TRANSECT

BIGELOW LABORATORY FOR OCEAN SCIENCES / SUMMER 2017 / VOLUME 9 / ISSUE 1

People frequently ask me about the effect of our current political environment on basic science research — particularly ocean and climate change research like we conduct here at Bigelow Laboratory. The new administration in Washington, D.C., has regularly expressed skepticism regarding environmental science and its relevance to the health of our planet and the growth of our economy.

While recent events have certainly provided scientists and science supporters around the world with new reasons for concern, the underlying challenges are not unfamiliar to the scientific community. Most federal research programs have been flat-funded for several years, and we've had to weather significant fluctuations in federal support from administrations in the past.

Several years ago, Bigelow undertook strategic planning that recognized these challenges and laid out a strategy to buffer against them. This strategic plan resulted in steady diversification of the applications of our science and the sources of funding support. We've expanded our work to directly connect students with our science, creating a suite of educational and training programs that take place throughout the year at our laboratory. We're building strong ties between our science and practical societal benefits through commercialization efforts and partnerships. We've also increasingly engaged with people and foundations that care about the future of the ocean, and their incredibly generous support has elevated our science to new levels.

In this issue of *Transect,* we highlight recent progress in each of these areas of our strategy. Certainly the most visible sign of growth in our education programs this year is the new Graham Shimmield Residence Hall. Dedicated to our late executive director, the residence includes dormitory-style accommodations and apartments for visiting students and scientists.

Also highlighted is a new program that provides early stage philanthropic investment in commercial applications of our research. These commercialization projects, as well as the research infrastructure needed to support them, would simply not be possible without the generosity of a growing group of private donors who are investing in the ocean through our work.

Basic marine science remains the core of Bigelow's mission and activity, and this issue of *Transect* shares the story of a recent research expedition to Antarctica. The Antarctic Peninsula — like the Gulf of Maine — is warming and changing significantly faster than the rest of the Earth. Our scientists are working hard in both the northern and southern polar regions to understand the significance of these changes for the long-term health of the planet.

As always, there's lots going on at Bigelow Laboratory, and we have a very busy summer planned. I hope you'll be able to join us for some of the upcoming events at our lab, such as our weekly Café Sci events or our annual Open House on July 14. We'd love to see you there!

BENJAMIN TWINING, PhD

ON THE COVER

The sun shines over the mountains of Antarctica as Bigelow Laboratory scientists arrive for two months of field work. Read about their research into the microbial communities that live in the Southern Ocean on page 9.

Photo by Carlton Rauschenberg

MANAGING EDITOR
Steven Profaizer

CONTRIBUTING WRITERS
Jake Beam
Rose Jones
Eric Walton
Dana Wilson

DESIGN
Simmons Ardell

Photo: Greta Rybus, right

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BIGELOW LABORATORY IS HOME to the National Center for Marine Algae and Microbiota. Its collection of more than 2,800 strains of algae serves as an important resource for scientists around the world.

New Residence Opens Doors

More than 300 friends, colleagues, and family members gathered on May 12 to celebrate the life of Graham Shimmield and dedicate Bigelow Laboratory's newly constructed student residence hall in his honor.

Graham Shimmield was executive director of the Laboratory for nine years and passed away last December after a hard-fought battle with cancer. He was instrumental in securing the funding and directing the design of the new residence hall, as well as the main laboratory. During the dedication ceremony, a selection of speakers shared stories of his many contributions to international ocean science, the state of Maine, and Bigelow Laboratory.

"The building design reflects things Graham valued — incredibly high energy efficiency, reduced ecological footprint, and architecture that is as innovative as Bigelow Laboratory's science," said Steve Malcom, member of the board of trustees and chair of the building committee. "It is a building that uses form, transparency, and landscape to blur boundaries inside and out."

Funded through the generosity of the Harold Alfond Foundation and an anonymous donor, the Graham Shimmield Residence Hall provides on-campus housing to scientists and students visiting our laboratory. This much-needed resource supports the Laboratory's expanding international partnerships and educational programs for students of all ages.

Overlooking the Damariscotta River, the new residence includes 32 dorm beds with a shared kitchen facility, as well as four fully equipped apartments and a conference space. A 264-panel solar array built as part of the project generates more than enough energy to power the highly efficient building.

Only two days after the dedication ceremony, the first group of student residents arrived for a professional development course in algal culturing techniques. They were followed closely by 16 high school students participating in our weeklong Keller BLOOM program. Twenty-three summer interns moved in three days later and began their independent research projects.

"Graham greatly expanded our impact during his nine years at the helm," said Benjamin Twining, a senior research scientist who is serving as interim executive director. "The building is a beautiful tribute, but the true legacy of his vision for Bigelow Laboratory is the thousands of careers that will be sparked and nurtured inside its walls."

Photos: Robert Mitchell

Investing in Ocean Innovations

Despite the many challenges it faces, the ocean still teems with potential. Cures, sustainable energy sources, and nutritional supplements await discovery. Countless industries and technologies await development. For all that people have taken from the sea, we have truly only skimmed the surface of the solutions it can provide.

Few know this as well as marine researchers, whose work at the forefront of scientific discovery gives them tantalizing glimpses at new possibilities. Bigelow Laboratory is committed to ensuring our research addresses real-world issues and opportunities, but traditional ocean science funding doesn't typically support early investigations into commercial applications.

Visionary philanthropists have emerged as essential partners in nurturing these fledgling ideas. One such generous donor helped us establish the Sash A. and Mary M. Spencer Entrepreneurial Fund in December 2015. It provides vital investment in promising concepts, giving our researchers the time needed to investigate opportunities and forge commercial partnerships to support them.

"This innovative funding is helping expand our enterprise activities," said Jim McManus, vice president for strategy and administration. "It is envisioned that the fund will allow our scientists to expedite the transfer of scientific discoveries to the markets that can benefit from them."

Spencer Fund grants are targeted investments designed to stimulate and support the utilization of our science for societal benefit. When our scientists identify a valuable idea or discovery as part of their research, they can apply to a review panel for funding. Evaluation criteria include commercial partnerships, marketability, and development strategy.

"Innovation and discovery are perhaps what is most exciting about this type of research, but a solid plan and verifiable data are at least as important to attracting commercial partners," said Mike Lomas, senior research scientist and recipient of two Spencer Fund investments. "Building a compelling case for commercial investment takes time and resources that we just don't have without early stage investment by the philanthropic community."

THE SPENCER ENTREPRENEURIAL FUND SUPPORTS OUR PURSUIT OF SCIENCE-BASED SOLUTIONS.

BIGELOW LABORATORY'S NEW ALGAE GREENHOUSE is designed to grow our collaborations with industrial partners.

Spencer Fund investments provide scientists with the time to prove their concepts, demonstrate their expertise, and attract commercial partners. Smaller investments, up to $10,000, can fund early stage market analysis, business plan development, intellectual property filings, and proof-of-concept experiments. Larger investments, up to $40,000, are intended to support activities such as prototype development, field trials, and pilot studies.

All Spencer Fund investments require matching support from a third party, and our scientists are actively seeking people and foundations to help them solve problems in the pharmaceutical, nutraceutical, energy, and aquaculture industries.

Another unique aspect to the Spencer Fund is that it is designed to be self-sustaining. A portion of the income generated by funded projects goes back into the Spencer Fund. Over time, this strategy will grow the fund and multiply the resources available to our scientists.

"Entrepreneurship is core to the culture of Bigelow Laboratory," McManus said. "The Spencer Fund is focusing that energy and creating a new way for donors to provide sustaining support for our innovative solutions to pressing ocean-related issues."

Photo: Stacey Cramp

CURRENT SPENCER FUND PROJECTS

Harvesting Natural Products

Microalgae naturally produce compounds that offer endless possibilities for commercial products. Senior Research Scientists Mike Lomas and Christoph Aeppli are using a Spencer Fund investment to develop new technology for growing algae that will enable efficient collection of those valuable compounds.

For this pilot application, the scientists are targeting glycerol. It is naturally released by certain microalgae and has been proven to reduce harmful emissions from marine diesel engines while increasing their fuel efficiency.

"Rather than harvesting all the algae, we only extract the compounds released into the water," Aeppli said. "This exciting, new technology allows us to keep the algae in optimal conditions, rather than regrowing it after each harvest."

This approach opens up many possibilities for targeting compounds that are naturally produced by algae. In addition to developing the diesel fuel additive, Lomas and Aeppli plan to use their Spencer Fund investment to pursue a patent for their novel alage growth and compound extraction technology.

Portable Pathogen Detection

Vibrio parahaemolyticus and *Vibrio vulnificus* are pathogenic marine bacteria that can accumulate in shellfish and cause foodborne illness in people. Exposure typically comes from consumption of raw or undercooked shellfish, particularly those that have been improperly handled.

As *Vibrio* causes no noticeable changes in the taste, odor, or appearance of infected shellfish, laboratory tests are required to determine its presence and abundance. With the help of a Spencer Fund investment, Senior Research Scientist Peter Countway is developing a real-time genetic test for *Vibrio* that can be carried out in the field using a handheld device.

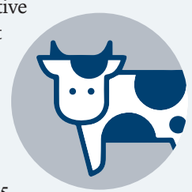
Countway is collaborating with a Philadelphia-based biotechnology company, Biomeme Inc., on the project. His tests will utilize their mobile PCR device, the two3. PCR, or polymerase chain reaction, is a quick and cost-effective technology that can be used to identify the presence of specific genes, including those of the targeted bacteria.

THE FUND HAS ALREADY INVESTED IN FIVE COMMERCIAL APPLICATIONS GENERATED BY OUR SCIENTISTS' RESEARCH.

"This test will provide the growing aquaculture industry with a simple way to check for the presence of these particular species of *Vibrio* and potentially enhance the safety of its products," Countway said. "In the future, we hope to build a network of citizen scientists who can use this technology to help us monitor and forecast the presence of *Vibrio* and other microbial threats along the coast."

Livestock Methane Reduction

Cows release an incredible amount of methane — polluting the environment and wasting energy that could otherwise be used for their growth and milk production. Senior Research Scientists Steve Archer and Dave Emerson are using a Spencer Fund investment to pursue the idea of using microalgae as a feed additive for cattle. Studies have shown that seaweed additives can reduce methane emissions in cows. Implementation of this idea, however, is limited by the need to massively scale up production and distribution of seaweed for the country's 35 million cows.



To address this challenge, Archer and Emerson are exploring microbial production of the essential agents responsible for suppressing methane production in cows.

"We have identified a microscopic algae that produces what we think are the essential agents," Archer said. "If we demonstrate that it is effective in laboratory experiments, we plan to conduct more realistic tests with scientists working on livestock metabolism and expand discussions with the cattle feed industry."

Standards for Molecular Analysis

High-throughput DNA technology has revolutionized science — providing fast, inexpensive methods of analyzing large amounts of genetic information. As the technology continues to rapidly evolve along several different paths, there is a growing need for standardization of methods and controls to ensure the integrity and comparability of scientific studies.

With the support of a Spencer Fund investment, Senior Research Scientists Dave Emerson and Mike Lomas are developing a set of standardized marine microbe communities that will represent open-ocean and seafloor microbes.

"These mock communities will provide a standard for assessing procedures, calibrating instruments, and developing methods," Emerson said. "Universal standards are essential to scientific collaboration, and these communities will offer a valuable control to scientists around the world."

Once the project is complete, these carefully calibrated communities will be available through the National Center for Marine Algae and Microbiota located at Bigelow Laboratory.

Seaweed Seed Storage

The sea green industry is rapidly growing in the United States, but aquaculture farmers still can't order "seeds" for seaweed. New farmers need to collect wild kelp and then induce it to release spores in a laboratory setting.

"Starting a kelp farm is like trying to grow a field of corn from a wild plant you found in the woods," said Senior Research Scientist Nichole Price. "It's easy to take for granted all the progress people have made with agricultural techniques and technology until you try to start a farm in the ocean. Almost everything we've learned about husbandry on land we need to relearn for aquaculture."

Price and Research Scientist Nicole Poulton are working to develop a reliable source for kelp spores — which only live for 24 hours after mature kelp release them. This Spencer Fund project also received a matching grant from Maine Technology Institute in March. Through this work, Price and Poulton aim to develop cryopreservation techniques that will allow sugar kelp spores to be stored long-term and thawed on demand.

"Storing the spores below -320°F allows us to pause their lifecycle until farmers are ready for them," Poulton said. "The techniques we're developing to sort and preserve spores will provide farmers with insurance against crop failure, the ability to selectively breed for characteristics, and a year-round source of spores."

PROFILE Dyke Messler

President, The Messler Family Foundation

A disturbing boat ride to a turtle preserve in Borneo left a deep impression on Dyke Messler. The unforgettable journey took him through 10 miles of thick garbage floating in the ocean. Local residents, not to mention the turtles and other marine life, were swimming in that water. Dyke has traveled extensively and witnessed first-hand the staggering pollution in our oceans.

"It's remarkable to me how much gets thrown into the water," he said. "It is really sad."

Having grown up in urban California in one of the most densely populated metro areas in the country, Dyke also has a deep appreciation for the unspoiled beauty and open spaces along the Maine coast. Almost 40 years have passed since he moved to the Camden-Rockport area and began to call Maine "home."

"I can't imagine living here and not spending time outdoors to enjoy the surroundings," Dyke said.

His concern for the health of our vast oceans, which cover 70 percent of the planet, is reinforced by his keen awareness of the development pressures on our coastlines. He is well-acquainted with this threat, particularly in South Carolina where he lives part-time. Dyke has dedicated the bulk of his career to restoring old houses and decries the ever-expanding coastal construction happening there. New houses are being built right up to the edge of the beach, seemingly just waiting for the next hurricane to wash them away.

'GLOBAL WARMING, RISING SEA LEVEL, POLLUTION — WHAT KIND OF WORLD ARE WE GOING TO LEAVE OUR KIDS?'

"Global warming, rising sea level, pollution," Dyke said, "what kind of world are we going to leave our kids?"

A friend introduced him to the work of Bigelow Laboratory for Ocean Sciences in 2013, after which he toured the new LEED Platinum-certified facility with past executive director Graham Shimmield. The experience further piqued Dyke's interest in the future of our ocean. He joined the Advisory Board one year later and continues in that role to this day, learning more each year about the Laboratory's efforts to understand how our oceans work and how they are changing.

From the study of vitally important plankton at the bottom of marine food webs, to groundbreaking research about the potential of the ocean's microscopic life, to the relentless curiosity that drives Bigelow scientists to explore and discover answers, Dyke said, "I am totally amazed by all that is going on there."

As president of the Messler Family Foundation, Dyke pursues his family's philanthropic interests, which are mainly focused on the environment, health care, and education. He is fascinated by what he has learned in the short time since his introduction to Bigelow Laboratory. It has solidified his family's support for the institution and provided a partner for which the staff and scientists are deeply grateful.

"As goes the ocean, so goes the planet," Dyke quoted. "I'm happy to help."

Gift Planning at Bigelow Laboratory

WE INVITE YOU TO LEAVE A LEGACY AND HELP ENSURE A HEALTHY OCEAN FOR FUTURE GENERATIONS.

Are you passionate about the bright ocean future that Bigelow Laboratory represents? We invite you to make perhaps the most meaningful of gifts to support our mission: a planned gift.

Whether you choose to name us in your will, or designate the Laboratory as a beneficiary of your IRA or life insurance policy, it is easy to create a lasting legacy that reflects your altruistic values and helps you realize significant financial and tax benefits. You become an invaluable, long-term partner in ocean research and science education far beyond your lifetime. Proceeds from planned gifts like these are invested in the Laboratory's permanent endowment fund.

It would be our honor to serve as steward of your commitment to the ocean for generations to come.

MEET DONNA LEE CHENEY

Donna has supported Bigelow Laboratory for close to 30 years and served two terms as chair of its Board of Trustees from 2001 to 2008. She also volunteered for more than a decade as a trustee of Westbrook College (her alma mater) and University of New England. Needless to say, she has a deep interest in ocean research and higher education. Thanks to her strong leadership and vision, Bigelow Laboratory was able to break ground on its new 64-acre campus in East Boothbay, Maine. Donna is proud of the expertise of Bigelow Laboratory's scientists, their innovative marine research, and their caring mentorship of young oceanographers. When she named the Laboratory in her will, she chose to make her planned gift in honor of Dr. Graham Shimmield, former executive director and president. "Graham did so much for developing the organization to where it is today and firmly placed it on the world stage of scientific institutions," Donna said. "I'm pleased to play this small part in ensuring the Laboratory's future."

SHARE YOUR COMMITMENT

CONTACT JENNIFER CUTSHALL, chief advancement officer, for assistance at jcutshall@bigelow.org or 207 315-2567 x106.

IF YOU HAVE ALREADY ESTABLISHED A PLANNED GIFT TO BENEFIT BIGELOW LABORATORY, THANK YOU! Please let us know about it so we can acknowledge you properly and ensure that your intentions are fulfilled.

Researchers Journey to Antarctica

The Drake Passage is a notoriously rough stretch of water that lies between South America and Antarctica. It is well known as a gut-wrenching rite of passage for any eager explorer or committed scientist looking to reach the continent's western shores, but it sometimes shows travelers its softer side.

A research team from Bigelow Laboratory had the pleasure of experiencing this firsthand last December, enjoying a relatively calm voyage across the often-treacherous waters. The Drake's unexpected mercy gave them an opportunity to jumpstart their research, and the team went to work assembling equipment and mapping out schedules. For the next two months, they would maintain a grueling pace in order to complete their research before it was time to again board the RV *Laurence M. Gould* for the return trip to Chile.

The scientists traveled to Antarctica to study the relationship between phytoplankton and bacteria and learn how one critical compound may help shape microbial communities in the icy Southern Ocean.

While that might initially sound like an esoteric endeavor, the interaction the team is studying has huge implications for our changing and warming planet. Certain phytoplankton produce copious amounts of a compound called dimethylsulfoniopropionate (DMSP). DMSP provides essential nutrients to marine bacteria and leads to the release of dimethyl sulfide (DMS) — a gas that helps form clouds and may therefore play a key role in regulating the Earth's climate.

"We want to know how the diversity of life in the ocean affects this very important process," said Senior Research Scientist Peter Countway. "To do that, we're looking at the changes that occur in the community, as well as the specific genes that are associated with the use of DMSP."

The cycling of DMSP provides a narrow focal point through which the scientists can study the complex relationship between bacteria and phytoplankton. They hope to be able to scale up what they learn to gain insights into other microbial interactions of profound influence.

"We need to understand how phytoplankton and bacteria interact throughout the entire ocean, but we have to start small," Matrai said. "We already know they are interacting, but we can't yet quantify it. When we have that information, we can use the data to build models and conduct simulations of more widespread processes."

Phytoplankton and bacteria depend on each other to grow and survive. In the same way that humans rely on a

Photo: Peter Countway

TOP LEFT Icebergs drift along the coastline of the Antarctic Peninsula. **TOP RIGHT** Carlton Rauschenberg and Paty Matrai drive a boat near Palmer Station. **BOTTOM LEFT** Rauschenberg, Kathryn Moore, and Peter Countway prepare the incubator they designed for their experiments. **BOTTOM RIGHT** Microscopic algae float in one of the team's samples.

PHYTOPLANKTON AND BACTERIA INTERACTIONS HAVE HUGE IMPLICATIONS FOR OUR CHANGING PLANET.

healthy relationship with the bacteria inside us, there is a similar codependency between phytoplankton and bacteria in the ocean.

This relationship has been extremely difficult for scientists to examine and many basic questions remain regarding production and use of DMSP by microbial communities. Molecular tools, however, are now providing scientists with new ways to examine the relationship, connecting physical and chemical measurements to genetic information.

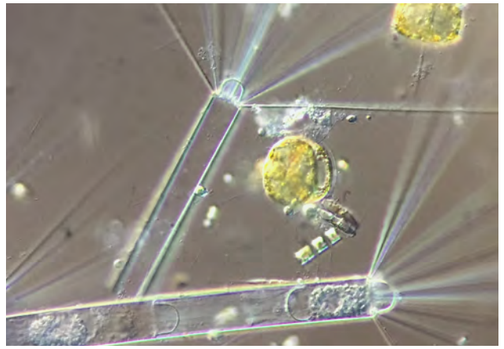
This cutting-edge approach is what sent Countway and Matrai to Palmer Station. They were joined on the expedition by Senior Research Associate Carlton Rauschenberg, as well as Kathryn Moore, an alumna of the Changing Oceans semester-in-residence program run by Bigelow Laboratory and Colby College.

Palmer Station, the smallest of the US Antarctic Program's research outposts, is located about 700 miles south of Chile on the west Antarctic Peninsula. While the station population varies throughout the year, it hovers around 40 people throughout the busy summer season.

Conducting research in Antarctica is everything people think it is, as well as a lot of things people wouldn't expect. The team navigated around icebergs and wildlife as they collected their samples aboard a small boat near the station. However, warm showers, reliable Internet access, and tourist cruise ships were no less common during their two-month stay.

"There were times when we were sampling and a humpback whale would pop up 10 feet from the boat or a passel of penguins would come by just to check us out," Rauschenberg said. "And on our day off, we had a hot tub, sauna, bar, and two amazing chefs to help us get ready for another busy week of research."

The team's fieldwork primarily focused on a series of experiments, each taking about 10 days to complete. The scientists transferred sampled seawater into 12 four-liter bottles held in an incubator they designed. Six of the bottles were left sealed as control samples. The others were divided into two groups and provided with a steady supply of nutrients and DMSP at two different rates. The team used this setup to study the compounds in the water, the released gasses, the DMSP metabolism genes being activated, and the composition of the microbial community.



"Through these short-term experiments, we could simulate an entire bloom cycle over the course of a few days," Countway said. "This allowed us to simultaneously study the effects of DMSP production and consumption from multiple angles."

The team used different seawater samples each time they ran the experiment, but they always exposed them to identical conditions. This allowed the scientists to examine the consistency of the interaction between different communities of phytoplankton and bacteria over the course of the Antarctic summer.

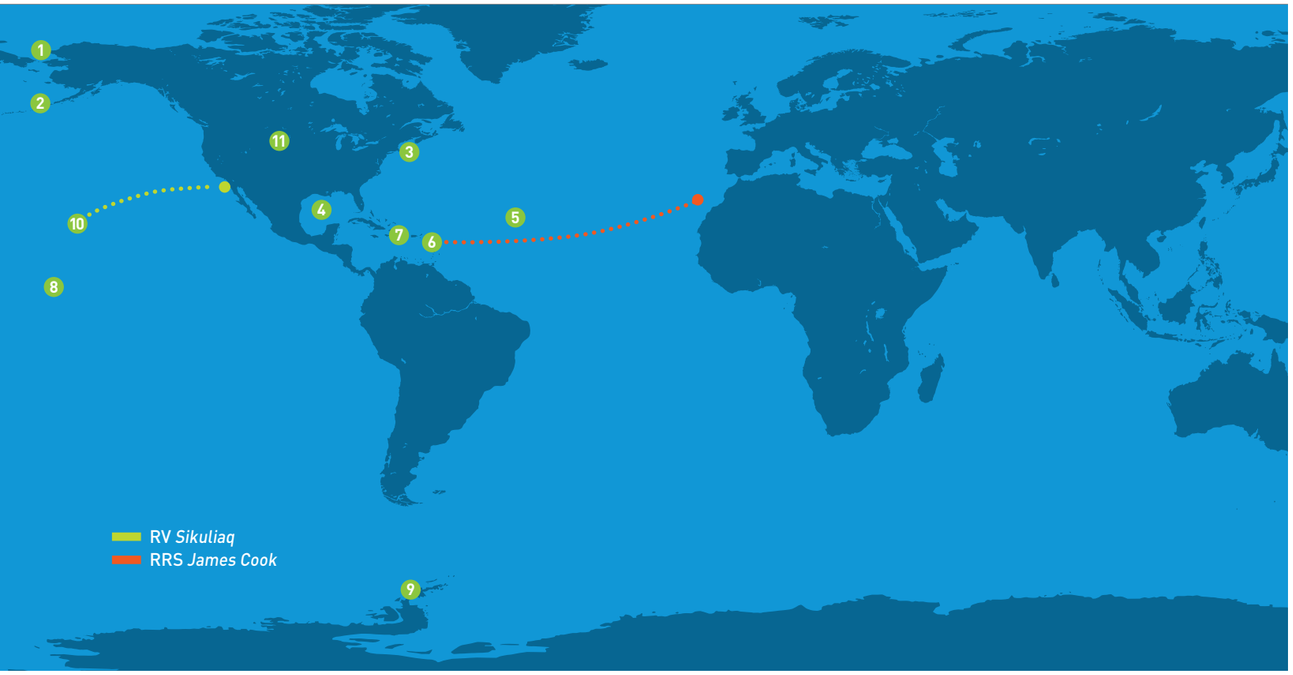
The team will be returning to Palmer Station in April 2018 to run the same experiments during a different time of the year. Life in the ocean goes through seasons just like it does on land, and different species of phytoplankton and bacteria will be "blooming" during their second visit. This will allow the scientists to further investigate the consistency of their results between communities.

"We first need to understand this interaction and how consistent it is," Matrai said. "Then, we hope to use what we learn to examine other significant interactions that influence the health of the ocean and the planet."

COUNTWAY AND MATRAI WILL HOST A CAFÉ SCI on July 25, 2017, to share more about their Antarctic journey. Learn more and register at bigelow.org/cafesci.

Photos: Carlton Rauschenberg, top left; Peter Countway, top right and bottom right; Paty Matrai, bottom left

FIELD WORK 2017 Overview



ALASKA/ARCTIC

1 **Dr. Mike Lomas** and Postdoctoral Scientist **Dr. Steven Baer** will each be going on a cruise, one in June and one in August, to study the Chukchi Sea as part of the Arctic Integrated Ecosystem Study. The goal of the study is to improve our current understanding of the processes that structure the Arctic ecosystem, which includes documenting many ecologically and commercially important species. The Arctic is rapidly warming, and the scientists will be helping conduct the baseline research needed to understand the vulnerability of key processes to the ongoing reductions in sea ice and increases in temperature occurring in the Chukchi Sea.

2 **Dr. Doug Rasher** will be heading to Adak, one of the Aleutian Islands in Alaska, for two weeks in June. There, he is studying how ocean warming and acidification are changing a reef-building coralline alga's ability to produce its calcium carbonate skeleton. He will also be studying whether grazing herbivores are consuming, and consequently eroding, the reef structures built by this alga. This work will document how climate change is already altering the ecology of coastal kelp forests in a region that sits at the forefront of climate change.

GULF OF MAINE

3 **Dr. Nichole Price** is continuing her research into the benefits of growing kelp and shellfish together. Last year, her team's field measurements at Ocean Approved's aquaculture farm showed that kelp remove excess carbon dioxide from their surrounding environment, lowering the water's acidity and potentially making it easier for nearby shellfish to grow. Her team, working in conjunction with the Island Institute and University of New Hampshire, returned to the field this year. They aim to better understand the scope and consistency of this effect and to map carbon dioxide concentrations in the seawater around the kelp farm.

OUR SCIENTISTS CONDUCT RESEARCH IN EVERY OCEAN AND BRING WHAT THEY LEARN BACK TO OUR LAB IN MAINE.

3 **Dr. Barney Balch** is continuing to expand his Gulf of Maine time series, now in its 19th year. His team's data provides NASA with a way to calibrate and validate ocean color satellites. It also provides an invaluable data set for studying long-term change in coastal phytoplankton productivity as well as a multitude of other physical, chemical, biological, and optical variables. This research is revealing insights into how phytoplankton productivity is responding after the massive decline that occurred throughout the Gulf of Maine in 2007.

GULF OF MEXICO

4 In April of 2017, **Dr. Beth Orcutt** and her team continued their observational study of the speed at which bottom-dwelling microbes in the Gulf of Mexico can degrade oil. This is a continuation of their long-term study of the impacts and fate of oil and gas released in the offshore waters of the Gulf of Mexico during the *Deepwater Horizon* spill.

4 **Dr. Christoph Aeppli** and his team went on three expeditions to beaches at Fort Morgan, Alabama, and Grand Isle, Louisiana, this spring to collect samples of oil remaining from the 2010 *Deepwater Horizon* spill and perform water quality analyses. This is a continuation of their study that started in 2010 to better understand how the various components of oil break down and change over time, and to determine the potential toxicity of the collected samples.

ATLANTIC OCEAN

5 In October, **Dr. Beth Orcutt** and her team will be spending a month at the Mid-Atlantic Ridge aboard the RV *Atlantis*. They will be using a remotely operated underwater vehicle, *Jason*, along with the RV *Atlantis* to visit subseafloor observatories and study life found in the deep biosphere of the oceanic crust.

6 **Dr. Elizabeth Mann**, a postdoctoral scientist in Benjamin Twining's lab, will be participating in the ZIPLOc (Zinc, Iron, and Phosphorous co-Limitation in the Ocean) cruise on the RRS *James Cook*. She will be sailing on an eight-week cruise leaving from Pointe-à-Pitre, Guadeloupe, in June and ending in Santa Cruz de Tenerife, Tenerife (Canary Islands). The aim of ZIPLOc is to gain a better understanding of how iron and zinc regulate the uptake of organic phosphorous, an important nutrient that can limit biological productivity.

7 In May, **Dr. Doug Rasher** went to the Dominican Republic to study the connection between fish biodiversity and reef health, specifically whether the diversity of herbivorous fish species supports the rate at which the herbivore community removes marine algae from the reef. Algae can be harmful to baby corals and can prevent a reef from recovering from disturbance. This work is important to increasing our understanding of the ecological role that biodiversity plays in nature, since it helps determine the conditions needed for corals to bounce back.

PACIFIC OCEAN

8 This summer, **Dr. Nichole Price**'s team will be conducting a three-week, NSF-funded study on the spread and severity of a coral reef fungal disease on Palmyra Atoll in the Central Pacific Ocean. Fungal disease, which episodically increases during extreme warming events, is one of many conditions impacting coral reef health and contributing to the rapid loss of coral ecosystems around the world.

ANTARCTIC

9 Starting last December, **Drs. Peter Countway** and **Paty Matrai** spent two months at Palmer Station in Antarctica to study the relationship between phytoplankton and bacteria. They aim to uncover the role a compound produced by certain phytoplankton plays in shaping microbial communities in the Southern Ocean. Read about their journey and research on page 9.

10 From the Pacific Ocean Aboard the RV *Sikuliaq* BY DR. JAKE BEAM

Being at sea keeps your feet on the ground — this sounds ridiculous but felt very fitting as we steamed across the nothingness of the North Pacific Ocean. Seeing the land disappear as we left port from Honolulu aboard the RV *Sikuliaq* brought relief and an almost immediate sense of tranquility and serenity. We were going to be at sea for 15 days, and I had never spent one night away from the comfort (or discomfort) of the continents. I had been gifted the wonderful opportunity to take part in a Chief Scientist Training Cruise sponsored by the National Science Foundation, and I intended to take it all in and leave all worries and anxieties back on Waikiki Beach.

There were no set research plans for this unique cruise, only a route laid out between Honolulu and San Diego that we had to complete by December 17. The only planned part of our itinerary was to make a "quick" stop at Station ALOHA just north of Oahu to collect some water for another scientist who was tagging along.

Before this training expedition, at the University of Hawai'i at Manoa, we learned the ins and outs of planning an oceanographic cruise, with a focus on marine geology — studying the seafloor from aboard a ship using instruments and sampling the seafloor by taking sediment cores. That is why I was there; I have an unhealthy obsession with the ocean floor and, in particular, mud. As a bonus, geologists are remarkably fun people to be around. We broke off into mini research groups and identified an interesting area to survey that was near our route.

Our cruise crossed a large section of the Pacific Ocean — the North Pacific Gyre — that has extremely energy-limited populations of microorganisms. The microbes in this region rely on wind-blown dust from continents that are thousands of miles away for their nutrients. This continental dust settles to the ocean floor at a very slow rate of about 1/1,000,000 of a meter per year. It is not every day that you're out in the middle of the Pacific, so I wanted to collect a sediment core of this mud to see what microorganisms are doing down in the eternal darkness of the seafloor.

While using gravity to drop an instrument 3.5 miles down to collect seafloor sediment sounds very easy on paper, it is, in reality, very difficult to accomplish. Fortunately for us, the *Sikuliaq* crew (and science party) is exceptional, and they deserve all the credit for successfully collecting that gravity core from the North Pacific Gyre.

In the end, my experience was about the science and also not really about the science — all the small interactions with the crew and science participants were what really made that cruise special. And as I sit in my office on this rainy spring day, I'm thinking less about the exciting scientific discoveries we might make with our samples as I am remembering the smiles on everyone's faces as the gravity corer came up out of the water covered in Gyre mud, and just reliving that moment.

Photo: Lauren Frisch

11 From Deep Underground in South Dakota BY DR. ROSE JONES

You might be thinking there is a mistake with the location, but my fieldwork really is that far inland. It is also around 4,100 feet below the Earth's surface, so approximately as far *down* as Saddleback Mountain in Maine is *up*. This study site is in the depths of an old gold mine — the former Homestake Mine, which is now the Sanford Underground Research Facility (SURF) in South Dakota.

It is not an obvious site for fieldwork at a marine research institute, but it is useful for accessing portions of Earth's crust. I look at the boundaries of *where* and *how* it is possible for life to exist, which applies equally to the deep continental and marine subsurface. Microbes can be found in these deep subsurface environments, but are they truly active? If so, how do they access resources from surrounding rock under crushing pressure, tight space, and total darkness? This research, funded by NASA's Astrobiology Institute (NAI), feeds into big questions about the role of Earth's vast but unfamiliar subsurface environment and about where we might look for life on other planets.

I LOOK AT THE BOUNDARIES OF WHERE AND HOW IT IS POSSIBLE FOR LIFE TO EXIST.

In order to look at these deeply buried microbes, you first have to reach them. So, every few months I head out to South Dakota along with other scientists from the NAI "Life Underground" team. We descend through hundreds of tons of rock in a rattling open lift, and then cart all our equipment through stygian tunnels illuminated only by the narrow beams of our headlamps.

Time is constricted, as the group has to work within established mine schedules. If something isn't done it may have to wait another three or four months before we can go back. Nevertheless, terrestrial sites like this one are much more accessible than deep marine sites, which require a ship and crew, a submarine or robot, and days of travel just to get on location.

In my experiments, water originating from deep within the rock flows over different rocks and minerals that are held within cylindrical containers. This encourages microbes from the deep water to set up home inside the cylinders, which allow for transport back to Bigelow Laboratory for further study.

The purpose of all this effort is to identify and understand the patterns between microbial communities on different minerals under the extreme conditions within the Earth's crust. This information is a starting point for working out exactly what these microbes are doing, how they might be doing it, and where they fit into a larger community.

I am currently processing samples and information from previous experiments and planning for the next installment of my journey to the center of the Earth. I am also looking forward to investigating the same questions at a site beneath the Mid-Atlantic in the near future — not quite 20,000 leagues under the sea, but close.

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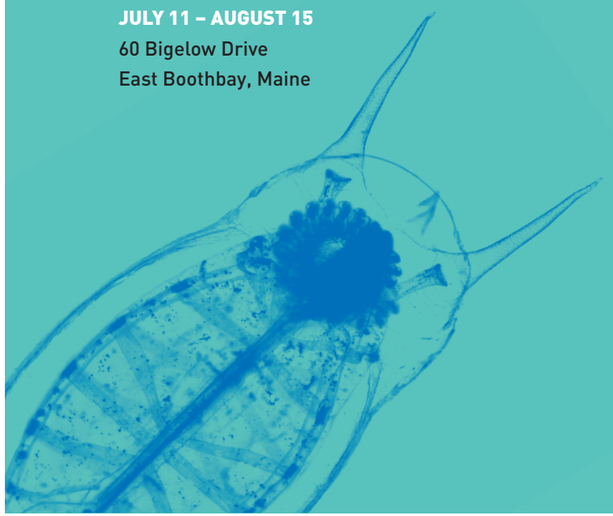

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