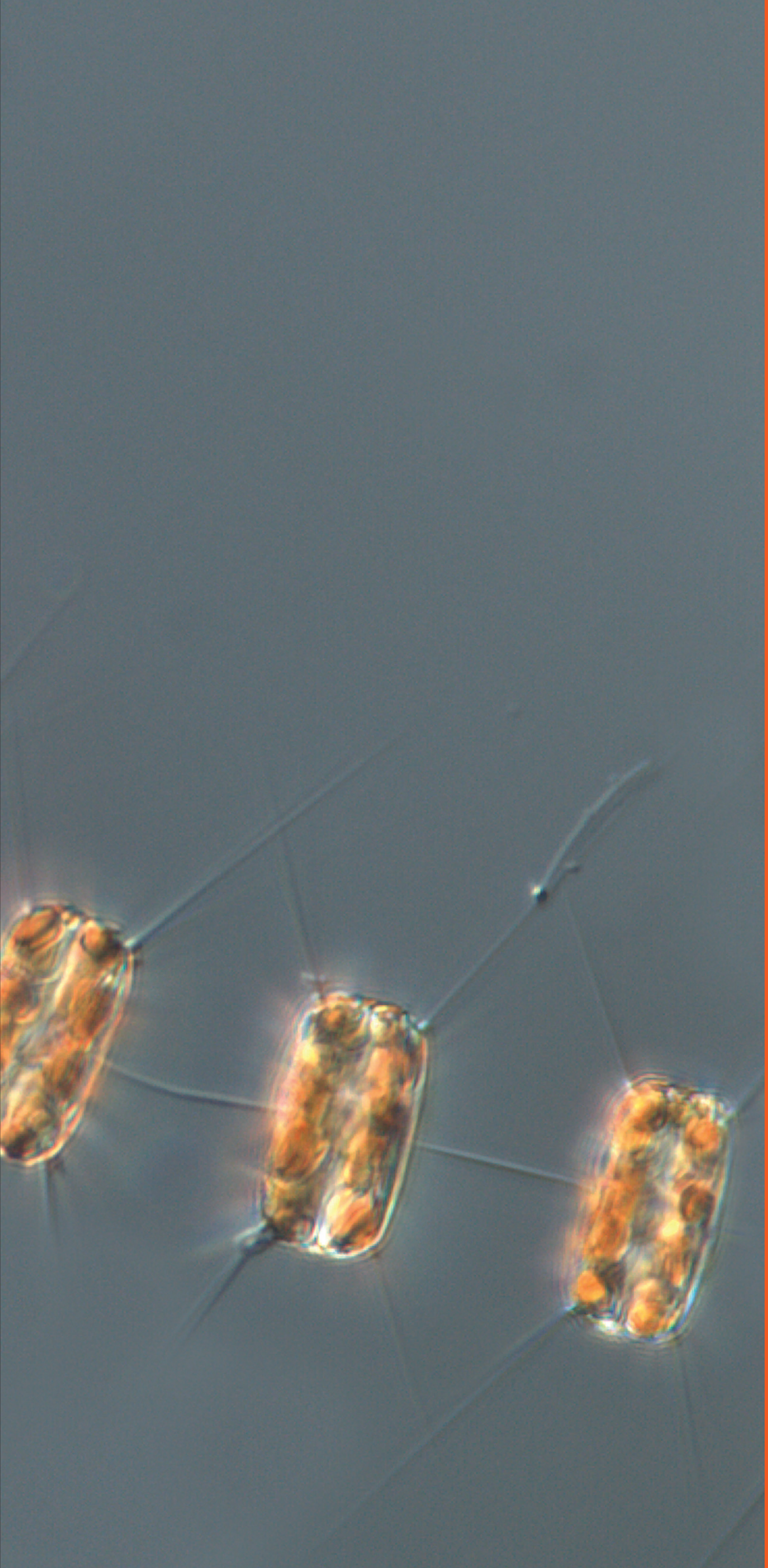
Bigelow | Laboratory for Ocean Sciences

2015 ANNUAL REPORT

TINY GIANT

Floating chains

Phytoplankton like these diatom cells obtain energy through photosynthesis and must stay afloat in the top layer of the ocean where sunlight penetrates. They have developed strategies to minimize sinking such as increasing surface area by forming long chains and possessing spines to increase drag.



STRATEGIC ACTIONS

- Increase the involvement, visibility, and support for our Senior Research Scientists and their staff
- Actively participate in international scientific planning and global research programs
- Strengthen technology transfer and fee-for-service applications
- Improve communication and public outreach to explain why the ocean (and microscopic life) matters

STRATEGIC RESULTS

By 2020, Bigelow Laboratory will have:

- An enhanced international reputation for scientific excellence
- Expanded funding sources to allow continued discovery
- A thriving practice as an applied research partner
- Informed public opinion and policy on ocean issues
- Recognition as an important contributor to Maine and beyond

GREETINGS—

2015 was indeed a very good year for Bigelow Laboratory for Ocean Sciences. Our scientists continued to significantly contribute to the understanding of how the global ocean functions, and the vital role played by its tiniest inhabitants—marine microorganisms.

While acknowledging the success of the present, this year we also began planning for the future. The Board of Trustees and Senior Research Scientists unanimously endorsed a detailed strategic plan that outlines specific ways the Laboratory will advance and grow its research, education, and enterprise activities through 2020.

Through implementation of this thoughtful and forward-looking roadmap, I am confident that the Laboratory will continue as a global leader in microbial oceanography and as a preeminent ocean research and education institution. Its tenets provide the means for us to advance knowledge about marine ecosystems, develop innovative scientific applications, and share knowledge to help educate and inform decision making over the next five years and beyond.

Sincerely,

Herbert Paris
Chairman, Board of Trustees

TINY GIANT

Predator in pink

Unlike other dinoflagellates, the pink-tinged *Protoperidinium* is capable of capturing and digesting cells much larger than its size by excreting cytoplasm to envelope and digest prey outside of its body.

YEAR AT A GLANCE

PEOPLE

84 employees

16 Senior Research Scientists

12 Postdoctoral Researchers

18 Research Experience for Undergraduate students

419 donors who support our research

VISITORS

600 guests at the open house

1,200 attendees at *Café Scientifique*

~10,000 viewers of *Tiny Giants*

PLACES

Conducted research in **EVERY OCEAN BASIN** from pole to pole

BOTTOM OF THE OCEAN
Beth Orcutt, senior research scientist, invited Graham Shimmield along for a ride aboard the submersible *Alvin*

TOP OF THE WORLD
Research Associate Sara Rauschenberg was aboard the USCG *Healy* as it made its historic crossing of the North Pole, the first U.S. ship to do so alone

SUCCESSES

Proposal submission success rate of **25 PERCENT** (national average is 15-18 percent)

20 PROPOSALS officially funded in 2015

NEARLY $1 MILLION in Office of Research, Commercialization, and Applications

KELLER BLOOM PROGRAM EXPANDED to North Yarmouth Academy

Research Experience for Undergraduates program **EXTENDED FOR FIVE YEARS**

Bigelow Laboratory's NCMA **LEADING** statewide algal cluster

PUBLICATIONS

90 PAPERS in peer-reviewed journals (~two/week)

Organized **FOUR SPECIAL EDITION JOURNALS** and contributed to two others

Output in peer-reviewed publications is **GREATEST IN LABORATORY'S HISTORY**

AWARDS

GRAHAM SHIMMIELD received the Society for Underwater Technology's President's Award for his contributions to oceanography and was named one of 50 bold visionaries in the State of Maine by *Maine Magazine*

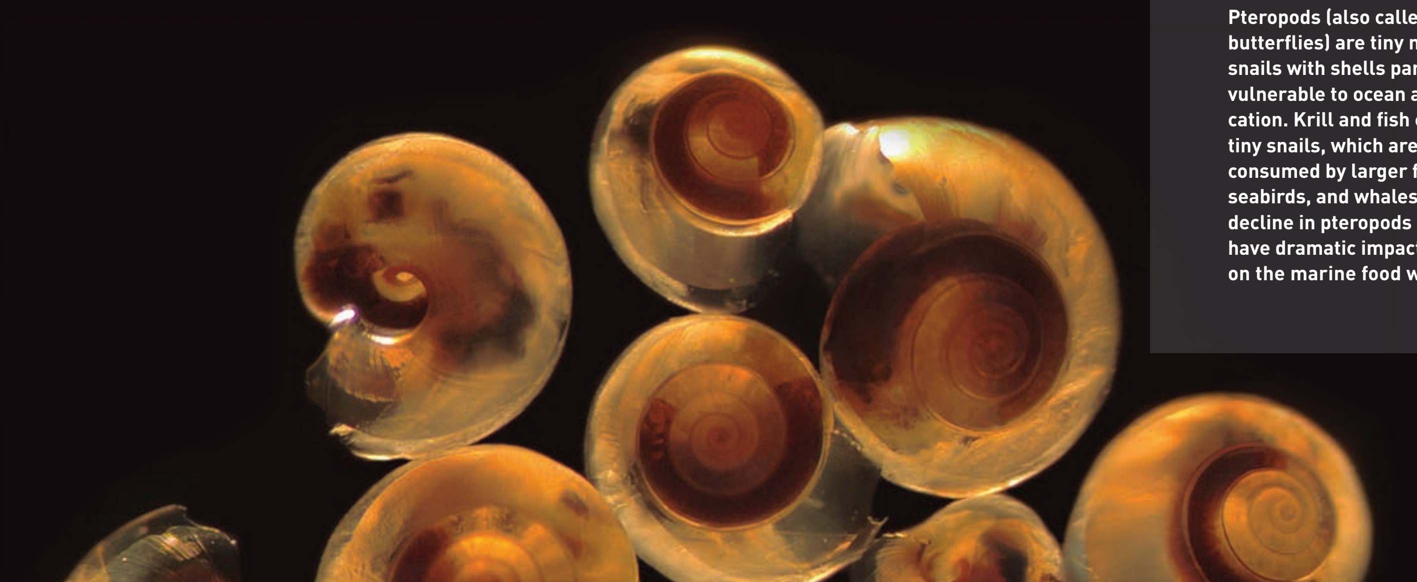
RAMUNAS STEPANAUSKAS received the Lithuanian Ministry of Science and Education award for achievements in science and was designated by *Mainebiz* as a *Nexter*, one of the ten people shaping the future of Maine's economy

BUILDING RECEIVED SEVENTH DESIGN AWARD for its sustainable design in an international competition among 40 applicants from nine countries

TINY GIANT

Last flight of the sea butterfly

Pteropods (also called sea butterflies) are tiny marine snails with shells particularly vulnerable to ocean acidification. Krill and fish eat these tiny snails, which are then consumed by larger fish, seabirds, and whales. A decline in pteropods could have dramatic impacts on the marine food web.



AS WE MOVE INTO THE LABORATORY'S FIFTH DECADE, 2015 IS A YEAR THAT STANDS OUT AND IS ONE THAT I FEEL MARKS A REAL RENAISSANCE IN THE REPUTATION AND MISSION OF THE LABORATORY.

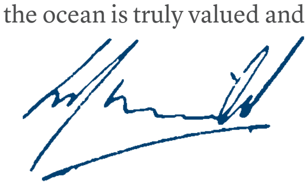
The opposite page gives the statistics, but I would like to add some color. I am immensely proud of the global reach of Bigelow Laboratory scientists and the projects they work on. From the deepest parts of the ocean— discovering and quantifying the role of unique microbiology—to the apex of the planet where change is so dramatic that vessels can travel independently—to defining the "new ocean" where biogeochemistry is responding rapidly, they are significantly advancing knowledge about the global ocean.

Our basic science mission is strong and productive. New proposals are being funded at a rate substantially above the national average, while the output in peer reviewed publications is the greatest in the Laboratory's history. Ensuring that both input and output of publicly funded basic science are nurtured is crucial in these days of fiscal probity. There is an important additional obligation in return for the public entrustment of these resources, however, namely the communication and illumination of why this work matters. We now deliver real public engagement through community presentations, the acclaimed *Café Scientifique* summer program and the blockbuster *Tiny Giants* visual experience, which reveals the exquisite detail and beauty of the organisms that help drive the planetary engine on which we all depend.

I want to emphasize that the connectivity from proposal to public engagement is not accidental. It takes real teamwork, planning, and commitment from all involved, but the result transcends the basic scientific data to capture the imagination and provide the insight as to why our society should value knowledge and informed discussion.

This year is also important personally as it marks my 20th year as a director of independent oceanographic institutions. Making the jump from a research academic with a full portfolio of projects, keen students, and post-docs to managing the ambition, reputation, and welfare of dozens of people from all backgrounds has been immensely rewarding.

Bigelow Laboratory in 2015 has demonstrated the very best in what small, dedicated, passionate, independent research institutions are capable of accomplishing. Our impact in basic science, education, public opinion, and community economic improvement is exceptional. I am so proud of what our entire community of scientists, technicians, support staff, trustees, students, and benefactors have achieved. In 2016, I am committed to leading Bigelow Laboratory as it continues to make important inroads to ensuring the ocean is truly valued and respected in our society.



Graham Shimmield
Executive Director and President

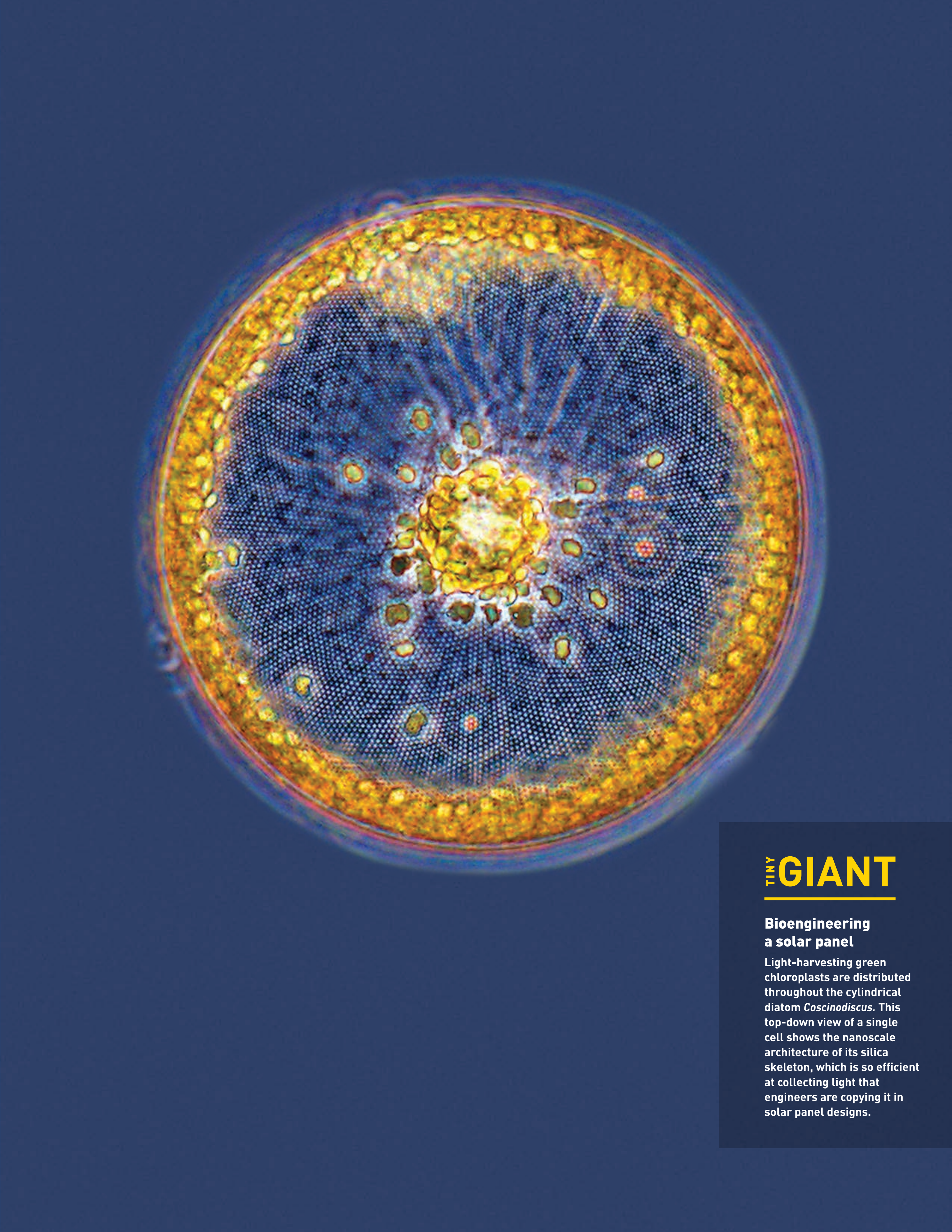
Unraveling the mysteries of the global ocean

We can only predict the ocean of tomorrow by understanding what's happening in the ocean of today.

Bigelow Laboratory for Ocean Sciences is advancing what is known about the global ocean, how it is changing, and how life within it is responding to change through research, education, and enterprise.

On these pages, you will learn how our scientists are increasing understanding of marine life and ocean processes. You will gain insight into how we are training the next generation of ocean scientists so they will be prepared for the ocean they will inherit. Lastly, you will be amazed at how we are finding ocean-based solutions to today's complex problems.

Our work is essential to the future of the ocean and the many valuable resources it provides.



TINY GIANT

Bioengineering a solar panel

Light-harvesting green chloroplasts are distributed throughout the cylindrical diatom *Coscinodiscus*. This top-down view of a single cell shows the nanoscale architecture of its silica skeleton, which is so efficient at collecting light that engineers are copying it in solar panel designs.

TINY GIANT

Revealing the past

Ostracods are shrimp-like crustaceans in a two-valved shell. They are incredibly numerous and an important food source for many marine species. They provide important information about water conditions, especially temperature in the fossil record.

DISCOVERING THE IMPACT OF THE OCEAN'S TINY GIANTS

The growing human population faces many challenges with respect to resources, changing climate, pollution, and health. Solutions to these challenges may be found within the invisible microbial world of the ocean. These tiny giants—invisible marine plants and animals—play a large role well beyond their diminutive size. Bigelow Laboratory's unique focus on marine microorganisms is providing key insights on climate change, aquaculture, and human health.

Changing food webs in the Gulf of Maine and beyond

While there is a clear consensus among scientists regarding changing global climate, many questions remain about the full impact of this change. Scientists understand the basic process, in which greenhouse gas emissions lead to increasing carbon dioxide in the atmosphere, which traps heat and increases global temperatures (global warming). The impact of carbon as it cycles through the atmosphere and dissolves into the ocean, however, is still not fully understood.

The ocean plays a key role in the carbon cycle, and even has the potential to offset greenhouse gases by taking up carbon from the atmosphere (carbon sequestration) through phytoplankton photosynthesis. Phytoplankton are marine plants that are the base of the entire ocean food web and provide half of the oxygen we breathe. In turn, phytoplankton sequester a quarter to a third of global carbon dioxide emissions from the atmosphere. As they die and sink to the ocean floor, they take this captured carbon withthem, helping to keep our planet's carbon dioxide level in balance.

Dr. Barney Balch and his postdoctoral researchers **Meredith White**, **Jason Hopkins**, and **Catherine Mitchell** are working to better understand the movement of carbon as it cycles out of the atmosphere and into the food web. Balch and his team have been running the Gulf of Maine North Atlantic Time Series (GNATS) survey for seventeen years, which makes it one of the longest running transect time series of coastal phytoplankton productivity in the nation. The transects measure ocean chemistry, biology, and optical properties to determine the abundance and composition of particulate and dissolved carbon in seawater samples over time. Balch and his team have documented evidence of significant changes in the Gulf of Maine ecosystem. The data show an 80 percent decline in the growth rate of phytoplankton, which indicates lower production of the critical plants at the bottom of the marine food web. Because phytoplankton are food for fish larvae, lower production by these microscopic plants could mean lower numbers of adult fish populations years from now. The researchers predict that the decrease in phytoplankton is due to increasing amounts of dissolved, humic materials leached from the soil into rivers after rains and ultimately flowing into the Gulf (the analogy is like tea being steeped from a tea bag). This humic material blocks the same colors of light required by plants for photosynthesis from penetrating into the ocean, effectively shading the phytoplankton and preventing their growth. If trends continue, Balch's team and their fellow investigator, Tom Huntington of the U.S. Geological Service in Augusta, predict this form of soil-derived, humic carbon will increase ~30 percent over the next 80 years, potentially causing further problems for the productivity of the marine food web.

Similarly, **Dr. Nicole Poulton**, Director of the J.J. MacIsaac Facility for Aquatic Cytometry at Bigelow Laboratory, provides ground truth data for the NASA satellites used by Balch and other scientists to understand the relationship between the color of the ocean as seen from space and the carbon distribution of microbes, including species composition and identification of other particles in the water. Using a flow cytometer aboard a research vessel, Poulton counts the number of microbes in water samples at sea that determines biomass—the total mass of organisms within the sample. Her results help to verify the accuracy of satellite-based data, which is important for measuring and understanding the global carbon cycle.

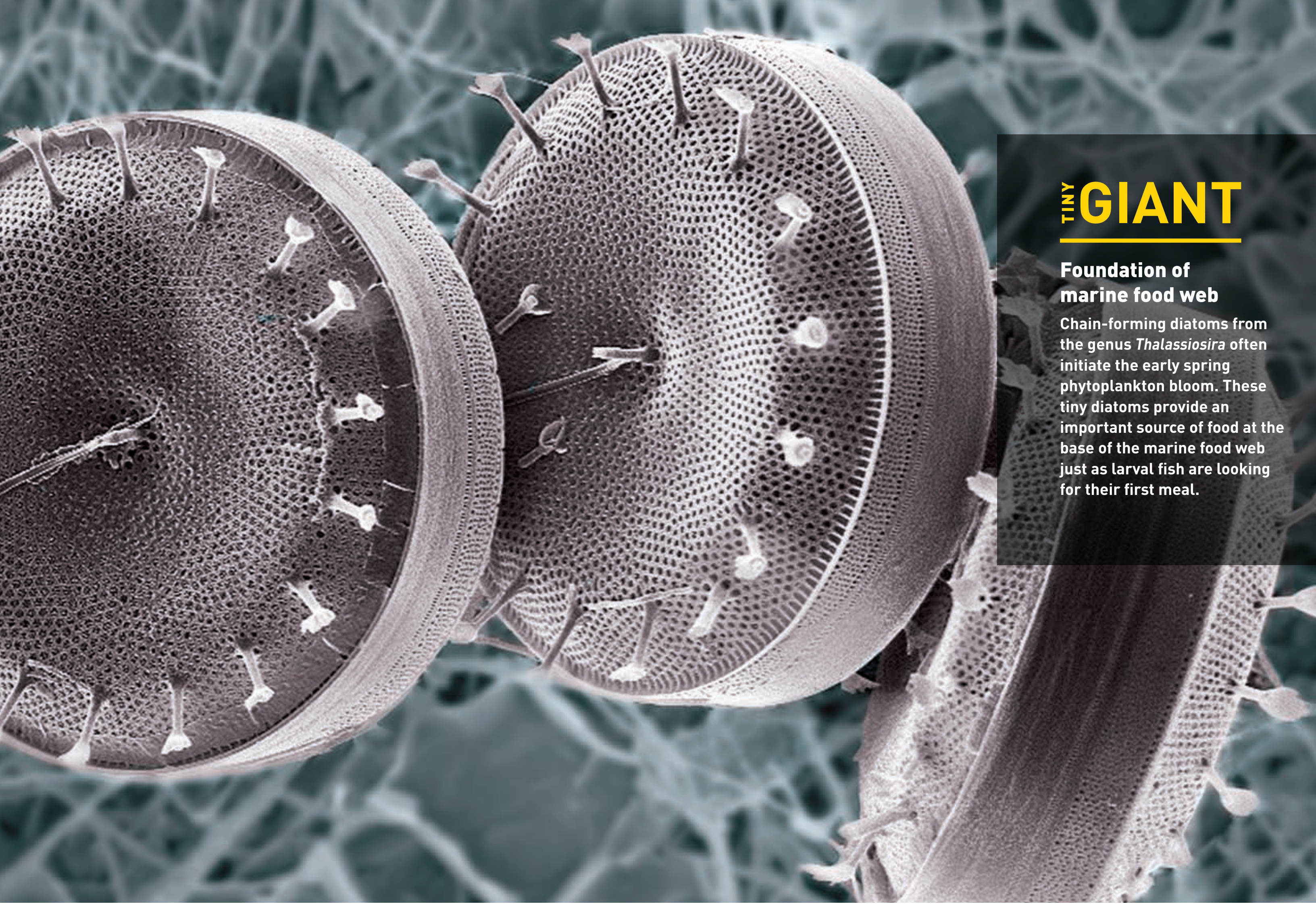
Dr. Pete Countway is also contributing to our understanding of the dynamics of ocean life by analyzing the seasonal changes in the genetic structure and diversity of microbial communities. He conducted sampling on a weekly basis over a two-year period at a coastal time-series station, a research site established 15 years ago by the Bigelow Laboratory Aquatic Cytometry lab. This project is revealing the extent to which grazing limits the timing and magnitude of specific types of phytoplankton blooms. Countway's work is helping to identify the organisms that feed on some of the smallest marine phytoplankton (< 2-3 microns), which are the first link in many marine food webs. The long-term sampling from the dock in West Boothbay Harbor is creating an increasingly important 'biological baseline,' given the current and predicted changes to environmental conditions in the Gulf of Maine.

Using datasets like those generated by Balch, Poulton, and Countway, other scientists can make predictions about future ecosystem changes. **Dr. Nick Record** uses ocean models and mathematical ecology to understand and predict what is happening in the ocean with a focus on the Gulf of Maine. Record is generating a model that maps where carbon entering the Gulf of Maine ends up—including the amount entering the food web, sinking, or being released back into the atmosphere. He is also modeling the distribution of the tiny copepod, *Calanus finmarchicus*, a primary food source for many species from cod to right whales. Interestingly, the species has persisted and even thrived despite predictions that warming would force it out of the Gulf of Maine and further north. Record also has begun a program to monitor the increasing numbers of jellyfish in coastal Maine by developing a citizen science reporting tool to share sightings information. This research provides a more complete understanding of how carbon dioxide is impacting the Gulf of Maine, as well as how the changing climate is impacting certain species in the Gulf, from *Calanus* to jellyfish.

SCIENTISTS ARE GENERATING DATASETS USED TO ASSESS CURRENT CONDITIONS AND MAKE PREDICTIONS ABOUT FUTURE ECOSYSTEM CHANGES

While Record focuses on developing a more accurate model of the tiny copepods in the Gulf of Maine ecosystem, **Dr. David Fields** is studying how young lobsters and copepod populations might be changing as a result of climate change. Fields' research focuses on the effects of increasing temperature and increasing ocean acidity caused by the high levels of carbon dioxide in the atmosphere. He is currently researching how increasing acidity and temperature affect the copepod, *Calanus finmarchicus*, and its tiny phytoplankton prey, *Emiliania huxleyi*, whose cells are made out of chalk plates that are susceptible to increasing acidity. His findings suggest that the ability of *Calanus* to store fat is hampered by increasing temperature and ocean acidification. This lack of fat storage is important because fish and marine mammals, which rely on *Calanus* as a food source, need fat to survive the winter; if their food has less fat, then their ability to survive is reduced.

This collection of research taken together gives an integrated understanding of how changing carbon



TINY **GIANT**

Foundation of marine food web

Chain-forming diatoms from the genus *Thalassiosira* often initiate the early spring phytoplankton bloom. These tiny diatoms provide an important source of food at the base of the marine food web just as larval fish are looking for their first meal.

levels and temperature are impacting the Gulf of Maine over time, and it will help us better understand what might lie ahead.

Investigating fast-paced changes in the Arctic

Climate is changing faster in the Arctic than anywhere else on the planet. Warmer temperatures are leading to the acceleration of sea ice melting, rapid thawing of permafrost (the year-round ice within the ground), and increasing release of greenhouse gases from Arctic environments. Acidification also is happening fastest in colder, polar waters because carbon dioxide is more soluble at lower temperatures. Observed changes in the Arctic waters may help with predictions of what may happen as acidification occurs at lower latitudes.

Microbes in the Arctic Ocean and surrounding environment may help to lessen the impact of these changes...or they might speed them up. Bigelow Laboratory scientists are involved in several research projects to understand the role of these tiny giants in the changing Arctic.

Dr. Paty Matrai leads a multi-year project to understand how air quality is changing above the Arctic Ocean as ice cover diminishes. Microbes can influence air quality by producing trace gases that eventually affect cloud formation and ozone. Continuously monitoring air quality over ice in the remote Arctic, however, is no small undertaking. Matrai and her team designed custom buoys that drift with ice floes and autonomously measure atmospheric chemistry, sending the data via satellite to computers back on land. This year, Matrai's team deployed four more buoys from icebreaker ships bringing the total in operation to 16. Matrai shares this first-of-its-kind data with colleagues around the globe, making it possible to validate three-dimensional Earth system models that allow prediction of changes in the Earth's climate and marine ecosystems.

Such models link marine microbes to air and water biogeochemistry in the Arctic Ocean. Comparing and validating simple and complex models for their capacity to reproduce current and past levels of phytoplankton growth in Arctic waters has been the focus of **Younjoo Lee**, a postdoctoral researcher in Matrai's lab.

TINY GIANT

Beauty belies danger

Closeup of *Protoceratium reticulatum*, a dinoflagellate. Some dinoflagellates can cause potentially toxic harmful algal blooms or "red tides," which occur when environmental conditions allow their populations to grow rapidly and accumulate to extremely high cell concentrations.

As increasing air temperatures progressively thaw Arctic permafrost, nutrients that have been trapped for thousands of years are now being flushed into the Arctic Ocean at a much faster rate than ever before. Sea ice melting is also increasing the availability of metal nutrients as metals once contained within the ice are released into open water. **Dr. Ben Twining** is working to understand how these additional trace nutrients might impact Arctic phytoplankton in areas that will be less ice-covered in the future. This summer, **Sara Rauschenberg** from the Twining lab spent 65 days aboard the USCG *Healy*, the U.S. Coast Guard's most technologically advanced icebreaker dedicated to Arctic scientific research, collecting samples from the Bering Sea up to the North Pole. The Twining lab is assessing if newly released metal nutrients support additional microbial growth in the Arctic Ocean, which could help mitigate the impacts of climate change by increasing carbon sequestration through photosynthesis. Postdoctoral researchers **Jeremy Jacquot** and **Dan Ohnemus** are complementing this Arctic analysis with trace nutrient measurements and experiments in the Pacific. Their results are helping to inform how phytoplankton physiology responds to strong environmental gradients, as trace metals are expected to increase in the warming Arctic.

As Arctic Ocean sea ice melts, shipping traffic and resource exploration will expand. **Drs. Paty Matrai**, **Christoph Aeppli**, and **Beth Orcutt** are examining possible effects of oil spills in the Arctic. Aeppli is an expert in tracking how various components of oil break down naturally in the environment. While microbes in warmer waters are known to play a large role in digesting oil, little is known about how microbes specific to the Arctic react to oil. Matrai and Aeppli were part of the Arctic Oil Spill Response Technology Joint Industry Project this year to quantify the effects of various oil treatments on microbial communities in surface waters and sea ice. Aeppli and Orcutt are also examining the ability of microbes to mitigate oiled beach environments in the Arctic. This research will inform methods for responding to oil spills should they occur in this fragile area.

Scientists at Bigelow Laboratory are leading the way in Arctic research on a variety of fronts. This expertise was a factor in Maine being selected to host the international Arctic Council in 2016—the first time ever that meetings will be held in Maine. Bigelow Laboratory scientists will continue to play an increasingly important role in investigating and communicating the changes occurring in this vulnerable ecosystem.

HAVING SAMPLED VARIOUS PARTS OF THE ARCTIC OCEAN FOR TWO DECADES, SCIENTISTS STILL STRIVE TO UNDERSTAND WHAT MAY HAPPEN AS SEA ICE DISAPPEARS

Pickling or prodding life in an acidifying ocean

As greenhouse gas levels rise, the amount of carbon dioxide in the air *and in the ocean* increases. When carbon dioxide dissolves in water, it leads to a chemical reaction that increases acidity. Increasing greenhouse gases are leading to ocean acidification and global warming. The pH of the ocean is already dropping, and scientists predict a decrease of 0.3 pH units in the next 100 years. That may not seem like much, but it equates to 3 times more acidity, as the pH scale is logarithmic. In comparison, if the pH of a person's blood (which has a salinity close to that of seawater) dropped by 0.1 units, he or she would end up in the emergency room with acidosis. This increase in acidity will impact shelled organisms the most, such as clams, oysters, scallops, and sea snails by reducing their ability to make protective shells.

A team of Bigelow Laboratory scientists **Drs. Steve Archer**, **Pete Countway**, and **Paty Matrai** and postdoctoral researcher **Kerstin Suffrian** are looking at the interaction of ocean acidification and the microbial release of trace gases that may bring about cloud formation. Cloud formation and its cooling effects can help to mitigate climate change, while reduced cloud formation can amplify warming. The team has quantified these interactions in both Arctic waters and in tropical waters off the Canary Islands. This year the team brought the experiment in-house, where they used mesocosms—large tanks where environmental conditions can be controlled and manipulated—in the Laboratory's Seawater Suite to test what might occur if the ocean continues to acidify over the next century. The team has noted a relationship between increased ocean acidity and decreased trace gas emissions in the surface ocean, and predicts that these effects could potentially amplify man-made warming by diminishing cloud cover.

They are examining if increasing ocean acidity leads to changes in gene expression among marine bacteria. Using high-throughput DNA sequencing, a technique that makes it possible to identify DNA by processing massive amounts of data quickly, they are able to decipher millions of DNA sequences. By exploring the connections between genes in microbial communities and ocean acidification, they hope to better understand the processes leading to changes in trace gas emissions, and subsequently to improve prediction capabilities. Clearly, the changing activity of tiny marine microbes could have a giant impact on global warming.

Dr. Nichole Price is looking at ocean acidification from other angles. She is working with a team of international collaborators to study the impacts of ocean acidification on highly sensitive seaweeds, known as red encrusting coralline algae. Coralline algae are distributed from the equator to the polar regions. In the tropics, certain coralline algae attract corals, helping to re-establish depleted reefs. Ocean acidity is especially problematic for these highly sensitive seaweeds, making them another 'canary in the coal mine' for rising seawater acidity. Price and her team are using mineralogy techniques gathering data from sites in the Atlantic and Pacific Oceans. Their goal is to to determine the physiological response of coralline algae species to natural variations in acidity, temperature, and disease over space and time. The team hopes to find instances of resilience to these changing ocean conditions and to identify species that may be useful bioindicators of environmental change.

The **Balch** and **Fields** laboratories are examining how ocean acidification affects a simple two-member food chain involving marine plants (coccolithophores) and their zooplankton predators. They are investigating how ocean acidification influences each organism independently and how it might be influencing their relationship with one another—the predator-prey relationship. Such interactive effects are the most difficult to tease-out, but are potentially the most relevant to understanding the overall effects of an increasingly acidic ocean on the marine food web. The Balch lab measures ocean acidification as part of its ongoing long-term sampling of the Gulf of Maine.

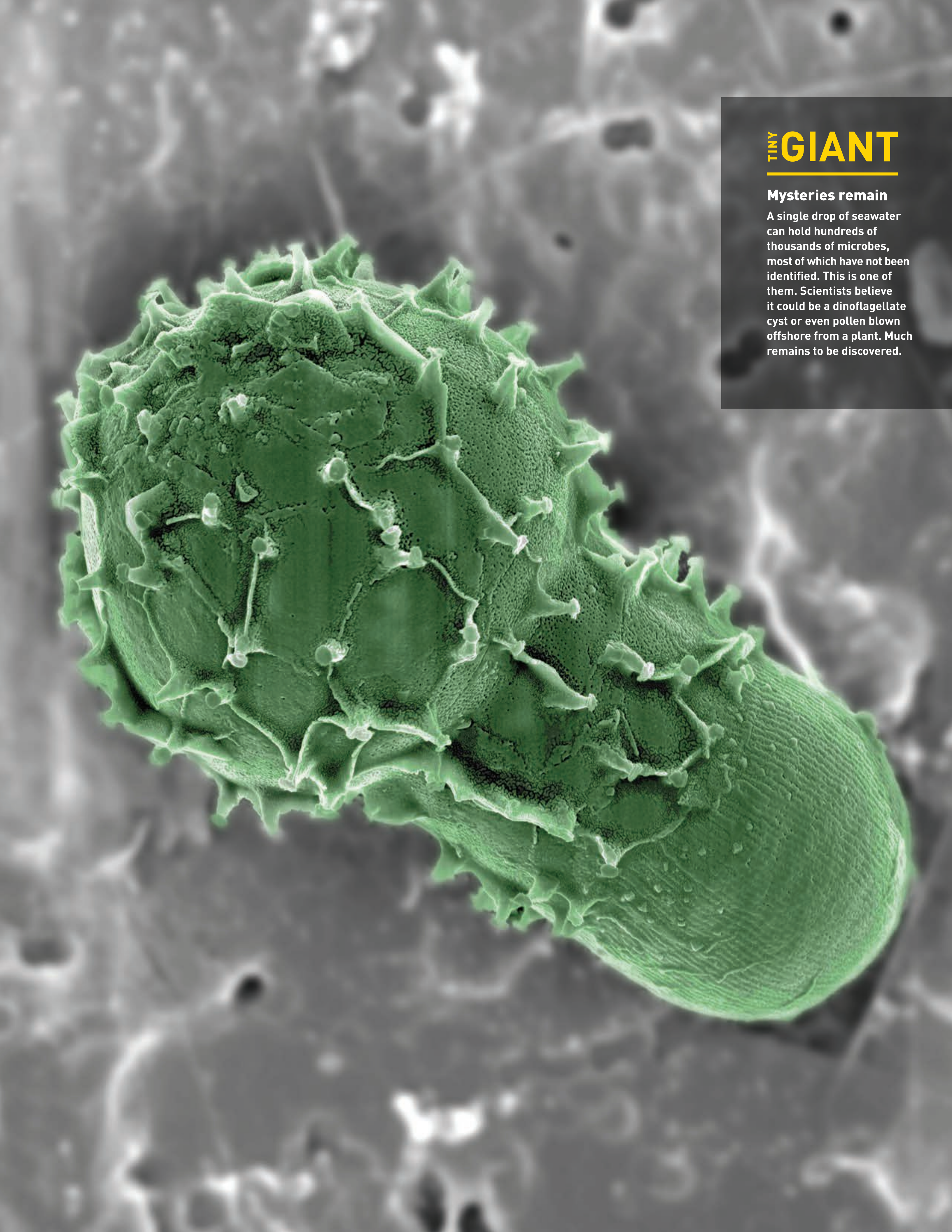
Researchers at Bigelow Laboratory are not only studying the consequences of ocean acidification in different ecosystems, but also contributing solutions to help mitigate its impacts. **Meredith White**, a postdoctoral researcher in the Balch laboratory, was named to the study commission established by the Maine legislature to investigate and report on the impacts of ocean acidification on Maine's commercial fisheries. Maine was one of the first states to take steps to study this important issue, and Bigelow Laboratory scientists have played a key role in informing lawmakers of the impacts ocean acidification is having here in Maine, and around the world.

Documenting the gigantic diversity of tiny life in the ocean

Although tiny in size, the vast quantity of marine microbes in the ocean comprise the largest reservoir of genetic diversity on Earth, yet they remain one of the least explored and understood groups of life. What is known, however, is amazing. Marine microbes have demonstrated astounding resilience, living in the harshest conditions on Earth—in boiling hydrothermal vents, in sediments deep below the seafloor, and in nutrient-depleted ocean gyres, to name a few. Marine microbes display an incredible ability to evolve, adapt, and impact the health and wellbeing of entire marine ecosystems. Bigelow Laboratory scientists are world experts in marine microbes, and they are leading efforts to understand the diverse makeup and interactions of the tiny giants of the sea.

The Single Cell Genomics Center (SCGC) at Bigelow Laboratory is at the scientific frontier, developing technological solutions that were not available even a few years ago and making them accessible to the broad research community. Single cell genomics has enabled scientists to analyze the physiology, viral infections, global distribution, and other features of marine microorganisms without having to culture them in a laboratory. As less than one percent of marine microorganisms have been successfully cultured in laboratories, this major breakthrough is providing a practical means of studying these organisms. There is great demand for this kind of technology and expertise, and the SCGC is currently collaborating with more than 100 universities, research institutions, and companies around the world.

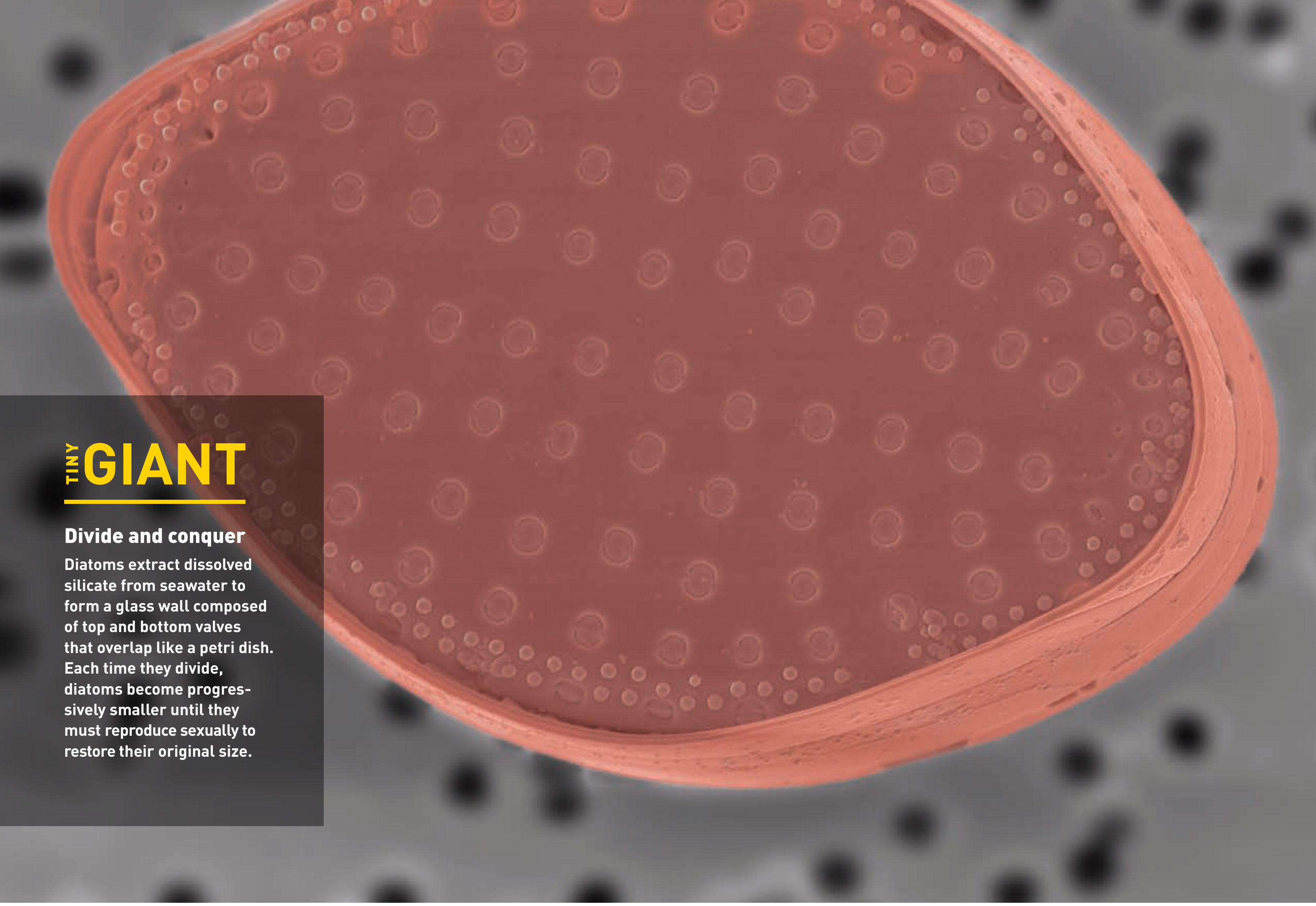
IF THE pH OF A PERSON'S BLOOD DROPPED AS MUCH AS PREDICTED WILL HAPPEN IN THE OCEAN, HE OR SHE WOULD END UP IN THE EMERGENCY ROOM WITH ACIDOSIS



TINY GIANT

Mysteries remain

A single drop of seawater can hold hundreds of thousands of microbes, most of which have not been identified. This is one of them. Scientists believe it could be a dinoflagellate cyst or even pollen blown offshore from a plant. Much remains to be discovered.



TINY GIANT

Divide and conquer

Diatoms extract dissolved silicate from seawater to form a glass wall composed of top and bottom valves that overlap like a petri dish. Each time they divide, diatoms become progressively smaller until they must reproduce sexually to restore their original size.

Dr. Ramunas Stepanauskas, director of the SCGC, has used this technology to study bacteria in the dark ocean, beyond the reach of sunlight where 90 percent of the entire ocean's volume is contained. He has discovered that bacteria in these waters consume carbon dioxide, which may have a significant impact on the global carbon cycle. More recently, Stepanauskas and his colleagues have been searching subsurface environments, as far as 2.5 miles underground in South Africa, to find and study microbes that have never been exposed to conditions on the planet's surface. With the use of single cell genomics technology, Stepanauskas' research program, supported and advanced by a team of postdoctoral researchers—**Maria Pachiadaki**, **Jessica Labonté** and **Eric Becraft**—is expanding our knowledge of the early evolution of life on Earth, and of the biology and planetary impact of some of the most abundant and mysterious organisms in the world.

Dr. Mike Lomas has also been examining marine microbes—eukaryotic phytoplankton whose cells contain a distinct self-contained nucleus—to test a long-standing concept in ocean science known as the Redfield Ratio. The Redfield Ratio has traditionally described the proportion of carbon, nitrogen, and phosphorus in plankton throughout the ocean—a key aspect of marine phytoplankton biology. Researchers had believed that the Redfield Ratio was dependent on evolutionary lineage. Lomas and his colleagues, however, have found that the chemical composition of marine plankton communities is significantly influenced by latitude and temperature, and relates to changes in the relative abundance of different plankton groups. Using the outstanding taxonomic diversity held in the NCMA, Lomas has been able to study this idea in depth. He has observed that while some families of phytoplankton's 'Redfield Ratios' seem to be impacted by lineage, the observation is by no means universal. Lomas' research is enhanced by the work of his postdoctoral researchers **Steven Baer** and **LeAnn Whitney**. Baer is researching how the Redfield Ratio varies in discrete natural phytoplankton populations. Whitney is studying the genetic response of phytoplankton to phosphorus stress and ocean acidification. Understanding the interplay between evolutionary diversity and the physiology of

THE LABORATORY IS COMBINING ITS EXPERTISE AND STATE-OF–THE-ART TECHNOLOGY TO ADVANCE UNDERSTANDING OF THE GLOBAL OCEAN AND TO DEVELOP OCEAN-BASED SOLUTIONS

phytoplankton in controlling global processes like carbon sequestration is currently a 'hot topic' in oceanography and one that Bigelow Laboratory scientists are uniquely situated to study.

Dr. David Emerson is advancing understanding of the diversity of marine microbes and their environmental implications. His investigations, and those of postdoctoral researcher **Jarrod Scott**, have ranged from studying bacteria that derive energy from rusting iron to the microbial community that lives inside whale guts. Their whale gut research demonstrates how both diet and evolution play a role in the community of microbes living in whales, and how these microbes are uniquely adapted to provide nutrition to their host. While baleen whales are carnivores, the microbes found in their guts share characteristics with both plant-eating cows and meat-eating predators. This community of microbes helps whales extract the greatest level of nutrients from their food sources. This study opens the possibility of being able to track and investigate the microbiota of wild animal populations to understand more about the dynamics of their diet, and how these organisms impact animal health.

Dr. Beth Orcutt explores some of the most remote and inhospitable environments in the ocean to understand how microbes survive there. Last summer, Orcutt dove in the human submersible *Alvin* to collect microbes from below the seafloor, and in the fall, Orcutt again dove in *Alvin* to study life on a previously unexplored undersea mountain in the Pacific Ocean, which hosts a unique hydrothermal vent environment. Microbes in these environments are able to gain energy from "eating" chemicals in the rocks, and Orcutt is seeking to understand how they do this. Postdoctoral researchers **Stephanie Carr** and **Jessica Labonté** support and advance this work in the laboratory. Orcutt also led two research cruises in the Gulf of Mexico this year to study the role that microbes play in degrading oil at the bottom of the ocean. Exploring the genetics of microbes from these extreme environments could lead to novel biotech applications.

Dr. Joaquín Martínez Martínez investigates marine viruses in extreme environments. Marine viruses are by far the most abundant life form in the ocean and the reservoir of most of the genetic diversity in the sea. Recent advances in genomic technology have made it possible to identify viruses, and Martínez Martínez is at the forefront of this work. He has identified viruses that are affecting the diversity and evolution of life in the ocean in deep subsurface hydrothermal fluid and vents. In the laboratory, Martínez Martínez is examining the interactions between viruses and their microalgae hosts, while also studying how viruses respond to increasing ocean acidity. Such knowledge will help us predict how viruses will continue to adapt, change, and affect all marine life as the ocean continues to change.

The variety of life in the ocean is not only astounding to behold, but as Bigelow Laboratory scientists increase what is known about this vast reservoir of life, they are also discovering life's potential to adapt, evolve, and provide many valuable services.

From research to problem solving: Aquaculture solutions

As the need for food and nutrients for the expanding global population continues to rise, aquaculture has an increasingly important role in helping to meet that demand. In Maine, the aquaculture industry is growing, but it faces challenges in its efforts to create a sustainable and profitable seafood market. Obstacles to growth and productivity include determining optimal sites, identifying marketable products, and controlling disease. In May, Bigelow Laboratory hosted a workshop with leaders in the aquaculture industry to introduce the Joint Industry Partnership Initiative. The central principle of the initiative is that, through collaboration, Bigelow Laboratory scientists and commercial partners can generate research-based solutions that can resolve many of the issues faced by the aquaculture industry, ultimately benefiting both parties.

Bigelow Laboratory is already proving this concept by providing important testing and analytic services to the Maine Department of Marine Resources (DMR). In its second year of a partnership with DMR, Bigelow Analytical Services (BAS) conducts testing for paralytic toxin levels in shellfish, including mussels and oysters. Using the first U.S. Food and Drug Administration-approved protocol in the country, BAS is providing efficient and timely results that allow DMR to be more targeted in its shellfish closures, benefiting both the industry and public health.

Dr. Nichole Price's research illustrates yet another example of how Bigelow Laboratory science has the potential to enhance Maine's aquaculture industry. Price is studying the distribution of seaweeds in the Gulf of Maine, which creates crucial nursery habitat and food resources for fish and lobsters. She has discovered that increased carbon dioxide in the Gulf is leading to greater productivity among large, edible seaweeds. Since commercial shellfish like mussels, oysters, and clams are negatively impacted by increasing acidity, Price is exploring whether commercially farming edible seaweeds near mussel, oyster, and clam beds may help moderate the effects of ocean acidification locally. If this proves to be an effective solution, it could be a boon to commercial shellfish farms in Maine and elsewhere.

As an extension of these efforts to bolster the state's aquaculture industry, Bigelow Laboratory initiated an effort to organize and form a marine algal cluster to help the Maine algal industry realize its potential and take advantage of a growing sea vegetable market. The cluster initiative is supported by a planning grant from the Maine Technology Institute, and encompasses both macroalgae (e.g. sea vegetables) and microalgae. Bigelow Laboratory is working closely with a diversity of partners from around the state on this initiative, all of whom are involved in sea vegetable wild-harvest, aquaculture, and processing.

The cluster has worked during the past year to come up with a roadmap to develop and promote a Maine Algae brand, identify and resolve potential bottlenecks to forward progress, and raise public awareness about the multiple beneficial uses of algae. The ultimate goal is to help the sea vegetable industry (macroalgae) develop new and innovative products, expand into new markets, and improve production and processing techniques. Similarly, goals for the microalgae industry are to develop new bioactive derivative products such as pharmaceuticals and nutritional supplements, support aquaculture sustainability through improved shellfish and finfish feeds, and contribute to research on green fuel alternatives. The algal cluster group is in the process of completing an implementation plan for growing this important industry sector in Maine.

Bigelow Laboratory scientists are also involved in several projects to study the threat of pathogens to Maine's oyster aquaculture. Tiny pathogens exist in oysters that represent a serious threat to oyster aquaculture in lost production, as well as a potential threat to those who consume raw oysters. **Drs. José Antonio Fernández Robledo**, **Pete Countway**, and **Nick Record** are conducting fieldwork to determine the location, prevalence, and abundance of oyster pathogens throughout Maine. Their research will assess the risk posed by waterborne human pathogens, as well.

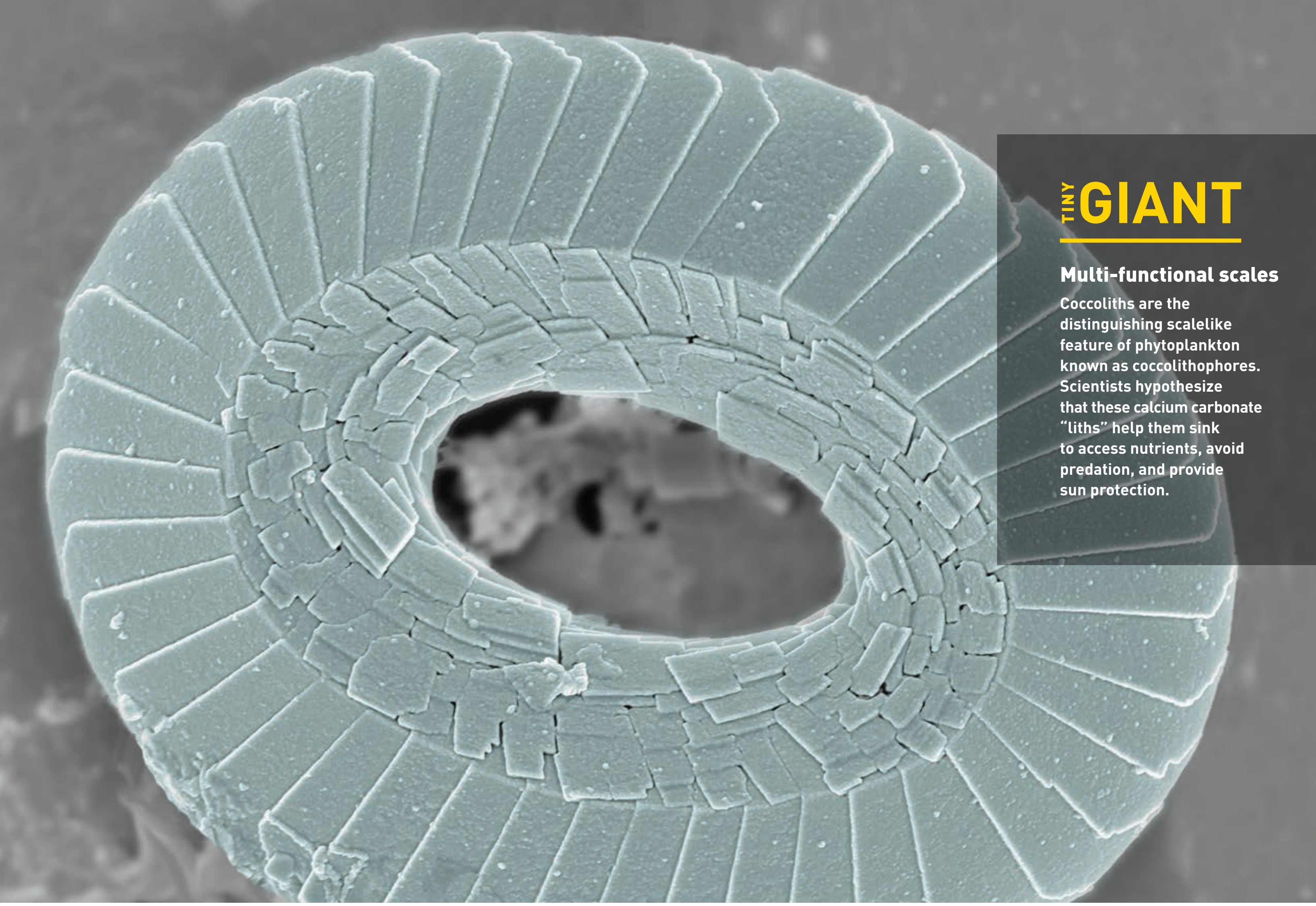
One parasite that **Dr. José Antonio Fernández Robledo** studies—*Perkinsus marinus,* which is responsible for "dermo" disease—weakens the immune system of oysters, making them up to three times more susceptible to invasion by other parasites. *Perkinsus* has caused large oyster casualties up and down the eastern coast of the United States and has resulted in a large net loss in the oyster industry. In collaboration, **Dr. Joaquín Martínez Martínez** is seeking to identify and isolate viruses that affect the oyster parasite *Perkinsus*, which is not toxic to humans. Martínez Martínez is investigating whether viruses either cause *Perkinsus* to become more resilient and virulent or if viruses can kill *Perkinsus,* providing a potential means to control its spread. Knowing more about how viruses impact the parasite *Perkinsus* may provide an innovative solution for how to protect oysters from this parasite.

By developing such creative solutions to applied problems, Bigelow Laboratory scientists are paving the way for an economically prosperous and environmentally sustainable aquaculture industry in Maine.

From research to problem solving: Human health solutions

The biodiversity of the ocean is, in some ways, an untapped resource. Microbes, their interactions, and their genetics contain information and materials that hold promise to benefit human health. The Provasoli-Guillard National Center for Marine Algae and Microbiota (NCMA) at Bigelow Laboratory houses one of the world's largest and the most diverse collections of marine phytoplankton, with about 3,000 strains of phytoplankton, bacteria, and viruses from around the world. This incredible resource drives many important applied research efforts.

The NCMA, directed by **Dr. Mike Lomas**, is collaborating with a number of national and international companies to identify an optimized source of phytoplankton derived lipids (fats) and other important metabolites. This project involves several steps, including bioprospecting of the NCMA algal collection to identify strains that produce the specific lipid of interest. Working with Bigelow Analytical Services and their advanced mass spectrometric analysis capabilities, Lomas can quantify the lipid of interest and other metabolites. They then grow the algae at pilot scale to determine if the lipid can be extracted and purified in an economically viable manner. The NCMA is also an active part of the continuing five-year



TINY GIANT

Multi-functional scales

Coccoliths are the distinguishing scalelike feature of phytoplankton known as coccolithophores. Scientists hypothesize that these calcium carbonate "liths" help them sink to access nutrients, avoid predation, and provide sun protection.

collaboration between Bigelow Laboratory and the University of Mississippi School of Pharmacy, where they are screening for compounds that might one day be used as novel anti-microbials or to treat malaria and other diseases. Collaborations such as these between NCMA and private industry are fostering not only innovative uses for marine microbes, but potentially yielding important medical breakthroughs.

While marine algae can be utilized for positive benefits to humanity, **Dr. Cindy Heil**'s research focuses on the harmful effects of the algal species *Karenia brevis* and potential methods to manage and mitigate these effects. This plant-like organism causes a bloom, also known as a red tide, and produces a suite of potent neurotoxins, which cause gastrointestinal, neurological, and respiratory problems in humans and are responsible for large die-offs of marine organisms and seabirds. Heil recently co-edited a special edition of the scientific journal *Harmful Algae*, which synthesized six years of red tide research conducted as a multi-partner project under the National Oceanic and Atmospheric Administration's Ecology and Oceanography of Harmful Algal Blooms program. The goal of the research was to understand which nutrients supported red tides and the extent to which coastal pollution might be contributing to them. This vast compilation of research is being actively used to help inform management recommendations on how to control nutrient sources into coastal waters and to identify ways to improve forecasting models to better predict red tides. Heil and **Dr. Mike Lomas** were recently awarded a grant from the National Oceanic and Atmospheric Administration to develop the first U.S. harmful algae taxonomic identification course for federal and state harmful algal bloom managers, in recognition of Bigelow Laboratory's vast expertise and resources in marine algae.

Bigelow Laboratory's investigation into the role of the ocean's tiny giants is reaping important results. Not only are we increasing understanding of the crucial role microorganisms play in maintaining planetary balance, we are also finding ways to harness their power in creating natural products, as food and fuel sources, and as potential remedies for diseases. Tiny giants hold a key to the future and we are helping to unlock their many secrets.

Hands-on, experiential science education

Bigelow Laboratory provides hands-on learning and exciting exploration and discovery of ocean science throughout the year. What's unique about these programs is that students and teachers work side by side with scientists using advanced, state-of-the-art technology. They learn how to ask the right questions so they can delve deep into how the ocean works.

This year, the excitement was palpable as each student group arrived on campus to begin their journey of learning what it is like to be a research scientist.

Keller BLOOM has sprouted an offshoot. North Yarmouth Academy will be offering a similar program to its students with the first cohort here next fall.

16 HIGH SCHOOL STUDENTS FROM ACROSS MAINE

2015 marked the 26th year of providing Maine high school juniors an opportunity to learn about the ocean at Bigelow Laboratory. In May,16 juniors from across the state—the goal is one from each county—participated in the Keller BLOOM high school program. Over the course of a week, students learn sampling and data collection methods, practice using standard oceanographic equipment on a research cruise, apply state-of-the-art techniques and instrumentation in the laboratory, and then present their research findings to family, friends, and scientists. Participants receive free tuition, room, and board through the generosity of donors, who believe in the caliber of the program and that all students should have the opportunity to learn about the ocean so vital to life in Maine. Each year, the number of applicants increases as students return to their classrooms and share their excitement about what they have learned.

PROVIDING TOOLS FOR TEACHERS

Building on the enthusiastic response to the Keller BLOOM program, in 2010 the Laboratory expanded its reach by offering an annual professional development workshop for high school science teachers. This summer, ten Maine high school teachers took part in a four-day workshop to better equip them to teach ocean science in their classrooms. Led by scientists **Drs. David Fields** and **Nicole Poulton**, the teachers learn the fundamentals of ocean science from a local and global context and are given the tools—curriculum materials, aquatic field sampling, and laboratory equipment—to effectively communicate the importance and excitement of ocean science to their students.

ACTIVELY ENGAGING IN OCEAN RESEARCH

Eighteen undergraduate students were lucky enough to be selected to spend their summer working alongside research scientist mentors at Bigelow Laboratory. This select group came to East Boothbay as part of the National Science Foundation-funded Research Experience for Undergraduates (REU) program. Participants were selected from an applicant pool of 250, which like the Laboratory's other educational programs, keeps on growing. The program is designed to offer opportunities for all, with the target of accepting 35 percent of students from under-represented groups.

Bigelow Laboratory's REU program is one of just 30 ocean science programs in the country and the only such program in Maine. Students came from as far away as Occidental College in California to as near as Boothbay Harbor, Maine. The National Science Foundation funds REU programs nationwide to provide students pursuing degrees in science, mathematics, and engineering with laboratory-based research experiences emphasizing hands-on, state-of-the-art methods and technologies.

Each student in the REU program is paired with a Bigelow Laboratory scientist based on mutual research interests. Over the course of ten weeks, the students identify and develop their own individual research project, submit a proposal, conduct their research, and prepare an abstract and poster, which they present publicly. Over the course of 2015, two papers written by REU students were accepted in peer-reviewed scientific journals, two students were invited to present their findings at a science meeting in Washington, DC, and another eight students will present their work at the 2016 Ocean Sciences Meeting in New Orleans.

In recognition of the exceptional REU program offered here, the National Science Foundation extended funding to Bigelow Laboratory for another five years.

PARTNERING WITH COLBY COLLEGE

Scientists **Drs. Joaquín Martínez Martínez** and **Nick Record** also took the Laboratory's educational program on the road, teaching JanPlan courses at Colby College.

Martínez Martínez taught a biological oceanography course, with an emphasis on microbes. His course culminated in a field trip to Bigelow Laboratory where students collected and analyzed biological samples off the Bigelow Laboratory dock. Interpreting results allowed the group to put into practice the theoretical information they had learned in class.

Record developed a course on modeling ocean ecosystems in which students were taught basic computer programming skills to create simplified ocean ecosystem models. As part of the course, Record brought students to Bigelow Laboratory for a tour of the facility as well as an opportunity to collect and analyze plankton samples.

The partnership with Colby College is a win-win for students, research scientists, teachers, and mentors.

The Laboratory's partnership with Colby College extends in other ways. Colby supports student interns at the Laboratory during summer months so they get hands-on practical experience. Several students have continued to work at the Laboratory following research internships. Sarabeth George and Julia Middleton both participated in the 2013 *Colby @ Bigelow Changing Oceans Semester Program* and continued to work with the Bigelow Laboratory advisers on honors theses. **Dr. Nick Record** advised Julia Middleton on her honors thesis, which is on its way to journal publication as a peer-reviewed paper. Sarabeth George worked with **Drs. Benjamin Twining** and **David Emerson** and is now working in Emerson's lab before heading to graduate school next fall. **Dr. David Fields** served as an adviser for Colby student Melanie Ross' honors thesis two years ago. She returned to the Laboratory this summer to work on a modeling project with Fields.

Three Colby College students also participated in the 2015 REU program. Rebecca Chmiel worked with **Dr. Pete Countway**, Anna Kronauer worked with **Dr. Nick Record**, and Madison Marra worked with **Dr. Joaquín Martínez Martínez** during the summer program.

PROVIDING PROFESSIONAL DEVELOPMENT

Equipped with the latest testing and analytical equipment and experienced scientists renowned in their fields, Bigelow Laboratory shares its collective knowledge in thirteen courses and workshops for professionals during the year. In May, ten professionals from around the globe participated in a National Center for Marine Algae and Microbiota course to learn algal culturing techniques. In June, 90 international scientists traveled to East Boothbay for the Third Annual Microbial Single Cell Genomics Workshop to share research, methods, and ideas about this rapidly evolving field.

PUBLICATIONS

SCIENTISTS PUBLISHED ABOUT TWO ARTICLES/ WEEK FOR A TOTAL OF

90 ARTICLES

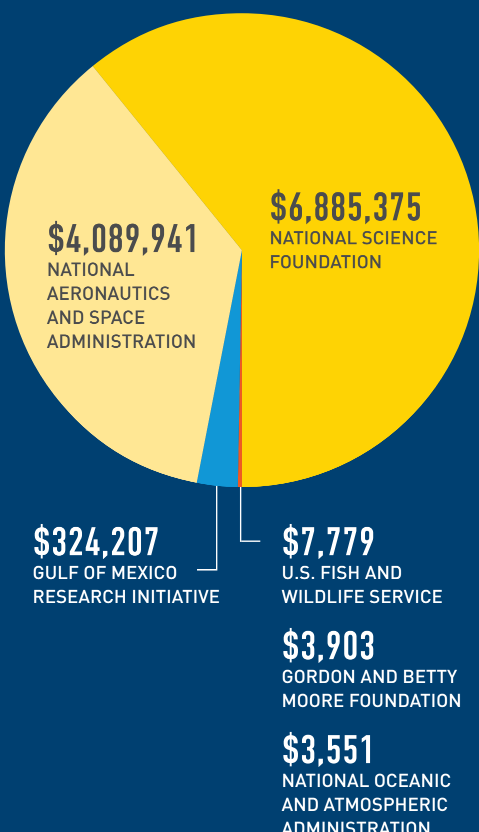
IN PEER-REVIEWED PUBLICATIONS, THE HIGHEST IN THE LABORATORY'S HISTORY.

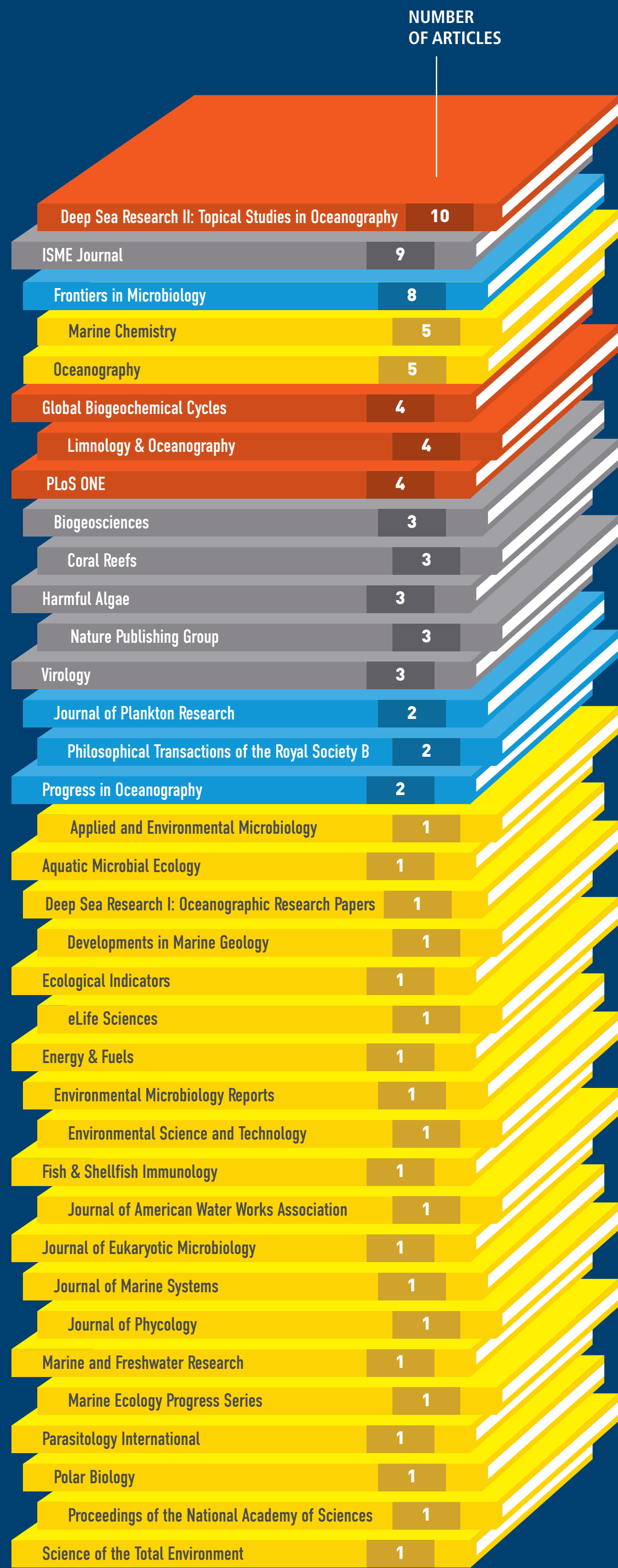
TOTAL RESEARCH PORTFOLIO

AS OF JUNE 30, 2015, THE LABORATORY HAD

$11,314,756

IN FEDERAL AND FOUNDATION FUNDS COMMITTED TO ITS IMPORTANT RESEARCH.





Sharing expertise with the world

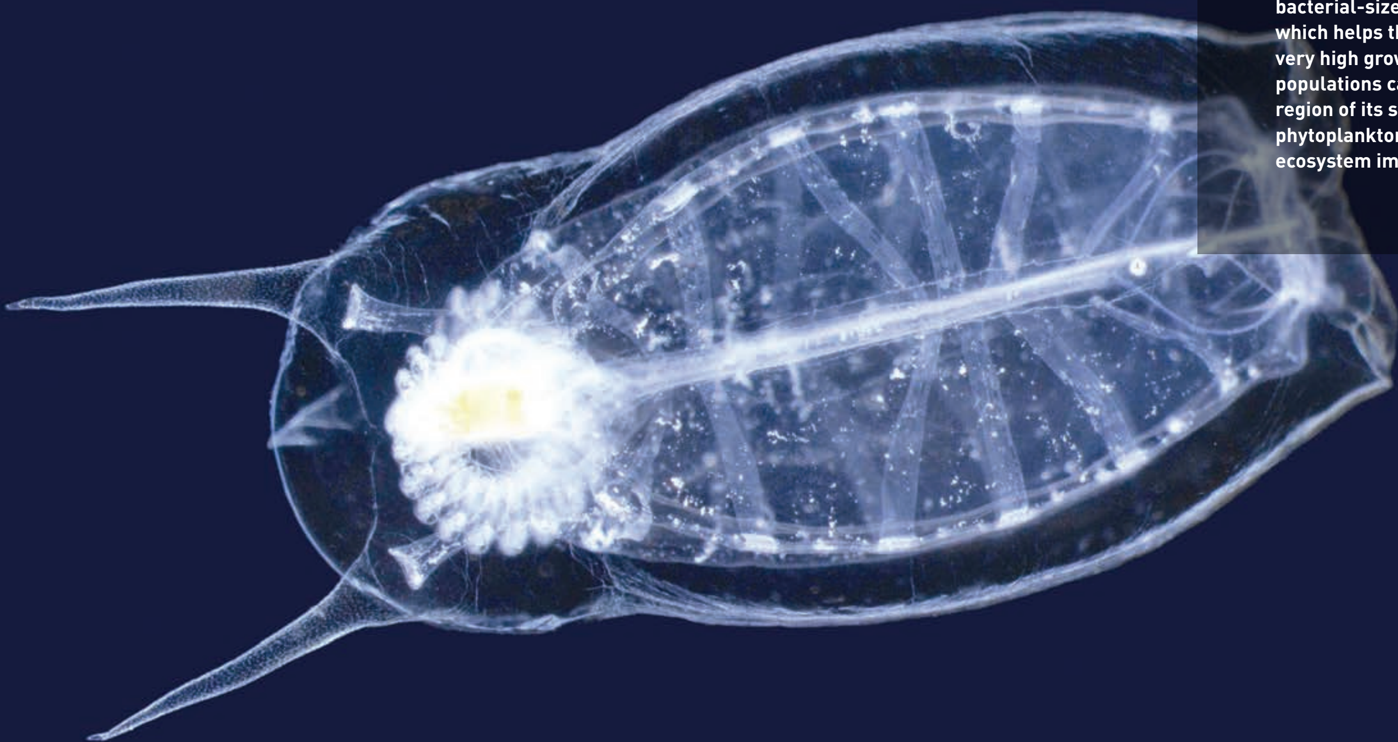
This year, Bigelow Laboratory for Ocean Sciences initiated a concerted effort to offer the same services used by our scientists to academic, industrial, and government partners. Our goal is to offer our expertise, experience, and equipment to help advance research, enhance discoveries, and find solutions to today's complex problems.

We have six Core Facilities that provide a wide range of advanced services to meet client needs.

TINY GIANT

Adaptable eaters

Salps are uniquely adaptive eaters feeding on the smallest phytoplankton to large bacterial-sized food particles, which helps them to achieve very high growth rates. Large populations can deplete a region of its standing stock of phytoplankton, with significant ecosystem impacts.



THE PROVASOLI-GUILLARD NATIONAL CENTER FOR MARINE ALGAE AND MICROBIOTA (NCMA) is the world's largest and most diverse collection of marine phytoplankton. NCMA offers about 3,000 strains of phytoplankton, macroalgae, bacteria, and viruses from around the world to support scientific and industrial research.

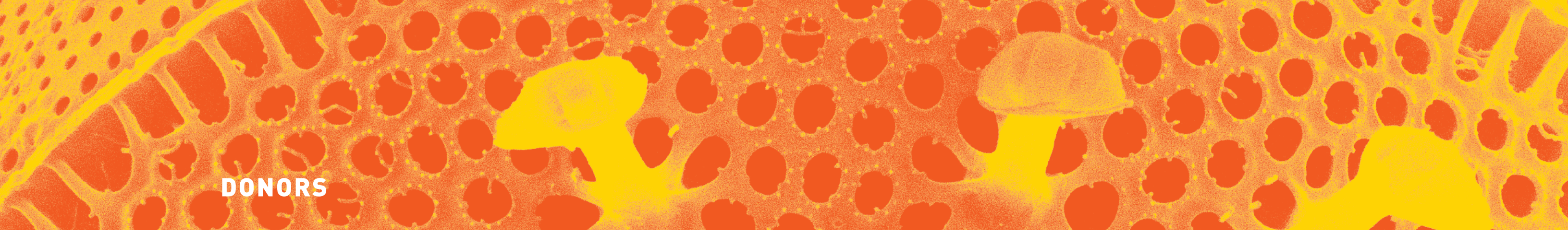
THE SINGLE CELL GENOMICS CENTER (SCGC) is the first of its kind in the world. Single cell DNA sequencing reads the genomic blueprints of the most fundamental units of life without the need for cultivation. This technique, pioneered at Bigelow Laboratory, is now available for use by clients around the world, offering opportunities for global advances in understanding the diversity and evolutionary history of microorganisms.

BIGELOW ANALYTICAL SERVICES (BAS) offers expert state-of-the-art analytical services to public and private entities. Bigelow Laboratory was the first in the nation to be approved by the U.S. Food and Drug Administration to conduct quantitative biotoxin analysis to determine shellfish safety that is now available to clients worldwide.

THE J.J. MACISAAC FACILITY FOR AQUATIC CYTOMETRY pioneered the use of flow cytometry for aquatic uses. The Center carries on this pioneering spirit by applying new and innovative technologies to advance the study of aquatic microbes in marine and freshwater systems.

THE SEAWATER SUITE provides a continuously flowing seawater system with the capability to replicate ocean conditions in a controlled environment. The system is used for experiments reflecting natural conditions or creating specific environmental conditions in a tightly controlled, measured way.

THE HIGH PERFORMANCE COMPUTE CLUSTER has extensive memory, storage space, bandwidth, and networking capabilities that allow it to handle a diverse range of scientific data processing needs. These computing capabilities are available to external clients who need fast, accurate processing of huge amounts of data without investing in a supercomputer of their own.



We extend our deepest gratitude

to the visionary Founders and generous friends of Bigelow Laboratory for Ocean Sciences. The transformation we made over the past few years would not have been possible without you. **THANK YOU** for believing in our mission to advance what is known about the global ocean.

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GIFTS IN KIND

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EDUCATIONAL PROGRAMMING

Mr. and Mrs. Paul M. Anderson
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Dr. and Mrs. Lee L. Thibodeau
Professor Gordon V. Wolfe in memory of Dr. Maureen Keller

CHARLES S. YENTSCH MEMORIAL SCHOLARSHIP

Joyce Sirois
Dr. Clarice M. Yentsch

Special thanks are due to the Morrell Family, whose challenge provided a significant boost to advancing the work of Bigelow Laboratory.

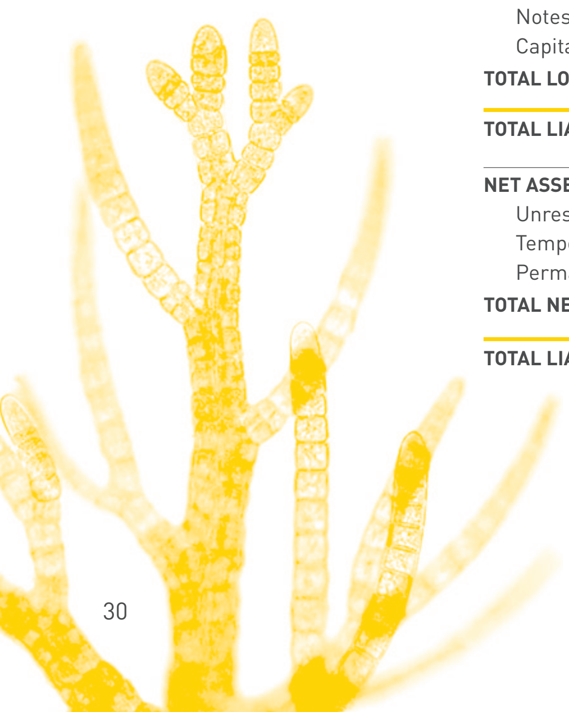
STATEMENT OF FINANCIAL POSITION

FOR THE YEAR ENDED JUNE 30

ASSETS	2015	2014
CURRENT ASSETS		
Cash	$ 749,827	$ 670,229
Cash restricted for research		137,419
Cash restricted for improvements	375,532	
Contracts and grants receivable	719,314	834,981
Pledges receivable	617,589	589,364
Other receivables	247,762	129,370
Prepaid expenses	16,185	94,601
TOTAL CURRENT ASSETS	**2,726,209**	**2,455,964**
PROPERTY AND EQUIPMENT		
Property and equipment, net	**35,857,410**	**37,249,271**
OTHER ASSETS		
Pledges receivable long-term	1,004,000	17,500
Investments	604,856	1,179,985
Investments—endowment	352,138	343,370
TOTAL OTHER ASSETS	**1,960,994**	**1,540,855**
TOTAL ASSETS	**$ 40,544,613**	**$ 41,246,090**
LIABILITIES AND NET ASSETS		
CURRENT LIABILITIES		
Accounts payable	$ 247,359	$ 536,381
Accrued payroll and expenses	636,054	559,624
Current portion of notes payable	119,626	39,644
Current portion of capital leases	46,005	47,479
Deferred revenue	209,606	353, 407
TOTAL CURRENT LIABILITIES	**1,258,650**	**1, 536,535**
LONG-TERM LIABILITIES		
Notes payable	13,083,711	13,182,517
Capital leases	97,142	143,147
TOTAL LONG-TERM LIABILITIES	**13,180,853**	**13,325,664**
TOTAL LIABILITIES	**14,439,503**	**14,862,199**
NET ASSETS		
Unrestricted	5,052,800	5,523,709
Temporarily restricted	20,849,786	20,657,658
Permanently restricted	202,524	202,524
TOTAL NET ASSETS	**26,105,110**	**26,383,891**
TOTAL LIABILITIES AND NET ASSETS	**$ 40,544,613**	**$ 41,246,090**

Auditors MacPage, LLP, have expressed the following opinion concerning its audit of Bigelow Laboratory's financial statement:

In our opinion, Bigelow Laboratory for Ocean Sciences complied, in all material respects, with the types of compliance requirements that could have a direct and material effect on its major federal programs for the year ended June 30, 2015.



STATEMENT OF ACTIVITIES

FOR THE YEAR ENDED JUNE 30, 2015
(WITH COMPARATIVE TOTALS FOR JUNE 30, 2014)

	2015				2014
	UNRESTRICTED	TEMPORARILY RESTRICTED	PERMANENTLY RESTRICTED	TOTAL	TOTAL
OPERATING REVENUE AND SUPPORT					
Grants and contracts	$ 5,099,158			$ 5,099,158	$ 5,129,834
Contributions to Comprehensive Campaign	2,159,331	$ 2,003,543		4,162,874	3,146,074
Contributions	29,933	415,666		445,599	986,785
Course fees	115,632			115,632	262,458
Other, including interest	1,443,397	3,165		1,446,562	1,030, 396
Net gain (loss) on investments	(12,776)	8,774		(4,002)	34,837
Net assets released from restrictions	2,565,536	(2,565,536)			
	11,400,211	**(134,388)**		**11,265,823**	**10,590,384**
FUNCTIONAL EXPENSES					
Research and education	5,365,285			5,365,285	5,384,002
Management and general					
Allocable for research	4,190,191			4,190,191	3,700,499
Other	1,450,626			1,450,626	1,934,255
Development	865,018			865,018	709,942
	11,871,120			**11,871,120**	**11,728,698**
CHANGE IN NET ASSETS FROM OPERATIONS WITH DEPRECIATION	(470,909)	(134,388)		(605,297)	(1,138,314)
ADD DEPRECIATION NOT FUNDED BY GOVERNMENT GRANTS	914,000			914,000	1,005,352
CHANGE IN NET ASSETS BEFORE DEPRECIATION NOT FUNDED BY GOVERNMENT GRANTS	**$ 443,091**	**$ (134,388)**		**$ 308,703**	**$ (132,962)**
CHANGE IN NET ASSETS FROM OPERATIONS WITH DEPRECIATION	$ (470,909)	$ (134,388)		$ (605,297)	$ (1,138,314)
NON-OPERATING REVENUE, GAIN, AND LOSS					
Grants and contracts for equipment purchases		326,516		326,516	477,619
Gain on sale of Boothbay property					89,991
CHANGE IN NET ASSETS FROM NON-OPERATING ACTIVITIES		**326,516**		**326,516**	**567,610**
TOTAL CHANGE IN NET ASSETS	(470,909)	192,128		(278,781)	(570,704)
NET ASSETS, BEGINNING OF YEAR	5,523,709	20,657,658	202,524	26,383,891	$ 26,954,595
NET ASSETS, END OF YEAR	**$ 5,052,800**	**$ 20,849,786**	**$ 202,524**	**$ 26,105,110**	**$ 26,383,891**

A team effort to advance knowledge, understanding, and discovery

The many successes of 2015 could not have been possible without the commitment of, and contributions made by our scientists, staff, board of trustees, students, and donors. Collectively, we have helped advance understanding of the global ocean, inspired students to be interested in ocean science, and applied the latest technology to develop ocean-based solutions to complex problems. Together, we will continue this important work of scientific discovery upon which our ocean, our society, and our planet depend.

PHOTOGRAPHY

DR. DAVID EMERSON, Bigelow Laboratory for Ocean Sciences with funding provided by the National Science Foundation and NASA: Cover.
DR. PETE COUNTWAY, Bigelow Laboratory for Ocean Sciences with funding provided by the National Science Foundation: Inside front cover, pages 3, 7, and 33.
LAURA LUBELCZYK, Bigelow Laboratory for Ocean Sciences, in collaboration with **DR. ERICA GOETZE**, University of Hawaii: Pages 4 and 8.
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DR. NICK RECORD, Bigelow Laboratory for Ocean Sciences with funding provided by the National Science Foundation: Page 27.
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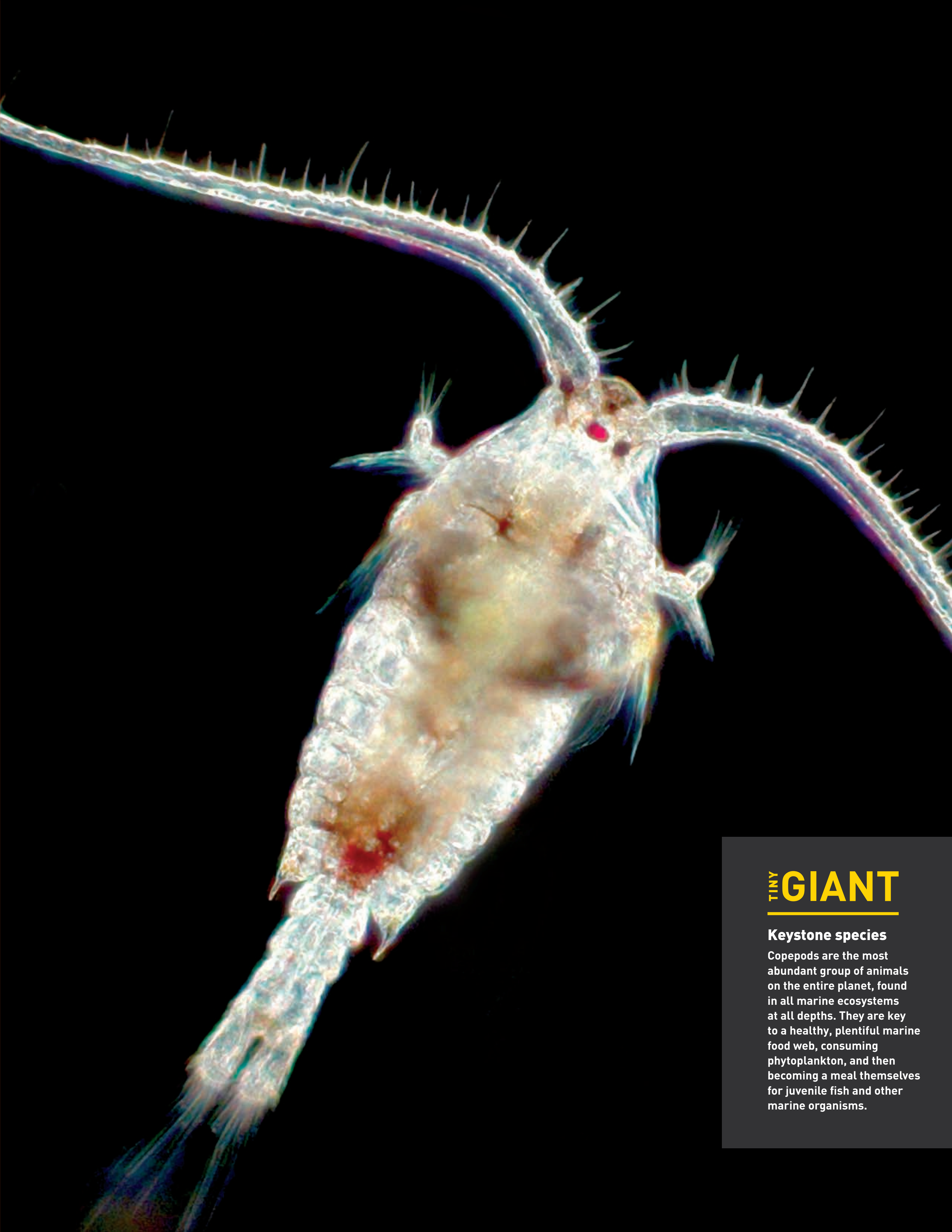

TINY GIANT

Keystone species

Copepods are the most abundant group of animals on the entire planet, found in all marine ecosystems at all depths. They are key to a healthy, plentiful marine food web, consuming phytoplankton, and then becoming a meal themselves for juvenile fish and other marine organisms.

TINY **GIANT**

Iron-eaters (COVER)

Some microbes use iron to grow prolifically, forming mats in environments as diverse as undersea volcanoes, salt marshes, and freshwater wetlands. Devouring iron has practical implications from removing pollutants from groundwater to mitigating biofouling and corrosion in water distribution systems.

Bigelow | Laboratory for Ocean Sciences

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