# TRANSECT

BIGELOW LABORATORY FOR OCEAN SCIENCES / SUMMER 2015 / VOLUME 7 / ISSUE 1

I am often asked, "Where do your scientists work? Is it the Damariscotta River or the Gulf of Maine?" Politely, but with great enthusiasm and terrific pride, I say... "In parts of the world's oceans where humans are very few and far between — or perhaps have never been." This edition of *Transect* brings our global activity to life. I was fortunate, with Beth Orcutt, to travel to the depths of the Pacific, over 3,000 meters down aboard the human submersible *Alvin*, to part of the seafloor previously unseen. Our scientists are conducting research all over the global ocean, with many in the Arctic Ocean, an area undergoing rapid and profound change. This year, the Arctic Council and its eight member countries will visit Maine, giving us an important opportunity to showcase our science and help inform deliberations.

The summer is a great time to be in the Laboratory (when not out on the ocean!). The atmosphere is energized by the influx of 20 undergraduate interns, most participating in the Research Experience for Undergraduates program sponsored by the National Science Foundation. This year, NSF extended support for this program for another five years, providing funding for ten students each year. Earlier this summer, 16 high school students participated in our 26th Keller BLOOM (Bigelow Laboratory Orders Of Magnitude) program, thoroughly enjoying their immersive experience into the world of planktonic and microbial oceanography. Just a few weeks ago, we signed a partnership agreement with North Yarmouth Academy to offer the BLOOM program to their students this fall.

To navigate the changing funding climate for environmental research, and ensure our work is both relevant and solution-oriented, we have published our new five-year Strategic Plan, which is available online. By investing in our scientists and staff and expanding our education and private sector activities, we will accomplish three key objectives: active participation in international scientific planning and global research programs, strengthening technology transfer and fee-for-service applications, and maximizing scientific communication with the public about why the ocean matters.

The work described in this issue is made possible by a combination of public research funds (NSF, NASA, Department of Energy, National Oceanic and Atmospheric Administration) and private individuals and foundations. Three new Founders have declared their support for our mission, joining the ongoing and vital support of charitable foundations. In this issue, we highlight the contribution to Maine's development provided by the Alfond Foundation, guided by the passionate commitment of its Chief Executive Officer Greg Powell. The Laboratory has greatly benefited from the Foundation's generosity. We are turning that investment into the next generation of scientific leaders committed to improving our understanding and relationship with the ocean.

I extend a very warm and personal invitation to you to participate in our summer public events — Café Scientifique on Tuesday evenings, public tour (August 14) and our Open House on July 31. Come to the Lab before the end of August to enjoy our traveling *Tiny Giants* photographic exhibit that reveals the wonder of microscopic life — microbes matter!

**GRAHAM SHIMMIELD,** PhD, FSB, FSRE

**THE COVER IMAGE**

Bigelow Laboratory scientists are at the forefront of investigating changes in the Arctic, as evidenced by melting sea ice pictured here.

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Carlton Rauschenberg, front and back covers, 6; Laura Lubelcyzk, 1; Paty Matrai 2-3; Carl Ballentine 4; Amy Kelly 5; Pete Countway 5, 17; Woods Hole Oceanographic Institution 7; Robert Mitchell 13-15; Allyson Fulton 13-14

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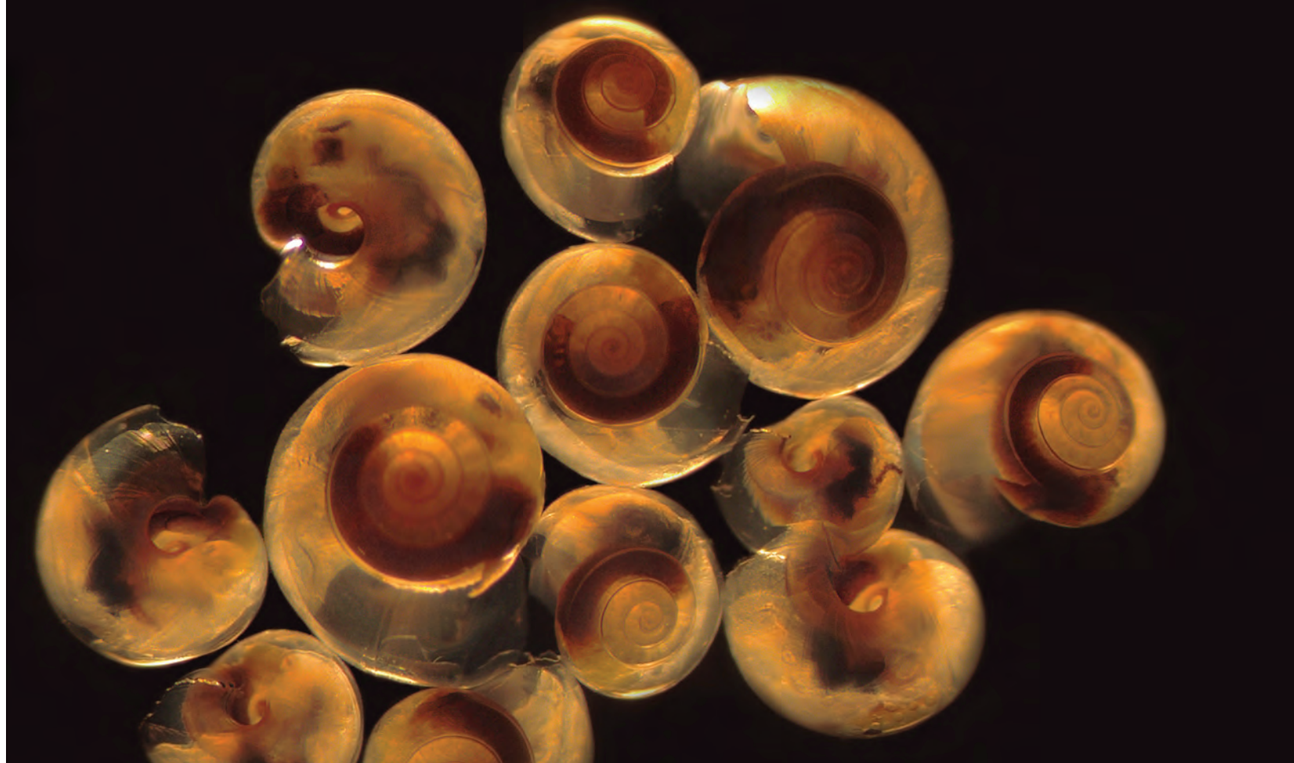


# Arctic changes are happening fast

BY DARLENE TREW CRIST/ALLYSON FULLER

Paty Matrai knows what it is like to be cold. During her seven trips to the Arctic Ocean and one to Antarctica, she has tried numerous types of gloves and mittens, "every type of sock known to humankind," and an assortment of extremity warmers to try to stay warm as she conducts field sampling near the the top of the planet or the high Arctic, mostly within the pack ice. Matrai is matter-of-fact about the physical discomfort and views it as simply being part of the important work of figuring out what is happening in the most rapidly changing place on the planet.

One aspect of Matrai's Arctic research looks at the question of how the ocean's surface and lower atmosphere interact and how this interaction may be affecting the climate. She pioneered and has overseen the deployment of 12 O-Buoys, which sample the Arctic's atmospheric chemistry automatically, sending huge swaths of data back to Matrai's lab. She was the first to develop this type of long-term automated, autonomous on ice sampling, which she started in 2007. This summer, four more O-Buoys will be deployed — two in the Beaufort Sea with the aid of a Canadian icebreaker and two in the East Siberian Sea from a Russian icebreaker.

Since their inception, the O-Buoys have collected significant data, which are immediately made publicly available. Matrai shares the collected data with colleagues around the globe, making it possible to create three-dimensional Earth system models to allow prediction of changes in the Earth's climate. Matrai has used Arctic data to reveal how aerosol-cloud interactions and other atmospheric processes are modulating the effects of climate change, yielding key insights into how the region, and especially Arctic marine microbiology, may fare in coming years.

**JUST BECAUSE THE OCEAN IS VAST AND DEEP DOESN'T MEAN THAT IT'S IMMUNE TO THE INJUSTICES OF MAN.**

This year, Matrai joined forces with Bigelow Laboratory colleague Christoph Aeppli to investigate the potential effects of oil in sea ice and in seawater under the ice in the Arctic. This work is particularly timely as the possibility grows of opening shipping channels and oil / mineral exploration in previously inaccessible areas. Matrai and Aeppli traveled to Shea, Svalbard in Norway in alternating months this spring. Their focus is on quantifying microbial composition and activity as a function of various oil treatments done in very controlled field experiments. They are also analyzing how microbes specific to the Arctic break down oil, and how microbial respiration might play a role in oil degradation should a spill occur.

Matrai collected samples from the water under the ice, and from water within the microlayer, a thin film immediately between the air and the water. Microorganisms that accumulate on this thin layer result in properties unique to that microenvironment, but few studies have looked at these interactions because of its hard-to-reach nature. Matrai explains that the microlayer is important because "it's the last boundary between a particle or a gas before it goes into the air" and influences critical atmosphere dynamics.

Matrai's vast experience working in the Arctic is being called upon to help craft and guide upcoming international research in this critical region. She is a member of the steering committee for the ArcticSTAR Initiative, with the goal of embarking on "Solution-oriented, TrAnsdisciplinary Research" for a sustainable Arctic. She is a principal investigator for Arctic-COLORS, which is striving to improve understanding and prediction of land-ocean interactions in the rapidly changing Arctic coastal zone.

Matrai was a key participant in an international workshop that came up with a plan to build international research partnerships to better and more cost effectively explore the North Atlantic and Arctic. And she also helped facilitate a workshop that planned upcoming joint U.S. and Swedish research in the Arctic using the Swedish icebreaker *Oden*. From her office in East Boothbay, Matrai has her hands in all aspects of Arctic research, even though she has yet to find the perfect mittens to keep them warm in the field.

# Challenges of conducting science in the cold

In May of this year, Dr. Christoph Aeppli, an environmental chemist and senior research scientist at Bigelow Laboratory, found himself in the middle of a frozen fjord on Svalbard, an island in the Arctic Ocean. A small coal mining community in this remote location is a hotbed for Arctic research. Aeppli had traveled there — his first time doing Arctic-related research — to find out whether Arctic microbes would behave similarly to oil-eating microbes known to exist in warmer waters. Aeppli is an expert on studying the fate of oil after spills and is shedding light on how and which microbes play a role in degrading oil when it finds its way into the environment. His previous work had been focused on the Gulfs of Maine, Mexico, and Alaska. On the Alaskan shores, using sophisticated gas chromatography equipment, he identified oil from the *Exxon Valdez* spill 25 years after it had occurred.

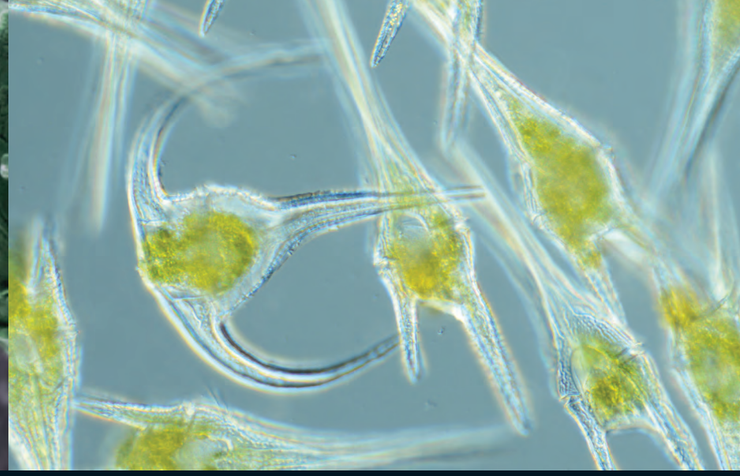
Aeppli disembarked from the plane in Longyearbyen, the capital of Svalbard — which has a population of only a bit more than 2,000 — and entered into an entirely foreign research environment. He had to accustom himself to the remoteness and unpredictable weather conditions that shaped both his research capabilities and everyday activities. In this frigid and pristine place, snowmobiles replaced cars, "night time" was replaced by 24 hours of brilliant sunlight, and the meaning of "safety" expanded to mean, "Look out for polar bears."

## SHEDDING LIGHT ON THE EFFECTS AND EFFECTIVENESS OF VARIOUS OIL SPILL RESPONSE

"In terms of doing science, everything is harder when it's cold," he explained. "This was especially true for me because I was collecting water samples to analyze how microbes specific to the Arctic break down oil. When the freezing temperature of water is -1.8°C and the air temperature outside is ten below, I could virtually watch my water samples turn to ice." Aeppli also had to reduce the size of the holes he would drill in the ice, so as not to make them too appealing for seals to use them as breathing holes (which would interfere with their measurements).

Aeppli's research will shed light on effects and effectiveness of various oil spill response techniques in Arctic conditions. His work and that of his Bigelow Laboratory colleague, Dr. Paty Matrai, with whom Aeppli is collaborating is part of the Arctic Response Technology Joint Industry Project (JIP) to enhance the ability to respond to oil spills in the Arctic if, and when, drilling occurs in this vulnerable area. Aeppli's work is helping to find answers to the important question, "What is the fate of oil in an Arctic environment?"





## TINY GIANTS ON THE MOVE

*Tiny Giants: Marine Microbes Revealed on a Grand Scale* debuted January 15 to a sold-out audience at District Hall in Boston, MA. This photographic exhibit highlights marine microbes invisible to the naked eye, in images taken by Bigelow Laboratory for Ocean Sciences scientists at three scales. Bigelow Laboratory, the New England Aquarium, and Women Working for Oceans co-hosted the January event. After enjoying the images, guests heard presentations from Drs. Graham Shimmield and David Emerson of Bigelow Laboratory and Drs. Nigella Hillgarth and Scott Kraus of New England Aquarium. The evening offered an opportunity to appreciate the intricate beauty of these tiny giants, and and to learn about their vital significance to our global environment.

From Boston, *Tiny Giants* moved to the Portland Public Library, where the exhibit was seen by thousands of visitors during the month of March. Special programming was held to accompany the exhibit, including a Café-Sci luncheon talk by Post-doctoral researcher Jarrod Scott on his exploration of marine microbiomes. Senior Research Scientist Beth Orcutt hosted an evening showing of *North Pond: Search for Intraterrestials*, a documentary that followed Orcutt and her colleagues on their quest for life in the deep ocean crust.

All summer long, *Tiny Giants* will be displayed at Bigelow Laboratory's Ocean Science and Education Campus in East Boothbay. The exhibit is self-guided using either a brochure or an app, for those who wish to view it in a green way. The Laboratory is open to the public from 8:30 am to 4:30 pm weekdays. Public tours are scheduled for July 17 and August 14 at 3:00 pm, with an Open House of the entire facility on July 31 from 10:00 am to 3:00 pm.

In the fall, *Tiny Giants* will move to Colby College, where it will be on display through the fall semester. Bigelow Laboratory scientists and Colby College professors from many disciplines are developing curriculum inspired by these tiny giants, with a culminating program at semester's end to share what was learned.

Planners of the Algal Bio Summit have requested that some *Tiny Giants* be displayed at this large annual international conference, which this year will be held in Washington, DC in September.

On October 10, select *Tiny Giants* also will be on display at Peabody Essex Museum as part of opening day festivities for its new exhibit *Nature and Scale*. Scientist and photographer Laura Lubelcyzk will be on hand to talk about the photographs and explain what life is visible using microscopes that will be part of the day-long opening.

Next summer's schedule is also shaping up with exhibits planned at the Portsmouth New Hampshire Public Library and at Waterfall Arts in Belfast, Maine. These numerous exhibits in a variety of locations are indeed helping to reveal these tiny giants — and the work of Bigelow Laboratory scientists — on a grand scale.

***TINY GIANTS** is a photographic art exhibit that brings the invisible world of marine microbes to life on a grand scale. It has captured the imaginations of many since its unveiling early in 2015.*


# Sharing cultures while exploring the Arctic

Voyaging up to the Arctic almost every year since 2008, Bigelow Laboratory Research Associate Carlton Rauschenberg has spent nearly 40 weeks — almost a year of his life — in this cold, desolate, and hard-to-get-to part of the planet. He has worked with colleagues aboard Canadian, Swedish, and Russian icebreakers, and since each expedition lasts a minimum of five weeks, his shipboard experiences have been culturally enriching ones, as well. The unpredictable tempo and rhythm of each trip depends as much on the international cooperation aboard the ship as on the ice formations that block the path to the Arctic Ocean.

As a member of Dr. Paty Matrai's Ocean and Atmospheric Chemistry research team, Rauschenberg's work takes place primarily on the ice. While travelling to deployment sites, he assembles the buoys and performs tests on equipment housed within the O-Buoy structure. O-Buoys, with a shape similar to a spar buoy, are equipped to measure ozone, bromine oxide, and carbon dioxide in the atmosphere, and a variety of seawater parameters such as pH, temperature, and fluorescence. Collectively, these data are providing scientists with the means to figure out how ocean-atmospheric interactions are affecting climate change. Typical deployment methods include shipboard cranes or helicopters. Once an ice-floe with optimal thickness and size has been located, the O-Buoy is transported to the deployment site where a 14-inch hole has already been drilled through 3 feet of ice. With the buoy placed in the ice flow, the remaining components are installed and the system is activated. These activities can be quite the challenge when language barriers impede the delivery of instructions such as up, down, left, right, slow, fast. "It is also handy to know a few important words such as 'bear and run,'" Rauschenberg says with a grin on his face. "You never want to make the bear guard unhappy." On some Russian icebreakers, a translator is key to successful operations and deployment.

Language barriers aboard the Russian ships can make for a lonely, long voyage: "It's just harder to get to know the crew in that situation," says Rauschenberg, but he also commented that regardless of the ability to communicate well, scientists do develop a camaraderie. He maintains that while at sea, "Your overall job description, and your main task, is to make yourself useful." Rauschenberg stressed that in the Arctic and similarly other remote places it is critical that scientists from different parts of the world work as a single team, especially when the unexpected happens. "At sea, regardless of rank or nationality, researchers and crewmates step up in the face of medical emergencies, warranting helicopter evacuations, or even bouts of seasickness that render scientists incapable of carrying out their work."

Aside from the challenges posed by different languages, Rauschenberg joked that food was the next biggest concern. "The Swedes and Canadians serve up food that is the most similar to Americans. But the Russians like their borscht and boiled beef tongue, and I tend to lose a fair amount of weight when I'm traveling with the Russians. One thing that always seems to resonate after a long expedition like this is no matter how different everyone and everything appears to be; that is exactly where the beauty of the situation can be found. I wouldn't trade it for the world."



# 3,000 meters below the surface

Since 1964 when the *Alvin* was first launched, the human submersible has made more than 4,600 dives, carrying two scientists and a pilot at a time to explore life forms at the bottom of the ocean. Four researchers (Pete Countway, Dave Emerson, Beth Orcutt, and Graham Shimmield) at Bigelow Laboratory have had the honor and opportunity to be *Alvin* explorers, joining an elite group of scientists who have seen the ocean depths close up.


FOUR BIGELOW LABORATORY RESEARCHERS ARE PART OF AN ELITE CORE OF *ALVIN* EXPLORERS.

On December 4th 2014, Graham Shimmield joined Beth Orcutt, lead scientist on the *Alvin*, on a journey to the seafloor to gather samples and data from the Dorado Outcrop in the eastern Equatorial Pacific. This was Shimmield's first dive. Accompanied by pilot Phil Forte, their journey took them over 3,000 meters, or nearly two miles down to the seafloor. The goal of the expedition was to understand how microbes influence the chemistry of water as it moves through the ocean crust, and the mission of the dive was to collect temperature loggers and fluid samplers placed during a prior mission, as well as to make new measurements of the fluid temperatures, and survey a newer location with small sediment cores.

The descent lasted nearly two hours, though after only ten minutes all visible light from the sun filtering down through the ocean had vanished. Bioluminescence and the glow of instruments provided light from that point on. The sphere containing passengers was tight—measuring only eight feet across, with much of the space taken up with equipment. This sphere, made of three-inch thick titanium, was all that protected the crew from the crushing pressure of the deep (2.2 tons of pressure per square inch). *Alvin* remained on the seafloor for about five hours, during which time Orcutt and Shimmield measured temperatures emerging from the thermal vent significantly warmer than the ambient water temperature.

Shimmield describes the highlight of the journey as the "octopus spa" where a colony of octopi clustered around the warmed rocks near the vent. For Shimmield the journey was his first, and offered an incredible opportunity to view first-hand the seafloor he has studied for decades, which in his words was "the experience of a lifetime."

## STARTED WITH SHOES

The history of the Alfond Foundation is a fascinating tale of Harold Alfond's vision, drive, innovation, and ultimate business and financial success. Alfond made his first million at the age of 30 when he sold the Norrwock Shoe Company only four years after he founded it. An ambitious young man, not content to rest on his laurels, Alfond next purchased an old mill in Dexter, Maine and, with his family, built Dexter Shoe Company into a manufacturing powerhouse.

Alfond pioneered the factory outlet store when he began selling factory seconds and outdated lines, and later top-quality shoes, at his Skowhegan plant. At its peak, the Dexter Shoe Company had more than 80 outlet stores nationwide, employed nearly 4,500 people, manufactured over 36,000 pairs of shoes daily or more than 7.5 million annually. The success of Dexter Shoes caught the eye of noted investor Warren Buffett, whose firm Berkshire Hathaway purchased the company for stock in 1993.

Harold Alfond and his wife Bibby established the Harold Alfond Foundation in 1950, the first private charitable foundation established in Maine. He and his wife passed on nearly all of their personal wealth to the Foundation, subsequently enhancing the lives of many in Maine by supporting projects that enhance education, health care, youth development, and other charitable causes that serve to advance the state of Maine. Alfond liked to say, "I'll retire ten years after I'm dead." The Harold Alfond Foundation is his lasting gift to the state of Maine.



# PROFILE Gregory W. Powell

Chairman, Board of Trustees, Harold Alfond Foundation

## INNOVATION, ENTREPRENEURIAL SPIRIT RESULT IN BIGELOW LABORATORY GRANT

Harold Alfond, founder of Dexter Shoe Company, handpicked Greg Powell to oversee the investment of his personal funds and, subsequently, how they would be spent to benefit the state of Maine. Having watched Powell grow up in Waterville, Maine and his subsequent law career unfold, Alfond asked Powell, during one warm summer day of golf in 1995, to help him start a wealth management office for his family and to help him with his philanthropy. Powell accepted, assumed the position of Chief Executive Officer and President of Dexter Enterprises, Inc., and never looked back.

The Harold Alfond Foundation has evolved into an innovative philanthropic organization significantly enhancing education, health care, and youth opportunities in the state of Maine. Led by Powell as Chairman, the Foundation's Board of Trustees consists of Alfond's sons and nephew, who had helped lead Dexter's success, and other highly skilled and committed individuals, some of whom Harold Alfond knew well and selected personally. As a group, the Trustees have deep expertise in finance, business, law, governance, education and non-profit stewardship.

Powell says, "Our philosophy at the Foundation is to make grants that are in the best interests of Maine. With Maine's limited financial resources, the way you get things done is through teamwork, through partnerships, through pulling institutions together, and getting groups to work together so that you can achieve excellence."

A very important part of the Foundation's work is to encourage collaboration and cooperation between and among high quality Maine institutions so that the Foundation is able to leverage maximum benefit to the state and its people. Powell cited the Bigelow Laboratory partnership with Colby College as an example of how partnering can benefit everyone and maximize success.

In 2013, Bigelow Laboratory for Ocean Sciences directly benefited from a grant from the Harold Alfond Foundation that enabled support for additional research scientists to meet the economic model of the research laboratory on the banks of the Damariscotta River in East Boothbay. Powell explained that Bigelow Laboratory was funded for many reasons: "Bigelow Lab is an up and coming institution that has great potential to add to the value of the state of Maine. It's got its own niche. It has high quality people. It is entrepreneurial."

Powell recited a fairly long list as to how and why Bigelow Laboratory fits the Harold Alfond Foundation's mold, ranging from the Laboratory's affiliation with Colby College to its commitment and contribution to the state of Maine through its investment in a new campus, to the quality of its leadership, scientists, and staff.

"The relationship between Bigelow Laboratory and Colby College was an indication to us that Bigelow was working to improve the state of Maine and be a good neighbor and friend and be a catalyst for enhanced educational opportunity and economic development," he explained. "It didn't take a lot to prove that the research Bigelow was doing was very important and of high quality. The institution had shown great foresight and guts in building a terrific facility in a beautiful location. It also has an excellent board, executive director, and staff. So all of those compelling characteristics were very attractive to us. Together with its outreach to other educational institutions within the state, Bigelow is a particularly attractive place for us to invest our money."

This year, Powell marks his twentieth year since that fateful warm summer day when he shared a round of golf with Harold Alfond. Bigelow Laboratory for Ocean Sciences is but one of many institutions that have benefited greatly from the Harold Alfond Foundation's innovation and commitment to improving the state of Maine.

# Six new things happening at the Single Cell Genomics Center


**1 UNTANGLING THE GENEALOGY OF MICROBIAL DARK MATTER** Dr. Ramunas Stepanauskas and his team are searching as far as two-and-one-half miles underground in South Africa to find and study microbes that have never been exposed to conditions on planet's surface. Analyzing the samples using single-cell genomics technology, the team will reconstruct the evolutionary relationships among bacteria and archaea, providing insights into the early life history of the planet. The research is part of the National Science Foundation's GoLife program.

**4 SCGC DIRECTOR ACCEPTS NOT ONE, BUT TWO HONORABLE AWARDS** Stepanauskas traveled to his native Lithuania to accept the Lithuanian Ministry of Science and Education award for achievements in science. During the same week, Stepanauskas was named a "Nexter," one of the ten people shaping the future of Maine's economy. MaineBiz selected Stepanauskas in recognition of his work in identifying secrets of microbial life in the deep ocean, and his global collaborations.

## SCGC HAS LED TO MAJOR DISCOVERIES IN MICROBIAL ECOLOGY, EVOLUTION, AND BIOPROSPECTING

**2 INSTRUMENT ACQUISITION INCREASING RESULTS, REDUCING COST** SCGC's recent acquisition of new instrumentation has vastly improved the efficiency of genomic sequencing and enhanced the recovery of DNA from individual cells. This new instrumentation, made possible by grants from the National Science Foundation and Illumina, has a two-fold benefit — an eight-fold reduction in cost for large whole genome sequencing projects, and a dramatically shorter completion time. The Department of Energy's Joint Genome Institute was the first to take advantage of SCGC's new multiplexed sequencing technology. The Institute is collaborating with SCGC on the sequencing of 384 single amplified genomes.

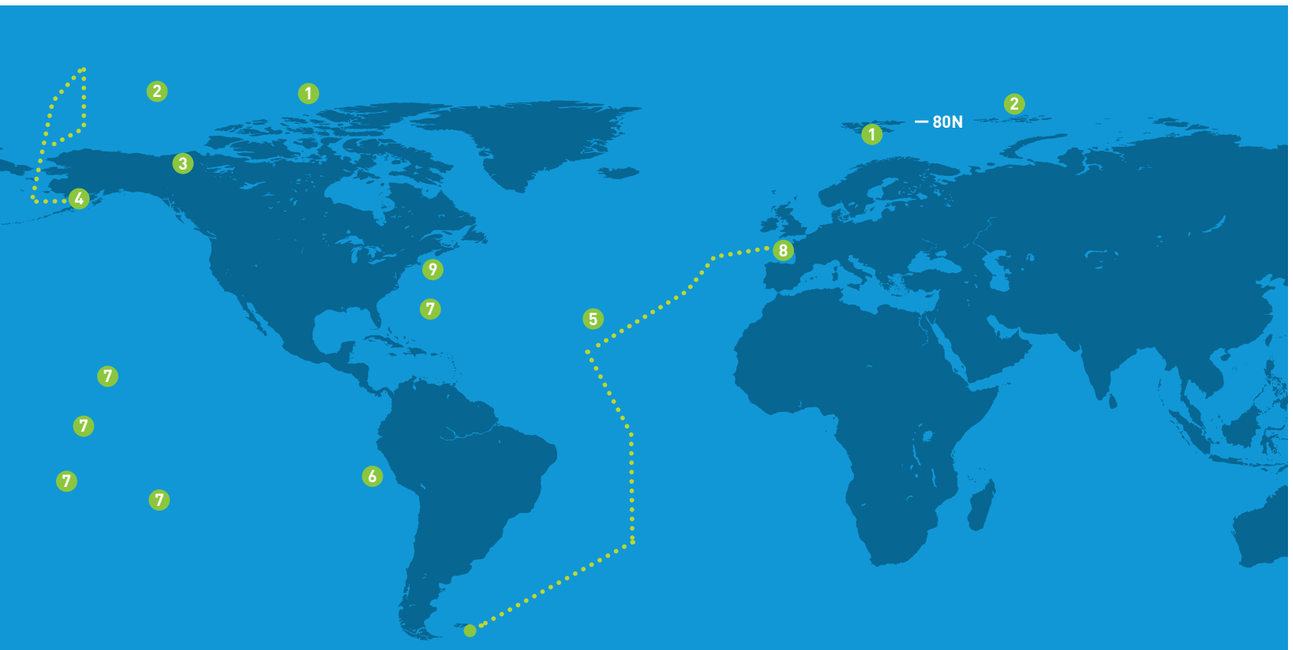
**3 SCGC CELEBRATES ITS FIVE-YEAR ANNIVERSARY** SCGC marked its fifth anniversary last year. As the first of its kind in the world, SCGC has led to major discoveries in microbial ecology, evolution, and bioprospecting. Since its establishment in 2009, SCGC developed partnerships and supported research projects at over 100 universities, research institutes, and companies in six continents. Over 1,000,000 individual cells have been processed through SCGC's high-throughput pipeline. Recent advances in efficiencies of genome sequencing and better recovery of DNA from individual cells are providing deeper understanding of natural microbial populations and improved prediction of their response to ongoing global change.

**5 THIRD ANNUAL MICROBIAL SINGLE CELL GENOMICS WORKSHOP** SCGC hosted its Third Microbial Single Cell Genomics Workshop in Boothbay Harbor, Maine on June 14-18, 2015. The workshops brought together over 70 participants from 15 countries to exchange research results, methods and ideas to advance the field of single cell genomics. Workshop participants had the opportunity to learn about the latest developments in flow cytometry, microfluidics, nucleic acid amplification, genomic sequencing, bioinformatics, and other SCG-related technology, as well as associated discoveries in ecology, evolution, biogeochemistry, and human health.

**6 NEW ADDITION TO SCGC ADVISORY BOARD** Dr. George Garrity is the newest member of SCGC's Advisory Board. Garrity is a professor of Microbiology and Molecular Genetics at Michigan State University and a co-founder and managing member of NamesforLife, LLC, a bioinformatics spin-off that was formed to commercialize proprietary terminology tracking and management technology developed at MSU. He is also a Fellow of the American Association for the Advancement of Science and the Society for Industrial Microbiology and Biotechnology, Chair of the SIMB Publications Committee and president elect, and the 2011 recipient of the van Niel International Prize for Studies in Bacterial Systematics.

# FIELD WORK

This summer and beyond, Bigelow Laboratory for Ocean Sciences researchers will be in many parts of the global ocean, collecting samples and making measurements for their ongoing research. Here's a sampling of upcoming expeditions:




## ARCTIC REGION

### 1 Oil in the Arctic

In May, **Dr. Christoph Aeppli** traveled to Svalbard, an island in the Arctic Ocean, to look at possible effects of oil in open water in the Arctic. Aeppli's research focuses on how microbes that are unique to this region of colder temperatures and sea ice might respond to an oil spill. Aeppli and Dr. Paty Matrai are working together on a project for The Arctic Oil Spill Response Technology Joint Industry Project, with the goal of improving the technologies and methodologies for Arctic oil spill response.

### 2 Arctic data collection

Senior Research Scientist **Paty Matrai** also is overseeing the deployment of four more O-Buoys, which gather atmospheric data while placed in sea ice in the Arctic. Research Associate **Carlton Rauschenberg** will leave for Kirkenes, Norway in mid-August to board the Russian icebreaker RV *Akademik Treshnikov*, where he will spend two months. Rauschenberg will be deploying two O-Buoys on the sea ice in the East Siberian Sea that will continuously and autonomously gather data. The atmospheric data makes it possible to analyze pan-Arctic scale patterns in Arctic air quality and long-term atmospheric trends in atmospheric chemical composition across seasons and years.

### 3 Methane in Arctic lakes

Methane is a potent greenhouse gas, which is expected to increase from Arctic sources as the climate continues to warm. Senior Research Scientist **Beth Orcutt** is headed to the Canadian Arctic in August to deploy autonomous sampling devices initially tested in the deep ocean to measure methane concentrations of lakes in the Mackenzie River Delta. Continuous sampling will occur for nine-months, spanning the previously under-sampled winter season, when the lakes are covered by ice, and the dynamic spring thaw period. Orcutt and her colleagues' work is designed to aid understanding of the changing amounts of methane in the Arctic atmosphere, a heat-trapping gas 25 times more potent than carbon dioxide, and to examine the role that microbes play in generating and consuming methane in the environment.

### 4 Newly introduced nutrients

The USCGC *Healy*, the U.S. Coast Guard's newest and most technologically advanced icebreaker, will head off to the Arctic Ocean at the start of August as part of a project to collect particulate trace metal samples from the Bering Sea up to the North Pole. For 65 days, Research Associate **Sara Rauschenberg** will be aboard *Healy* working with Co-Principal Investigator Peter Morton from Florida State University. They will be measuring particulate substances that have washed into the ocean and sending back data to Senior Research Scientist **Ben Twining** here. As increasing air temperatures are progressively melting the Arctic permafrost, nutrients that have been trapped in the ice for thousands of years are now flushing into the Arctic Ocean at a much faster rate than ever before. This newly released material may have significant effects on the carbon cycle, with subsequent effects on climate.

## GLOBAL WATERS

### 5 Ocean drilling in mid-Atlantic

On October 24, Dr. Beth Orcutt will board the UK's Royal Research Ship *James Cook*, where she will spend two months as co chief-scientist of an ocean drilling expedition to the Atlantis Massif on the Mid-Atlantic Ridge, which is about midway in the Atlantic Ocean between North America and Africa. Her research will focus on the nature and distribution of microbial communities in rocks beneath the seafloor, one of the largest potential habitats for microbial life on Earth. This expedition is unique in several ways, as it is the first in the history of the international ocean drilling program to use seabed rock drills, and to have a shipboard crew comprised of two-thirds female scientists and led by two female co-chief scientists.

# SAMPLING THE GLOBAL OCEAN TO AID UNDERSTANDING OF HOW MICROBES AFFECT OCEAN PROCESSES

### 6 Ocean chemistry and phytoplankton

For most of October, Senior Research Scientist **Mike Lomas** will be studying the complex relationships between ocean chemistry and phytoplankton biology off the coast of Peru. In studying how the relative proportion, of carbon, nitrogen, and phosphorus in phytoplankton interact with the changing biogeochemistry of the ocean, Lomas' recent work has challenged the long-standing Redfield Ratio, first described by American oceanographer Alfred C. Redfield in 1934. Analyzing these relationships in the unique waters off the coast of Peru is a step toward understanding whether the physiologies of phytoplankton are capable of impacting the biogeochemical carbon pump of the global ocean.

### 7 Indicators of ocean acidification

Senior Research Scientist **Nichole Price** is working with a team of international collaborators who are generating ocean acidification data across 45 degrees latitude in the Pacific (from Tahiti, to American Samoa, to Palmyra Atoll, to Hawaii) and to Bermuda in the Atlantic Ocean. Price is using this data to explore how highly sensitive calcium-containing seaweeds, coralline algae, respond to variations in pH concentrations over space and time. To access these remote study sites, Research Associate **Emily Donham** has participated in her own, personal "Amazing Race" over the past year — boarding research vessels, chartering planes, and traveling internationally — to collect algal samples for later analysis in Price's Laboratory. The coralline algae samples reflect recently experienced environmental conditions, providing a tool to retrospectively explore the changing chemical landscape of the ocean.

### 8 Groundtruthing satellite data

From September to November of 2015, Postdoctoral Researcher **Catherine Mitchell** of the Balch Laboratory will be aboard the British Antarctic Survey vessel, RRS *James Clark Ross*, as it makes its 25th transect of the Atlantic Ocean from the UK to the South Atlantic. The ship will depart from the port of Immingham, UK and arrive in Port Stanley, Falkland Islands some eight weeks later. While aboard, Mitchell will be validating satellite remote sensing data via on-the-ground measurements of particulate inorganic carbon for NASA.

## GULF OF MAINE

### 9 DMS gas and ocean acidification

This summer and into fall, Senior Research Scientists **Steve Archer**, **Pete Countway**, and **Paty Matrai** are collaborating to study to study the interaction of ocean acidification with the metabolism of dimethylsulfoniopropionate (DMSP) by marine microbes, producing the gas DMS. DMS, when released into the overlying air, is capable of altering cloud processes that dictate patterns of heat on Earth. The research team has already quantified these interactions in Arctic and tropical waters and will continue experiments in July and September using Bigelow Laboratory's 3,000-liter mesocosms with coastal waters from the Gulf of Maine.

### 9 Marine food webs

Senior Research Scientist **Pete Countway** also will be working with samples collected from the McKown Point dock in West Boothbay as part of a project to characterize plankton community dynamics and the effect of protistan grazers on blooms of some of the smallest marine phytoplankton. These small phytoplankton (< 2-3 um) are the first link in many marine food webs, yet very little is known about the identity of the grazers that may control the timing and magnitude of phytoplankton bloom formation. Sampling from the dock in West Boothbay has been ongoing for the past 14 years and forms an increasingly important baseline data set given the predicted changes to environmental conditions in the Gulf of Maine.

### 9 Harmful cyanobacteria

**Dr. Countway** is also collaborating with Drs. Denise Bruesewitz and Whitney King of Colby College to investigate the harmful cyanobacterium Gloeotrichia in the Belgrade Lakes Region of Maine. Countway is investigating the genetic diversity of Gloeotrichia and the overall diversity of the microbial community, while his Colby colleagues will measure nitrogen fixation and characterize the physical and chemical status of the lakes. The team will use Bigelow Laboratory's analytical facilities to measure cyanobacterial toxins.

### 9 NASA/*Nova Star* sampling

The longest running time series of coastal phytoplankton productivity in the nation (38 years) will continue this summer under the direction of Senior Research Scientist **Barney Balch**, with the support of his Bigelow Laboratory team aboard the *Nova Star* Ferry. Once each month in the summer, Balch and his team take water samples while aboard the *Nova Star* during its crossing from Portland, Maine to Yarmouth, Nova Scotia. The research team provides groundtruthing for NASA satellites, while collecting data that are providing valuable insights about the long-term oceanographic carbon cycle changes in the Gulf of Maine. This long-term sampling transect will be done aboard the RV *Connecticut* during the fall and winter months.

### 9 Restoring eelgrass beds

Eelgrass was once abundant in Casco Bay, but coverage has declined dramatically over the past decade, likely impacting how the ecosystem functions. In collaboration with Hilary Neckles from the US Geological Survey and Mike Doan from Friends of Casco Bay, Senior Research Scientists **Nichole Price** and **Nick Record** and Research Associate **Emily Donham** are conducting a pilot study from July-August in Casco Bay. The study, funded by the Nature Conservancy of Maine, will help define the role eelgrass beds may play in improving water quality and mitigating localized acidification believed to be responsible for pitting and dissolution of Maine's clams.

### 9 Warming and keystone plankton

Productivity of many commercial fish and protected mammal species in the Gulf of Maine is tied to a keystone plankton species, C*alanus finmarchicus*, a critical source of lipids in these cold waters. This copepod is at the southern edge of its range in the Gulf of Maine, and some scientists have predicted that it will shift northward in a warmer ocean. Despite recent rapid warming, *C. finmarchicus* has persisted and even thrived. Senior Research Scientist **Nick Record** is monitoring this species and the related environmental conditions on monthly cruises for the next two years. The goal is to understand the processes underlying the unexpected persistence of *C. finmarchicus*, and to form better predictions of the effects of changing conditions on this species and consequently on the Gulf of Maine ecosystem.

### 9 Oyster stock

Senior Research Scientist **Peter F. Larsen** will be continuing his seven-year documentation of native oyster populations in Maine. Throughout the summer, he and Dana Morse of the UMaine Cooperative Extension will visit know populations in the headwaters of the Sheepscot and Damariscotta estuaries to ascertain their continued existence and evaluate their population size to determine how they are faring in the warm water of the last few years. Anecdotal reports indicate that the populations have been reproducing successfully and healthy oysters of several year-classes exist. If confirmed, this observation would be consistent with the warm-water periods of the 1950's and the 19th century when oysters were a viable and exploited marine resource.

# GIVING Founders grow to 15


## WAYS TO GIVE

Would you like to contribute to our 2015 Annual Fund? We offer several easy ways to make your fully tax-deductible donation:

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Bigelow Laboratory
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*"We are very grateful for the support of the Lerners, Throns, and the Alfond Foundation. Their support makes it possible for us to carry on research that is critical at this time of ongoing global changes," said Laboratory Executive Director Graham Shimmield. "Their support also has the ancillary benefit of investing in local communities, as our staff lives, works, shops, and contributes to the fabric of the Boothbay Peninsula and region."*

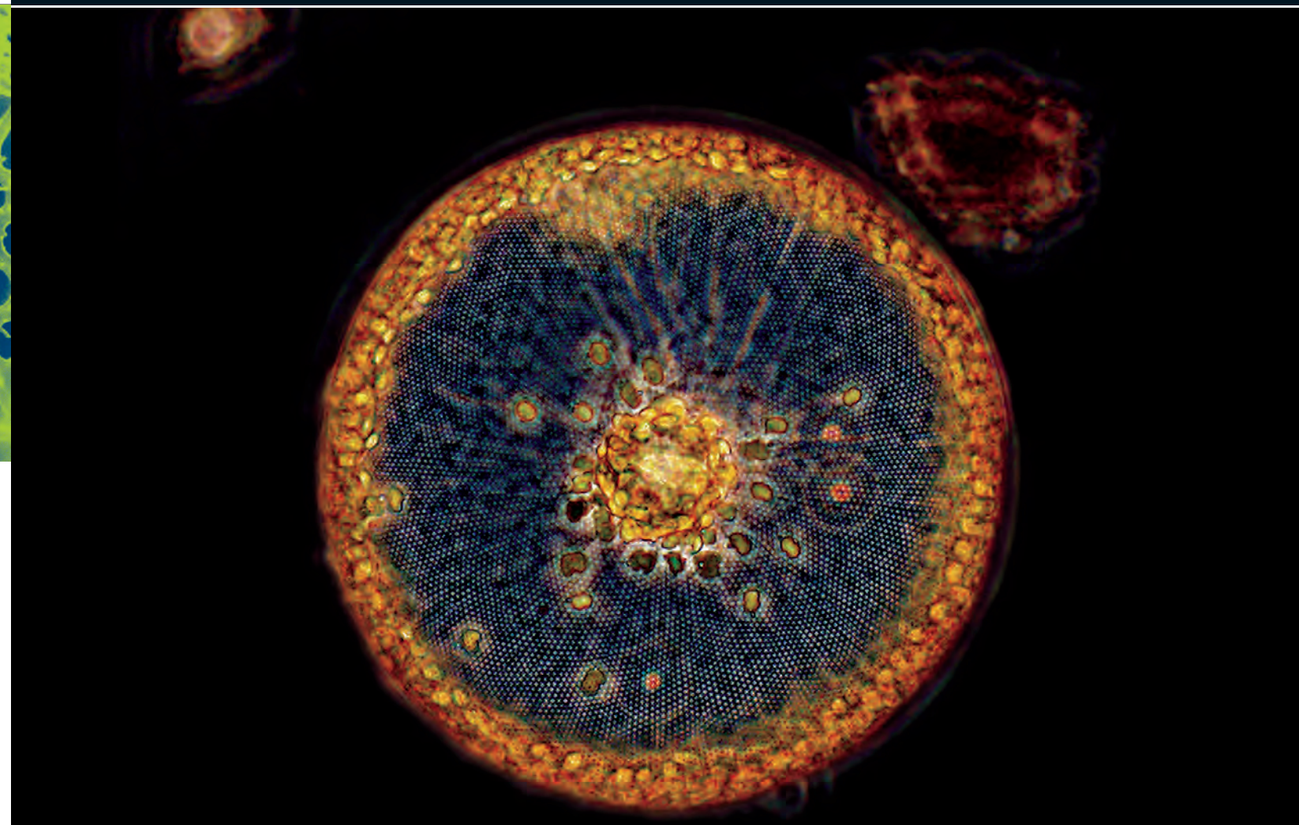
Bigelow Laboratory has gained three new "Founders," bringing the total number of Founders to 15. The Founders Campaign was established in 2010 to support the Laboratory's expanding operations and implementation of its strategic plan as it opened its new campus in East Boothbay in 2012. Thanks to the generous support of the three latest Founders — Lyn and Daniel Lerner, Anna Marie and John E. Thron, and the Harold Alfond Foundation — Bigelow Laboratory can continue advancing what is known about the global ocean, how it works, and the important role marine microbes play in maintaining planetary balance.

The Founders Campaign is limited to the first twenty donors who provide unrestricted support of $250,000 or more to the Laboratory. A permanent display is in the works that will prominently identify the Founders and the key role they play in supporting research that is essential to the future use of the ocean.

More information about the Founders Campaign is available by calling Dana Wilson at 207-315-2567, ext 112 or via email at dwilson@bigelow.org.



# MAGNIFICATION



**NATURE AS A TEMPLATE FOR MODERN DAY SOLUTIONS**

Light-harvesting green chloroplasts are distributed throughout the cylindrical diatom *Coscinodiscus*, depicted above. The energy that diatoms harvest from the sun make them giants of the microbial world — some in a test tube of sea water are even visible to the naked eye, with individual cell dimensions of nearly half a millimeter! This top-down view shows the nano-scale architecture of its silica skeleton, which is so efficient at collecting light that engineers are copying it in solar panel designs.

Bigelow | Laboratory for Ocean Sciences

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Bigelow Laboratory for Ocean Sciences is materially advancing what is known about marine microorganisms and how they affect global ocean processes. What we are learning is essential to the future of the ocean and the many valuable resources it provides.

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