several experiments have shown that the method can deliver deep water to the surface and stimulate a measurable biological response, but the research has been limited to controlled, small-scale environments. Efforts in the ocean have not yet demonstrated that this approach could effectively sequester atmospheric carbon.

Archer is working with international teams to better understand the impacts of artificial upwelling in the environment around the Canary Islands and Peru. His research shows that added nutrients from deep water increased phytoplankton growth more strongly than predicted. The process also led to a large spike in dimethyl sulfide — a gas that helps form clouds, which reflect the sun's rays and keep the planet cool.



SCIENTISTS USE containers of isolated seawater in the Canary Islands to study the potential of artificial ocean upwellings.

Despite the positive results, Archer thinks artificial upwelling may be better used as a supplementary carbon dioxide removal method. The pumps and infrastructure required would be difficult to deploy on a large-enough scale to draw down atmospheric carbon dioxide.

"Rather than thinking about upwelling as a global solution, it is probably most promising as a targeted strategy for nutrient-starved ecosystems," Archer said. "It could deliver a pulse of phytoplankton that would locally boost carbon removal and support the foundation of the food web."

Photo, left: NASA Earth Observatory

Photo: Kevin Posman

5 STRATEGY

OCEAN ALKALINIZATION

One of the most promising carbon dioxide removal approaches is perhaps the most ambitious. Archer is also part of an international project to explore the possibility of altering the chemistry of ocean water to absorb more carbon dioxide from the atmosphere.

About a third of the carbon dioxide that humans have pumped into the atmosphere has been absorbed into seawater through chemical reactions. This has changed the character of the ocean, making it more acidic and less able to draw in more carbon.

Research suggests that it is possible to reverse these effects by adding crushed minerals to seawater at a large enough scale to impact global carbon dioxide levels. This "alkalinization" would mimic an acceleration of the natural weathering processes that have balanced the ocean's chemistry on geologic timescales. The technique has the added benefit of counteracting ocean acidification, which threatens many marine ecosystems and shell-forming organisms.

"You always get winners and losers with these kinds of changes because the ocean is so diverse," Archer said. "We want to understand which organisms really benefit from this and how detrimental it is to others."

The team recently simulated alkalinization in the first experiment of its scale with large test chambers in nearshore waters around the Canary Islands, followed by a similar experiment in Norway. Using dissolved minerals to alter the water chemistry, the scientists tested the effectiveness of different treatments and investigated their impacts on marine life.

AN EXPERIMENTAL SETUP in the Canary Islands was used by Senior Research Scientist Steve Archer in 2021 to test the effectiveness of different ocean alkalinization treatments and investigate their impacts on marine life.

Even if this strategy is proven to work and the minerals can be effectively dispersed with enough regularity to maintain higher ocean alkalinity, obtaining the needed minerals represents a large hurdle. It would require development of a new mining industry, perhaps one even on the scale of current global cement production.

"The fact that this strategy is being seriously considered speaks to how dire the problem is. Governments and scientists wouldn't be thinking about these kinds of options if they weren't confident that dealing with the unmitigated consequences of climate change will be worse," Archer said. "But, like with renewable energy, it's important to also see the opportunities to develop new industries and boost economies."

'We can't continue to pump carbon into the atmosphere at the current rate and hope we will eventually capture enough of it to offset our lifestyle.'

THE PATH FORWARD

Regardless of how well any one technique works, scientists believe that no carbon dioxide removal strategy will prove to be a silver bullet. Multiple methods will need to be employed alongside significant reduction in carbon emissions.

"We can't continue to pump carbon into the atmosphere at the current rate and hope we will eventually capture enough of it to offset our lifestyle," Rasher said. "We also need to rapidly and dramatically reduce our global greenhouse gas emissions if we are really going to curb the impacts of climate change."

Scientists around the world are working on research to guide the pressing decisions that need to be made. However, the potential options become fewer and more extreme with each passing year that society fails to meaningfully address carbon emissions.

"The human race has put ourselves in a corner: we're either going to deal with a world of doubled carbon dioxide concentrations, or we're going to deal with how we take carbon dioxide out of the atmosphere," Twining said. "There are good reasons why we might not want to fiddle with the oceans, but I think every strategy should be on the table until we have reasons to take it off. And the way we figure out those reasons is by doing ethical, transparent research."

Photo: Michael Sswat/GEOMAR

PROFILE Wendy Wolf

Trustee, Bigelow Laboratory

Wendy Wolf became a doctor to help alleviate people's suffering. After two decades in medicine, she transitioned toward public health to tackle broader issues. Those perspectives fuel her passion for ocean health.

"Medical care is just a small part of how we remain healthy; our environment plays a huge role," she said. "There is an intrinsic relationship between our individual health, the land, and the sea, and we can't divorce them."

Wolf has always felt drawn to the ocean. From Los Angeles to Maine, she has lived near the water most of her life, and she said it helps her feel centered. The animals and communities that thrive along the coast bring her comfort, reminding her of the unseen yet vibrant life that fills the ocean. She and her partner, Dr. Mary Neal, get great joy from sharing their passion for the sea with their grandchildren during long summer visits in Maine.

Wolf often thinks about what the ocean will be like when her grandchildren are older. She says it heightens her commitment to be part of the positive change she wants in the world, and the sense of urgency to enact it. She is concerned for the future of the planet and sees many ways that climate change is affecting human health, reshaping our ability to respond to new illnesses, and even driving changes to our diets. However, she believes that the ocean has the capability to heal if we let it.

"I have tremendous faith in the regenerative power of the ocean to help preserve life on the planet," she said. "We have to think globally about how we maintain and preserve health, and protecting the ocean is a vital part of that."

Wolf's professional experience has also shown her the importance of using science to guide critical decisions. In Washington, D.C., she worked on issues at the intersection of national health and public policy. Years later in Maine, she served as the founding President and CEO of the state's largest health philanthropy organization, the Maine Health Access Foundation.

"When addressing issues of ocean or human health, the best decisions are grounded in the best science," she said. "Science is essential to making good policy and personal decisions about how we address some of the most important challenges we have to confront."

Wolf has brought the same approach home to her local community. She has lived in Boothbay Harbor since 1996, where she has served as a select board member for eight years. She is currently in her second term on the Bigelow Laboratory Board of Trustees.

"Our local community is made up of lobstermen, fishermen, kelp farmers, and so many others that rely on the ocean," she said. "The work at Bigelow Laboratory has so many diverse touch points that are important to our community. It's essential for us all to have a better understanding of how we can protect and sustain our ocean to maintain our coastal communities' economies and quality of life."

WENDY WOLF (right) and her partner, Mary Neal, sit on their dock.

'There is an intrinsic relationship between our individual health, the land, and the sea, and we can't divorce them.'

That broad impact is a part of what drew her to the work at Bigelow Laboratory. She is inspired by its ongoing efforts to integrate new senior research scientists whose expertise and approaches extend beyond traditional oceanography. It is this interdisciplinary approach that excites her about the laboratory's work and makes her believe in its potential.

Wolf appreciates research that looks to identify and answer pressing questions. From projects that explore the ways water health impacts people to how microscopic organisms can inspire medical treatments, she is interested in research that has relevance for understanding our planet and solving problems.

"Our society really needs scientists who can keep their horizons broad and collaborate across disciplines to synergize their research and maximize its impact," she said. "Bigelow Laboratory scientists embrace this approach, and it enables them to be proactive about informing policy and make a real difference in our lives."

Gulf of Change

20 YEARS OF DATA REVEALS FOUR KEY TAKEAWAYS FROM MAINE'S WATERS

Senior Research Scientist Barney Balch has been studying the Gulf of Maine for over five decades, but it still manages to amaze him. This year, he published a comprehensive report on 20 years of data that illuminates a wealth of information on the physical, chemical, and biological conditions in the Gulf — and the dramatic transformations they have gone through.

"Even after decades of research on this body of water, I was surprised by some of what we found," Balch said. "We were able to illuminate a new web of interconnections because of the huge dataset we've collected. It allowed us to take a holistic look and determine what the changes we identified mean for Gulf of Maine processes and the life that depends on them."

Balch and his team started the Gulf of Maine North Atlantic Time Series study in 1998 to collect the data needed to observe long-term environmental changes and to validate measurements made by NASA ocean-observing satellites. Since that time, the team has collected a suite of measurements at the same geographic points about 10 times a year across the Gulf of Maine.

Their data show many trends that point to an overarching pattern. The Gulf is being increasingly influenced by factors beyond its waters, and this is changing the very foundation of its food web.

Reflecting on this new synthesis of his findings, Balch teased out four key lessons from his team's 20 years of observations in the Gulf of Maine — and some thoughts on how to move forward.

LEFT Senior Research Scientist Barney Balch measures ocean color in the Gulf of Maine. **CENTER** Senior Research Scientist Catherine Mitchell, Research Associate Bruce Bowler, and Senior Research Associate David Drapeau work inside a mobile laboratory during a research cruise across the Gulf. **RIGHT** Mitchell and Drapeau prepare an autonomous glider to collect measurements.

PHYTOPLANKTON GROWTH HAS SIGNIFICANTLY DECREASED.

Phytoplankton are one of the ocean's most important organisms. These microscopic plants use sunlight to convert carbon dioxide into a foundational food source for the entire ocean.

"We've seen that the growth rate of phytoplankton is about a third of what it was 20 years ago; that's a really big deal," Balch said. "These tiny plants are the base of the food web on which all ocean life depends."

This decline is tied to climate change and ocean physics. Increasing water temperatures affect currents, which alter the physical and chemical properties of the ocean. This alters what nutrients are available at various depths and locations, reshaping whole ecosystems.

Each phytoplankton species needs different quantities of environmental nutrients, like silicate and nitrate. As nutrient availability changes, so does the balance between phytoplankton populations. In turn, this reorganizes the food web in a way that impacts animals of all sizes — from zooplankton to whales.

"The ocean is such a dynamic, complex, and diverse environment that rarely just one organism changes in response to a new situation," Balch said. "And these changes are connected to patterns and processes well beyond the Gulf of Maine."

WATERS ARE DRAMATICALLY WARMING, BUT ISOLATED COOLING IS ALSO PRESENT.

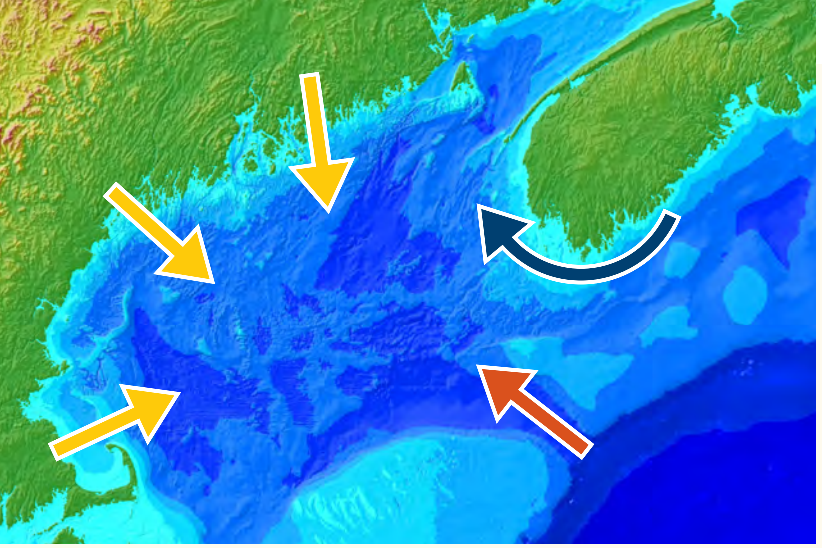
The data show that the Gulf of Maine is rapidly warming overall. At the average depth of the Gulf, around 500 feet, mean temperatures have increased almost three degrees Fahrenheit over the last 20 years. Shallow waters have warmed slightly less during that time and, surprisingly, have cooled in the spring months. Balch's new study is the first to show it.

"We all work with this mantra that the Gulf of Maine is one of the fastest warming bodies of water on the planet," Balch said. "Well, there's an asterisk next to that now, which is really important in order to understand the complex changes we're seeing."

Famed oceanographer Henry Bigelow noted a similar pattern almost a century ago. Using basic measurements taken from his wooden schooner, he saw cooling spring waters in the 1920s as part of a 12-year study in the Gulf of Maine. Now, with modern instruments and cutting-edge technology, Balch was able to uncover more.

His data show that the cooling is only happening at depths above 160 feet and only during the spring season. The pattern suggests an increasing amount of cold surface water is coming into the Gulf of Maine from cooler regions to the north, around the east side of Nova Scotia.

Photo, center: Andrew Collins



CHANGES TO THE WATER flowing into the Gulf of Maine are major contributors to its transformation. More soil-tinted water is washing out from land. More cool surface water is entering from the north in the spring. And more warm and salty deep water is intruding from the Atlantic Ocean.

THE GULF IS STRONGLY INFLUENCED BY OUTSIDE FACTORS.

Cooling in the Gulf of Maine is discrete and not representative of the overall trend. Warm and salty water from the North Atlantic has been intruding into deep parts of the Gulf since 2008.

"It's not like the Gulf of Maine is an isolated pond and all the warming happening here is only happening in place," Balch said. "Rising temperatures are in large part due to a large influx of North Atlantic water, which itself is getting warmer. These changes take time, and they are fundamentally altering the planet."

Climate-driven changes over land have also affected the Gulf. As rain percolates through soil on its way to the ocean, it is discolored by earthen materials, like a tea steeped from dead leaves and soil. Extreme precipitation events paired with warming temperatures have been increasing this process and sending more of this yellowed water to sea. There, it absorbs some of the sunlight phytoplankton need for energy and causes a decline in their growth. By comparing his ocean color measurements to those made by Henry Bigelow more than 100 years ago, Balch was able to determine that the Gulf of Maine has noticeably yellowed over that time.

"As you heat up the earth, organic materials in the soil break down more rapidly and get extracted as water flows into the sea," Balch said. "Like tea, the higher the temperature, the stronger the steep."

Balch has seen this colored water intrude more than 60 miles offshore into the Gulf of Maine. Due to ocean currents, it is not likely to extend much further from the New England coast. However, these discolored waters are now also coming in from the Saint Lawrence watershed and Gulf of Saint Lawrence — a further demonstration of the expanding forces that influence the Gulf of Maine.

A HOLISTIC APPROACH IS NEEDED TO UNRAVEL COMPLEX CHANGES.

Even after more than 50 years of research on the Gulf of Maine, Balch was surprised to discover the spring cooling patterns and the extent of the Gulf's growing interconnectedness.

"I continue to be amazed at the complexity of this place," Balch said. "To really understand what's happening to the Gulf of Maine, you can't just look at the chemistry, physics, or biology on their own. You have to look at all these factors together. When you do that, you find unexpected patterns."

Balch said that approach was critical to illuminating his discoveries. The study looked at around 300 variables, allowing an unprecedented perspective inspired by those before him.

"The most important aspect of this work is that we are taking a holistic approach to the Gulf of Maine," Balch said. "It's what Henry Bigelow did. He believed that a holistic approach of investigating the Gulf of Maine was the only way to do it because of all the interconnections — and that's what we see here."

THE DECADES TO COME

Despite the alarming trends, Balch remains hopeful for the Gulf of Maine. Organisms are finding new habitats, filling niches, and adapting. Things may never be what they once were, but the planet could heal if our society gives it the chance.

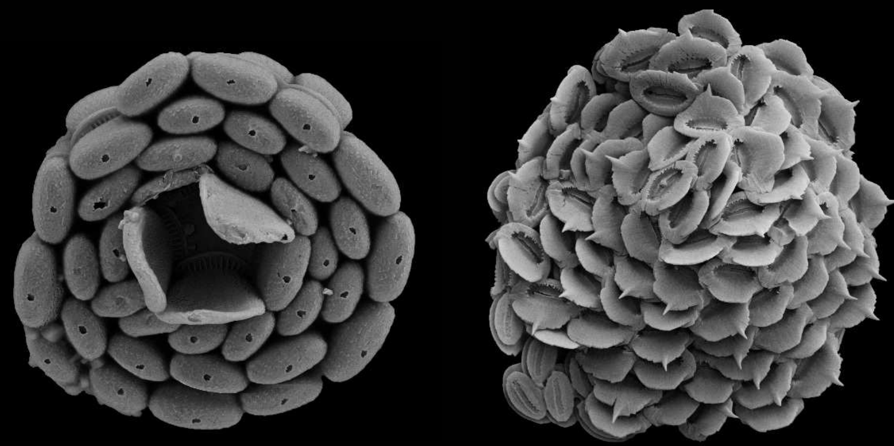
"These changes are the results of our actions — the grand experiment that we humans have run on this planet since the industrial age when we started burning fossil fuels," Balch said. "The future of the Gulf of Maine relies on us keeping our carbon dioxide emissions down, and that choice is completely under our control."

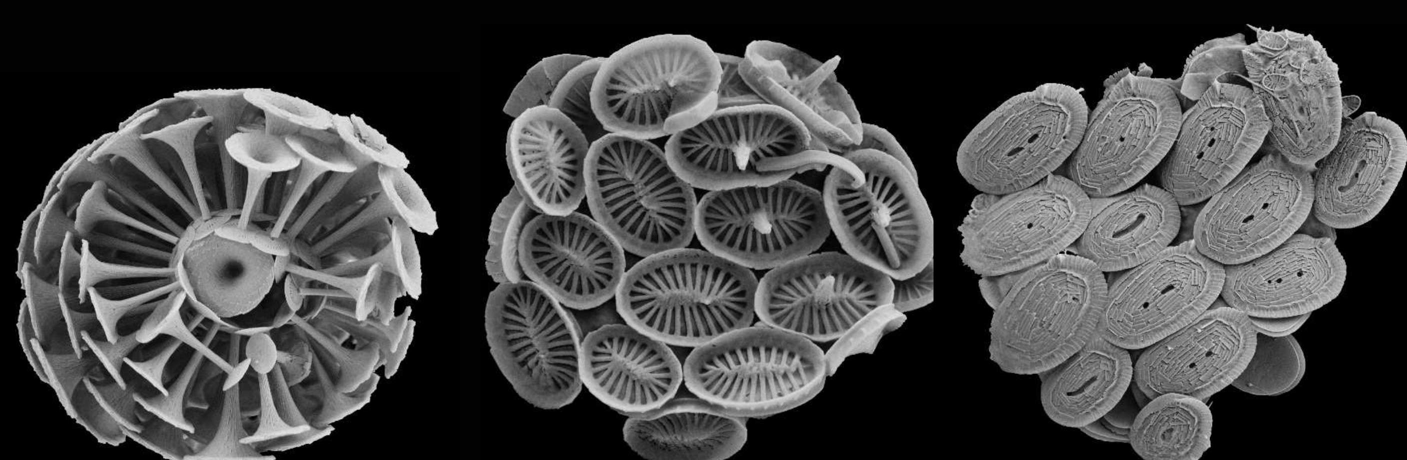
BALCH COLLECTS a temperature profile of the Gulf of Maine from the surface to the seafloor.

Map: Rich Signell, USGS

SCIENCE SNAP

COCCOLITHOPHORES, one of the most ubiquitous types of phytoplankton on the planet, have a major impact on food webs and the global carbon cycle. Senior Research Scientist Barney Balch and Research Technician Colin Fischer recently published "Ultra-Fine Art of Coccolithophores." The book is now available in print and as a free e-book at bigelow.org/coccolithophorebook. The images draw on decades of field research around the world to share the beauty, diversity, and science of these tiny ocean wonders.





Photos: Colin Fischer

FIELD NOTES

POSTDOCTORAL SCIENTIST Aurora Martinez Ricart (right) and Research Associate Brittney Honisch prepare sensors for deployment at Seagrove Kelp farm in Alaska.

Alaska and Norway

BY AURORA MARTINEZ RICART, Postdoctoral Scientist

"It's working!" Those magic words brought great relief at two critical moments during our recent international trip to explore beneficial environmental effects of growing seaweed.

This spring, Research Associate Brittney Honisch and I went to deploy identical, state-of-the-art sensors in several coastal kelp farms around the globe. Our trip took us through seven towns to visit farms in Maine, Alaska, and Norway. We had a whirlwind month and the jet lag to prove it.

The work is part of a project led by Senior Research Scientist Nichole Price and I to explore how seaweed farming can remediate negative effects of climate change. Kelp soaks up carbon dioxide as it grows. The process can lower the acidity of the surrounding seawater and raise oxygen levels, creating an area of improved water conditions for growing shellfish around it. Our mission was to deploy underwater sensors to monitor these conditions, and investigate the potential of seaweed aquaculture to improve local water quality.

After spending two days deploying sensors in Maine, we traveled to Craig, Alaska. There, we spent several days preparing the next set of sensors before loading them onto a boat, putting on our cold weather gear, and heading out to the Seagrove Kelp farm. It was chilly, but sunny and without wind. We even spotted humpback whales and bald eagles in the beautiful Alexander Archipelago!

The sensors include an internal water pump that enables them to take continuous readings. The final, and maybe most difficult, step before deploying them is to make sure the pump is operational. After a few tense minutes of troubleshooting, I shouted our first "It's working!" We then used a crane from the boat to deploy the sensors about seven feet under water, secured to a mooring and a buoy.

It took us three days to get across the world to the Seaweed Solutions farm in Frøya, Norway. The weather was not as favorable in Scandinavia, and we only had a small window of not-too-terrible conditions to deploy the sensors. This forced us to do all our work in a single, cold and rainy day!

As we prepared for deployment, the laptop we needed for the work didn't turn on. Thankfully, we take backups of our most important gear. We looked at each other with disbelief as the spare wouldn't work either. It took us a minute to realize the cold temperature had discharged the batteries. Luckily, we had a charger and access to power on the boat. We got the laptops turned on, but both refused to work without software updates! At least this gave us some short breaks. At 2 a.m., we heard the magic call, "It's working!"

The sensors have been recording water quality conditions at the farms for months now. However, we can't help but feel some anxiety every time we think about them. The ocean is unpredictable and leaving our scientific instrumentation under water for months is not without risks. Soon we will be going back to recover the sensors and examine the data. Hopefully everything will go smoothly, and we can again say, "It's working!"

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