THE current

RESEARCH AND HAPPENINGS FROM
RHODE ISLAND NSF EPSCoR | SPRING–SUMMER 2014

FRONTIERS OF SCIENCE:

EPSCoR TAKES THE LEAD IN RESEARCH, EDUCATION

Rhode Island NSF EPSCoR
Experimental Program to Stimulate Competitive Research

THE current

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From the whale's tail to seagull wings, the margins or tips of animal propulsors bend to the same degree, according to a study by EPSCoR researchers. Photo credit: Mike Baird

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Greetings from Dr. Jennifer Specker

The Project Director & Principal Investigator of Rhode Island's Collaborative Agreements with the National Science Foundation's Experimental Program to Stimulate Competitive Research

Dr. Jennifer Specker, Professor of Oceanography at the University of Rhode Island Graduate School of Oceanography, has served as Project Director (PD) and lead Principal Investigator (PI) of Rhode Island NSF EPSCoR since 2010.

Under her leadership, the Ocean State's institutions of higher education have established the administrative capacity to become — both individually and collaboratively — leaders in research on the ecological effects of climate change. Dr. Specker navigated the challenging course of bringing together nine institutions, forging innovative relationships that have yielded unprecedented gains and hold great promise. [See below]

As a result of Dr. Specker's vision and drive, the Ocean State stands firmly on the frontier of moving science forward and training the next generation of scientists. Preparing to hand over the reins, Dr. Specker takes a step back to consider Rhode Island NSF EPSCoR and its bold achievements:

Thank you, Rhode Island, for the chance to see a wide-angle view of our state's potential and what we can achieve by working together. It is from this perspective that I can share the many joys of our Collaborative Agreement with the National Science Foundation:

- The uncontainable enthusiasm of students and teachers, from grades 6-12, as they share in the discovery of small forms of life called plankton. Thank you, Tim Pelletier and all the teachers and students, who participate in our many outreach programs.
- The intensity of undergraduates who spend time in laboratories and learn the satisfaction of original scholarship. Thank you, Jim Lemire and all the teachers and students, who engage in experiment of early independent research.
- The satisfaction of sharing stories of our experimental program so that the taxpayers of Rhode Island appreciate the benefits of investing in research and education. Thank you, Amy Dunkle and others, who work together to produce high quality content for this newsletter, the web, and other media outlets.
- The pleasure of participating in the collaborative efforts among the institutions of higher education as they inform each other about available technologies, skills, and other resources, which then become shared. Thank you, Pamela Swiatek and all the liaisons at the individual schools. And, thank you, Sally Beauman and Shelley Hazard for greasing the gears to make all this possible.
- The company of like-minded individuals who serve on the Steering Committee and work hard for the greater good. Thank you, Christine Smith, for your

guidance as the go-between for the Science and Technology Advisory Council and the NSF EPSCoR Agreement. Thank you, Ed Hawrot, Charlie Cannon, and Sheila Adamus Liotta for your contributions above and beyond anything expected of you by your own institutions.

And, from the start, thank you to Brad Moran, Professor of Oceanography, for working tirelessly with a small group of us to write the original successful proposal in the hot summer of 2009, and to Peter Alfonso for the opportunity to work together on executing this award.

Of course, as with all things, we are held accountable for the federal and state investments made into this experimental program. Thank you to the hundred-plus people involved in the seemingly interminable process of reporting our accomplishments and impact.

Beginning in July, the state will be served by two very capable investigators. URI's Carol Thornber, Associate Professor of Biological Sciences, and Art Gold, Professor of Natural Resource Science, will assume leadership for Rhode Island's Track-1 and Track-2 Collaborative Agreements with the National Science Foundation. It is my sincere hope that the NSF EPSCoR effort will augment both our excellence in marine and environmental science and our ability to provide opportunities for scholarship to all students with curious minds.

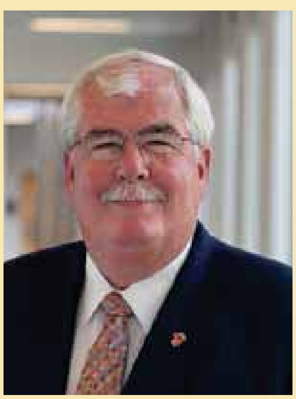
I wish both Dr. Thornber and Dr. Gold and all of you the very best, whether you leave a large wake or sail smoothly and leave none.

Jennifer Specker, Ph.D.
Rhode Island Project Director
of NSF EPSCoR Tracks 1 and 2
Professor of Oceanography
University of Rhode Island

Our Mission is to provide a platform to promote collaboration and cooperation among Rhode Island's institutions of higher education (IHE) and to enable alignment of our efforts with the needs of the state to increase research competitiveness, especially in marine life science and affiliated sciences.

We believe this will improve the employment rate, provide more attractive employment opportunities, create new businesses, and preserve and strengthen our connection to Narragansett Bay, its watersheds, Rhode Island Sound, and the Atlantic Ocean.

welcome



Dr. John Kirby is the Dean of the University of Rhode Island College of Environment and Life Sciences. He has been named Project Director for Rhode Island NSF Experimental Program to Stimulate Competitive Research (EPSCoR).

Greetings,

It is a pleasure to have the opportunity to work with the diverse and exciting partners in the Rhode Island NSF EPSCoR community. As I look through the portfolio of the program, I see an exceptionally abled faculty, staff and student body participating in moving science forward in our state.

The blend of institutions and the unique focus of each provide for an exciting trans-disciplinary vision for approaching large and complex scientific and societal issues. The abilities to facilitate long lasting and fruitful collaborations and drive innovation in research and scientific education at all levels play key roles in our pursuit of the EPSCoR mission.

I look forward to working with the broad EPSCoR family to continue the quest for increased opportunities and success across the many facets of our collaborative activities. Rhode Island is a tremendous classroom and laboratory. The opportunities envisioned through our activities will bring better understanding of the world around us, and how we impact and integrate with it.

Dr. John Kirby, Dean of the University of Rhode Island College of Environment and Life Sciences

welcome

Dr. Carol Thornber joins the Rhode Island NSF EPSCoR leadership team

Dr. Carol Thornber is an Associate Professor at the University of Rhode Island in the Department of Biological Sciences. Her main research interests include quantifying the impacts of climate change, harmful algal blooms, and invasive species in structuring communities. Most of her research involves marine systems, but she also works in terrestrial habitats.

Currently, Dr. Thornber is spearheading plans for the annual site review by the Research Competitiveness Program of the American Association for Advancement of Science (AAAS), which will occur in late May 2014. She is the lead PI for the next Rhode Island NSF EPSCoR proposal, due in early August 2014. She assumes the lead PI position for the existing EPSCoR grant, entering its fifth and final year, on July 1, 2014.

Greetings!

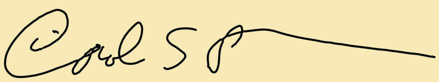
I am excited to become a part of the Rhode Island NSF EPSCoR administrative team, and this spring is a time of transition for me as I take on more EPSCoR duties.

Our next NSF EPSCoR proposal will focus on strengthening Rhode Island's research infrastructure, competitiveness, and potential for economic development, with a research theme of "Enhancing the Coastal Environment."

We will utilize scientific, applied mathematics, and engineering approaches, combined with creative excellence in art and design, to assess the impacts of global climate change and associated environmental stressors on Rhode Island's watersheds and coastal and marine environments.

We have a strong group of faculty from nine Rhode Island institutions, actively working to create an innovative and competitive grant proposal. As with our existing grant, we also will support numerous outreach and diversity efforts on behalf of the EPSCoR mission.

I strongly value the connections across Rhode Island's colleges and universities, which have developed, in part, due to Rhode Island NSF EPSCoR. I welcome this new challenge, and I look forward to working with you!



Dr. Carole Thornber
University of Rhode Island, Department of Biological Sciences

Watershed health study gets underway

In addition to the melting snow and winter runoff, there is something new in our watersheds this spring — state-of-the art sensors that will allow Rhode Island researchers to take the pulse of freshwater resources in the Ocean State.

Funded by a three-state, National Science Foundation (NSF) $6 million grant, the Rhode Island sensors are being set up in three streams that drain watersheds surrounded by differing land use — rural, agricultural and urban — yet, are similar in terms of size, soils and geology.

Researchers in Delaware and Vermont are carrying out similar operations, which will provide a comprehensive regional picture of how climate variations may play a role in water quality and quantity during extreme weather events.

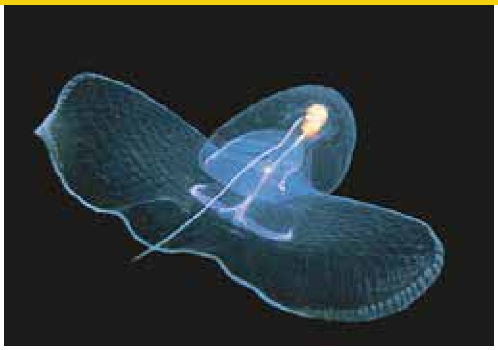
At the same time, economists in the three states are collaborating on social science experiments to gauge how better information about water quality affects people's decisions that play a role in water quality.

For a comprehensive look at the watershed study and what is involved in the project, watch for our next issue of The Current.

Following in Nature's footsteps

In humankind's quest to travel farther and faster, we apparently neglected to consider one pivotal question — how would Nature do it?

By Amy Dunkle


DR. JACK COSTELLO, PROVIDENCE COLLEGE, AND DR. SEAN COLIN, ROGER WILLIAMS UNIVERSITY

The thought about the natural state of propulsion occurred to Dr. Jack Costello, a Biology Professor at Providence College, and his colleagues, upon discovering that a jellyfish robot swam significantly faster when the part of the body that propelled it was flexible.

That realization led the scientists to wonder how much the flexible margin should be. And, from a design standpoint, how would you incorporate the benefit of flexibility to enhance propulsion?

"When we looked at the literature, we found a lot of work, very nice work, but it makes all kinds of assumptions," said Dr. Costello, a Rhode Island NSF EPSCoR researcher. "One alternative was too look at nature and see if there were any common features of natural propulsion. No one had really looked to natural examples to see what the common patterns were."

The study team included fellow EPSCoR researcher Dr. Sean Colin, Associate Professor of Environmental Science at Roger Williams University, and Dr. John O. Dabiri, Professor of Aeronautics and Bioengineering at California Institute of Technology. In addition, several students from PC and RWU worked on the study during their undergraduate years.

The scientists confined the scope of their study to the steady state, or regular motion, as opposed to takeoff or landing. What they found was that once moving regularly, whether through water or air, be it fish or bird, or marine swimming snail, the margins or tips of animal propulsors tended to bend to the same degree.

Photo courtesy of Mike Baird

(Titled "Bending the Rules," the team's paper was published in the journal Nature Communications Feb. 18, 2014.)

Manmade propulsive devices typically are rigid; yet, natural propulsors have evolved along a substantially different course, which provides an entirely new perspective. For some reason, despite all of the rigidity found in nature — bones, shells, etc. — evolution went flexible for propulsion.

"Can we achieve that?" asked Dr. Costello. "As biologists, it's very interesting to us and helps us understand animals. And, in this case, understanding animals probably has a very substantial e ngineering application."

Both the study and the experience proved meaningful for everyone involved — the students, the biologists and the engineers. And ultimately, as is the case with scientific research, society will benefit as well.

Dr. Colin said the U.S. Navy, in particular, puts a lot of resources into this type of research and provided funding for the study.

He noted, "If all of these animals are doing the same basic motions in order to swim or fly, it suggests that there are some important constraints. And, understanding those constraints can help us better understand how we can design vehicles to swim or fly."

Dr. Costello said if it were not for the engineers, he would not have been trying to answer the question about propulsion and flexibility in nature. Likewise, he added, the engineers were eager to learn from the biologists.

"Performance characteristics of animals are off the charts in many areas compared to designs that we currently have for human vehicles," Dr. Costello said. "There is the potential to learn very important lessons from animals and how they operate."

The multiple discipline approach is essential, he added, if scientists are going to unravel mysteries and solve complex problems.

Said Dr. Colin: "We can learn a lot from the world around us, and apply that knowledge to human engineered vehicles. Hopefully, these observations can improve and innovate designs."

(Read about the impressive undergraduate student who served as lead author on the propulsion paper. see p 21)

In their own words: Gordon Ober and Eric Ricci

Gordon Ober, University of Rhode Island

Ocean acidification and eutrophication are significant components of global change, and understanding how organisms respond to these changes is important to understanding how ecosystems may function under new climatic conditions. Atmospheric carbon dioxide (CO_2) has been increasing at an exponential rate since the start of the industrial revolution and the burning of fossil fuels. As atmospheric CO_2 increases, more CO_2 dissolves into ocean waters, lowering the pH, making oceans more acidic.

Most studies on acidification focus on calcifying organisms (such as corals), but acidification is just as likely to affect productivity and function in all marine organisms as well as their communities. Coastal and estuarine zones also are being threatened globally by anthropogenic nutrient loading, or eutrophication. This process describes the influx of nutrients from human sources to coastal waters. This can lead to harmful algal blooms and hypoxic events.

While increases in atmospheric CO_2 may be detrimental to calcifying species, non-calcifying photosynthetic organisms, such as macroalgae, may benefit. CO_2 is a necessary molecule for photosynthesis, and increased CO_2 availability can promote growth and productivity in certain species of algae.

In high CO_2 conditions, red algae are predicted to thrive, as red algae lack carbon-concentrating mechanisms (CCM), which allow organisms to easily assimilate carbon dioxide for photosynthesis. With increased CO_2, it should be easier for red algal species to assimilate this molecule. By contrast, other algal divisions (green, brown algae) whose members have CCM would gain no advantage from an increase in CO_2.

Photosynthetic organisms also need nutrients in order to grow. However, when excess nutrients enter a system, photosynthetic organisms can bloom and begin to choke out other organisms. When these blooms start to decay, oxygen is quickly removed from the system resulting in hypoxia. This lack of oxygen is detrimental to ecosystems and communities.

Ecosystems are not influenced by one environmental factor; rather, it is a suite of factors that effect systems and the organisms living in them. My research looks at how ocean acidification and eutrophication change the health and productivity of two local species of algae: *Gracilaria vermiculophylla* (an invasive red alga), and *Ulva rigida* (a native green alga) as well as the food webs they support.

Testing aspects such as growth rate, photosynthetic rate, tissue quality, and competitive ability in these species are good indicators on how they respond to global change and variability and also provide insight as to whether or not there is a shift in species assemblage.

Future research will involve broadening my experiments to include herbivores and predators, testing behavioral changes as well as feeding efficiency and preference. Being able to characterize how small-scale food webs respond to climatic variability works as an indicator for larger, broader food webs and communities. Changes at one trophic level likely will send rippling effects through the rest of the system. This research also aims to determine how environmental factors interact to influence communities.

Eric Ricci, Rhode Island College

To minimize water loss, the leaves of land plants are covered with a lipid-based cuticle. The cuticle typically consists of two major hydrophobic or water fearing components: cutin and waxes. In contrast to more advanced land plants, research reports indicate that some primitive plants, such as mosses, lack a cuticle. There is confusion as to whether or not the moss *Physcomitrella patens* has a leaf cuticle. My research, performed with the assistance of the RI NSF EPSCoR program, under the study of Dr. Eric M. Roberts, of Rhode Island College, helped clarify the confusion surrounding the *Physcomitrella* cuticle. This study provided the first direct evidence for the existence of a hydrophobic cuticle on the leaves of the moss *Physcomitrella patens.*

Histochemical staining (color changing dyes and stains) was used to investigate the presence of a cuticle on Physcomitrella leaves. Experiments employing dyes that stain hydrophobic substances were generally consistent with the presence of a cuticle. Hydrophilic dyes were also used to identify the presence of a cuticle through an absence of staining. Histochemical results were supported by observations made using freeze *(continued on p 22)*

You can go anywhere from here

EPSCoR serves as springboard to new opportunities

By Amy Dunkle

"Being an EPSCoR fellow was a rewarding experience. EPSCoR provided a year of funding for my research and tuition, and supported a portion of my travel to an international oceanographic conference. My outreach activities as an EPSCoR fellow allowed me to improve on my science communication skills, and provided useful tools for telling my scientific story. Interaction with other EPSCoR fellows created a great support network in which we could practice different techniques for communicating our work, and exploring its broader implications."

Kerry Whittaker, University of Rhode Island Graduate School of Oceanography

Ordinarily, the successful defense of a thesis might mean an opportunity to slow down and celebrate.

Not for Kerry Whittaker, University of Rhode Island Graduate School of Oceanography (GSO) doctoral candidate and Rhode Island NSF Experimental Program to Stimulate Competitive Research (EPSCoR) fellow.

One moment she masterfully presented her thesis — exploring the global distribution of genetic diversity in the marine diatom *Thalassiosira rotula* to better understand the intersection between diatom evolution and the marine environment.

Within days, Whittaker packed up her Rhode Island life and moved to Washington, DC, for her yearlong Knauss Sea Grant Fellowship.

"I'm settling in," she reported in a quick email. "But, it's been a pretty momentous 10 days!"

The 28-year old from Bridgewater, Mass., will spend the next year in the National Sea Grant John A. Knauss Marine Policy Fellowship program, which pairs highly qualified graduate students with hosts in branches of the federal government or associated organizations to work on substantive national policy issues related to aquatic resources.

Whittaker will spend her fellowship with the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service, in the Office of Protected Resources.

"I knew that once I defended my thesis, I really wanted to get another perspective on how science filters into policy-making, and how these really important political decisions that affect our natural resources are being made," Whittaker said.

All things biological

A dual major at Colby College (Waterville, Maine), Whittaker graduated in 2008 with bachelor degrees in English and Environmental

EPSCoR Fellow Kerry Whittaker. Photo by Katherine Touzinsky

Science. She traced her interest in science to a young age, having enjoyed a childhood of spending summers at the beach, hiking and camping.

As an undergrad, Whittaker gained some experience studying the paleoecology of ancient conifers. A semester abroad in Mexico, studying sea turtles and coastal conservation, hooked her into oceanography and the marine science field.

At the same time, she was drawn to environmental literature in her English classes: "There's a strong focus on the ocean as a literary concept as well. The ocean is really poetic, and inspires the human imagination, whether you're a scientist, author, or an artist."

For graduate school, Whittaker narrowed her interests to study diatoms and the role they play in the ocean's biogeochemistry, or the cycles of chemical elements such as carbon and nitrogen and the interaction with marine life.

Diatoms, a major group of algae and the most common type of microscopic organism known as phytoplankton, serve a significant ecological role. During photosynthesis, the tiny, single-celled plants that cover the ocean's surface turn carbon dioxide into organic carbon, generating oxygen.

Whittaker said she was particularly interested in the diversity of diatoms, and how that diversity factors into their survival in a changing world — the more diversity, the greater the ability to adapt to changing environmental conditions.

Diatoms are found throughout the globe, and Whittaker has located the same species distributed literally from one end of the earth to the other, from the poles to the tropics. Her work *(continued on p 22)*

"EPSCoR is a cog in that great wheel. The benefit to us in two EPSCoR awards to the state has provided us with the infrastructure that allows us to compete at a national and international level."

› Dr. David Nelson

The four questions propelling EPSCoR's research forward

By Amy Dunkle

Rhode Islanders don't have to look any farther than Gov. Lincoln Chafee's 2014 State of the Union and budget address to understand the critical connection between the Experimental Program to Stimulate Competitive Research (EPSCOR) and the future of the Ocean State.

From an educational perspective, the National Science Foundation's (NSF) EPSCoR program works diligently to train the next generation of scientists, from delivering outreach and education to K-12 students and exposing them to opportunities in science, to providing a platform where cutting edge research can take place.

This function alone makes EPSCoR an invaluable program, worthy of investment of both time and money. As Gov. Chafee said, "Education has always been the great equalizer. No matter where you start, if you get access to a good education and work hard, you can succeed."

Quoting President Lyndon Johnson, in his Great Society speech of 1964, Chaffee added: "Poverty must not be a bar to learning, and learning must offer an escape from poverty."

Nowhere does this sentiment hold greater meaning than in the state of Rhode Island, which, in November 2013, was about tied at 9 percent with Nevada for the worst unemployment rate in the country.

Dr. David Nelson, a microbiologist and professor in the University of Rhode Island College of the Environment and Life Sciences, reflected on the mission of Rhode Island NSF EPSCoR the day after Gov. Chaffee's address:

"We are doing this because as Gov. Chafee said in his speech last night, there is a direct correlation between the education level of a population and the economic well-being of that population."

That concept alone is rooted in the federal Morrill Act of 1862, which established the land grant university system and made education available to the masses.

Dr. Nelson, also director of the Genomics and Sequencing Center at URI, said, "People work better with more knowledge; they come up with brilliant ideas that lead to whole new industries."

Funding the areas of physics and chemistry led to computers on our desktops and smartphones in our pockets. Basic research in the fields of microbiology and biochemistry spawned the multi-billion dollar biotechnology industry.

"EPSCoR is a cog in that great wheel," Dr. Nelson said. "The benefit to us in two EPSCoR awards to the state has provided us with the infrastructure that allows us to compete at a national and international level."

Question #1: What are the stress responses and evolutionary potentials of marine organisms in response to climate change?

Lead research team: Tatiana Rynearson, University of Rhode Island; Rebeka Merson, Rhode Island College; David Rand, Brown University

Collectively, the community of Rhode Island NSF EPSCoR scholars works to answer the overarching question: "What is the response of marine life to climate variability?"

Under that umbrella fall three distinct research questions about adaptation, food webs, and pathogens, all of which are bringing greater understanding of the world around us.

Explaining the importance of the first research question, Dr. Rand said, "We need to know all of these responses so we can properly manage and sustain populations and species in their natural habitats."

He offered this example: If street runoff into coastal waters or outboard motor pollution increases the sensitivity of an organism to the stress of heat, that could reduce the availability of critical species in the food chain. In turn, fewer food items could reduce fish stocks, which affect fish landings, business income, a family's paycheck, recreational opportunities, and the tourism economy.

If we better understand how organisms respond to stress, we can better protect ourselves and preserve the biodiversity that sustains our everyday life.

Consider the tiny mysid shrimp, which live in Narragansett Bay. They are not for human consumption, but rather exist lower on the food chain, eaten by larger marine organisms such as the fish that wind up on our dinner plate.

Although small in size, the viability of this little native shrimp carries tremendous consequences. Whether they can adapt and survive at higher water temperatures directly correlates to the abundance of seafood and health of the Rhode Island economy.

"This research is very important to understanding how our marine and coastal communities may be impacted by climate change," explained Dr. Carol Thornber, URI Biological Sciences, a collaborator on the mysid shrimp research project with URI colleague and lead investigator Dr. Jason Kolbe and Dr. Jason Grear, U.S. Environmental Protection Agency (EPA), Narragansett.

"Most species are affected by the presence of other species — frequently because they may be in the same food web and, thus, eat or get eaten by another species," Dr. Thornber said. "So, if one species is affected by climate change, there can be a cascade of effects that impacts other species as well."

In the short term, there are behavioral and physiological responses, such as moving underneath seaweed or a rock when the tide goes out, or regulating salt content when rainfall alters the level of salt in the surrounding water.

But, what happens if change persists? How do organisms and their habitats adapt?

Dr. Rand explained: "On longer time scales, there are ecological shifts, such that salinity or temperature stress could alter the competitive or predatory interactions between organisms."

Extending out further, on the longest time scale, Dr. Rand said, "There are evolutionary responses that can change the genetic make up of populations such that the resistant types survive and the sensitive types die, shaping the genetic composition of populations and the types of genes and proteins found in organisms that have evolved to live in a particular habitat — high vs. low intertidal, surface vs. deep water."

There is, however, no single or easy answer.

The complexity of climate variability

Scientists can look at the responses of marine organisms to specific stressors such as chemical exposure or habitat changes, and make predictions based on how climate change likely will affect the frequency and severity of stressors, which dictates the response and course of adaptation.

Aided by a comprehensive training in environmental sciences, cellular physiology, genomics, and toxicology, Dr. Rebeka Merson said she approached ecotoxicological (which integrates ecology and toxicology) questions with a holistic style, thinking broadly about cause and effect.

"Some species are incredibly tolerant to changes in salinity and temperature," she said. "For example, the widely distributed species called the mummichog, also known as the Atlantic killifish, can rapidly adapt to salinity changes from full seawater salinity to freshwater. They are extremely tolerant to a broad range of water temperatures as well."

Consequently, she said, many researchers are using the sequenced genome of the mummichog to assess the genetic basis of the plasticity or evolutionary potential of these traits. Knowing more about the potential genomic responses in this species, scientists can make predictions and then test the possibility of plasticity in other species that may be challenged by the same environmental conditions.

"We are all in this together," Dr. Merson said. "Humans are being exposed to the same environmental chemicals as are wild organisms, and understanding the mechanisms of adaptation and consequences of this exposure in marine, aquatic, and terrestrial organisms will inform us of potential responses humans may have."

Getting a better grasp of how species respond to climate change also will provide better management of scarce and dwindling resources to cope with the impacts of climate change.

Dr. Rand said, "It may be that some organisms are very resilient to climate change, and we should not waste money trying to 'save' them. Other species may be very sensitive to particular stresses, so those details can result in more efficient use of taxpayer dollars on marine conservation efforts."

To date, the research has yielded vital information that is setting the stage for greater understanding. In Narragansett Bay, Dr. Thornber said, different species of the mysid shrimp revealed that they have different ranges of temperatures in which they can survive. And, their swimming speed is tightly linked to water temperature.

Dr. Rand said his research has found that a natural mutation in a protein-coding gene that helps digest sugar affects how barnacles survive, and Dr. Rynearson has learned that different populations of diatoms (a major group of algae and common type of phytoplankton) are genetically distinct and respond differently to both temperature and ocean acidification.

Behind the scenes of discovery

Studying the complex and multi-faceted impact of climate change requires a substantial investment of time, patience and money. For his lab alone, Dr. Rand ticked off a long list of demands — field collections, laboratory sorting, DNA preparations, stress analysis in the lab or field, DNA sequencing, RNA preparation or sequencing, and data analysis.

And, that's just when things go right.

Dr. Thornber recounted what happened last year in the mysid shrimp project, which is located at the U.S. EPA facility in Narragansett. Researchers could not enter the facility during the 2013 federal government shutdown, but the shrimp have to be checked on and fed every day to ensure survival.

"We invested several months of work only to have nearly all of our organisms die when the government was shut down," Dr. Thornber said. "So now, we are starting over. This was supposed to be a one-year project, but likely will be two years. We are hoping to have preliminary results this summer, with more results in the fall."

But the long hours and painstaking effort, the occasional failure and setback, are all part of the process of moving science forward, both in the name of discovery and training the next generation.

The mysid shrimp project alone represents a collaborative effort between three scientists with complementary skill sets and expertise, making the group approach significantly stronger.

Dr. Kolbe is an evolutionary biologist and gives the 'big picture' framework, explained Dr. Thornber, who is a marine ecologist with many years of experience working in Narragansett Bay and on marine food webs. Dr. Grear is a marine ecologist with extensive experience in working with mysid shrimp.

Graduates and undergraduates gain essential hands-on experience in the labs. For the older students, the research may become part of a Ph.D. thesis; for the underclassmen, the work offers an opportunity to learn research skills in animal rearing, video use and data analysis.

Dr. Merson also engages graduate and undergraduate students, who work with her on identifying the responses and adaptations to exposure to toxic environmental chemicals.

And, she said, "They benefit directly by having a stake in the research. They learn and practice the process of scientific inquiry, and gain practical skills in molecular biology and evolution."

Dr. David Rand, on the lead team for the first research question, works in his Brown University lab.

Dr. Rand echoed the importance of the training, from undergraduate to post-doctoral fellow and faculty member: "We all learn from doing work together. Some learn the basics from the more experienced, and even the professors learn from the students."

Question # 2: How are the structure and function of coastal marine food webs and biogeochemical cycling being redirected in response to climate change?

Lead research team: Susanne Menden-Deuer and Bethany Jenkins, both University of Rhode Island; Breea Govenar, Rhode Island College; and Patrick Ewanchuk, Providence College

Biological diversity or biodiversity refers to the variety of life that teems within the ecosystem of a particular area or region.

Scientists aligned with Rhode Island NSF EPSCoR's second research question are trying to understand the organisms of the state's marine system, what they are doing and how they are interacting.

How do environmental changes affect the composition and structure of marine communities? How do organisms respond to both natural events, such as seasonal fluctuation and periodic storms, and to manmade influences?

"The planet is changing at such a rapid rate, such as in temperature and carbon dioxide, we want to know how do these organisms respond to the changes and how do we anticipate what the ecosystem may look like in 100 years," said Dr. Menden-Deuer.

From the air we breathe to the food we eat, the homes we live in, the paychecks we cash, and the recreational activities we enjoy — life here in Rhode Island and beyond the state's borders depend largely on the ocean's waters.

A rise in sea level threatens habitation for marine organisms and humans alike; transportation and tourism industries feel the impact as well. How much carbon dioxide pumps into the air and courses through the bones and flesh of fish directly affects the breaths we take and the food we eat.

Simply put, Dr. Menden-Deuer said, "It's important to study the ocean from a biological perspective if we want to derive its benefits."

By studying how the marine food webs work and respond to changes already taking place, scientists can predict future implications and provide essential information for better preparedness and policies.

Rhode Island NSF EPSCoR researcher Dr. Breea Govenar teaches a class at Rhode Island College.

Relevance in research

Dr. Govenar's research focuses on ribbed mussels, commonly found in salt marshes, yet typically not harvested for food, nor regulated. That means no one is introducing or removing and transplanting the mussels from their natural system; they are not being modified like other bivalves, similar to an agricultural crop.

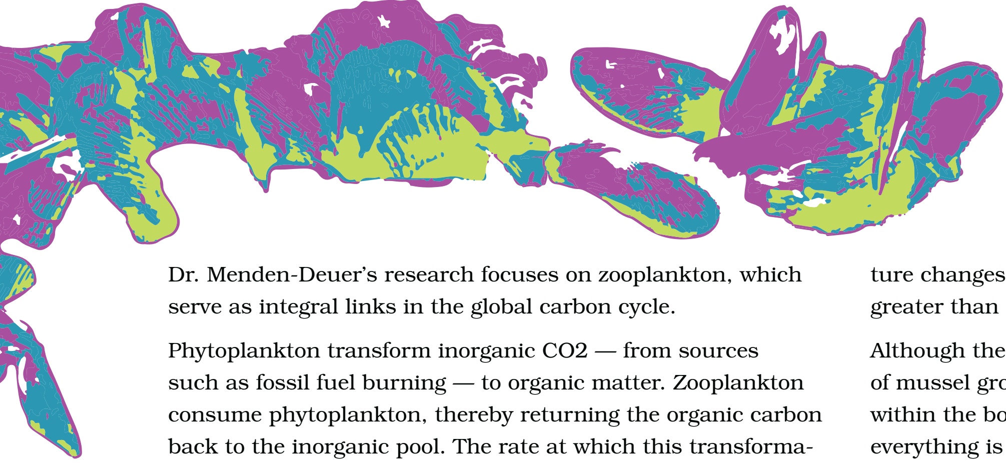
The stability allows scientists a clear vantage point from where they can observe the impact of environmental shifts. For the ribbed mussels, climate change is not causing the species to become diseased or die off; the mussels are not relocating or running out of food. As it turns out, the impact of climate change is not always such a clearly cut case of cause and effect.

What Dr. Govenar finds is that increased amounts of nitrogen generate more food for the ribbed mussels to eat: "It becomes too much of a good thing and ends up being detrimental."

The increased availability of food means more eating, more reproducing, more surviving, and ultimately overcrowding that results in smaller mussels. An increased population crowds the salt marsh habitat. Sea grasses may not be able to colonize, which, in turn, degrades the salt marsh.

"Salt marshes are incredibly important," said Dr. Govenar. "They are a highly productive ecosystem. Plants take up CO2 in the summer; they die and decompose in the winter, and then start all over again."

Salt marshes have been identified as areas that might be good for expansion of carbon sequestration. They also serve as buffers from storms and reduce coastal flooding. They filter out pollutants that otherwise might enter the bay, locking up contaminants such as metals and hydrocarbons.



Dr. Menden-Deuer's research focuses on zooplankton, which serve as integral links in the global carbon cycle.

Phytoplankton transform inorganic CO_2 — from sources such as fossil fuel burning — to organic matter. Zooplankton consume phytoplankton, thereby returning the organic carbon back to the inorganic pool. The rate at which this transformation happens (respiration) is key to estimating how much inorganic carbon is removed from the atmosphere.

Rhode Island NSF EPSCoR's Question #2 is concerned with these rates, and how they might change in response to climate change, meaning, will higher temperatures increase the rates of respiration?

What the science tells us

Conducting experiments and tracking changes that may or may not evolve quickly demand patience and tenacity, particularly when there is no certainty where a research path might lead or what findings might result.

Dr. Menden-Deuer explained: "Science is a long-term endeavor that takes a lot of serendipity. We know very little about the basics of how the ocean works, how the ecosystems work."

Developing public understanding to generate support and initiate societal change only adds to the layers of complexity.

Dr. Govenar said, "Climate change is a large scale problem, so sometimes the effects are acute and immediate; sometimes the effects are spread out over a long period of time. So, we compare the past and the present. Elevated temperatures and increased flooding are immediate effects of larger scale problems. Are they permanent? Maybe not."

Whether the impacts of climate change occur within the span of one study, on the scale of centuries or confined to a decade or two, people tend to look at only what directly affects them.

"But," said Dr. Governar, "Science is something that is more global than individual. Stronger storms or planetary temperature changes, even though the cause and effect are much greater than Narragansett Bay, it still occurs in our backyard."

Although the general public may not grasp the finer data points of mussel growth and density, there does exist a simple concept within the body of Rhode Island NSF EPSCoR research — everything is connected.

Reason for hope

According to Dr. Govenar, accepting that truth poses a great challenge: "Previous generations did not always experience the consequences of industrialization and other types of habitat modification. But, we are now experiencing those effects and realizing the interconnectedness of our individual decisions and the decisions of our communities."

Ultimately, the prospect for human survival will come down to humans themselves; whether there is the capacity to understand the implications of climate variability and enact prudent policies and lifestyle changes.

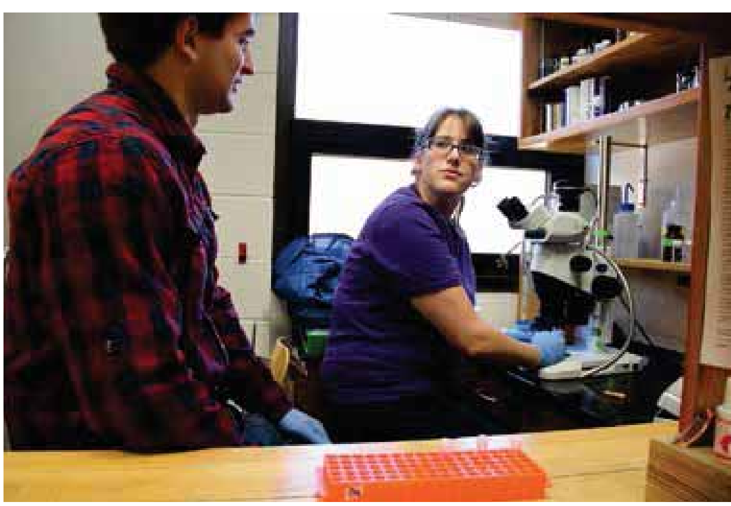
The planet, however, will live on, predicted Dr. Menden-Deuer, who in tandem with her science is drawn to the splendors of the sea and the intricate beauty that exists in the diversity of the tiny microbes she studies and their ocean habitat.

"I'm always going to be optimistic, because humans are the ones at risk," she said. "We have the potential to make things really bad on this planet, and the situation may be very dire. The quality of life for humans could be reduced, and humans may even die out. But, the planet itself is full of wonderful potential and will be populated with organisms until the sun stops shining."

It may take serious consequences to ignite action, but Dr. Menden-Deuer held out hope that humans always seem to rally. The spark just isn't there, yet.

"I'm hopeful," she said. "But, I'm not hopeful that the response will be quick or easy."

Joe Burgess and Leah Smith, senior biology majors at Rhode Island College, discuss research on the bacteria found in the digestive tract of gastropods, collected from hydrothermal vents. The bacteria eaten by these snails form the base of the food web at the vents, which are found deep in the ocean, where sunlight doesn't reach.



Question #3: How will global climate change affect the ecology of marine pathogens and parasites?

Lead research team: Dr. David Nelson and Dr. Christopher Lane, both at University of Rhode Island; Dr. Roxanna Smolowitz, Roger Williams University

Rhode Island NSF EPSCoR research projects seeking to help answer this question focus on finding answers to how warmer water temperatures brought on by climate change affect the pathogens and parasites that cause disease in their marine organism hosts.

The ocean, its inlets and intertidal waters are intricately woven into the identity of Rhode Island and the psyche of its citizenry. We are, after all, the Ocean State.

Developing a better understanding of marine relationships is crucial to the future of Rhode Island, where Narragansett Bay and surrounding coastal waters figure prominently in the state's environmental, economic and recreational health.

The cycle precipitated by warming waters means a thorough shift that ripples out from the most basic level of the marine ecosystem and ultimately extends to the safety and security of our food, jobs and quality of life.


Whitney Jaillet, a senior marine biology major at Roger Williams University, extracts DNA from oyster tissue to determine how much pathogenic DNA is present in the tissue.

"If temperatures are warmer and stay warmer longer, the pathogens stay in the water and their hosts — fish, shellfish — longer," explained Dr. Nelson. "Their hosts are going to be subjected to potential infections over a longer period of time."

Typically, most pathogens recede when the colder water temperatures of winter arrive. Either diluted or killed, the pathogens stop feeding on their hosts. Warmer waters, however, allow the pathogens a longer period in which to feed, the fertile environment increasing their metabolism and inducing them to feed more.

Any pathogens that do better in cold water will decrease, but that decline will be matched or surpassed by the growth of pathogens in warm water, according to Dr. Nelson: "We'll probably see infections and diseases increase."

Gaining insight to the cause and effect is crucial, said Dr. Smolowitz: "If we understand what is happening, we may be able to help or prevent at least some of the outcomes that will significantly impact the plants and animals around us, and ultimately us."

The implication is clear — more diseased fish means less to eat and a less healthy diet, and staggering economic losses. We can try to compensate and maintain sufficient supplies through aquaculture, but any gains will be offset by disease transmitting more quickly in large concentrations of organisms, whipping through higher density populations more frequently and at a more rapid pace.

The question then becomes how to deal with the threat, which is where the research question comes into play. If we can understand the dynamics wrought by climate change, how the ecology of marine pathogens and parasites adapt, then we can develop a response.

Research at work

"We have to know how the disease is caused so we can understand how to interrupt it," explained Dr. Nelson. "You can throw antibiotics at it, but there are problems with that."

Antibiotics in the food chain pose a significant issue for people who are allergic or sensitive to antibiotics. Antibiotics also can cause the unintended evolutionary consequence of resistant bacteria that ultimately render antibiotics useless.

A more pragmatic approach instead targets aquaculture, or the breeding of aquatic organisms, making the marine farming practice cleaner and utilizing proper management techniques to reduce the incidence of infection. Or, develop a vaccine that fish can be fed or immersed in to cause a protective immune response.

Dr. Nelson has been studying the organism *Vibrio anguillarum*, which causes vibriosis, for more than 20 years: "What we are currently doing is understanding how it causes disease in fish. We've identified the genes that encode virulence factors; some are toxins, some are enzymes that break down proteins. We've looked at how it affects fish, the role in causing disease, the role in the fitness of the *Vibrio*, and we use this knowledge to understand how we can construct the vaccines necessary to protect the fish."

Another project, in collaboration with URI professors Dr. David Rowley, College of Pharmacy, and Dr. Marta Gomez Chiarri, College of Environment and Life Sciences, looks at *Phaeobacter gallaeciensis*, a probiotic organism that can protect its oyster host.

The researchers have found that putting *P. gallaeciensis* in the water with oyster larvae provides protection in three ways: The organism makes an antibiotic, TDA; it forms a biofilm that multiplies and crowds out the pathogen; and it makes a substance that disrupts the pathogen's ability to be toxic, but does not kill the pathogen itself.

The role of climate change

Pathogenic disease occurs naturally and populations are affected as bacteria evolve. Just as humans endure flu epidemics, marine life will be subjected to viruses and bacterial infections that can spike mortality rates. That will happen regardless of temperatures.

"The question is," said Dr. Nelson, "Are we going to see severity increase or decrease, or will those limited to the tropics spread into more temperate areas? Will there be more disease, more widespread? In the short term, will we see a great increase in the number of animal deaths due to infectious agents?

"The suggestion is, yes. At some point, evolution keeps happening. Either a species will be wiped out or it is going to evolve in some fashion and we will see a new norm. Maybe we will see more frequent epidemics, or maybe endemic disease."

According to Dr. Smolowitz, disease affects both the abundance and quality of life for the host animal or plant and how the host interacts with the environment. If hosts die or become incapacitated, the implications will reverberate and multiply throughout the ecosystem.

She cited critical interactions induced by climate change, starting with the movement of animals or organisms into areas where they had not been able to survive before or to a location that was not within their temperature and salinity range.

Another important factor to consider is the increased stress on organisms as the normal climate in their area changes, Dr. Smolowitz said: "Disease is always an interaction between the agent, the host and the environment. In the waters, fish and invertebrate metabolism varies directly with the temperature since they do not maintain a constant temperature as we do and so are more likely to undergo such stress."

Top: Kate Markey, technician at the Aquatic Diagnostic Laboratory at Roger Williams University, shows the oyster seedlings that are being cultivated to replenish wild populations. Bottom: The rainbow of algae being grown to feed the shellfish.

The EPSCoR impact

The key is to understand the dynamics and implications of what is taking place so that scientists can either prevent or help mitigate the severity of the consequences.

Although the probiotics and immunology approach are fairly new, and the Rhode Island researchers are one of only a handful of groups worldwide focusing on *V. anguillarum*, Dr. Nelson said efforts were yielding notable progress in securing a safe food supply.

"What we're discovering will have tangible, practical benefits," he said. "People will benefit by being able to raise more fish and more oysters, which hopefully will be tastier, more abundant and available at a reasonable price."

As part of the exploration and discovery process, the research labs also provide a cutting edge training ground for the next generation of scientists. In any given semester, Dr. Nelson has up to three undergraduates working on any aspect of the projects and has trained a significant number of graduate students on their way to a master's degree, Ph.D. or postdoctoral work.

Dr. Smolowitz said students help plan and conduct the work, and often take on a portion of the research as their own under the faculty supervision. Doing so, she said, provides hands-on experience in a research lab and develops the process of logically seeking out and finding answers to research questions.

Dr. Nelson added that if the research work leads to intellectual property, the university would reap financial rewards as well from the generated income.

Ultimately, the research conducted by the Rhode Island NSF EPSCoR grant comes back to the benefit of the state and its citizens. On a grand scale, finding answers to these complex questions will aid the world's response to climate change, fending off disease and securing a safe and abundant food supply.

What that means here in Rhode Island is a stronger, marine-based economy, from the seafood sold in restaurants and roadside clam shacks to jobs created by companies developed to supply new products like the vaccines discovered in our university labs.

Question #4: How can scientific findings and forecasts in the area of climate variability and marine life be made more accessible to the public through a variety of media?

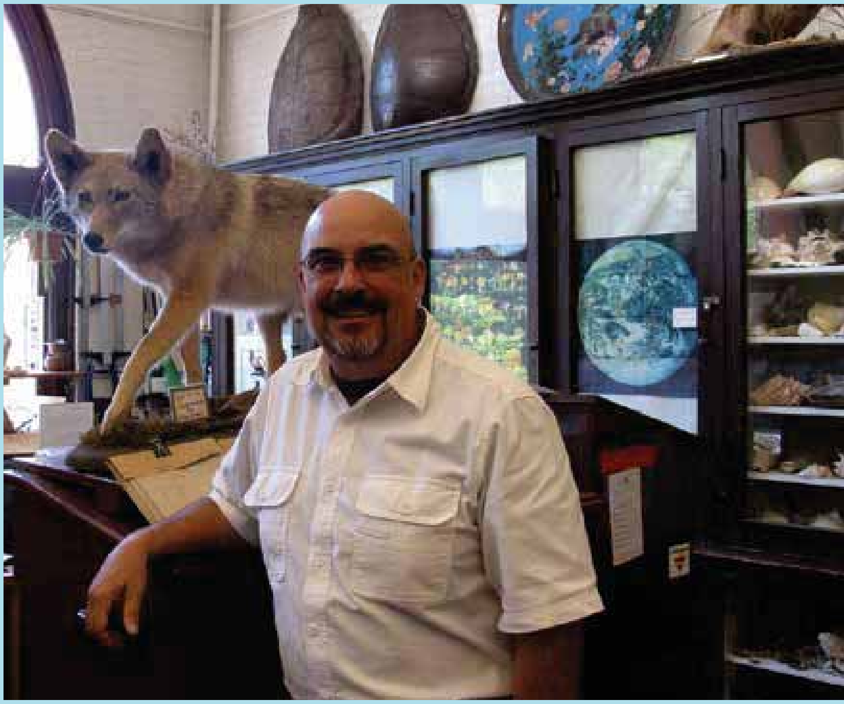
An interview with Neal Overstrom of Rhode Island School of Design's Edna Lawrence Nature Lab

The National Science Foundation (NSF) Experimental Program to Stimulate Competitive Research (EPSCoR) counted 31 jurisdictions in 2013. Only one — Rhode Island — involves an art and design school as a partner institution.

This relationship with the Rhode Island School of Design provides the Ocean State with an invaluable asset in its research quest to explore the impact of climate variability on marine life and ecosystems.

Neal Overstrom serves as director of the RISD Edna Lawrence Nature Lab, founded in 1937 by long-time faculty member Edna Lawrence, where a hands-on natural history collection and studio environment offer the opportunity to examine and explore the patterns, structures and interactions of design in nature.

In a conversation earlier this spring, Overstrom, who holds graduate degrees in zoology and landscape architecture, contemplated the RISD connection to Rhode Island NSF EPSCoR, what the institution brings to the partnership, and the importance of the cross-disciplinary approach of the Science, Technology, Engineering, Art, Mathematics (STEAM) initiative.



Neal Overstrom, director of the RISD Edna Lawrence Nature Lab, serves as institution's partner liaison to Rhode Island NSF EPSCoR.

The Current: What is the purpose of the EPSCoR research question #4 and how does RISD fit into the equation?

Neal Overstrom: "The world is so complex and people are inundated with information, we need to get more creative about conveying the significance of the information we're putting out there. Why is this information important? We need to cut through the complexity and work on making science both more visible and accessible, working with scientists to share their discoveries in innovative ways.

"The goal is to communicate in ways that foster not only understanding, but also broader engagement and caring, something I think artists and designers can do especially well."

TC: RISD also brings a new perspective to the equation, particularly with the studio-based approach to instruction and learning. Can you explain and elaborate?

NO: "Bringing together artists, designers and scientists in collaborative, studio-based research environments can change the way we look at problems. What is unique to art and design school studios is that the process of developing creative work occurs through critique in an environment that is a safe and encouraging place for students to both succeed and fail in order to see what works and what doesn't.

"To me the idea of critique isn't about imparting information, but rather helping students explore ideas. Asking, what are they trying to accomplish? How are they thinking through a problem? How then do they express that thought process and how successful were they in representing the meaning they derived through whatever medium — digital tools, sculpting clay, paint, charcoal — they used?"

TC: What is the connection between the studio process and scientific research?

NO: "What's intriguing to think about is the type of inquiry inherent in studio and how it relates to the modes of inquiry pursued in the sciences. There are similarities and differences. So, it's not only the disciplines themselves, but also the way in which we go about studying problems.

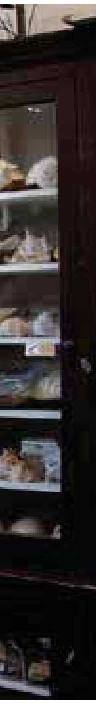
"When we use the words art and science, we often have preconceived notions about what they represent. If I use the word inquiry, however, whether in art or science, there are certain qualities that people might think of instead— for example, for many, art tends to be qualitative and science tends to be quantitative. There is a level of subjectivity with art. Science tends to be objective. Science tends to be driving toward a particular truth; the processes of art may yield many truths.

"So, I prefer to think of art and science as different but complementary modes of inquiry, and exploring questions using both can facilitate more innovative problem solving."

TC: How does this approach facilitate climate change research and the study of how marine organisms respond?

NO: "The thesis once again is that by bringing an interdisciplinary approach to problems we can solve more complex questions in more innovative ways. From my perspective, art and science both start with a question; both have bodies of knowledge; both have processes, both have technologies. The difference is that an artist can explore a question and have many answers. In science, we're trying to ensure that we don't do that; that we have one answer to an investigation.

"It's very exciting having an art and design school as part of EPSCoR, particularly an institution that practices creative and, what RISD calls, 'critical' making. For me, the beauty of this is expressed in the concept of STEAM. The goal is to help students benefit from practicing multiple modes of inquiry.



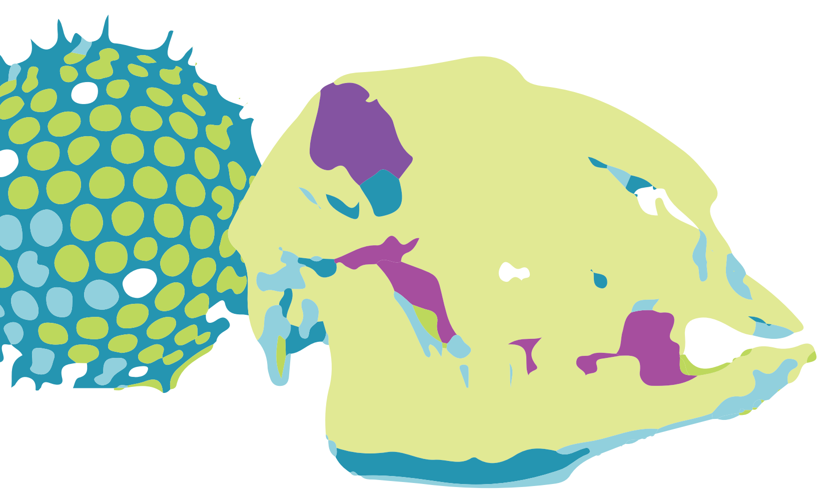
"They learn to look at questions with an open-ended, divergent way of exploring, but they also can slide back and be more focused. I think the ability to move back and forth between being expansive and very direct is a remarkable and important skill to hone."

TC: The Nature Lab utilizes a taxonomy experience, grouping a variety of objects from the natural world, to help expand people's views and broaden perspectives. Can you explain the purpose of this exercise?

NO: "Asking people to organize natural science specimens based on whatever relationships are apparent to them yields very interesting outcomes. It's not that there is no right or wrong. The question we are asking is what does it reveal? We're looking at objects and re-categorizing them, which demonstrates the way prior knowledge can bias our perceptions or prevents us from seeing new ways of organization.

"If you ask someone to do this exercise who is familiar with these objects from a natural science perspective, they typically start thinking about evolutionary relationships, who is related to who and they categorize that way. Or, they know the life history — these guys fly — and group them that way.

"Sometimes, however, people come in and simply group from light to dark, rough to smooth, big to small. It all depends on the question. It can be very revealing. Often, people don't see other broader possibilities. What does it sound like if you shake it? What if we group solely by pattern?"



"We're creating our own narratives. It is in that process — and I think what studio allows us to do and what studio process can bring to science — where we can potentially see data in new ways; new ways of combining and new ways of organization that we might not have seen if we were working within our original disciplines alone."

TC: What do we gain from this exercise?

NO: "From my experience, process is as important as the outcome. When we share our work in the sciences, we're usually sharing an outcome and demonstrating to the best of our ability that the process we used was correct. We're answering a specific question with an outcome. We don't want to share anything until we're sure we have the right answer.

"As in the taxonomies exercise, studio, however, is about that process, about sharing our thinking, regardless of whether it is going to be the final outcome or not. It's about seeing new opportunities."

TC: That brings us full circle back to the EPSCoR research questions and RISD's role.

NO: "From my chair, I see a growing cadre of students who are electing to pursue professional careers that work across disciplines. There are so many remarkable students coming to us, students from all disciplines, who are not just interested in one field of study. Our 2013 SURF (Summer Undergraduate Research Fellowship) students are good examples. Priscilla Ahn is a dual degree student studying geology at Brown and furniture design at RISD. Nic Baird graduated from Brown majoring in biology and visual art.

"They are bringing both the arts and sciences together in their work, bringing fresh perspectives to these compelling questions and problems. People are seeing the benefits of integrating art and science in K-12, and in colleges and universities. We are cultivating young researchers who can both better communicate scientific principles and finding and also apply these different modes of inquiry to research settings

"And, it's not just in their professional careers, but in the lives they lead and their values and priorities. It's about reimagining and reinventing our future societies. For example, many students are thinking about new ways of ethical making related to the material systems on which societies depend."

TC: Does this make you optimistic for the future, that we will solve these pressing problems and ease the threat of climate change?

NO: "I see students who are passionate about tackling the issues. They know about our forecasts, that there is a certain momentum that we have to reverse. But, it's going to take some time. This is the genesis of a new way of not just thinking about the problems themselves, but also changing society.

"The decline of fish populations, ecological shifts in oceans, ocean acidification — these are big challenges and I think we have the insights. We know a lot about what's happening, and what many of the drivers are, but how do we facilitate broader engagement so people are willing to make these changes? This is where artists are especially well-positioned to work with scientists in shaping a new world view."

Seven teams to share $806K in 2014 collaborative research grant awards

With the goal to make Rhode Island an international leader in understanding and predicting the response of marine organisms and marine ecosystems to climate variability, Rhode Island Gov. Lincoln D. Chafee and the Rhode Island Science & Technology Advisory Council (STAC) announced the recipients of the 2014 Rhode Island Research Alliance Collaborative Research Grants.

The awards, totaling $806,501 will fund seven diverse teams bringing together deep expertise in the natural and social sciences as well as the arts and environmental conservation to study how marine plant and animal life are responding to climate change in Narragansett Bay. Data from these projects will lead to improved strategies for fisheries and aquaculture management, better understanding of how to predict harmful algal blooms and the development of communications tools to engage and inform the public on the localized effects of climate change.

The Impacts of Climate Change and Variability on the Biogeochemistry and Ecology of RI's Coastal Waters – Regional Climate Modeling

Since the 1950's, Narragansett Bay has been the site of two long-term marine monitoring studies. This team brings together an ocean chemist, physicist and ecologist to use a computer simulation specifically designed for the coastal waters of Rhode Island to model the complex data that has been collected to better understand the impact of our warming waters on animal and plant life. The data also will help groom the next generation of scientists from kindergarten to the college level, by providing new material that can be included in the K-12 Next Generation Science Standards and a recently added Environmental Chemistry track at Rhode Island College.

Collaborators:
Lewis Rothstein, University of Rhode Island Graduate School of Oceanography
Susanne Menden-Deuer, University of Rhode Island Graduate School of Oceanography
Sarah Knowlton, Rhode Island College

Data Narratives: Climate Change in Narragansett Bay as a Case Study for Engaging Communication of Scientific Information

This team's efforts will focus on gaps in data collection and its dissemination to scientists, decision makers and the public. Bringing together deep local expertise in the natural and social sciences as well as the arts, this project will improve communication and understanding of localized effects of climate change by developing interactive, highly engaging data narratives. Their goal: to develop the proof of principle necessary to demonstrate RI's national leadership in this area.

Collaborators:
Susanne Menden-Deuer, University of Rhode Island Graduate School of Oceanography
Neal Overstrom, Rhode Island School of Design
Sunshine Menezes, Metcalf Institute for Marine and Environmental Science

Developing an Aerial Imaging System Using a Robotic Helicopter for Tracking Harmful Algal Blooms in Narragansett Bay

Working in partnership with the state Department of Environmental Management and the federal Environmental Protection Agency, an ocean engineer and marine biologist will develop a unique approach to monitor and analyze of harmful macroalgal blooms in Narragansett Bay. The proposed method — a low altitude aerial survey with small robotic helicopters — is a means to provide high resolution, large area data coverage over time at a reasonable cost. Once proven, this new autonomous robotic imaging can be used to not only to collect data, but also to visualize global climate change in compelling and immediate ways.

Collaborators:
Stephen Licht, University of Rhode Island
Carol Thornber, University of Rhode Island
Christopher Deacutis, Rhode Island Department of Environmental Management
Giancarlo Cicchetti, United States Environmental Protection Agency

Resilience to Climate Change: Testing Sculptural Forms for Coastal Habitat Restoration

Bringing together artists, biologists and conservationists, this project will develop sculptural forms for a future coastal habitat restoration project at an urban site in RI. In addition to providing a platform for direct engagement of the public into research on the impact of climate change on coastal ecosystems, this project also hopes to lead to commercial investment on the development of new materials and sculptural forms for coastal habitat restoration and shore protection from the impacts of climate change.

RHODE ISLAND SCIENCE & TECHNOLOGY ADVISORY COUNCIL

The Rhode island Science & Technology Advisory Council (STAC) is a coalition of leaders in the field of science and technology representing business, medicine, higher education, and government. Our mission is to establish long term economic vitality for Rhode Island, build on world class research and development, design and cyber resources.

Left: Pradeep Sharma, Rhode Island School of Design Interim Provost, welcomes the award winners to the Fleet Library. This page: Governor Chaffee and STAC Co-Chair David Savitz award team members Susanne Menden-Deuer of the University of Rhode Island Graduate School of Oceanography and Sarah Knowlton of Rhode Island College, for their work on The Impact of Climate Change and Variability on the Biogeochemistry and Ecology of Rhode Island's Coastal Waters – Regional Climate Modeling. They are joined by Rhode Island College President Nancy Carriuolo.

Collaborators:
Marta Gomez-Chiarri, University of Rhode Island
Scheri Fultineer, Rhode Island School of Design
Edythe Wright, Rhode Island School of Design
Breea Govenar, Rhode Island College
Dale Leavitt, Roger Williams University
Pam Rubinoff, Rhode Island Coastal Resources Center/Rhode Island Sea Grant
Steven Brown, The Nature Conservancy

Changes in Plankton Bloom Patterns and Trophic Relationships in Response to Climate-induced Warming of Narragansett Bay

This project builds the case for selection of Narragansett Bay (NB) as a designated sentinel site for global coastal monitoring. By combining the synergy of two remarkable, multi-decade long-term NB data studies with the Bay's unique position at the convergence of two climatic zones, this project will demonstrate how the effects of climate change are intense and detectable in NB.

Collaborators:
Theodore Smayda, University of Rhode Island Graduate School of Oceanography
David Borkman, Salve Regina University

Molecular Basis for Pathogenesis in the Oyster Pathogen, Roseovarius Crassostreae

Oyster aquaculture is expanding in Narragansett Bay, but this economic endeavor is threatened by a variety of pathogenic infectious agents including the causative agent of Roseovarius oyster disease (ROD). Warming waters that stress the host have led to devastating ROD outbreaks which have resulted in some cases in losses of oyster seed of greater than 90%. This project combines the talents of a molecular biologist, a natural products chemist and a shellfish pathologist to seek a better understanding of ROD in order to better manage the disease.

Collaborators:
David Nelson, University of Rhode Island
David Rowley, University of Rhode Island
Roxanna Smolowitz, Roger Williams University

Environmental Genomics and Proteomics of Nitrogen Stress in Narragansett Bay

Because phytoplankton forms the base of the highly productive food web in Narragansett Bay (NB), understanding their adaptive potential and evolutionary responses are fundamental to understanding the past and future ecological responses of the entire Bay system. This trans-disciplinary project, which is the first study of its kind in NB, brings together oceanography, ecology and evolutionary biology to gain insight into the environmental stresses and adaptive responses of important phytoplankton.

Collaborators:
Tatiana Rynearson, University of Rhode Island Graduate School of Oceanography
David Rand, Brown University

Stephen Licht and Carol Thornber, both of the University of Rhode Island, are part of the award winning team that worked on: Developing an Aerial Imaging System Using a Robotic Helicopter for Tracking Harmful Algal Blooms in Narragansett Bay.

Outreach experiences engage young minds across RI

Along with research into the impacts of climate change, Rhode Island NSF EPSCoR carries out an ambitious outreach and education program for K-12 students.

A collaborative effort in concert with state organizations and EPSCoR partner institutions, opportunities range from one-day experiences to ongoing programs, all with content aligned to Rhode Island Grade Span Expectations (GSEs).

"We want to introduce students to opportunities in marine biology as well as other areas in the STEM (science, technology, engineering and math) fields," said Tim Pelletier, RI EPSCoR outreach and education coordinator.

Pelletier is based at the Community College of Rhode Island (CCRI), and networks with state agencies and schools, leverages relationships, and creates the programs.

Some students dissect sheep hearts or examine river water quality in college lab settings. Others test hypotheses with experiments at the Marine Science Research Facility on URI's Bay Campus. When weather permits, students wade into the shallow waters off Jamestown with nets to study marine organisms.

The programs also help raise awareness of water quality, said Pelletier: "In Rhode Island, everything we do affects Narragansett Bay and our water sources. Anything dumped in upstream winds up in the Bay and affects our drinking water, the microscopic organisms and the fish we eat."

Even if students do not choose a STEM career, Pelletier said, the information is critical. The more knowledge people have, the more likely they are to get involved and positively impact their communities and the state.

Initiatives under way this year include:

The South POLE: A new program with The Learning Community in Central Falls, the South POLE (Public Outreach and high Latitude Exploration) paired Abigail Bockus, a URI graduate student, with the public charter school's eighth graders.

Adjunct Professor Erin Davis, Roger Williams University, works with Hope High School students during a Hands-on Science Experience that involved dissecting sheep hearts and learning about the circulation system.

Bockus, supported by Rhode Island NSF EPSCoR, spent the winter in the South Pole, studying how krill populations in the Southern Ocean react to climate change. She uploaded a weekly video feed that aligned her research with the state's GSEs and linked to the school curriculum. In class, teachers rolled the footage to launch scientific thought and exploration, with the opportunity for Bockus to answer student questions through the videos.

Students at a Hands-on Science Experience at the URI Bay Campus construct and test plankton models as part of a learning module that aligns with their science curriculum and the state Grade Span Expectations.

Graduate outreach: Rhode Island NSF EPSCoR works with Educational Talent Search (ETS), a member of the federal TRIO programs, and serves youth from low-income families in the state state's urban centers.

EPSCoR graduate students visited several schools this academic year to share their career paths and their science with students in the ETS program. The mutually beneficial relationship opens up new opportunities to the youngsters and provides graduate fellows the chance to enhance communication skills and give back to the community.

Hands-on Science Experiences: Daylong events combine trips to the URI Bay Campus, Fort Getty on Jamestown, and EPSCoR partner institutions.

Typically, Pelletier first visits ETS students at their school and gives an overview of what they will experience. The following week, students arrive at the Bay Campus for the hands-on experience, which often includes lunch and an admissions tour on the Kingston campus.

Other trips involve visiting an EPSCoR partner institution, where they might gain their first dissecting experience or conduct water quality tests from an inland watershed source and learn about the impact on Narragansett Bay.

Biotech labs: Teaching biological sciences at a public high school presents many challenges, particularly providing materials, equipment and consumables needed to perform procedures and experiments taught in the biotech curriculum.

Rhode Island NSF EPSCoR works with school biotechnology programs and supports training for educators, college lab experiences for students, and supplies and equipment.

Classroom hydroponics: Dr. Jameson Chace, Associate Professor of Biology and Biomedical Sciences, and Environmental Sciences, at EPSCoR partner institution Salve Regina University, launched a hydroponics module at All Saints Academy in Middletown to build a hydroponic garden from scratch.

Elementary schoolers learn critical skills such as science writing and data collection. Dr. Chace's college students gain work-study hours and experience making a difference in young lives and a community. The hydroponics project also addresses societal issues such as food needs and sustainability.

Riding SURF to graduate school

To measure the success of Rhode Island NSF EPSCoR's Summer Undergraduate Research Fellowship (SURF) program, we can look at any number of concrete data points, from the highly competitive applicant pool and number of students mentored to the tally of research projects and the ways in which they move science forward.

But where in the spreadsheet do we factor in experience gained? What formula calculates how a life changes? How many doors open? Which new paths unfold?

For all that the SURF program accomplishes in the name of science, the 10-week intensive summer research fellowship also boasts a profound and lasting impact on the individuals involved. SURF, it turns out, can be as life altering as the research it produces.

The surf advantage

A 22-year-old from Salem, Conn., Kelsey Lucas graduated in December 2012 from Roger Williams University with a bachelor's of science degree in biology and a minor in mathematics.

Today, she is enrolled in her first year of graduate school at Harvard University — an opportunity, Lucas said, made possible by the Rhode Island NSF EPSCoR summer research program:

"If it wasn't for the SURF program, I probably would not be at Harvard right now. The SURF program was extremely valuable — it let me do more extensive research than I would have been able to do during the school year, juggling classes."

On one level, Lucas said, SURF exposed her to different aspects of research, which helped her figure out where she wanted to head. She gained insight and skills from fieldwork, setting up equipment, and producing a poster presentation.

As she narrowed down her focus and set her sights on graduate school, Lucas said SURF proved to be invaluable.

"The SURF program made my application so much stronger than it would have been otherwise," she said. "One of the comments I got a lot during my interviews was they were impressed by how much research experience I had."

Upon her December 2012 graduation from RWU, Lucas secured a spring internship at the California Institute of Technology before being accepted into graduate school, where she had her pick from a prestigious list — Harvard, Brown, Tufts, University of North Carolina, and Georgia Institute of Technology.

Kelsey Lucas identifies organisms sheltering in the grasses near the shore to better understand the coastal ecology in the area. Lucas said it was fascinating to observe how the fish maneuvered so quickly through the grass.

One thing leads to another

Both of her parents work in science-related fields, so Lucas had a lot of exposure to the discipline and knew in high school and going into college that she was interested in both science and math. But the specifics eluded her until she began working with Dr. Sean Colin, associate professor of environmental science at RWU.

Lucas said she started on a marine biology and aquaculture track, but her research experiences eventually led her to the physics of biology and Dr. Colin, who was studying the physics of jellyfish swimming. His field of expertise lies in biomechanics and evolutionary ecology.

The summer between sophomore and junior years, Lucas started working on an animal propulsion study with Nathan Johnson, then a biology undergraduate at Providence College and now a graduate student at Texas A&M-Galveston, helping collect data under the guidance of Dr. Colin and Dr. Jack Costello at PC. *(Read more about the study in "Following in Natures footsteps." see p 05)*

The researchers were looking at nature's design of the animal propulsive structure, specifically, both swimmers and fliers, and how they moved in water or air.

Attention to detail

Tedious at times, the data collection involved scouring the Internet for videos of animals moving through the air and sea, following strict criteria to fit the study and then analyzing the data. Sometimes, the search proved futile, when a promising link turned out to be a home video with someone walking in front of the camera.

But in all of the frames of movement recorded from the 10 different species they had viewed by that time, Lucas said, the pair of student researchers hit on something:

(continued on p 22)

GRADUATE RESEARCH *(continued from p 6)*

fracture electron microscopy. Leaves consistently fractured through an extracellular layer having a rippled texture, which resemble cuticles known to occur in vascular plants. Attempts to isolate a cuticle from Physcomitrella leaves by partial digestion (degradation and removal of organic matter) with chromic acid or treatment with polysaccharide-degrading enzymes were also successful, and consistent with the presence of a Physcomitrella cuticle.

The existence of a cuticle on the leaves of Physcomitrella is further supported by genetic observations. The P. patens genome contains several genes that are homologous genes (similar and of common origin to other genes) known to participate in the creation of the building blocks of the plant cuticle. One of these, a gene that is similar to the Solanum lycopersicum CD1 gene (SlCD1), may participate in cutin biosynthesis and was selected for further characterization. In order to examine the genetics of the Physcomitrella cuticle, a specific type of genetic technique was used. Homologous recombination is a type of genetic recombination that involves exchanging nucleotides between identical or similar DNA molecules. Using this method, knockouts of Physcomitrella samples deficient in the homolog CD1 were generated (PpCD1KO). Unfortunately, knockouts showed no changes in phenotype and may indicate the presence of a cuticle, supported by other genes with similar functionality.

After graduating Rhode Island College in May of 2013, I am excited to use the skills and expertise that I gained through the RI NSF EPSCoR program, as I pursue my Doctorate in Dental Medicine, at Tufts University School of Dental Medicine, as a proud member of the Class of 2017.

FELLOW IN FOCUS *(continued from p 7)*

has focused on exploring the diversity within the species and mapping its distribution, improving our understanding of how the diversity is structured throughout the globe and the environmental factors that contribute to the diversity.

A new perspective

Taking leave from behind the microscope, Whittaker and her peers in the Knauss Fellowship program have been dispersed throughout the policy-making machinery of the nation's capital, working with members of Congress and various federal agencies and departments.

Although the projects vary, they all fall under the main umbrella of marine science policy and work to improve both the communication and connection between science and policy.

She said she was excited to see where the opportunity takes her, whether down the policy path, a career in academia, or a completely different direction.

"Wherever I go, this perspective is so incredibly valuable and unique," Whittaker said. "If I really like it, I'm hoping for the option to stay and continue to do policy, see what kind of doors open."

Now pursuing a Ph.D., former SURF student Kelsey Lucas makes routine animal care observations on the fish studied at Harvard University's Lauder lab to make sure that they are healthy and the tanks have good water quality.

SURF RESEARCH *(continued from p 21)*

"We were actually going to a meeting with Dr. Colin and Dr. Costello, and we had plotted all of our numbers on a graph to make the data presentable. We looked at the graph and suddenly we saw this straight line, and thought this actually could be something really cool. So we expanded our search to more animal groups and got more replicates."

The unexpected find was the similarity in the movement of all of the animals even though air is less dense than water. They looked at more videos and animal groups — 59 species, ranging from insects to whales — yet the line remained straight.

When Johnson graduated, Lucas took over the project. After this year's winter break, she received word that the paper would be published February 2014 in the journal Nature Communications.

"I was really, really excited," she said. "I think the first thing I did was step out of my office and tell my lab manager, 'You'll never believe what just happened!'"

Moving science forward

Dr. Colin said Lucas' trajectory is exactly the intention of mentoring and the opportunity SURF provides — train students to do research, and prepare them for graduate school and a career in science, where publications are the primary metric to gauge how individuals progress.

The research relationship begins with strict instructions and guidance as students develop the necessary skills and confidence in their judgment.

"It moves from a relationship where you are instructing them to becoming more of a collaboration," Dr. Colin said. "It becomes a give and take between professor and student. If good student can get to that point, it helps influence the direction that research takes."

Lucas' journey began sophomore year, working with Dr. Colin, analyzing video of jellyfish, and wound up with two publications and lead authorship on a groundbreaking study. It was the perfect juncture of a lot of hard work and a little bit of happenstance.

Dr. Colin noted, "Kelsey had two publications, and that's pretty rare. She's definitely an extraordinary student, probably one of the brightest students I've ever had."

For Lucas, the Colin lab and the SURF program provided the best possible opportunity: "I ended up in the completely right place."

The path taken

Jeremy Carreiro, standing, works with high school students during a biotech lab at the Community College of Rhode Island.

Negotiating his way between tables in a Community College of Rhode Island lab, Jeremy Carreiro alternatively checks equipment and assists high school students working their way through the steps of a biopharmaceutical manufacturing process.

His youthful demeanor and quiet confidence in handling the lab equipment belie his age — 33 — and a background that includes playing in a band and working in retail.

"As a child, I was fascinated by science and I wanted to be a scientist," said Carreiro, who grew up in Riverside and nurtured his passion for music by joining a band in high school. "When I graduated high school, I originally planned on taking a year or two off to find myself and focus on my music."

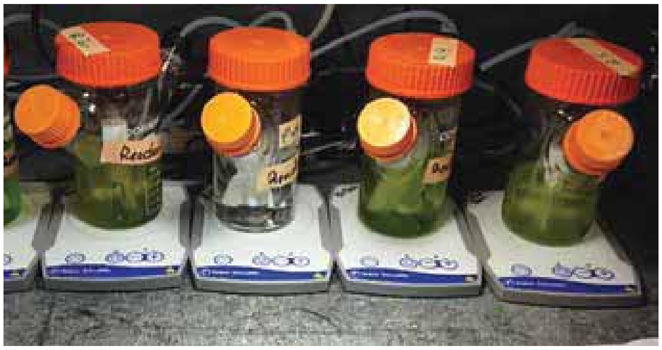
But, as life often goes, one year turned into nine. Carreiro worked full-time in the retail industry and formed several bands that played locally and one nationally. Although fulfilled by his music, Carreiro said he felt burned out in his retail job.

"For a while, I wasn't really sure how to take a step away from it until one day the decision was made for me," he recalled. "In 2009, I got laid off from the job I had for almost a decade."

At the time, Carreiro conceded, he felt lost, but quickly found a new path. He decided to go back to school despite not having any idea about what direction to pursue. Taking science classes at CCRI, he returned to his childhood passion.

He took biology from Assistant Professor Scott Warila and did an honors project working with Chinese Hamster Ovary (CHO) cells: "I really enjoyed the project because I learned a lot and it gave me hands on lab experience."

Warila also told Carreiro about the Summer Undergraduate Research Fellowship opportunity through Rhode Island NSF EPSCoR. Carreiro applied for the intensive 10-week research program, and was accepted for summer 2012, gaining hands-on experience in the lab and out in the field.



Having honed his research skills in the SURF program, Jeremy Carreiro now is growing algae cultures to see which will yield the most biomass. He will harvest the culture with the most growth and extract biodiesel.

Through SURF, Carreiro said he tested nitrogen removal in local, intermittent streams located in Rhode Island's South County: "That additional lab experience definitely helped in my own development. It increased my hands-on skills, and confidence."

Upon completing SURF, Carreiro took a position in Warila's biotechnology program at CCRI and enrolled at the University of Rhode Island, where he is pursuing a B.S. in Biological Sciences and is on track to graduate in the spring of 2015.

Last summer, sponsored by EPSCoR funding, Carreiro traveled to BIOMAN, a conference about biotech education and curriculum development, and discovered his interest in biodiesel.

He is now replicating at CCRI what he learned at the conference, growing algae cultures under different conditions to see which will yield the most biomass. From there, he will harvest the culture that has the most growth, and extract biodiesel from it.

Under Warila's supervision, Carreiro also is working with an honors student on the effects of fertilizer runoff on algae growth.

Warila said Carreiro's hard work compensated for his inexperience early on: "His technical skills were a bit green, but he was an eager student and quick learner. He often put in time outside his normal work hours to research possible labs and supplies that would be beneficial to the biotech program."

Carreiro said once he earns his B.S. next year, he hopes to pursue a Master's degree, but may take time off to explore other opportunities.

In the meantime, he said he was reaping the rewards of working with the Rhode Island EPSCoR's Hands-on Science experiences through the CCRI position in Warila's lab. He sets up the lab prior to the visit, ensures all of the components are in order for the experiment and provides support to the students when needed.

"It gives me the opportunity to be involved in an experience that is on the other end of the educational spectrum," Carreiro said. "I enjoy working with the students and it's nice to see their interest in science. Learning about the sciences is important, but gaining that hands-on lab experience in addition to the knowledge is so crucial."

Reflecting on his journey, Carreiro noted that he had no idea where he was headed in 2009, when he was laid off from his job. And, he said, he certainly did not envision himself doing what he is doing today: "It's been an exciting ride, and I can't wait to see what else is in store."

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RI Science and Technology Advisory Council

Launched in 2005 and sustained by legislative statute in 2006 to make innovation central to the state's leadership agenda, the Rhode Island Science and Technology Advisory Council (STAC) is the official oversight body of Rhode Island NSF EPSCoR.

In 2007, STAC created the RI Research Alliance to establish a statewide platform for collaboration across the state's research organizations, increase competitiveness for federal funding, and support efforts such as the EPSCoR, Centers of Biomedical Research Excellence (COBRE) and IDeA Networks of Biomedical Research Excellence (INBRE) networks.

STAC Council members represent the academic, business and policy leadership of Rhode Island. They meet on a regular basis to review progress and develop new recommendations for enhancing research and development, supporting entrepreneurial activity, and increasing innovation in Rhode Island.

Christine Smith is Director of Innovation Programs at the RI Commerce Corporation and serves as STAC executive director.

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