THE
current

RESEARCH AND HAPPENINGS FROM RHODE ISLAND NSF EPSCoR | SPRING 2015

Core Facilities

The shared resources of Rhode Island NSF EPSCoR build research capacity, help resolve complex questions and boost the potential for groundbreaking discoveries.

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Rhode Island NSF EPSCoR
Experimental Program to Stimulate Competitive Research

THE current

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On the cover:
RISD student Yajingzhi Gao looks at a pathogen slide under a compound microscope for a class with Peter Yeadon, professor, interior architecture.

The Current
Rhode Island NSF EPSCoR
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welcome

Photo by Beau Jones.

Dear Colleagues,

Thanks to all who participated in our fall annual meeting, as it was a pleasure hearing about the EPSCoR activities at our different institutions. I continue to be very impressed with the diversity of activities and the breadth of research that our community is involved with.

Several of our staff recently participated in a national NSF EPSCoR administrators' meeting, where we shared ideas with our colleagues from several other EPSCoR jurisdictions. We look forward to continuing these collaborations so that we can strengthen our program and better link with EPSCoR at a national level.

We are looking forward to a busy and active spring, and planning for the 2015 SURF program is well underway. As in past years, we are working with RI INBRE to host this fantastic program for our undergraduate students.

Best wishes,

Carol Thornber

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.

In this issue

SACNAS joins outreach effort

Kevin Aviles-Rodriguez, who earned his master's in biology this spring at the University of Rhode Island, talks about opportunities in science with RI NSF EPSCoR outreach students at the URI greenhouse.

Rhode Island NSF EPSCoR welcomed an enthusiastic, resourceful group to its ranks of outreach partners this fall — the University of Rhode Island chapter of the Society for Advancement of Hispanics/Chicanos and Native Americans in Science.

SACNAS, as the group is known, is dedicated to fostering the success of Hispanic/Chicano and Native American scientists to attain advanced degrees, careers, and positions of leadership in science.

"Collaborating with URI SACNAS has been a great opportunity," said Tim Pelletier, RI NSF EPSCoR education, outreach and diversity coordinator. "The group provides a diverse network of instructors, graduate and undergraduate, to connect with the students we bring to our partner campuses."

Melanie Garate and Kevin Aviles-Rodriguez, URI SACNAS president and vice president, jumped at the chance to engage in outreach with RI NSF EPSCoR, eager to connect with young students and give back to those following in their footsteps.

Garate is pursuing a Ph.D. in ecology and ecosystem sciences. Aviles-Rodriguez earned his master's in biology this spring and will be pursuing his Ph.D. at University of Massachusetts-Boston. Although focused and accomplished in their studies, both know the struggle firsthand that many students, particularly those from underrepresented minorities, face.

Melanie Garate, a University of Rhode Island Ph.D. student, demonstrates equipment use during a tour of the Center for Biotechnology and Life Sciences (CBLS).

Born in Chile, Garate moved with her family to the U.S. when she was seven years old and grew up in Waltham, Mass. Although new to the country and unaware how to navigate its educational system, her parents instilled the belief that knowledge was power — and this is the message Garate passes on.

"If they take away one thing from the experience, I hope it is that I am similar to them," said Garate. "I want them to know that it has been hard, but I have succeeded."

Last fall, Garate introduced Central Fall High School students to classrooms and laboratories in the URI Center for Biotechnology and Life Sciences (CBLS), demonstrating some of the science that takes place there. The students arrived for the campus visit through the partnership of RI NSF EPSCoR and RI Educational Talent Search (ETS).

ETS — funded through the Community College of Rhode Island by a grant from the U.S. Department of Education under the Office of Postsecondary Education TRIO Programs — provides free help to about 1,000 students in grades 6-12 at 11 urban middle and high schools who want to complete high school and enroll in a post-secondary institution.

Aviles-Rodriguez grew up in Puerto Rico and earned a Bachelor of Science in Biology at the University of Puerto Rico, Rio Piedras Campus.

"As a minority student," he said, "part of the reason why I am in grad school today is because I was accepted to opportunities such as research experience for undergraduates (REUs). Part of why I am in SACNAS and why I am eager to help out in outreach activities is because I feel the need to pay it forward."

Aviles-Rodriguez said he had no idea what he wanted to do when he started out. He did not know that opportunities such as REUs, conferences, lab work or research existed until teaching assistants pointed them out to him.

"I felt lost in the chaos of all the things happening — taking classes, college life, etc.," he said. "I think many students go through the same experience. There are so many opportunities out there, but you really have to know where and how to look."

Relaxed and confident in his demeanor, Aviles-Rodriguez led the Central Falls high schoolers through the URI greenhouse. He talked with the students about educational paths and his own

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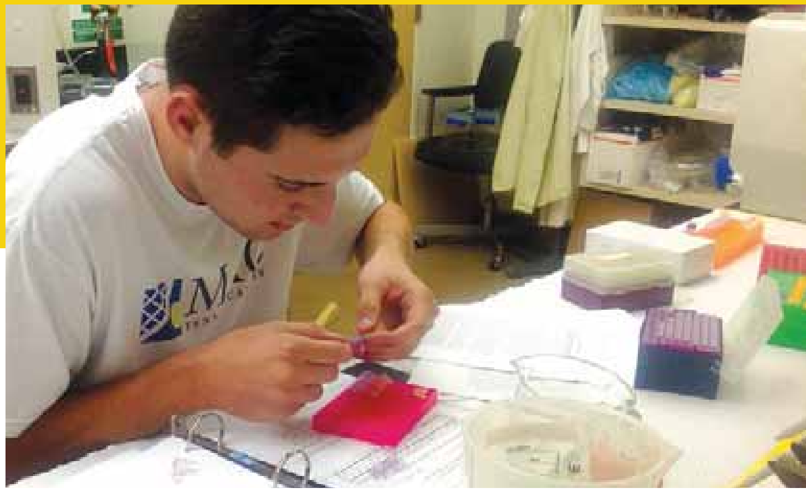
Providence College researchers pool talents, resources

A faculty team project gives undergraduate students experience and exposes them to career possibilities



Providence College senior biology major Anthony Del Pizzo works in the lab during his RI NSF EPSCoR 2014 Summer Undergraduate Research Fellowship (SURF) experience.

On the surface, Rhode Island NSF EPSCoR researchers Elisabeth Arévalo, Maia Bailey and Jeffery Markert seem to be an unlikely team given their respective focuses on wasps, plants and African cichlid fishes.

But, the Providence College trio formed an innovative alliance through the microscopic mysid shrimp last summer that continues to advance conservation science and further the education of undergraduate students.

"It's a true collaboration, where you really rely on the expertise of your colleagues," said Markert, whose marine-based research inspired the connection.

Yet, added Bailey, "All of us bring different parts of evolutionary biology to the project."

The three researchers teamed up for the 2014 RI NSF EPSCoR Summer Undergraduate Research Fellowship (SURF) program, mentoring a total of four students through three projects:

- Evolutionary relationships of the species of the mysid crustacean *Americamysis* — Arévalo, associate professor, molecular evolution
- Effect of climate on competition — Bailey, assistant professor, evolutionary biology
- How can cutting edge genetic methods best be used in conservation biology? Markert, laboratory coordinator and instructor, evolutionary genetics

Thomas McGreevey, University of Rhode Island, and Anne Kuhn and Diane Nacci, both with the Environmental Protection Agency (EPA), worked alongside the PC faculty members as mentors, and two additional PC students joined the project as well.

Jim Lemire, RI NSF EPSCoR undergraduate coordinator, said he was excited to have the collaborative project part of the SURF program.

"Very rarely is science done in isolation, so it is important for students to learn how to work as part of a larger research team," said Lemire, adjunct professor, biology & marine biology, Roger Williams University. "These students also got more out of this experience thanks to having multiple mentors, with different areas of expertise, as well as different approaches to research and to teaching."

On the heels of the summer's success, the researchers decided to keep the teamwork going throughout the academic year.

Finding common ground

Arévalo, RI NSF EPSCoR partner liaison for Providence College, said an EPSCoR review meeting prompted the initial joining of forces, when they learned about Markert's research focus.

He brought to the table experience in marine systems and conservation genetics, investigating the ability to adapt and avoid extinction. This provided a crucial connection to the EPSCoR theme — what is the marine response to climate variability — and the potential to secure funding from the statewide grant.

At the same time, there was a commonality in the broader questions of genetic variability and conservation that resonated with Arévalo and Bailey, and their work.

Markert's post doctoral project, conducted at the EPA's Atlantic Ecology Division labs with Diane Nacci and Mark Bagley, offered inspiration with its unique look at how genetic diversity plays a role in adapting to stressful environments, and the finding that lab creatures with low genetic diversity did not fare well. More intriguing, perhaps, was that even modest losses of genetic diversity hindered the potential for these creatures to adapt to environmental stress.

Climate change poses huge stress and a continual threat, Markert noted: "The environment is always changing — a rainy year can cause salinity to be below normal. There are always diseases sweeping through so no population of any animal or plant is stable forever. Look at the human population — SARS one year, Ebola the next."

Given that reality, Bailey added, if organisms have to make small adjustments to keep up with the changing environment from one year to the next, how do they maintain their genetic diversity?

Another important aspect of the project was grounded in the support the team received from their school's strong culture of undergraduate research.

"Providence College has invested heavily in general research tools and state-of-the-art genotyping equipment that we expect will go a long way toward helping us measure genetic diversity in both the mysid shrimp and other groups," Markert said. "It's exciting to be at a place where both the administration and our departmental colleagues support our efforts and understand the challenges we face."

Additionally, he said, the researchers were looking forward to working with Kris Monahan, PC director of sponsored research, to leverage investments made by both Providence College and RI NSF EPSCoR.

Promoting undergraduate research

For senior biology major Jenn Cyr, helping to answer the team's research questions meant spending her 2014 SURF experience investigating the phylogenetic and morphological aspects of several shrimp species in the genus *Americamysis.*

"I was working on classification for these organisms based on both physical appearance and genetic makeup," she said. "The lab work mostly focused on extracting shrimp DNA and performing molecular assays that allowed us to sequence particular areas of the genome."

Cyr said comparing these areas between individuals allowed the group to look at how they were related genetically.

Team member and SURF 2014 student Anthony Del Pizzo, senior biology major, also worked on the genetics: "This included lots of polymerase chain reaction (PCR) technology, gel electrophoresis, computer data analysis, and genetic sequencing/aligning. We got to go down south to collect mysids — Mississippi and Florida — where we worked in the Gulf of Mexico collecting and identifying different species."

Jenn Cyr, a senior biology major at Providence College, distinguishes mysid species at a field collection site in Charlestown, RI, as part of her work in the 2014 Summer Undergraduate Research Fellowship (SURF) program. Photo by Elisabeth Arévalo.

Also engaged through the SURF program, sophomore biology major Elizabeth Kawa focused on establishing a baseline feeding rate for male, female, and juvenile opossum shrimp, which allowed the students to observe whether there was a relationship between gender and age and the amount of food consumed.

Kawa said she and her research partner performed many behavioral assays, or analytic procedures, to explore the interactions and movement patterns between the various species of the opossum shrimp. As a result, she said, the students were able to correlate the data received from the behavioral assays with the amount of the food consumed in the trials.

Exploring career paths

These training and learning opportunities, provided with the RI NSF EPSCoR summer fellowships, guided by the PC mentors and bolstered by college investments in equipment, serve the college's mission as a primarily undergraduate institution (PUI) to offer undergraduate research experiences.

Bailey said, "We prepare kids to either get a job or go to grad school. They're all interested in the organismal work, but they still need to have some lab bench experience. It's really important that they go to Elisabeth's lab and learn how to extract DNA. So, we're cross training individuals."

Markert added, "A big part of the culture at a PUI is to include students in research. The other part is getting students interested in careers, showing them what other options are out there."

And, Market said, the collaboration with the EPA scientists significantly broadened the perspective: "Up until now, their only role models have been us. But there are a lot of other career paths if you aren't going to be a professor or you're not going to med school. You just see the students light up."

Once Arévalo, Bailey and Markert forged their partnership, they cobbled together the equipment they needed to turn their vision into a reality, retooling tanks and a circulating water system borrowed from colleagues.

They also set up the parameters for working together, establishing such practices as joint lab meetings and cleaning responsibilities. The summer wasn't all fun and sampling in the waters off the Gulf Coast, and there were a few unanticipated lessons along the way.

"We learned so much this year," Arévalo said. "Sometimes, we learned the hard way. The first time we put the shrimp in the tank, the next day they were all in the filter."

As it turned out, the tanks the group repurposed had been used for larger organisms. Mysid shrimp, however, measure about a centimeter in length, and the brine shrimp, food for the mysid shrimp, less than a millimeter. Another issue tackled was, how do you get brine shrimp to grow?

Students gained time on the lab bench, perfecting isolating and genotyping DNA and learning how to culture and take care of animals. PC's investment in microscopes introduced bioimaging and photographic tools.

Bailey said, "A lot of it is transmitting the knowledge, saying here is what you should look for, here is how they grow. … Or, just coming up with the basic design skills of making an experiment, learning how the experimental process works in real life. You see

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Discovering science and self

Undergrads learn, thrive with research opportunities

Rhode Island NSF Experimental Program to Stimulate Competitive Research (EPSCoR) covers a lot of bases and cuts a wide swath with many initiatives in play across the Ocean State.

The federally funded program with matching state funds supports:

- Research that investigates the impact of climate change on marine life and ecosystems
- Undergraduate and graduate education and training to develop the next generation of scientists
- Efforts to engage K-12 students to broaden and diversify the pipeline into the science, technology, engineering and mathematics (STEM) fields

In pursuing these goals, RI NSF EPSCoR draws on the collaborative power of the state's nine institutions of higher education, a well coordinated balancing act of human resources, facilities, events and activities.

If there is any single sweet spot, however, where the myriad forces of RI NSF EPSCoR mesh, it can be found in the annual Summer Undergraduate Research Fellowship (SURF) program.

(*Top*) Joseph Guerreiro spent two unforgettable summers with the RI NSF EPSCoR Summer Undergraduate Research Fellowship (SURF) program. Photo by Hallie Steele.

(*Left*) Sara Moore sets up her computer in a salt marsh so she can plug in the temperature loggers, download the data to the computer, and then place the equipment back in the marsh. She collected weekly temperature readings from the marshes throughout the summer. Photo by Meg Warburton.

Run by undergraduate coordinator Jim Lemire, Roger Williams University adjunct professor, biology and marine biology, SURF advances technical and cognitive skills through 10-week independent research experiences in the labs of faculty mentors.

"The SURF program is really about providing opportunities for young scientists to experience science in its truest form — not through three-hour blocks of lab exercises like they get during the academic year," Lemire explained. "By engaging in true research full time, students not only learn more about the scientific process, but also about their place in it."

Since the program's inception in 2007, SURF has placed 215 fellows in the labs of 76 different faculty members at the nine partner campuses. The fellowships, awarded on a competitive basis, help students define a clearer picture of their career path while working to advance the field of science.

For some, SURF opens up future paths students never knew existed. For others, the experience helps solidify thoughts about post-undergraduate plans. Even students who learn that research is not an avenue they wish to pursue discover valuable lessons as well.

"The SURF program has allowed me to work on an ecologically driven project as well as a molecular biology project, which has given me a broader research experience and helped to guide me in a direction of future study," said Joseph Guerreiro, a Rhode Island College biology major wrapping up his senior year.

Guerreiro spent both summer 2013 and 2014 with SURF. The first year, he worked in the lab of RIC Assistant Professor Breea Govenar, biology, investigating the effects of nitrogen addition, as a result of wastewater that was historically released directly into the bay, on the growth and abundance of ribbed mussels in Narragansett Bay. Govenar also serves as the RIC partner liaison for RI NSF EPSCoR.

The project involved field collections, laboratory dissections, and statistical analyses. It showed that wastewater input in areas closer to Providence leads to dense populations of very small mussels and low pollution farther south, in Jamestown, creates sparse populations of larger mussels.

The research was part of a multi-year project that coincides with the Narragansett Bay Commission's installation of a sewage abatement system that redirects sewage so that it will not go into Narragansett Bay, explained Guerreiro: "The hope is that over time there will not be such drastic effects on different areas of the bay."

During the 2014 SURF program, he worked with Associate Professor Chris Lane, biology, University of Rhode Island, using genetic markers and morphology as a means to identify different species of red algae in the genus *Cryptonemia*.

Guerreiro said the lab only project involved doing a lot of genetic sequencing and some bioinformatics to create evolutionary trees and helping to identify new species of algae within the genus. The work also was part of another, larger project that focuses on identifying many different species of algae from tropical climates in Bermuda, St. Croix and Key West.

Science, and so much more

Both research experiences made a significant impact on him, according to Guerreiro.

"The EPSCoR program helped me greatly in my academic and personal life," he said. "It has helped guide me in a direction in a field that has so many options and different paths. I also have learned more important skills for being a scientist by having the freedom to work on my own research project under my own conditions."

At the same time, he added, the SURF experiences have carried over into his personal life, strengthening his time management skills and making him more aware of the world around him through the rigor and questioning that comes with research.

Sara Moore graduated from RIC last spring with a bachelor's degree in biology and minors in chemistry and behavioral neuroscience. She began research in Govenar's lab the fall of 2012 and continued through SURF in the summer of 2013. Her project involved characterizing the microbial content (essentially the bacteria) in the digestive tract of the ribbed mussel, a dominant invertebrate in marshes along Narragansett Bay.

"We were interested in knowing what bacteria were present inside the mussel because these bacteria potentially had the capability of emitting greenhouse gases such as methane and nitrous oxide through their metabolic processes," Moore said.

The experience, she added, made a compelling difference: "The three words that best describe what I've taken away from my research opportunity are responsibility, experience and community."

Moore said the responsibility came from the tasks given to her, including adapting protocols, maintaining careful notes and inventories, data analysis, and presenting her results at several regional meetings and a national meeting. Like Guerreiro, she said juggling the demands and responsibilities of the lab work taught her time management skills and multi-tasking. Having Govenar believe in her potential enough to grant her so much responsibility encouraged her to work hard and strive for success.

She said she gained many new biological science skills working in the lab that could not be taught in a classroom, learned from Govenar's molecular biology expertise and figured out many things on her own.

"Having this opportunity for so much learning provided me with a solid foundation to enter a new lab upon graduation," Moore said.

She also found herself at home in RIC's small, but lively and supportive research community. When she joined Govenar's lab, she said, she quickly gained introduction to many researchers, both faculty members and students.

"I found an inspiring, encouraging and friendly mentor in Dr. Govenar," Moore said. "I made friends with students from other labs in the biology department and we frequently discussed our research obstacles and offered each other solutions. This sense of shared passion across the department gave me a chance to open up and thrive at RIC."

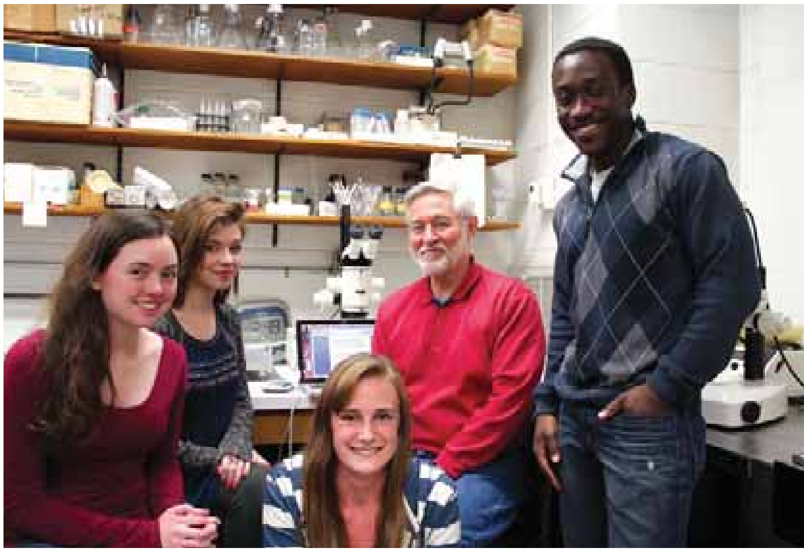
A meaningful outcome

Govenar said although students often noticed the more tangible results of enhanced science skills and efficient time management, she saw a broader, deeper impact of being part of the research community.

"That level of engagement is ultimately what becomes the fuel or the driving force for greater personal development," Govenar said. "The experience helps students see the interconnections among researchers, at all levels of experience, and the cumulative nature of research – more than what can be presented in courses."

RIC faculty mentor Thomas Meedel, biology professor, worked with three EPSCoR SURF students last summer — one each from RIC, RWU and the Community College of Rhode Island — on a collaborative project with Associate Professor Steve Irvine, biological sciences, URI. He also took on four undergraduates through the RI Institutional Development Award (IDeA) Network of Biomedical Research Excellence (INBRE), which collaborates with RI NSF EPSCoR for the SURF program.

"For me, the best thing that both EPSCoR and INBRE do is give these students an opportunity that they never would have had otherwise," Meedel said. "It's really a transformative experience."



RIC Professor Tom Meedel sits with students, from *left*, Lindsay Ratcliffe, Megan Warburton, Taylor Ferrare, and Emmanuel Asiedu, all of whom have participated in either EPSCoR or INBRE SURF, or both of the programs. Photo by Hallie Steele.

Meedel said that for many RIC students, finances, or the lack thereof, pose an obstacle to doing research work in a lab. The typical student needs a job to support his or her education, and can't abandon the income. The $4,500 stipend that comes with the SURF award offers a way to conduct research and earn money.

Equally important, he added, as Guerreiro and Moore indicated, SURF teaches valuable skills and helps students find their way regardless of the project.

"The technologies and the methods we use can be applied to many questions, and the critical thinking skills students develop, how

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Outside the Ann Durbin Aquarium Building on the University of Rhode Island Narragansett Bay Campus, Gordon Ober and Rose Martin set up their experimental mesocosms (or tanks). Each one of these tanks represented a different experimental treatment. Photo by Gordon Ober.

From ales to ailing marshes

The genesis of scientific collaboration and its big impacts

By Gordon Ober and Rose Martin

The words science and progress often conjure images of sterile laboratories and white coats, not dimly lit bars and pints of beer. However, both are common breeding grounds for scientific research and collaboration.

When graduate students have time to turn their heads away from their computer screens or escape the lab, they gather at coffee shops and bars, venting frustrations and hashing out ideas. This is an important component of scientific research: Communication with peers.

In academia, we often are so focused on our specific research question that we lose perspective and put our blinders on. Peer-to-peer communication provides an opportunity to regain perspective and can be the foundation for collaboration.

At the local graduate student watering hole, the Mews Tavern in downtown Wakefield, we launched a collaborative research project early last spring to help address the question of how interacting climate change impacts alter salt marsh functioning.

We both are Ph.D. candidates in the biology department at the University of Rhode Island, but our research focuses are quite different: Rose studies salt marsh ecology and biogeochemical cycling; Gordon works with marine communities and food web interactions.

Despite the research differences, we found common ground as Rhode Island NSF EPSCoR graduate fellows, studying the impacts of climate change on coastal ecosystems. Throughout the course of a few pints, we first jokingly talked about how climate change would cause our respective ecosystems to merge.

But then, we pondered a serious question: Given distinct, but complementary skill sets, would it be possible to combine forces to address questions about the response of salt marshes to climate change in novel ways?

Salt marshes, with their characteristic expanses of grassy meadows and glistening mudflats, are defining features of our coastal landscape in the Ocean State. In addition to their beauty, these marshes provide critically important services including habitat for commercially important fish and wildlife, protection against storm surges, trapping land-derived pollutants such as fertilizer before they enter Narragansett Bay, and reducing climate change by absorbing and storing atmospheric carbon.

In the past 300 years, 53 percent of Rhode Island salt marshes have been lost to development, and our remaining marshes are threatened by a combination of nutrient pollution, invasive species, and sea level rise.

The importance of salt marshes to the health of the environment and society is clear now, but this has not always been the case. In the past 300 years, 53 percent of Rhode Island salt marshes have been lost to development, and our remaining marshes are threatened by a combination of nutrient pollution, invasive species, and sea level rise.

Increasing sea level will present a particularly difficult management challenge, since marshes moving landward to escape rising tides will meet with resistance in the form of shoreline development. As Rhode Island coastal communities prepare to deal with effects of climate change, understanding the ways that salt marshes respond to sea level rise will be an important tool for management and planning.

Salt marsh response to sea level rise has been investigated throughout the past few decades, in a variety of methods. From modeling to field studies and laboratory-based projects, scientists have been able to show the negative effects of sea level rise on marsh ecosystems, structure, and productivity.

However, rising seas alone do not stress marsh ecosystems: There are a number of other factors that could work in concert with sea level rise to exacerbating impacts to marshes.

Testing multiple factors of climate change on marsh responses is not only relevant; it is necessary. Teasing out which factors are the most important or most influential often poses the greatest challenge, but if we ask the right questions, science has the tools to provide answers.

After deciding to combine our perspectives, we began a flurry of brainstorming as we sought the main research question.

There are many facets of climate change, and many of them act in conjunction with one another to impact species and ecosystems. Sea level rise was the main focus, as this is the force joining marine and marsh systems, but we added the addition of algal blooms as a factor of global change.

Algal blooms occur due in part to nutrient loading along the coast, and if occurring alongside sea level rise, their presence in salt marshes could affect ecosystem function. Salt marshes are not only under pressure from rising seas on one side, but on the upland side they are being squeezed by development and invasive species. This has resulted in merging of plant communities that, in marshes not impacted by human activities, are usually distinct from one another. Since plants are responsible for many of the important functions of marshes, changes to plant communities may have profound impacts for the salt marsh ecosystem.

In this study, we decided to take our two factors of climate change (sea level rise and presence of simulated algal bloom) and measure the response of two salt marsh grasses, *Spartina alterniflora* and *Spartina patens* in terms of plant success, biomass quality, impact on soil environment, and associated greenhouse gas fluxes. These grasses, respectively, represent two marsh zones — high and low marsh. Consequently, responses of these different marsh elevations could help predict responses for the marsh system as a whole.

In order to study the impacts of sea level rise and algal blooms on salt marsh grasses, we developed an experimental setup that let us test impacts of multiple factors on plants and soil collected from a Rhode Island salt marsh. Field manipulations of sea level are difficult to recreate and the experimental setup, or mesocosm, allowed for research to be conducted in a controlled manner.

First, we determined current levels of seawater inundation in Jamestown. These levels were determined by measuring the depth of water across marsh zones at both high and low tide. These levels act as controls and were coupled with projected sea levels 50 years and 100 years from now based on accepted Intergovernmental Panel on Climate Change projections.

An ecologist's budget often pales in comparison to those working in other fields, so that demands creativity. We developed water transport to the mesocosm tanks as well as simulated tides, but finding large enough tanks proved difficult.

Getting the project off the ground hinged on finding the appropriate vessels, and help came from an unexpected source — a restaurant supply company. This company offered large, clear trash cans that could hold the necessary levels of water and allow for light to shine through.

While we pieced together much of the setup on a shoestring budget, cutting-edge technology helped address the research questions from several angles.

Dr. Serena Moseman-Valtierra's lab provided access to probes for measuring soil characteristics, including pH, oxidation-reduction potential, and temperature, as well as access to a Picarro Gas analyzer that uses new technology (cavity ringdown spectroscopy) to measure carbon dioxide, methane, and nitrous oxide concentrations in real-time.

(*Top*) Gordon Ober and Rose Martin are both Ph.D. candidates in the University of Rhode Island's Biological and Environmental Sciences Department. Photo by Elizabeth Brannon.

(*Left*) One of the duo's replicate salt marsh cores contains the low-marsh species, *Spartina alterniflora*, and is covered by a simulated algal bloom composed of *Ulva spp*. (green) and *Gracilaria vermiculophylla* (red). Photo by Gordon Ober.

The information gained from using these instruments allowed us to make observations regarding impacts of sea level rise and algal deposition on biogeochemical activity, especially carbon cycling, in the plant-soil system from high and low marsh zones. With the help of some undergraduate research assistants, we collected data and maintained the set-up through the course of the growing season.

Now sitting on top of a pile of data, we have begun to look back and analyze our findings. Weekly observations allowed us to track changes in the salt marsh grasses, and we noted that even early on in the experiment, simulated sea level rise took a toll on the health of the two grass species.

We corroborated these observations by statistical analysis, which indicated that grasses had a much poorer survival rate under sea level conditions predicted for the year 2100 than for present-day or year 2050 simulations. Gas flux measurements revealed that algal enrichment drove emission of the potent greenhouse gas methane from the low marsh mesocosms. *(continued on p 27)*

Conversations: Big data

Keeping science discoverable and useful

Andrew Creamer, photo by Ben Tyler

Andrew Creamer joined the Brown University Library last year as the new scientific data management specialist.

He previously supported and taught research data management to librarians in his position at the University of Massachusetts Medical School Lamar Soutter Library and National Network of Libraries of Medicine, New England Region (NN/LM NER).

Creamer studied and taught biology for several years, and then went to library school to become a science librarian. He coordinated and contributed to the New England Collaborative Data Management Curriculum (NECDMC) from 2012-2013.

Creamer also serves as a contributing editor to the e-Science Portal for New England Librarians, and is a co-instructor of the Scientific Data Management course offered by the School of Library and Information Science at Simmons College.

He is the lead author of a chapter on research data management in the Health Sciences Librarianship (Rowman & Littlefield, 2014). Creamer holds a Bachelor of Science in Biology from Capital University, a Master of Arts in Education, Curriculum, and Instruction from Virginia Tech, and a Master of Science in Library and Information Science from Simmons College.

Creamer talks to The Current about the field of data management and its increasingly visible role in research today.

The Current: How did you get into the data management field? What drew you to it?

Andrew Creamer: As a graduate student I interned under Dr. Elaine Martin, the current director of UMass Medical School's library, who had a grant from the National Library of Medicine to develop e-Science roles and provide data management support for STEM and health sciences librarians and initiatives in New England. After I graduated from library school, I went to work for her full-time as a coordinator for research data management education initiatives, including developing a curriculum for teaching research data management and a scientific data management course at Simmons College with the library community in New England.

I was drawn to research data management as a career because I believe in the principles underlying the open data and open science movements, namely that publicly funded data belongs to the public, and that it has value for reuse and repurposing. Libraries should be involved in the curation of data as we have in the past with other types of information so that it is discoverable, accessible, useful, and preserved.

TC: What is data management? Who does or should do it?

AC: Research data management is usually defined by the activities that occur involving data throughout the lifecycle of research, extending from the moment a project is being planned, up through the creation and collection of the data, and all the way up until after the project is complete and decisions are being made about what to publish and archive so that others can find, access, and possibly reuse the data.

So data management encompasses planning for the collection, description, storing, backing up, securing, appraising, publishing, disseminating, archiving, and the possible preservation, reuse and/or repurposing of research data. Data management has a lot of stakeholders: the funder, the institution, the investigator, scientific publishers, and the public.

The principal investigator and the lab team obviously have important day-to-day roles managing data, but the university also has a responsibility and accountability, and should provide support in the forms of infrastructure such as research computing and storage, and support for documentation and metadata, and services for preservation, retention and long-term archiving, and publishing.

TC: Why is data management important; what's the purpose?

AC: There are several reasons why data management is important. First, the scientific community believes in the reproducibility and replicability of research results, so that research findings can be substantiated and science can move forward. There have been recent cases in which data has been falsified and false claims made about discoveries. Having data available allows the community to make judgments about the quality and integrity of its research.

Then there are funder expectations that the research they fund will be made available to others, and by using sharing and preservation-friendly formats and metadata (descriptions of data that help people discover and navigate another person's data), and by depositing data into public data sharing repositories scientists can comply with these expectations.

Lastly, there is the personal benefit of saving time and money in the lab. If a researcher's experiment is systematically recorded and documented, then the researcher does not have to waste time looking for that data or doing an experiment over just to get that data. It's a win-win for both the public and the individual researcher.

TC: What's behind the increasing demand for more and better data management? What do we get out of it?

AC: There is evidence that data that is well managed is more likely to be shared, and data sharing can allow other researchers reuse and repurpose data to move science forward. In the U.S., since

2007 the National Institutes of Health (NIH) began requiring a data sharing plan for certain proposals, but the real demand for better data management did not start until 2011 when the National Science Foundation (NSF) began requiring a two-page data management plan for all proposals for funding.

Then, in 2013, the Office of Science and Technology Policy (OSTP) asked the federal funding agencies providing at least $100 million in research funding to create a public access plan for both the publications and data resulting from the research they sponsor. So in the last year, the Department of Energy, NASA, Department of Defense, among others, have come out with new requirements for sharing data. The National Institutes of Health will also require a genetic data-sharing plan for research generating genetic sequences starting this year.

"The academic community should realize that depositing a copy of their data along with adequate metadata and any relevant code into a data-sharing repository is the best way to ensure that their data will be accessible by others in their communities for the long term."

The results of these mandates include the rise in importance of data sharing repositories, data policies, and scientific communities getting together to talk about metadata and formats for data sharing. It has caused the university community to come together to draft policies that address questions about who owns data, data retention timelines, who is responsible for managing data, and what role do universities have to assist their researchers with data management.

It has made the community confront issues associated with long-term storage such as costs for server space, lack of metadata and software support services, and protecting privacy and confidential data.

TC: What should the average person know about data management?

AC: The average person should know that the research they fund through his or her taxes has value, and that the government and universities believe that better data management will make research data more discoverable and likely to be useful for future innovation and maximization of benefit.

Even with our own personal digital data, such as digital photographs or financial documents, we need to think about data management best practices for naming our files so we can locate them when we need them, storing and backing up our digital files so we are covered when hard drives fail, securing these files to protect our private information, and choosing the formats, technology, and physical media that we can use to preserve these files and their use in the future.

TC: How about faculty, staff and students?

AC: The academic community should realize that depositing a copy of their data along with adequate metadata and any relevant code into a data-sharing repository is the best way to ensure that their data will be accessible by others in their communities for the long term. For too long researchers have been publishing data on web servers that are not adequate long-term solutions, and the risk is that this data will ultimately be lost. One only has to look at the recent papers retracted in scientific journals because the original underlying data could not be found.

TC: It seems like data management gets a bad rap; it's viewed as a burdensome task. Is it just misunderstood?

AC: Yes, I think it is misunderstood. I think the funders and universities need to do a better job of making the case for data management. Someone who has been doing science for a long time may have to change something in his or her workflow. I encounter resistance on a regular basis by some who feel that data management is an unfunded mandate, or that the funders don't really look at data management plans, and they want to clone or re-use somebody else's plan, etc., without actually following through with what they have said they will do in their plans.

TC: If you have to do a data management plan, what's the best way to start?

AC: If you are an EPSCoR researcher, then I hope you would contact your data librarian or me. For the NSF, the best way to start is to read their brief policy on sharing and dissemination of research results and the general proposal guidelines section on data management, and then look at the specific directorate-level guidance and requirements.

Then, sit down with your team and look at your project and how you will manage the data as you have planned it, to see if it fits or does not fit these expectations. Have discussions about ownership, roles and responsibilities, about resources and predicted needs, and expectations for post-project retention, archiving and dissemination.

TC: What are the key components to a good data management plan? *(continued on p 27)*

URI digs into data management

At the University of Rhode Island library, Julia Lovett, digital initiatives librarian, says data management is gaining increasing focus and attention.

"As many grant funding agencies now require that researchers create data management plans, we have become aware of the need for data management education and support," Lovett notes.

As a first step at URI, Lovett says she and Karen Markin, director, URI Office of Research Development, created a LibGuide for researchers on data management planning: http://uri.libguides.com/data_management.

Lovett also invited Andrew Creamer, Brown University, to speak about data management after he coordinated a training day for RI NSF EPSCoR partner institutions.

The URI workshop was part of an annual professional development series for library faculty, but Lovett says they also opened the talk to URI researchers and administrators to help raise awareness about key issues in managing and sharing research data.

The essence of Rhode Island NSF EPSCoR can be found in the sum of its parts and the framework that embraces nine institutions of higher education. Individually, no campus, no single scientist, can achieve alone what the breadth of the program allows through its research infrastructure and collaborative venture.

Developed by incisive planning and a deep commitment, RI NSF EPSCoR's shared research facilities make discovery in the Ocean State possible, helping us understand the impacts of climate change on marine organisms and ecosystems and better prepare for any uncertainties the future may hold.

Ed Baker, seawater facility manager, says the greatest strength of the Marine Science Research Facility has been steadfastly serving science and students for decades. Photo by Hallie Steele.

Down by the sea

Marine facility boosts research capacity

What do you need to know about marine life?

The impact ocean acidification has on lobsters? Can marine ecosystems and wild fish populations be better preserved with fishmeal replacement in aquaculture fish feeds? How and why do harmful phytoplankton blooms occur?

What are nutrient levels, driven by sewage and fertilizer run-off, doing to Narragansett Bay? Can squid shut down their oxygen consumption and control their metabolism?

Responses to these and myriad other questions are sought and found within the low-slung buildings and specialty laboratories that sit bayside on the University of Rhode Island Narragansett Bay Campus.

Together, they form the Rhode Island NSF EPSCoR Marine Science Research Facility (MSRF), valued and supported by both the URI Graduate School of Oceanography (GSO) and College of Environment and Life Sciences (CELS).

"Think of how much biomass is in the ocean," says Lucie Maranda, MSRF supervisor and marine research scientist at the GSO. "How healthy is this biomass? Is it affected by climate change, by pollution? And if so, how is it affected? We need to understand the resilience of marine populations, and how the environment responds to different conditions."

By measuring the response of the ocean and its inhabitants, says Maranda, we can learn and verify, for example, that pollution does matter; if we put contaminants in the water, we can see the cause and effect, that before we had species 'x,' and now we have species 'z.' We can compare a pristine environment with one that is polluted, and we can demonstrate that problems exist.

The pursuit of answers brings researchers from URI, the EPSCoR community and the state, to the literal end of South Ferry Road, where the asphalt meets Narragansett Bay and Rhode Island Sound. The view alone is worth the drive, not to mention the incredible science that takes place in the buildings there.

"There is magic when cresting the hill at the South Ferry Church and seeing the condition of the Bay — angry and covered with white caps, foreboding with icy sea smoke or resting flat and glassy calm," reflects Ed Baker, seawater facility manager. "I look for it each morning."

The flowing seawater wet lab space, environmental chambers, and array of analytical equipment combine to provide unique opportunities for marine scientists and students. With the R/V

(continued on p 14)

Endeavor and other research vessels able to dock at the GSO pier, scientists can collect organisms at sea and bring them to the MSRF where marine conditions are mimicked or slightly changed for experiments.

Samples from the experiments then can be analyzed with a host of specialized equipment such as microscopes, a flow cytometer, and a nutrient analyzer. Samples also can be processed conveniently for later DNA sequencing. The aim is to offer one-stop-shopping to all types of scientists.

Maranda doesn't have to look far or wide to sum up the importance of having these capabilities close at hand. She cites a long-term GSO study that began in the 1950s, taking weekly water quality samples to determine bay conditions and phytoplankton and zooplankton abundance related to such indicators as temperature, salinity and a host of nutrients. Nutrient measurements once conducted by hand are done today with the MSRF nutrient analyzer, generating more data faster.

"This long-term study allowed us to document an increase in the Bay's water temperature," Maranda says. "It is how we found out there are changes to nutrients in the Bay. If we had not done the analysis, we would not know."

Sea squirts to seaweed

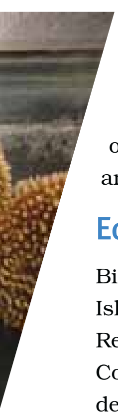
Baker oversees the activity that takes place throughout the four-building complex and hurricane-hardened pump house. Along with 7,000 square feet of wet lab space, there also are seawater intake pipes, eel grass mesocosms, a large laminar flow tank, specialized respirometer tanks, pathology and transgenics labs, filters, heaters, chillers, alarms, and back-up generators.

With RI NSF EPSCoR funding and support, the seawater facility has seen major renovations and updates to accommodate what Baker describes as a remarkable diversity of research — benthic soil chemistry, macro algae ecology and invasive species, marine degradation of newly developed plastics, functional morphology of sharks, effects of neuropeptides on lobster behavior, sea star disease, tunicate development, effects of ocean acidification, effect of rising sea level on marsh grass survival, and novel anti-fouling surfaces, among many other enterprises and the periodic verification that sea-going instruments work properly.

"We're essentially bringing the ocean into a laboratory where scientists are able to address local, regional and global issues," he says. "The facilities and equipment can emulate nearly any marine condition on the planet except for vastness and depth."

For example, one researcher is attempting to establish an ice cap in an environmental chamber to better understand the dynamics of microbial communities residing under the vast polar ice caps.

The MSRF also has been the springboard for the expanding oyster aquaculture industry here in Rhode Island and along the eastern seaboard. Investigation into oyster



At the Marine Science Research Facility, flowing seawater, wet lab space, environmental chambers, and array of analytical equipment accommodate a remarkable diversity of research.

growth and their pathogens continues today.

Baker says the MSRF has a long history of providing for scientists and students studying bacteria, phytoplankton, zooplankton, mollusks, crustaceans, echinoderms, finfish, and sharks. From sea squirts to seaweed — essentially all manners of sea life — the MSRF has been a conduit for graduate students and scientific papers for decades, a great asset to the university and the state.

The MSRF makes equipment available for use both in the labs and out in the field or off the shores of Rhode Island. The facility also accommodates visiting scientists, has undertaken contract science, and at times conducts replicate scientific studies and hosts research activities sponsored by other universities.

And, the MSRF draws in the next generation with an outreach program, hosting groups of young people through their school, organization or camp, to expose them to marine science education and careers.

Education, research & training

Biologist Rebeka Rand Merson, associate professor, Rhode Island College (RIC), says the MSRF is an indispensible asset. Recently awarded a Rhode Island Science & Technology Advisory Council (STAC) collaborative grant, Merson focuses on evolution, development, and effects of environmental stress in cartilaginous fishes (sharks, skates, and rays) with specific aims to determine sensitivity of these animals to chemical pollutants present in Narragansett Bay.

"We anticipate that our results will contribute significantly to our understanding of current stressors and emerging issues related to climate change," Merson explains, noting that the research animals she studies are too big and sensitive to maintain at RIC and they require flowing seawater to survive and reproduce.

The MSRF offers world-class physical facilities, she says, and Baker is highly knowledgeable about the operations of the facility: "Most importantly, he has expertise in maintaining healthy environments for marine organisms, including the group of animals I work with. His advice on day-to-day care of the animals and considerations for planning upcoming experiments is invaluable."

Merson says access to the MSRF undoubtedly has played a role in her successful grant awards; reviewers recognize that investigators have the research capacity to complete their proposed studies.

Second-year Ph.D. student Erin McLean, URI biological sciences, with specialization in integrative and evolutionary biology, works in the lab of Associate Professor Brad Seibel. She says her research work with juvenile lobsters, six months old and about an inch long, would not be possible without the MSRF.

"As we put more and more CO_2 into the atmosphere, the CO_2 also goes into the ocean," McLean explains. "Once there, it forms a weak acid that is lowering the pH of our oceans, making them more acidic."

Numerous studies have shown that higher acidity levels make it harder for animals to deposit their shells, reproduce, and survive. McLean wants to find out how the lobsters fare in acidic conditions.

She says her work involves exposing juvenile lobsters to higher acidity and measuring their growth during a four-month period. She chose juvenile lobsters because they are a key component of the lobster fishery pipeline, an enormously important fishery in New England and the Canadian Maritimes.

McLean's experiment, which Baker describes as ingenious, introduces different levels of CO_2 to flowing seawater in three tanks. Each has 24 lobsters, all getting the same seawater from the Bay, the same food conditions, and the same light conditions.

The only difference among the tanks is the pH of the water, which is controlled by the CO_2, thereby mimicking different atmospheric concentrations. By early February, McLean had spent about four months on the experiment, measuring the lobsters every few days to gauge growth.

She says preliminary results suggest that the lobsters in the lowest pH tank (the most acidic) are not growing nearly as well as the lobsters in the tank that represents ambient conditions. This spells bad news for the industry — if lobsters take a longer time to grow to legal size, fishery profits will decline.

The next big breakthrough

"My research couldn't be done without the MSRF," says McLean. "My tanks require a constant supply of seawater, and without the pumps and filters and supply lines at the aquarium building, the experiment wouldn't work."

At the same time, McLean adds, having tanks available for her use at the MSRF meant a smaller budget, which given the country's science funding climate, figured critically in green lighting the experiment.

"It's so important to have a facility like this in Rhode Island, because without it, innovative projects like mine wouldn't be able to happen," McLean says. "Having an idea for a project is fantastic until you realize you need a ton of money and a ton of space to make it happen."

With the facilities and infrastructure in place and accessible, young scientists like McLean can skip the step of purchasing tanks and finding a reliable seawater supply.

"Once I knew it was possible to get space in the MSRF," she says, "I was able to more fully develop my idea — how do lobsters grow under ocean acidification conditions — into a full blown study that will likely be important for many people in the field, as well as fishermen and policymakers."

Maranda says these capabilities for research open up new avenues for collaboration among scientists, within and beyond Rhode Island's borders as well as between disciplines, to address issues in basic as well as applied ecological and physiological science with potential implications in environmental management.

Baker also points to the dedicated study of real world marine questions and the dynamic, diverse research that takes place at the MSRF on a daily basis, its quiet presence and supportive role often unnoticed: "Its real strength has been serving science and students steadfastly for decades."

Founded in 1937, the Rhode Island School of Design Edna Lawrence Nature Lab features a hands-on natural history collection and studio environment that allows users to examine and explore the patterns, structures and interactions of design in nature. Photo courtesy of RISD.

The power of perspective

Part museum, part cabinet of curiosities, RISD's Nature Lab opens the doors to discovery with new ways of thinking

The Edna Lawrence Nature Lab at Rhode Island School of Design houses a vast collection of specimens, a stunning showcase of the patterns, structures and forms found throughout the natural world.

An inspiration to RISD design and art students since its inception in 1937, the lab today serves as the physical and intellectual home of Rhode Island NSF EPSCoR on the RISD campus, according to Neal Overstrom, Nature Lab director.

"Historically grounded both physically and pedagogically in first-year Foundation Studies, the Nature Lab is now viewed as a scientific resource for the entire RISD community and beyond," says Overstrom, also RISD's partner liaison for RI NSF EPSCoR. "Most recently the Nature Lab has been supporting the broadening campus dialogue on the relationship between art, design, and science."

Both EPSCoR and RISD Academic Affairs made major investments in research-grade microscopy and micro-imaging systems for the lab throughout the EPSCoR grant period. Such equipment, says Overstrom, like the Nature Lab itself, provides access to high quality instrumentation and opens a portal to the sciences for RISD's visually oriented art and design students and faculty.

At the same time, the equipment sets the stage for the collaboration of art and science across the Rhode Island EPSCoR community. The resources — formally shared with EPSCoR partner institutions through the CoresRI network — include both compound and stereo microscopes with full-color cameras, a Phenom G2Pro desktop scanning electron microscope, standard and high-speed video cameras, and geospatial imaging workstations with large format multi-touch screen and plotter dedicated to geographic information systems (GIS).

"Together, this technology allows the exploration of pattern, form and structure, from the micro- to ecosystem-level scale in one location, all designed for rapid imaging and ease of use," Overstrom explains.

An Ocean State resource

Use of the Nature Lab extends well beyond the campus borders of RISD's community, hosting classes and colleagues from multiple Rhode Island institutions and EPSCoR partners. And, the facility has initiated relationships with local K-12 schools to develop projects and curriculum with opportunities for trans-disciplinary classroom activities, Overstrom notes:

"We are exploring ways that RISD can be not only a physical place where teachers can bring their classes for inspiration, but also a resource of collected research on art and science collaboration, exemplary STEAM (science, technology, engineering, art, and mathematics) projects, and how we best teach and learn."

As the only EPSCoR state to count a major art and design school among its partner institutions, Rhode Island stands poised to examine science questions from new perspectives and provide novel ways to address and represent information and data.

To help the Nature Lab fulfill its role and push the boundaries of investigation and discovery, RISD maintains an ongoing investment in the facility and its equipment, including the purchase of additional compound microscopes and camera systems, a lab-grade refrigerator and freezer, and other wet lab equipment — instrumentation accessed by hundreds of students and faculty from every RISD department and utilized in many ways.

For example, one student used the equipment to study different surfaces of candy for a project that dealt with the topic of diabetes. A Textile Department Nature Lab project completed in Spring 2014 was driven by the questions: Why do forms in nature exist? What is the narrative of their existence? How does habitat give rise to behavior? How are features linked to the environment?

Overstrom says students investigated concepts such as biomimicry (using nature-inspired designs and processes to solve human problems) and functional morphology (studying relationships between the structure of an organism and the function of its various parts) to find links between creatures and their habitats.

"Just as scientific theories are advanced one step at time, artistic ideas and innovations are built from many microshifts in seeing and understanding materials," Overstrom says. "The basis of EPSCOR is 'experimental research,' that is, research in which the path may not be linear or known, and which can lead to new ways of seeing a problem."

Bold thoughts, bright vision

And, as much as RISD has influenced the science, so, too, has the science put its imprint on the art and design institution.

The 2014-15 academic year saw the introduction of a Nature-Culture Sustainability Studies program, the college's first cross-divisional degree concentration. The new 21-credit concentration allows students to combine interests in sustainable design with the fine arts and science-art, along with the environmental social sciences and the humanities.

RISD's commitment to engaging in multiple modes of inquiry can be seen in the increased number of science courses made available to the school's students, now including 12 ongoing offerings and multiple individual courses, Overstrom notes: "Since the onset of the grant, we have presented more than 27 science-related courses, including the seven EPSCoR-funded studios."

He cites the work of RISD professor, Dennis Hlynsky, a member of the EPSCoR Advisory Council and collaborator with the Susanne Menden-Deuer lab at the University of Rhode Island.

Hlynsky's experimental videos depicting the multiple paths of birds in flight (along with his work with marine plankton and insects) captured attention of media outlets and sparked interest from scientists who see applications for his art in not only bird and insect behavior, but also in studying such phenomena as the flow and clustering of red blood cells.

Says Overstrom: "These kinds of insights could never have been anticipated had these researchers not seen his creative work. Another opportunity is to bring discovery to audiences that science may not normally reach."

He also points to RISD faculty member Cynthia Beth Rubin and her Plankton Portraits EPSCoR Studio. Her representations of marine plankton, in collaboration with the Nature Lab and the Menden-Deuer lab at URI, found wide exposure at diverse venues, from the Cotton Club Outdoor Screen in New York, to the International Symposium on Electronic Art in Dubai. Her video, "TRACES," from this collaboration, was included in the SIGGRAPH Art Gallery special issue MIT Press, Cambridge, MA.

A new, permanent, full-time position at the lab — biological programs designer, funded by the Nature Lab and RISD Academic Affairs — will play a critical role in expanding Nature Lab course content and work with partners in the EPSCoR community.

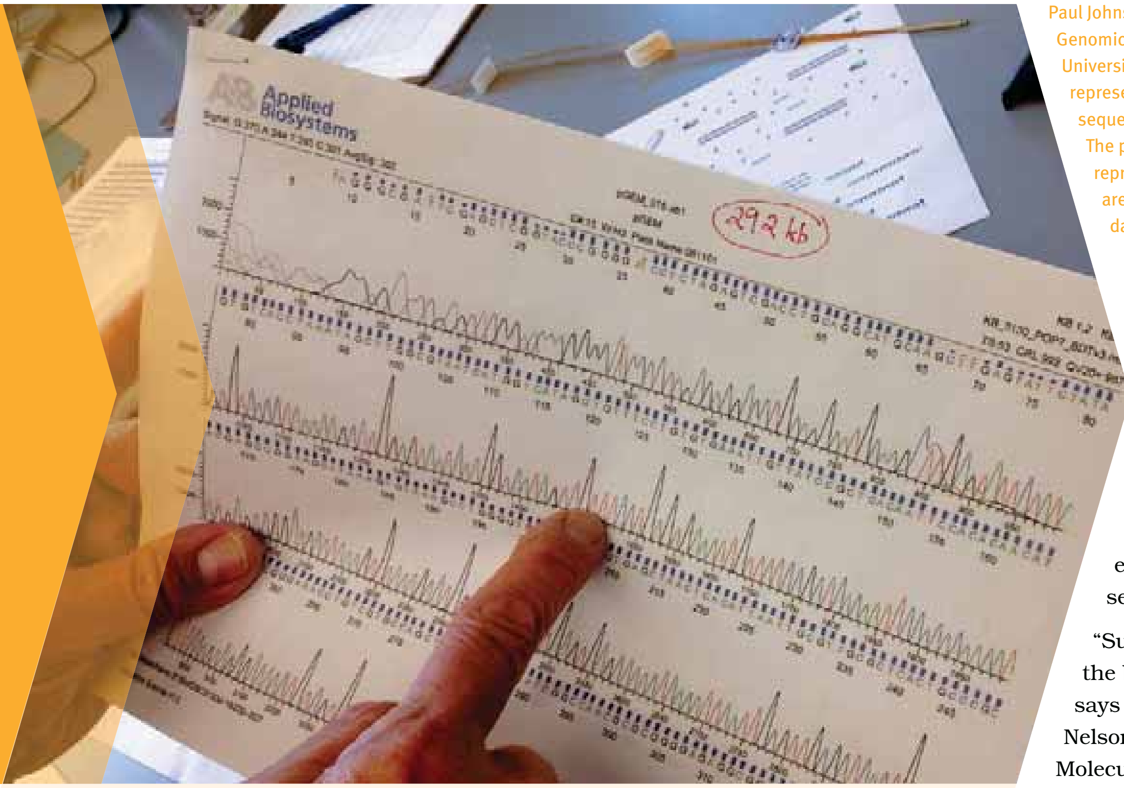
The equipment and the exhibits, the expanding capabilities and collaborations — the sum total extends far beyond the academic curriculum. The far-reaching implication of this investment lies in how we make sense of the world around us and find answers to the complex problems that elude easy resolution and traditional thought processes.

Overstrom notes, "Artists and designers explore problems in ways that often have unpredictable outcomes."

The RISD Nature Lab supports the growing dialogue on the relationship between art, design and science, and serves as the physical and intellectual home of RI NSF EPSCoR on the RISD campus. Photo courtesy of RISD.

Precision science

URI center decodes life's mysteries at the genetic level



Paul Johnson, manager of the Rhode Island Genomics and Sequencing Center at the University of Rhode Island, points to a graphical representation of a DNA sequence from Sanger sequencing known as an electropherogram. The printout shows colored peaks that represent each of the four DNA bases as they are successively determined from the raw data acquired by the instrument.

The Rhode Island Genomics and Sequencing Center sits tucked away on the third floor of the Center for Biotechnology and Life Sciences (CBLS), overlooking the University of Rhode Island's North Woods.

The presence of room 352 easily passes without notice, the daily grind of academic and research activity drowning out its quiet and unassuming significance.

But inside the modest 1,600-square-foot suite of rooms, the boxy array of equipment and computers resting on tables and desks holds exciting promise for discovery and vast potential to alter the course of human existence.

Every detail about every living thing — human, animal, virus, bacteria, everything — comes down to the sequence of nucleotide bases coded in its DNA.

These foundational building blocks — adenine (A), guanine (G), cytosine (C), and thymine (T) — provide a blueprint that determines the myriad qualities of each living thing; how an organism grows, the traits it develops, how it acquires food and stores energy, the environmental conditions it needs to survive, how it finds mates or defends itself.

If we know what these genes are, we can begin to understand how life processes work. We can use this information to help determine both the causes and cures of disorders, and to develop preventative measures such as vaccines and treatments such as antibiotics to eradicate disease and safeguard against infection.

Through RI NSF EPSCoR research, genetic sequencing is used to learn how climate variability affects marine life and ecosystems — information which is critical to preserving sources of food and water, adapting to environmental changes, and securing economic viability.

"Suppose we want to examine the bacteria in an environment," says microbiology Professor David Nelson, Department of Cell and Molecular Biology, URI College of the Environment and Life Sciences. "If we take samples, extract their DNA, and sequence one particular gene marker found in all bacteria, we can determine the diversity and abundance of the different microbes based on that gene's sequence diversity in the different species of microbes.

"Further, we can compare specific gene abundances over the seasons and over years to see the impact of temperature change on a population."

Additionally, explains Nelson, who founded the Genomics and Sequencing Center and serves as director, we can use gene sequence information with another technique known as reverse transcriptase quantitative PCR to find out how individual genes in a particular organism respond to rising sea temperatures or the presence or absence of a toxin or disease: "We can answer all sorts of questions at the genetic level."

Nelson and a couple of colleagues wrote a grant proposal in 2001 for the center. With no facilities in Rhode Island at the time, Nelson says he had to send out samples for sequencing at $16 each, which took not only money, but also time for results that were not always accurate.

Established in 2002 and continuously enhanced and expanded with EPSCoR funds since the first grant was awarded in 2006, the RIGSC today provides faculty, staff and students with technical and analytical support for molecular biology and genomics research at the nine EPSCoR partner campuses.

The center offers services in robotic sample preparation, DNA library preparation, DNA sequencing (Sanger and Next Generation), fragment analysis, quantitative PCR (or polymerase chain reaction) and in the identification of microbial species and their phenotypes. The center also provides imaging services using transmitted light, epifluorescence and scanning confocal microscopy, and cryostat sectioning of frozen specimens. The center has two full-time employees – Paul Johnson (RIGSC manager) and Janet Atoyan (DNA sequencing technician).

Johnson says the center's basic mission is to provide and maintain the research tools, and instruct users how to operate them: "Then, they take the data and run with it."

Pushing science forward

For Associate Professor Chris Lane, URI, Department of Biological Sciences, the Illumina MiSeq Next Generation Sequencer, which can generate sequences of small genome organisms such as bacteria or viruses, has been particularly helpful.

"We've used it a lot to check samples before spending tens of thousands of dollars sequencing them more deeply," Lane says. "It's also been great for quick projects and samples we need quickly for preliminary data. The combination of fast turn-around and Janet's expertise with the library construction side of things has been extremely helpful."

URI Professor Marta Gomez-Chiarri, department chairman of Fisheries, Animal & Veterinary Science, says the center plays an integral role in her research program and her lab uses the equipment on nearly a daily basis.

She, too, credits Johnson and Atoyan for their technical expertise: "They provide excellent training to undergraduate and graduate students, allowing us to use techniques that we were unable to use before due to lack of expertise in the laboratory."

According to Nelson, both Johnson and Atoyan are essential to the center's success, making it an invaluable resource for the state's researchers. They pay attention to detail, ensure samples are made properly and work closely with researchers to resolve any problems.

Beyond cutting research costs and making the equipment conveniently accessible, Nelson says the center also holds value in building research capacity, both in attracting faculty and students and strengthening grant proposals.

"For someone who does molecular-related work, if you can say we have this genomics and sequencing center, their eyes light up," Nelson says. "When kids look at it for grad school, they notice that *(continued on p 23)*

This small blue disc is a DNA chip used in the Bioanalyzer at the RIGSC to determine the quality and quantity of DNA in samples that will be run on the MiSeq next generation sequencer. This is a critical step to ensure the success of the run, which may cost more than $2,000.

Chris Reid, photo by Hallie Steele.

For researchers, core facilities make all the difference

Bryant University's Christopher W. Reid, assistant professor, biochemistry, divides the research in his laboratory into three central themes.

The initiatives differ in their individual pursuits, but one common denominator factors into each project — the Rhode Island NSF EPSCoR core facilities.

Without the Proteomics Shared Resource Facility at Brown University and the RI Genomics and Sequencing Center at University of Rhode Island, Reid said his research would come at a much higher cost and jeopardize the pursuit of science.

"Without access to the proteomics facility, there would be a severe impact on research in the laboratory," Reid said. "It would be not feasible or practical to have this level of instrumentation at Bryant."

The genomics center plays an equally critical role. Reid said the cost of analysis at the genomics center allowed for more efficient use of lab resources. The alternative would be to use commercial sequencing labs at a significantly higher price.

The three areas of Reid's work include:

- The microbial resistome — Antibiotic resistance is a major health concern and has been shown to be associated with environmental reservoirs, both water and soil, which are traditionally associated with human activities. His lab is investigating the role of legacy pollutants (for example, heavy metals) in the Narragansett watershed's Blackstone and Providence Rivers, and the impact on the associated microbial communities, and selection for antibiotic resistant organisms.
- Molecular characterization of adhesive secretions of mollusks (A collaboration with Andrew Smith, Ithaca College, Joseph Bliss, W&I Hospital.): Reid and his collaborators have been using proteomic and genomic tools to understand the composition of these secretions. The goal of this project is to develop a bio-inspired medical adhesive based on these secretions.
- Chemical genomics probes for studying microbial physiology — In collaboration with Amit Basu, associate professor, chemistry, Brown University, the lab is developing chemical probes that can be used to study bacterial cell wall metabolism. *(continued on p 23)*

Rhode Island Hospital researcher Steven Berardinelli, who graduated from Rhode Island College with a chemistry degree, prepares samples for the QExactive mass spectrometer at the RI NSF/EPSCoR Protoemics Shared Resource Facility at Brown University.

Seeking clues in the sequence of proteins

Brown center gives researchers tools to explore new frontiers in science

In establishing the Shared Resource Facility at Brown University in 2007, Rhode Island NSF EPSCoR set the stage for cutting edge research to take place in the Ocean State with implications reaching far beyond its borders.

Located in Brown's Laboratories for Molecular Medicine, 70 Ship Street, Providence, the RI NSF EPSCoR core facility provides state-of-the-art instrumentation and expertise in the proteomics field.

"Just about every process in cells — all cells — is mediated through proteins," explains Facility Manager James Clifton. "In proteomics, we attempt to characterize all the proteins in a particular system."

The founding grant for RI NSF EPSCoR provided funds for the majority of the facility's equipment; additional support came from the Rhode Island Science and Technology Advisory Council (STAC), the Rhode Island Research Alliance (RIRA), and Brown University.

This research capacity, paired with the Rhode Island Genomics and Sequencing Center, another EPSCoR core facility, located at the University of Rhode Island, gives scientists in the EPSCoR community the tools they need to explore new frontiers and charter the unknown.

Such goals sound lofty and noble, but this is the best way to put into context the potential these capabilities provide. We look to genomics for insight into the instructions of life, the essential structure and the make-up of an organism. Proteomics guides us to understanding life functions, what organisms are doing under any set of circumstances.

Genomics will tell us where an aberration exists in a sequence of DNA. But to determine what exactly is taking place, the mechanisms occurring at the cellular level, we need to investigate the expression of protein — the how and the why of the system at work.

More specifically, says Clifton, if we sequence the genome of a cancer cell, we can see how it is different than a normal cell, which leads to understanding what causes the disease. However, the problem does not usually lie within the gene, but rather in the RNA or protein being expressed.

"So the idea of proteomics — let's characterize everything if we can — stems from the fact that your DNA in every cell is the same, but individual cells are different, which is almost always caused by the different expression of proteins," Clifton says. "If we can identify the proteins and ultimately quantify their levels, that, hopefully, leads to understanding what is going on."

A work in progress

To be sure, though, even with the technological advantages gained through the last two decades, identifying every protein is no simple task.

The early technology could separate and define 500 to 1,000 proteins. Today's equipment can identify upward of 8,000 to 10,000 proteins from one single analysis. Once defined, however, those proteins may not hold the most interest; rather, they may just be the most abundant.

Considering that any given cell produces 10,000 to 20,000 different proteins, there remains ample territory to discover.

Whereas every cell in an organism contains the exact same genome, cells don't necessarily express the same protein; the eye and stomach cells have the exact same DNA, but express different proteins relevant to the cell function.

"We are early on, but ultimately the idea is to use this to understand basic things or to give leads," Clifton says. "If you find a new protein or this protein is 10 times higher than others, it becomes a potential drug target."

Called biomarkers, or an indicator of biological condition, these proteins can be either diagnostic or prognostic in nature. Perhaps they indicate an underlying disease or point to a specific treatment. Either way, obtaining this information and understanding the details is part of the trend toward personalized or individually targeted medicine.

Still, Clifton notes, much of proteomics centers on basic biology and efforts to investigate the various developmental processes. Proteomics can be viewed as a tool and applicable to any system, whether seeking clues to the underlying causes of extreme autism or understanding the sequence of events during and after a heart attack.

Proteomics also can be used to figure out how climate change alters a marine organism at the molecular level, the implications of which carry no less importance than curing disease.

How organisms respond

Professor Tom Meedel, Biology Department, Rhode Island College, came to the Proteomics Center through his work with the sea squirt *Ciona intestinalis* and a project with Associate Professor Steve Irvine, URI College of the Environment and Life Sciences (CELS).

The intent wasn't so much determining the sea squirt proteome, but rather investigating physiological changes wrought by climate change. Meedel anticipates the next question:

"Who cares about sea squirts?" he asks. "First, as a filter feeding organism, they do process a lot of the water that exists in Narragansett Bay. They play a major role in the composition — one *Ciona* could filter several liters of water in an hour."

Consequently, if all the sea squirts disappeared, the absence would have a dramatic impact on water quality not to mention the food chain, both scenarios that would wreak havoc with the money we make, the food we eat and the coastal areas that attract Rhode Islanders and tourists alike.

Having the capability in the state to explore the ramifications of climate change provides a fundamental tool to researchers. And, the protocol for sharing not only increases capacity, but also makes it more affordable and accessible, which ultimately multiplies the potential for discovery.

Prior to the center's establishment in the EPSCoR community, the only option for proteomics was either sending out a sequence to an out-of-state lab and paying a fee for the service or finding a lab with the equipment and a project that aligned with a particular research area.

Clifton says that like genomics, proteomics is a tool that can be applied to any number of systems. Since the knowledge base remains relatively young, he notes that in addition to supplying the instrumentation, the Brown center also works with researchers and gives insight on the possibilities of what can be achieved with this technology.

What the future holds

Clifton took on his role at the center in 2006, at the tail end of the first EPSCoR grant. Since then, he says, the center, under the direction of Associate Dean for Biology Ed Hawrot, also an RI NSF EPSCoR Steering Committee member, steadily has ramped up its capabilities.

The 2010 start of the current five-year RI NSF EPSCoR grant initiated steps toward increasingly powerful technology and advanced instrumentation, allowing the center to build a user base and enhance the state's research infrastructure.

Clifton says genomics had about a 10-year start on the proteomics field, and ultimately proteomics depends on the sequencing of genes: "But, they're doing things that maybe in five to 10 years we'll be doing."

Although it is difficult at this point to say with any clarity what the outcome may be and where proteomics will lead us, Clifton figures the potential exists to answer just about any question. The only limitation will be people, not technology.

"We might be seeing a plateauing of instrumentation," he says. "To have more complete descriptions, we need more people. Technology will solve some of our problems, but we need to invest in more infrastructure and more people."

Far from having the full capability that comes with having various types of instrumentation needed for technically demanding proteomics research, the proteomics center at Brown has the manager — Clifton — and one mass spectrometer.

"If instead we had five mass spectrometers," he says, "then we could do all sorts of complete proteomics."

James Clifton, Proteomics Center facility manager, says proteomics can help researchers understand how climate change alters a marine organism at the molecular level.

Crunch time

CCV hosts high-performance computing resources

Biochemistry students use Visual Molecular Dynamics (VMD) software to explore a 3D model of a protein molecule (Alkaline Phosphatase) in the virtual reality CAVE located in the Brown University Center for Computation and Visualization. Photo by John Huffman.

Before researchers can answer questions about the impact of climate change on marine life and ecosystems, they have to collect data — reams of facts and statistics that must be stored and studied, assessed and analyzed.

But, as anyone with a household of Wi-Fi dependent gadgets might be able to relate, harnessing technological output, whether sending, streaming or downloading, demands capacity and efficiency.

Alone, Rhode Island scientists and their respective institutions can't afford what they need. But together, through the EPSCoR effort to share resources, they can tap into the high performance computing and research data services of the Center for Computation and Visualization (CCV) at Brown University without having to leave their laptop.

Housed at Brown's Providence campus, the CCV and its vast capabilities can be accessed by RI NSF EPSCoR researchers at any one of the nine partner institutions across the Ocean State. The high-performance computing resources equip the research community to undertake complex numerical simulations, modeling, and data analysis.

Part of Brown's Computing and Information Services (CIS), the CCV fosters and manages high performance computing, highly reliable research data storage, visualization resources, physical and virtual server hosting, high-performance backup and archival services, and scientific support to empower computational research, scholarship and creativity, according to CCV Executive Director Gurcharan Khanna.

"We have large scale computers that are faster and can handle more data than what may be available on their campus, whether they're processing numbers or creating visualizations," explains Khanna. "We work alongside researchers to optimize their workflow and get their research done efficiently."

RI NSF EPSCoR collaborates with the CCV to promote the use of cyberinfrastructure, computational science, and bioinformatics in studying the responses of marine life to climate variability. The initiative has marshaled the forces of the research community and led to integration of resources.

EPSCoR researchers have access to a dedicated portion of the computer cluster for high performance computing and data services for data analysis. If a research project aligns with the EPSCoR questions, then every researcher and his or her group can have accounts set up to access the system. With virtual server hosting, high-performance backup and archival services, scientific support and pre-installed software tools, the facility provides an invaluable platform for scientific research.

High throughput analysis holds the key to solving many critical research questions, and recent advances have decreased the cost to procure data. Yet, with more data, the need increases for data management, analysis and archival storage.

The CCV allows scientists to log in, whether from a terminal in their office or on the go with a mobile device, and connect to powerful technology. Equally important, the CCV provides individual support throughout the course of the workflow.

"Whatever it takes to help get the science done," Khanna says. "The CCV is really about people first — the researchers and our staff, who are often themselves research scientists, helping researchers use the technology effectively."

However, capacity alone cannot meet the demands of scientific pursuit to answer the complex and compelling questions faced by humankind. Researchers also must be able to transmit the huge amounts of data collected, which is why RI NSF EPSCoR in the beginning grant years made significant investments to improve the state's cyberinfrastructure and develop resilient, high-bandwidth connectivity between research and academic institutions.

Those early partnerships and collaborations between EPSCoR and other Rhode Island organizations means researchers today throughout the state can upload big batches of data for processing and storage at the CCV.

To gain a sense of what this means, think about the latest and greatest in personal computing — a typical laptop may have a storage capacity of 250 gigabytes. The CCV currently has the capacity of about 2,000 such laptops or 500 terabytes, which equals a half of a petabyte, and is considering requests for one petabyte, which equals 1,000 terabytes or 1 million gigabytes.

Once the data arrives at the CCV, a computer program there can sort, manipulate and visualize the data, and all at a high speed.

"Even if you're dealing with 100 gigabytes of data," explains Khanna, "you want to make sure you're not moving it at Wi-Fi speed."

This is a critical point because data, once collected, is in a continual state of movement in the workflow. Data gets gathered, stored, modified, moved, modified again, and analyzed. Results might be brought back to an individual's computer; results might be disseminated and then sent back again.

As Khanna notes, with all this movement, it doesn't matter how fast the long haul is if the point of use is slow. To make all parts compatible and useful, from collection to processing and, ultimately, storage, the system needs both the high speed of fiber optics plus the equipment capacity along the way to handle the delivery. If researchers need additional capacity at the CCV, the facility can add on storage.

In all of the talk of terabytes and moving ginormous quantities of data at high speeds, Khanna finds greater meaning in what this system allows.

First, from an economic standpoint, there exists significant value in a shared system. What the CCV offers is bigger and more capable than what any single person or institution can afford alone.

There also is the factor of speed and what that allows researchers to accomplish. What used to take an hour, now may consume only a single second; or, what previously took years, today may take minutes. So, imagine the possibilities.

Yet, there is more to consider than merely speed and function, as exciting as the potential promises.

CCV staff member Ben Knorlein uses the CaveWriting application to explore a virtual poem, "Cubes," in the new 3D virtual reality environment (called a YURT). "Cubes" was created by Ian Hatcher and Adam Veal. Photo by John Huffman.

Khanna reasons, if the process takes a long time, researchers may not be compelled to ask the questions. So, the capacity alone prompts scientific pursuit.

"One aspect, certainly, is sheer speed," says Khanna. "But now, there also is the qualitative aspect. It's not just that we couldn't do it before and now we can do it faster.

"Now, people can ask bigger questions, questions that weren't practical to ask."

And therein lie the beauty and the wonder, and the possibility. Not only do we have the technology to support our quests, but also where else might we now be able to go?

Precision Science *(continued from p 19)*

they can do DNA sequencing on campus. And, it helps when we apply for grants."

The benefits extend beyond the URI campus to the rest of the state, he adds. Any researcher at the other eight EPSCoR partner institutions can send samples to the center. With a common, shared resource, no individual school has to spend inordinate sums of money to acquire the capabilities.

For example, he points to the Illumina MiSeq at URI and the Illumina HiSeq at Brown University. The MiSeq is good for sequencing small genome organisms like bacteria or viruses. In comparison, the HiSeq is used for large genome sequencing — it can do humans, trees or mice.

Whatever the need, both Nelson and Johnson say, having the technological capability in state, guided by the proper expertise, and at affordable and competitive rates benefits all researchers in multiple disciplines, from microbiology and engineering to physics and pharmacy.

Referring to the technology, Johnson says, simply, "It's allowed science to go forward here in Rhode Island."

Core facilities make all the difference

(continued from p 19)

Reid said the EPSCoR facilities provide state-of-the-art equipment and expertise, both of which figure heavily into his research.

He turns to the genomics center for the validation of genes cloned in the laboratory as well as identification of microbial species in water and sediment samples from the Blackstone and Providence Rivers.

At some point, all of the projects in his lab require the mass spectrometry instrumentation at the proteomics center. The center has facilitated the analysis of mollusk secretions with Reid's collaborators and has allowed the acquisition of preliminary data for a future grant application.

Without the access he now enjoys, Reid said his other options would be to use mass spectrometry facilities housed at other universities and pay outside user rates, which at $125 to $342 per sample would be cost prohibitive and impede progress on several projects.

The proteomics center, said Reid, "has provided a high quality, cost effective resource that opens up areas of scientific inquiries in the lab."

Paul Cuffee School & RI NSF EPSCoR: A match made in maritime

In just four months of the 2014-15 academic year, Rhode Island NSF EPSCoR hosted six outreach events for a total of 155 middle and high school students from five schools.

The daylong Hands-on Science Experiences involved EPSCoR facilities and partner institutions, and tapped into the expertise of volunteers — undergraduate and graduate students as well as staff at the University of Rhode Island Graduate School of Oceanography and the National Oceanic and Atmospheric Administration (NOAA).

By year's end, RI NSF EPSCoR will touch the lives of more than 1,500 students through the Hands-on Science program, purchases of equipment and supplies to supplement class curriculum, and one-day events.

But behind these metrics, a deeper exchange takes place, creating a meaningful impact on the lives of Rhode Island schoolchildren who otherwise might not have the chance to explore an education or career in the science, technology, engineering and mathematics (STEM) fields.

As part of its outreach mission and initiatives, RI NSF EPSCoR cultivates varied and unique partnerships with schools — public, private and charter — throughout the Ocean State.

"We have a captured audience of students who need to learn and we want to expose them to the widest variety of opportunities," says Maria Monteiro, director of institutional advancement for the Paul Cuffee School in Providence. "And, we know the power of on-site, hands-on experience — it's exciting and sparks an interest in learning, particularly in math and science.

"It's fun and brings learning to life, and keeps students engaged."

A broad approach to learning

Late last fall, RI NSF EPSCoR brought two Paul Cuffee School groups to the Marine Science Research Facility on the URI Bay Campus, where the students engaged in Hands-on Science modules. The planning, collaboration and visits marked the renewal of a promising partnership with the innovative public charter school.

Founded in 2001, the school was named after Paul Cuffee, the seventh of 10 children born to a freed African slave and a Wampanoag Indian. Cuffee lived from 1759-1817, and today his Quaker spirit, maritime passion and relentless resolve live on in the classrooms and halls of his namesake school.

The school, which graduated its first senior class in spring 2014, encompasses the K-12 grade levels, distributed among three locations — the Lower School, grades K-5, 459 Promenade St.; the Middle School, grades 6-8, 30 Barton St.; and the Upper School, grades 9-12, 544 Elmwood Ave.

Today, the Paul Cuffee School student body numbers 780 students; 62 percent are Latino, 22 percent African American, 11 percent Caucasian, 4 percent Asian/Pacific Islander, 3 percent are multi race, and less than 1 percent Native American; and 75 percent qualify for free/reduced lunch.

"As we do our job of educating kids, we embrace the whole child," Monteiro explains. "There is social and emotional learning — not just academic. This is an example of a man who became a successful merchant and captain in those times, when there were so many obstacles. His perseverance, integrity and a sense of social responsibility — these concepts are featured prominently both in our mission statement and in our day-to-day work with kids."

Visitors to the Lower School readily notice the distinctive atmosphere — a quiet, yet busy hub of attentive learning. And, on a slushy winter day, the hallways remain conspicuously clean.

"We emphasize that this is our place," Monteiro says. "We take care of ourselves, we take care of our community, and we take care of our world. It's social responsibility. Our students are given opportunities to practice all of that and develop leadership skills."

Building new opportunities

Like Monteiro, Christopher Haskins, who came on board as head of the school in July 2014, sees value alone in the excitement and fun Hands-on Science Experiences add to learning.

"The adventure part of it is hugely important to adolescents," he says. "A lot of science and math isn't fun, but the field experiences make it a worthwhile learning experience."

And once Paul Cuffee School students are engaged, Haskins says he envisions them pursuing a college education and a career in the STEM fields.

"It is a priority in my work to achieve educational equity," Haskins adds. "There are many levels to it, but the science fields do not represent the communities of color as well as they should."

For RI NSF EPSCoR, the Paul Cuffee School partnership aligns perfectly with what the outreach program strives to accomplish.

"We want to reach students, especially those who come from underrepresented minorities and don't have equal exposure to STEM education and career opportunities," says Tim Pelletier, RI NSF EPSCoR education, outreach and diversity coordinator. "Also, the maritime theme dovetails with the EPSCoR mission to research the impact of climate change on marine life and ecosystems."

Monteiro and Pelletier want to forge a relationship that transcends individuals, bonds the institutions and serves the needs of both communities for betterment of students and society. They seek to ensure that the relationship lives on regardless of personnel and grant proposals.

For the Paul Cuffee School, RI NSF EPSCoR provides access to off-site, experiential learning opportunities and connections to faculty, staff and students who can talk about educational and career paths. At the same time, institutions of higher education need to conduct outreach to broaden the academic pipeline.

From Monteiro's perspective, both the school and RI NSF EPSCoR bring lasting value to the table: "These relationships are mutually beneficial and strengthen both of our programs. It's what we need to do."

Out of the silo & into the field

Melita Morales, photo courtesy of RISD.

Each partner campus in the Rhode Island NSF EPSCoR grant adds to the collective value through individual strengths.

For Rhode Island School of Design, the multi-institutional collaboration has sparked serious dialogue, introspection and action, from exploring the concrete concept of how we visualize data to considering the more fundamental questions of how we approach challenges and find solutions.

The intent is to create a new cognitive space for working through problems, utilizing the expertise and methodologies of multiple domains, says Melita Morales, EPSCoR|STEAM engagement and communications coordinator at RISD's Edna Lawrence Nature Lab.

"We see that problem solving is often guided by a disciplinary frame of reference, which can restrict our ability to see new possibilities," Morales says. "We believe there is more than one way of analyzing and knowing the world, and that through multiple ways of knowing, we develop more complex understandings and new solutions."

To reach this end, RISD's Edna Lawrence Nature Lab, in particular, embraces a journey that begins in the early stages of education, when the foundation for learning is established and the mind is not yet set in its ways. Morales, who taught art in San Francisco schools for 15 years and now is a teaching artist with the Rhode Island Museum of Science and Art (RIMOSA), plays an instrumental role in nurturing the initiative.

She explains: "We work with teachers to coordinate classroom activities and field trips that can open pathways for students to approach the natural world through object based inquiry, building their sense of wonder about living systems and an intuitive drive to ask questions and understand."

The RI NSF EPSCoR and Paul Cuffee School relationship provides the perfect launch for RISD to jump aboard. Conversations and planning with educators at the Providence public charter school have led to a unique approach, depending on the school level.

For the elementary grades, students will engage in a classroom show and tell session on insect morphology and physiology. A visit to the Nature Lab in May will focus more on bird taxonomy. The upper division portfolio class will head to the RISD campus in April to draw from lab's biophilic space and gain exposure to the experience of being a RISD artist.

"The focus of the STEAM work at RISD's Nature Lab is not about dissolving the structures of art and science methodologies, but rather about taking away the notion that they are oppositional."

The potential to bring about change and broaden horizons through these and other partnerships generates a lot of excitement and ideas. Most educators today grew up within a system structured around silos, each discipline working within its individual structural pedagogy and methodology, Morales notes.

RISD, however, does not view the relationship between disciplines as adversarial. Rather, the opportunity exists to learn new methods that can be brought back to each discipline and expand our perspective of the world around us.

She says: "We believe there is a great opportunity in creating renaissance teams of educators to tackle learning outcomes that can help young people grow their confidence in being able to move fluidly between knowing when to be subjective and when to be objective, identifying appropriate times for qualitative and quantitative investigation."

SACNAS joins the outreach effort *(continued from p 3)*

journey, while sharing intriguing points about plant science.

He said he wanted the students to know that REUs were one of the key reasons that brought him to study at URI. He encouraged them to be brave and apply for opportunities.

"Before these summer programs I had no experience with North American schools and no networks with U.S. professors," he said. "As a consequence of these programs I interacted with faculty and grad students, who helped me see firsthand what science and research were about."

One of the faculty members in his second research experience knew Assistant Professor Jason Kolbe and recommended him as a potential adviser.

"For me, by being involved, I can be a role model and a source of guidance toward these opportunities," Aviles-Rodriguez said. "Many students start out with an idea of what they should do, which is often a mix of what their families want them to do and what they think is an acceptable career."

He said he enjoyed the chance to listen to the young students talk about their goals: "I always remind them that college is also about exploration and integration of different disciplines. It's OK to start somewhere and end up in a different place, that's just part of the experience."

Although busy with the many demands of Ph.D. life, Garate welcomed the chance to get involved and said the RI NSF EPSCoR outreach was rewarding work.

"I didn't have that exposure when I was younger," she said. "Even if it's just for one day, we try to integrate professional careers and ideas into their life, and to have them see people like me and Kevin succeed in fields other than the typical areas."

Providence College researchers *(continued from p 4)*

the animal act in this way — what does it mean for its ability to get food, its ability to survive?"

A win-win proposition

Arévalo said the project also allowed the students to finesse their grant writing skills, and a competitive campus grant delivered stunning results. In a field of 80 to 90 applicants for a round of $500 grants, all six of the project's students succeeded in gaining funds.

The students found the team experience equally rewarding even though group projects often wind up with the brunt of the work falling in the laps of a few. Kawa said she typically preferred working individually, but the summer collaboration proved to be incredibly valuable.

"Everyone was able to offer new ideas as to how we could expand our research and we were a great deal more productive," she said. "Our group dynamic was spectacular and overall the experience was great."

Cyr echoed Kawa's thoughts: "I can honestly say I have never had a research group that worked as hard and yet was as much fun as my summer collaborators were. The group definitely made some of the more demanding aspects — like 6 a.m. wakeups or long days of classifying shrimp — truly enjoyable. I'd jump at the chance to work with those kids — and professors — again."

Del Pizzo, too, gave the experience high marks, saying that the group dynamic allowed each individual student to flourish in his or her own field.

"It was great to come together at the end of each week, to go over results, and talk about what was working or what wasn't, and how we could potentially fix something or help each other," he said.

The students all cited the trip south to collect samples as the highlight of the summer. Said Del Pizzo, "Traveling with the large group also made us a really close and comfortable research group, which I found really cool. We knew we had to get to work, but it didn't feel like work because we all enjoyed being in the lab and out in the field with each other."

Markert said the experience was unusual for the researchers, too, since they typically don't get the opportunity to take students out in the field, whether off the coast of Rhode Island or beyond.

"The SURF program is a really positive use of EPSCoR funds," he said. "As a small school, we can't each have our own individual mysid culturing project. But, there are an awful lot of projects we can do together; there are a lot of unanswered questions in environmental genetics."

The best possible outcomes

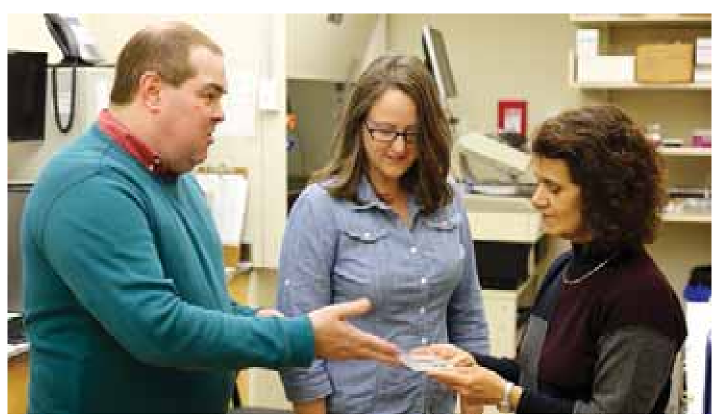
Arévalo said that, together, the EPSCoR program and the investments by PC sustained the evolving culture of research at the undergraduate institutions, making it possible to pair research with a liberal arts education.

For Del Pizzo, the SURF experience and what he learned about genetics carried into his senior year and helped narrow his professional focus.

"It was a remarkable summer," he said. "Doing this program and working primarily in the lab also led me to the realization that I wanted to incorporate more business into my career, as well as maintaining a heavy science portion."

With the perspective of another academic year almost behind her, Kawa said the team SURF project increased her interest in biology. She has continued the research during the school year, and ultimately hopes to publish a paper with any findings. She said the skills she learned applied to what she was doing in biology class

(continued on p 27)



Providence College researchers, from left, Jeffrey Markert, Maia Bailey and Elisabeth Arévalo have pooled their talents and their disciplines to enrich the undergraduate research experience. Photo by James S. Waters

Providence College researchers (continued from p 26)

and increased her proficiency in thinking critically.

"I have become more self-reliant and have gained a new set of leadership skills," said Kawa, who intends to go to medical school and specialize in pediatrics.

Cyr also discovered more about her interests, which turned out to be substantially broader than what she had imagined. And, the new skills she gained gave her confidence about what lies ahead. She is applying to Ph.D. programs at veterinary schools with wildlife medicine and conservation programs, and more specifically to those focused on environmentally infectious agents.

"I have always been interested in medicine, disease, and animals, but I never thought phylogenetics would have appealed to me," Cyr reflected. "I guess the greatest impact of the whole experience was learning that even if my future career path does not go as planned, I will be able to find interesting opportunities in many fields of biology, not just in the small sector I had originally thought."

Looking back on the summer, Cyr said perhaps the biggest lesson she learned was that there can be success in failure: "Learning to think like a scientist means realizing that a failed experiment can sometimes tell you more than a successful one can."

Discovering science and self (continued from p 6)

they learn to look at a problem, carry over into whatever they eventually do," Meedel said. "It's a good, rigorous experience that they benefit from."

As a faculty member, Meedel said having the students in his lab and watching their transformation take place remains the best part of the experience for him. He has seen students arrive without a firm idea of what they wanted to do. Some discover they don't want to be holed up in a lab and turn their focus in another direction. For others, the lab is heaven.

For all students, whether late bloomer, drifter or knowing exactly what they want to do, the SURF program is life changing.

Guerreiro, who plans to work as a research scientist and attend graduate school to study molecular biology and microbiology, said doing actual research allows students to get into the lab and see firsthand how science is done and do it.

"It's one thing to participate in labs that are part of a class," he said, "but you are always doing labs that are supposed to work. In true research, things might not work, and you will have to figure out ways to make it work."

Moore said it was her experience as well as that of her peers that research significantly enhances undergraduate education.

"At small schools like RIC, where graduate students are not as common in labs as they are at larger universities, undergraduates are given tremendous opportunity to champion their own projects and become leaders in the lab," she said.

Moore currently is working in a laboratory affiliated with the Massachusetts Eye and Ear Infirmary/Harvard Medical School in Boston, where she is studying the role astrocytes (a cell found in the nervous system) play in the eye disease, glaucoma. She also is applying to medical school and hopes to continue research as a physician.

Looking back on the time she spent in Govenar's lab, she said, "You can learn science through your courses, but what you teach yourself and learn from your mentor in your research lab, brings course work to life and makes science even more exciting."

From ales to ailing marshes (continued from p 8)

Based on its location in the low marsh, *Spartina alterniflora* will be the first salt marsh grass species to feel the effects of sea level rise. These findings show that seawater inundation causes a major decline in the density of this species. As a result of algal deposition, *S. alterniflora* has the potential to emit significantly more methane relative to its mid marsh counterpart.

Our findings suggest that the low marsh species first to feel the impact of sea level rise may find itself stressed to the point of significant die-back, a phenomenon that would have severe repercussions for coastal marsh stability and productivity.

Further, anthropogenically stimulated algal blooms may simultaneously drive increased fluxes of the greenhouse gas methane from the low marsh. This effect could shift coastal marshes from net sinks of greenhouse gases to net sources, with potential positive feedbacks on climate warming.

We now are at the stage of putting our analysis together and creating a narrative, which we plan to share via scientific publications and conference presentations. We hope that by shedding light on how marshes respond to sea level rise and other climate related factors, this research helps inform management decisions related to salt marsh protection and the maintenance of these ecologically critical systems and their important functions.

We also hope that a few more projects may come out of the collaboration before our respective graduations, and we look forward to hammering out the details of some budding ideas – most likely over a few pints at the Mews.

Conversations: big data (continued from p 10)

AC: A good data management plan outlines the data you will be producing, the formats that they will be shared and stored in. It will document the steps you have planned for storing, backing up and securing the data. It will address documentation: metadata (the contextual information that make data discoverable and useful), data dictionaries, codebooks, etc.

It will acknowledge that the team will be on the same page for formats, file naming and organizing folder directories. Then, it will discuss how data will be retained for the duration mandated by the institution and funder, and how it can/will be shared with the public or reasons why it cannot be, and the policies for its post-project access and re-use.

TC: Do you have any inside tips or tricks of the trade?

AC: Knowing from the beginning what will happen to the data after the project ends will save a lot of time. By using a data repository and choosing an open license to share data, metadata, and software with the public, you will already have the answers to many of the core questions that need to be addressed in the data management plan, such as the who, where, how and when for discovering and accessing your data. In addition to institutional repositories, such as the Brown Digital Repository, there are many open data repository options that are suitable for almost all data types, including Dataverse, Figshare, Zenodo, Dryad, and ICPSR Open.

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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.

Council members are:

David A. Savitz
Vice President for Research, Brown University (Co-Chair)

Gerald Sonnenfeld
Vice President for Research and Economic Development, University of Rhode Island (Co-Chair)

Janet Coit
Director, Rhode Island Department of Environmental Management

Pierre Corriveau
Chief Technology Officer, Naval Undersea War Center

David Hibbitt
Founder and Former Chairman, ABAQUS, Inc.

Molly Donohue Magee
Executive Director, SENEDIA

Jay Marshall
Executive Director of Quality, Amgen Rhode Island

Patricia C. Phillips
Dean of Graduate Studies, Rhode Island School of Design

Thomas Rockett
Former Vice Provost for Research and Graduate Studies, University of Rhode Island

Peter Snyder
Vice President of Research, Lifespan

Donald Stanford
Chief Technology Officer, GTECH Holdings Corporation

Marcel A. Valois
Executive Director, RI Commerce Corporation