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MAINE EPSCoR

Maine EPSCoR

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Expanding our understanding of Maine's waterways through interdisciplinary research

THE UNIVERSITY OF MAINE
1865

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From Maine EPSCoR LEADERSHIP

We are excited to share the research that personnel have conducted across EPSCoR grants in Maine and look forward to the upcoming summer field season. This newsletter will not just look at our current work but also the impacts of past Maine EPSCoR research and participants — how they have and continue to impact workforce and economic development in Maine.

The University of Maine recently gained Carnegie R1 status, a level of recognition that speaks to the quality and scale of research happening at Maine's land grant, sea grant, and space grant institution, and across the state as a whole. Research institutes, centers and labs established because of NSF EPSCoR RII Track-1 grants have created a significant and lasting impact in Maine. These entities include the Advanced Structures and Composites Center, Frontier Institute for Research in Sensor Technologies, Forest Bioproducts Research Institute, and Mitchell Center for Sustainability Solutions, which have generated over 500 million dollars in new R&D funding for the state following the completion of their RII Track-1 support.

Maine EPSCoR's current NSF EPSCoR RII Track-1 grant, Maine-eDNA, is set to embark on a full field season with work occurring throughout the state. We recognize the researchers, staff, graduate students, and undergraduate students who continue to actively participate in this work. Their effort and resilience in the face of uncertain and changing circumstances is inspiring and makes real contributions in our efforts to expand educational opportunities in STEM, drive workforce development, and strengthen research capacity in the state of Maine.

We are proud to present this exciting and enthusiastic newsletter to you. Thank you for your continued support and interest in our work.

What is Maine EPSCoR?

Maine EPSCoR (Established Program to Stimulate Competitive Research) at the University of Maine seeks to expand opportunities for more diverse faculty, staff and student populations. Diversity brings different perspectives and skill sets, and helps broaden our vision. We recognize that geographic and societal challenges exist that require pragmatic solutions with achievable and measurable goals. Maine EPSCoR strives to enhance diversity in all elements of EPSCoR programs while increasing participation of underrepresented minorities in science, technology, engineering and mathematics (STEM) disciplines.

Front cover: Jeremy Rich and Nichole Price collect samples on the Damariscotta River. Photo by Kristina Cammen

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Developing Innovative Partnerships

How the Maine eDNA Program May Impact Maine's Department of Transportation

By Bhavana Scalia-Bruce and Marcella Silver

DR. MICHAEL KINNISON IS A PROFESSOR OF EVOLUTIONARY APPLICATIONS AT THE SCHOOL OF BIOLOGY AND ECOLOGY AT THE UNIVERSITY OF MAINE, AND HE SERVES AS A CO-PI ON MAINE'S CURRENT NSF EPSCOR TRACK-1 GRANT: MAINE-EDNA.

Photo by Jennifer Smith-Mayo

Kinnison also works as the Director of the Maine Center for Genetics in the Environment (MCGE), which is a direct product of the Maine-eDNA grant. His background is rich in researching evolution and the application of evolutionary and genetic principles to real world challenges. Kinnison enjoys finding new ways to adapt evolutionary and genetic tools to meet the various needs of fisheries, conservation efforts, and other types of human interests such as protecting wild animal populations, food resources, or the ocean. Kinnison has emphasized that the application of research and discovery is very important to him. "I spend a lot of time thinking about how organisms are evolving now, and what new discoveries and applications may result from those new adaptations," Kinnison said.

As part of his involvement in the Maine-eDNA program (which is a multi-institutional initiative that is working to establish Maine as a national leader in environmental monitoring, ecological understanding, and the sustainability of coastal ecosystems), Kinnison has acted as a primary coordinator. Since Maine-eDNA officially began, Kinnison has been developing a collaborative effort with the Maine Department of Transportation (DOT).

In 2019, staff at the Maine DOT heard about work being done at the University of Maine during a meeting where Kinnison was presenting project updates to the Maine Department of Inland Fisheries and Wildlife. The Maine DOT requested to work with Kinnison to construct a safe and effective way to collect water samples that could be used to assess whether an area is a safe space to work without harming wildlife.

Kinnison and his team proceeded to engage with the Maine DOT, brainstorming ideas on how they could go about doing this type of sampling. As a part of this collaboration, the Maine-eDNA team and the Maine DOT joined forces with the Maine Department of Marine Resources (DMR) and a group called Project Cher, which works with stream restoration regarding culverts, wooding debris, and more.

The initial sampling experiment involved putting salmon in a cage to measure eDNA downstream from the fish. From that sampling effort, they were able to receive information about how well different numbers of fish are detected, as well as from how far away. The conclusion revealed that the best place to detect a salmon is not in direct proximity to the salmon, as originally anticipated, but further away. Detection turned out to be more difficult up close because the eDNA found in shed cellular material, such as skin and excrement, is more likely to be localized. When testing, the sample collector should travel approximately 50-100 meters downstream from the suspected population.

The Maine DOT is a pioneer in using this sampling method. Kinnison is not sure about what collaborations may be occurring in other states with groups like the Maine DOT when it comes to restoration and preservation. He emphasized that it makes a lot of sense for the Maine DOT to take such environmental precautions and to conduct due diligence in the form of eDNA sampling.

Jennifer Smith-Mayo (Ph.D. student UMaine) conducts eDNA sampling at Basin Pond in Monroe, ME *Photo by Jennifer Smith-Mayo*

For example, when the Maine DOT replaces a culvert, it fixes the road and improves flow passages. This level of construction often poses a risk, as it could disturb or harm ecosystems and organisms such as an endangered species at the stream crossing. Kinnison believes that the Maine DOT is doing the right thing as they have mandates and regulations in place to ensure culverts are passable by vulnerable organisms such as salmon.

The sampling method is easy and accessible, and simply involves using bottles to collect water samples in the field. Members of the Maine DOT are able to collect samples themselves; the method does not require a scientist to perform the collection. Maine DOT employees can then drop off the sample at Kinnison's lab in Orono, where the MCGE team will analyze the sample and report the results back to the Maine DOT.

One factor that initially drew Kinnison to eDNA research is that it has applications here and now, which is how he likes to focus his research. He elaborated by saying that working on a Maine EPSCoR grant allows participants to focus a lot of their energy on real world applications. Kinnison stated, "I think that EPSCoR is getting the word out broadly about all these types of applications," Kinnison said. He sees a strength of the Maine-eDNA program being that personnel are continuously communicating and pushing everyone not to do science just for the sake of science, but rather to do science for the sake of Maine's citizens and key stakeholder groups such as the Maine DOT.

This type of natural link-up is exactly what Maine-eDNA needs in order to impact the state in meaningful ways, and to get these types of tools and procedures out and ready for regular use. Kinnison strongly believes that making credible and reliable tools for people who need to use them for situations that have societal, legal, or ethical consequences is important, and is a large part of the EPSCoR approach.

Now that the sampling method has proven successful, Kinnison explained the next step is to get the ball rolling on eDNA training workshops for these natural-resource-based partners. Training would include: how to take the water samples, interpreting what the data means, and reviewing definitions for some of the lingo that researchers use. These workshops will provide information to understand the type (and significance) of the data after collection. Of course, Maine-eDNA will strive to facilitate the adoption of these resulting methods beyond Maine.

A LIVING LEGACY

How SEANET lives on through its innovations, discoveries, and past participants

By Marcella Silver

In a variety of ways, January 2020 feels as if it were a lifetime ago. For many of those who participated in Maine EPSCoR's previous Track-1 award, the Sustainable Ecological Aquaculture Network (SEANET), this may feel especially true. So much has been accomplished since SEANET was officially completed in January 2020. Facets of its research and educational programming have lived on through successful spin-off projects, in many cases leveraging SEANET funded facilities expansions at multiple constituent sites, and ongoing collaborations and continued partnerships.

The EPSCoR award's ability to have its discoveries, research, and impacts continue on after its official end date was an integral part of the original strategic plan. This is especially true of the UMaine Aquaculture Research Institute (ARI) which is officially named as SEANET's legatee. ARI has achieved increased capacity and innovation as a direct result of SEANET investment.

Faculty and staff at partner institutions such as the Downeast Institute (DEI), the University of New England (UNE), Maine Maritime Academy, Bowdoin College, St. Joseph's College, the University of Southern Maine (USM), and the University of Maine remain engaged together through a network created and formalized by the SEANET grant, which will yield long term benefits to Maine's coastal communities.

This is no surprise, given the fact that SEANET was the first multi-year effort in the nation to research sustainable ecological aquaculture (SEASs) and as such, made many valuable discoveries and direct contributions to Maine and the aquaculture industry. The five-year, $20 million grant facilitated expansion within the aquaculture sector and its Workforce Development (WFD) outcomes have gone on to inform sustainable practices among a wide variety of age groups, genders, and occupations.

SEANET's stakeholders from institutions such as the Maine Aquaculture Innovation Center, Maine Technology Institute, Alliance for Maine's Marine Economy, the Maine Aquaculture Association, as well as Maine businesses that participated in SEANET research, have also continued to further their expertise as a direct result of SEANET's innovations and discoveries, thus sharing the award's accomplishments far and wide.

This is visible through the aquaculture industry's continued statewide (as well as nationwide and worldwide) growth. SEANET is cited as playing a key role in helping stakeholders and community members alike better understand how sustainable aquaculture can support the state as a whole.

Such impacts have continued to be shared with state legislators and leaders. For example, in February 2021, Maine state EPSCoR Director Shane Moeykens, and SEANET researcher and UMaine Associate Professor of Oceanography, Damian Brady, met virtually with federal legislative offices in Washington, D.C., to share how SEANET research has been inherited and utilized by a wide variety of successors who have gone on to receive additional funding and support.

Some of SEANET's key projects, such as the LOBO (Land/Ocean Biogeochemical Observatory) buoy monitoring system, have continued. These buoy systems have been integrated into a water quality (WQ) observation service program that helps RAS (Recirculating Aquaculture System) companies better monitor their outputs and gauge any changes in the environment into which they are discharging. RAS companies have been seen as a way to "revolutionize" Maine's aquaculture industry, but many Mainers are still uncertain, so the continued supervision via buoy monitoring may help businesses and citizens better understand if, or where, boundaries should be established.

The National Oceanographic and Atmospheric Administration (NOAA) was also a beneficiary of SEANET's research and discoveries, especially regarding work with remote sensing. NOAA readily makes use of tools and methods that were originally created by SEANET researchers.

In addition, the United States Department of Agriculture (USDA) has recently expanded its research on aquaculture, specifically utilizing experimental systems in order to establish sustainable methods. They plan to invest $5-6 million every five years in aquaculture research. ARI has partnered with the USDA's named Agricultural Research Service (ARS) and Auburn University in Alabama as a "commitment to an ongoing conversation between researchers and the aquaculture industry to increase production and industry sustainability," said Meggan Dwyer, Associate Director of ARI and the former Research Coordinator for SEANET, in an October 2020 release.

"The resulting cooperative research agreement, eligible for renewal every five years, was funded by $950,000 from USDA ARS for the first year, and $872,000,000 annually thereafter," Dwyer explained. "The Aquaculture Experiment Station will harness the expertise of ARI-affiliated faculty in Orono and at UMaine's Darling Marine Center (DMC), and National Cold Water Marine Aquaculture Center ARS researchers based on the Orono campus, in Franklin and at the University of Rhode Island."

With high-level backgrounds in aquaculture, the ARI faculty leads, Deboarda Bouchard, Damian Brady and Paul Rawson, work to align

work to address USDA ARS priorities, such as alternative feeds for finfish, selective breeding in oysters and "off-flavor" in salmon meat. The experimental station will allow researchers to provide rapid response to industry in a farm and hatchery setting. New research initiatives, focused on genetic improvement of North American Atlantic salmon and the Eastern oyster for aquaculture production, advance the goals of localized selective breeding strategies that improve performance for economically important traits.

New investments at the Darling Marine Center will help develop a scallop hatchery, and UMaine research faculty and extension agents are studying everything from siting and ecosystem dynamics to production methods and bio-economics. A new Scallop Research Collaborative (SRC) was established in order to help researchers and farmers better collaborate around scallops as a resource, fishery, and industry in the rapidly changing Gulf of Maine ecosystem.

As a direct result of SEANET's success, ARI has also been able to grow its Workforce Development (WFD) capabilities in a variety of ways. This includes the hiring of a new education and outreach coordinator, Scarlett Tudor, the integration of other aquaculture-based curriculum (such as the 4-H aquaponics program and the Maine Sea Grant Aquaculture Educators Group), and the development of a Sustainable Aquaculture Certificate program and summer industry externship program.

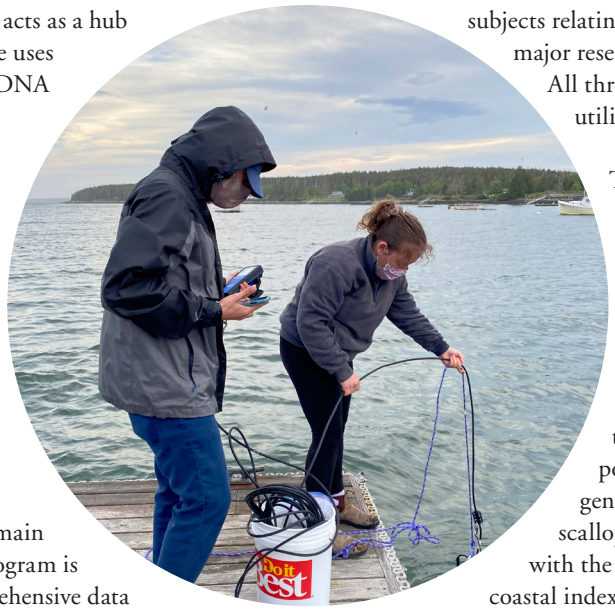
ARI has also grown its research capabilities by adding new affiliates and hiring two joint faculty members in fish nutrition research, Michael Habte-Tsion and Matt Hawkyard, and a new aquaculture Innovation specialist at the DMC, Adam St Gelais, who previously served as the SEANET research coordinator at UNE. ARI continues to build upon SEANET infrastructure and networks in order to leverage more funding and build a new Sustainable Aquaculture Facility on campus and establish ARI as a Center of Excellence in Aquaculture.

These types of institutions, programs, collaborations, and funding opportunities are helping Maine to continue its growth in the aquaculture sector in innovative, yet sustainable ways. This is especially true of the new Maine Aquaculture Hub. This collaborative effort is coordinated by by Gayle Zydlewski (director of Maine Sea Grant and UMaine professor of marine sciences), Deborah Bouchard (Director of ARI and the SEANET Research Network), Sebastian Belle (Executive Director of the Maine Aquaculture Association), Chris Davis (Maine Aquaculture Innovation Center), and Teresa Johnson (UMaine Professor of Marine Sciences). All of these collaborators have either worked with or served as stakeholders for the SEANET program. $1,199,996 of a $1.6 million NOAA award was secured in order to jumpstart the hub, which will help build capacity for industry-driven innovation, diversification, and workforce development. This new hub, along with the wide variety of continued research efforts, and newly utilized technologies directly resulting from SEANET, stand as a testament to the long-lasting impacts of a Maine EPSCoR Track-1 award.

Maine-eDNA students make headway on sampling index sites over the summer

By Attis Bielecki, ME EPSCoR Student Writer

EPSCoR's Maine-eDNA program acts as a hub of research that is searching for the uses and limitations of environmental DNA (eDNA). Many graduate students are conducting research on this program; Sharon Mann from the Ecology and Environmental Science department and Emily Pierce from the Marine Science department are two such students. One of the cornerstones of the overall program is the samples collected from locations across the state of Maine.



According to Mann, "One of the main objectives of the Maine-eDNA program is to obtain and organize this comprehensive data set, and one of the only ways to do this is to spread out across the state and collect water samples for eDNA. That's the purpose of the index site sampling."

Index sites are the various locations throughout Maine where researchers, graduate students, and undergraduate students alike are deployed to collect samples that contain cellular material shed by organisms within an environment, which is also known as eDNA.

"A lot of these index sites are sort of an anchor for everyone's research under the Maine-eDNA program," Research Organizer Lauren Crofton-Macdonald explained. "These sites are spread out along the coast of Maine with the purpose of collecting a standardized set of data which other researchers can potentially harvest to round out the data they're collecting."

The index sites are one of the primary focuses of Crofton-Macdonald's research. There are over 20 index sites where samples are collected across Maine, covering places such as Casco Bay, Machias, and the Penobscot area.

"In these areas the sampling happens once a month from May to October," Crofton-Macdonald stated. As a co-PI, senior researcher, and faculty member, Kate Beard explained there are major "themes" to the Maine-eDNA program. A theme is a division of the program that covers certain subjects relating to the use of eDNA that major research projects would fall under. All three themes within the program utilize the index sites.

Theme 1 encompasses fisheries and environment restoration. Within this theme, work includes alewife restoration as well as understanding larval blackbox. Beard clarified, "With the larval blackbox, researchers are looking into the larval production and population growth for the newer generations of lobster, as well as scallops, and seeing if this is possible with the use of eDNA collected from coastal index sites."

Theme 2 is divided into two parts. The first is looking at harmful algae species in both fresh and coastal water. This part of the theme uses eDNA to identify the specific species that are causing the bloom and determining if they are toxic or not. The second part of theme two is looking into changes in the kelp beds along the Gulf of Maine. This primarily uses eDNA along with traditional diving methods to track the change in species, which is taking a northward shift due to climate change.

Theme 3 covers macrosystems integration which involves observing every aspect of the Gulf of Maine. This involves two other facets, including using eDNA to track microorganisms and use them as sensors to predict sudden environment changes. The other piece is about the social science side of the whole program and how people from different disciplines are interacting with each other within the Maine-eDNA program.

To ensure useful data is generated within these themes, eDNA collected from these index sites are utilized in a wide variety of research.

Index sites are also a core benefit for graduate students like Mann and Pierce, with their research being supported by the eDNA gathered through this process. For example, Pierce, who heavily researches invasive invertebrates, is able to utilize the standardized data to see if identifying the quantity of certain invasive species is possible.

"The graduate students are 'regional leaders' over the undergraduates, and what we do here allows these undergraduates to build experience through real world application," Crofton-Macdonald said. "Undergraduates are also very helpful. It would be a lot to put all this sample collecting on the graduate students who also have their own research to conduct, so it helps divide the work while providing experience for undergraduates."

From the undergraduates' perspective this is also a huge benefit. They learn how to properly collect water samples (to avoid contamination) that are in line with Maine-eDNA standards. They are also learning how to use specialized equipment that collects environmental data besides the sample, such as water temperature or water turbidity.

Apart from giving them experience, index site sampling also provides undergraduates with the opportunity to build connections with other researchers, and possible future colleagues. Therefore, a lot of undergraduates see it as building bridges in their careers.

As one Maine-eDNA undergraduate student and nutrition major, Benjamin Rico, explained, "The connections I make through this program and the experience gained through the index sites will be very nice to have, and it definitely leaves the door open for me with marine biology."

The importance of these index sites is without question. It can vary as to how important it could be to a student's work, as some may just use it as background information. But it is also critical to many of Maine-eDNA personnel's research that utilizes it in a centralized capacity. Everyone's research is improved and supplemented by these index sites, which help connect and contextualize the entire Maine-eDNA program.

Julia Sunnarborg (Ph.D. student, UMaine) trains undergraduates Sydney Jackson (UMaine), Maddy Brethauer (UMaine), and Elidh Sidaway (Saint Joseph's College of Maine) on how to use the Niskin bottle to collect water samples.

Photo by Grayson Huston

Catching up with past Maine EPSCoR

WHERE ARE

Former students, employees, and participants of Maine EPSCoR projects explain

BRIANNE SULDOVSKY was a valuable member of the Maine EPSCoR research community during her graduate studies. Suldovsky completed her Ph.D. in communications from the University of Maine in 2016, where she simultaneously worked with the Maine EPSCoR office.

At Maine EPSCoR Suldovsky worked as a graduate research assistant on two projects, the Sustainability Solutions Initiative (SSI) and the New England Sustainability Consortium (NEST) Safe Beaches and the Shellfish Project. Suldovsky explained how she was once a climate skeptic and a young earth creationist. However, she has since made a career studying the public understanding of science and looking for ways to improve the relationship between science and society. Currently, Suldovsky works as an Assistant Professor of Science, Environment, and Risk Communication at Portland State University in Oregon.

Fondly, Suldovsky reminisced of her time working with Maine EPSCoR, emphasizing how the experience helped her in a multitude of ways. During her Ph.D. studies, she worked closely on a large interdisciplinary grant-funded team which made her feel prepared for her current position.

On account of her work with Maine EPSCoR, she felt ready to write and manage grants. Her confidence in working in large teams, and knowing what to expect when working across disciplines was bolstered throughout the duration of her time with Maine EPSCoR.

Suldovsky is dedicated to making her research impactful on society, as well as her own field. During her time working on EPSCoR projects, she gained experience balancing multiple demands,conducting research, attending conferences, and networking in ways that would not have been possible if it were not for the grant funding she received. She feels as though this work is a contributing factor to what made her a competitive candidate for a postdoc and tenure-track position.

She praises the wide range of people she met during her work with Maine EPSCoR. The skills she acquired during her work with EPSCoR have informed how she currently approaches all of her present research. For example, she feels as though she is able to successfully collaborate with experts outside of her own field and with non-academic stakeholder partners because this was a major part of her work with EPSCoR during her graduate studies.

EMMA TACCARDI, a recent graduate of the University of Maine, completed her Ph.D. in Marine Biology in August 2020. Taccardi studied as a graduate student at UMaine for five years, and was a fellow on the Sustainable Ecological Aquaculture Network (SEANET) grant through Maine EPSCoR. Her research included year-round fieldwork on salmon farms at the border of Maine and Canada.

Taccardi fondly recalls days in the field being exciting and, “full of adventure and team bonding.” She had the opportunity to learn from charismatic farmers while she worked on the boat. Through her research, she participated in a significant amount of fieldwork on the water and in various lab settings.

Currently, Taccardi works in the office of Senator Edward Markey as a Knaus Fellow for Sea Grant. Her work focuses on a variety of policy areas within the energy and environment portfolio. Through this position, Taccardi enjoys learning about and contributing to the federal legislative process.

During her graduate studies, Taccardi worked on a Maine EPSCoR Track-1 award that allowed her to network with a wide range of colleagues while gaining experience as one moving part of a large, interdisciplinary grant. The interdisciplinary approach fostered her growing interest in the human side of marine issues.

As a result of her experience with Maine EPSCoR, Taccardi decided to apply for her current fellowship in marine policy, with the aim to explore decision-making processes and the implementation of science. Her experience with Maine EPSCoR strengthened her communications surrounding science, networking, and facilitation skills, all of which have been critical in the positions that she has held since graduating from UMaine.

participants

THEY NOW!

how their experience has boosted their skills in their current positions.

THOMAS FOUCHEREAUX of Yarmouth, Maine graduated from the University of Maine with a Bachelor of Arts in New Media. During his junior year at UMaine, Fouchereaux became a video editor at Maine EPSCoR and produced video content for the office in addition to handling his normal classwork and capstone requirements.

Currently, Fouchereaux works as a filmmaker, editor, and a photographer for the Jackson Laboratory, a nonprofit biomedical research institution, based out of Bar Harbor. He creates and produces externally and internally facing videos for the laboratory. With the new initiative the organization is pursuing, the majority of Fouchereaux's time is spent making videos and commercials that further the understanding of their audience and stakeholders towards the crucial paradigm shift.

During the last two years of his undergraduate career, Fouchereaux contributed to a variety of Maine EPSCoR projects. Maine EPSCoR had interest in creating a video showcase requiring the team to follow up with researchers engaged on NSF grants for interviews about the work and the impacts they facilitated. Back in the editing room, Fouchereaux threaded a total of 16 projects together, forming a narrative that complemented the message that these initiatives were emerging epicenters of economic growth for the state. There were also stand-alone initiatives that needed videos to supplement the article. At one point, Fouchereaux animated the Maine EPSCoR logo for use in video and online publication. Working with Maine EPSCoR was his first experience where he pitched his own work.

"The ability to use skills in video production to create a pilot representation of the product our team is aiming to fund has only become increasingly relevant as I further my career in video production," he said. "Maine EPSCoR gave me a window into what this profession could expect on the corporate side of the spectrum, with regards to making pitches, managing production budgets, and editing on stringent deadlines."

The most valuable piece of information Fouchereaux learned during his work with Maine EPSCoR was how to professionally handle criticism. He explained,"By presenting my work to multiple departments within EPSCoR I came to terms with my resistance towards accepting feedback. Everybody needs to be able to contribute what they feel are necessary changes, because in the end, it helps the entire team publish a better article."

CHEYENNE ADAMS is currently an aquaculture scientist with the Maine Department of Marine Resources (DMR) helping manage one of Maine's largest natural resources. After finishing her undergraduate studies at the University of Southern Illinois, Adams came to Maine to work at the National Cold Water Marine Aquaculture Center, which led her to graduate work at UMaine.

Guided by her advisors Paul Rawson and Larry Mayer, Adams' research took place at the intersection of marine biology and oceanography. Adams' research focussed on whether detritus was a significant food source for oysters, and measuring the oysters' response to changing oceanographic conditions.

Adams elaborated, "Being based at the Darling Marine Center for a lot of my graduate program really made me want to stay in Maine and do more fieldwork." This love for Maine and the field led Adams to DRM where she started in the sea sampling program, a fieldwork-heavy program, working with lobster and scallop fisheries.

Three years into her time at DMR, Adams is working in the aquaculture program, inspecting new and current aquaculture sites for the department.

Not only does Adams' experiences from SEANET fit perfectly with her work at DMR but so do the connections she made. The people and institutions Adams worked with during her time at SEANET continue to help her work in aquaculture and managing one of Maine's greatest natural resources.

The Language of Maps

The biography of the species adaptation process under climate change and its effects on cultural evolution

By Stefania Irene Marthakis

"I have long, indeed for years, played with the idea of setting out the sphere of life — bios — graphically on a map," philosopher Walter Benjamin once wrote. Maps have a long history of helping humans explain and navigate their world.

Biodiversity and Rural Response to Climate Change Using Data Analysis (Barracuda) is made possible through a four-year, $4 million (RII Track-2 FEC) grant from the National Science Foundation (NSF). Brian McGill, whose career passion has been to combine environmental data and Big Data (large, complex, fast-growing data that cannot be efficiently stored or processed by traditional methods), is hoping to answer critical environmental conservation and global change questions.

How will several hundred species of animals, plants, crops, and zoonotic diseases get from where they are today to where they need to be in a new climate? And what are the implications for farmers and rural communities, whose livelihoods depend on these natural resources? For 14 glacial cycles (a time period marked by the growth of large, continental ice sheets), species have successfully tracked climate, but here is the rub: Today's landscape is vastly more challenging, with an abundance of movement barriers due to human development and human land use (e.g., parking lots, suburban lawns). This is the single biggest issue for natural systems adapting to climate change.

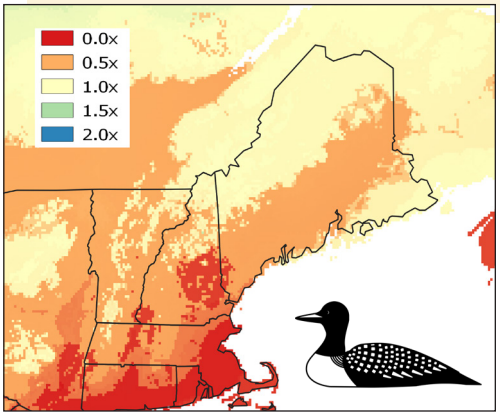
As an ecologist, McGill knows that some degree of climate change is inevitable. Increasingly, a lot of academics are transitioning to studying how the world adapts rather than solely focusing on prevention. McGill is working with his longtime collaborator, Nicholas Gotelli (Co-PI) from the University of Vermont, to form an interdisciplinary team with the University of Maine, University of Vermont, University of Maine at Augusta, and Champlain College (Co-PIs: Timothy Waring (UM), Meredith Niles (UVM), and Matthew Dube (UMA), as well as Laurent Hébert-Dufresne (UVM), Kati Corlew (UMA), and Narine Hall (Champlain)).

Barracuda (which focuses on Maine and Vermont but may be applicable to the rest of the country) aims to understand the climate change adaptation process, while maximizing that adaptive capacity and unleashing it. Although preventing climate change has felt remote and is largely the responsibility of the federal government, adapting to climate change will require actions at the level of local policymakers and even individual farmers.

Barracuda will study, understand, and implement several novel approaches to advance environmental conservation, thus creating the first eastern-U.S.-wide analysis of several hundred species.

So far, most studies of ecological adaptation to climate change have used a correlation approach, which uses a species distribution model to predict 100 to 200 years into the future. In other words, when researchers find a species in this climate today, they identify these are aspects of the climate that are important, and assume that these species will be in the same climate in the future. Scientists have gotten very good at doing this. "The harder problem is when we look at the transitions, which is what we're trying to do on this project," McGill stated.

"When you want to predict where something is going to live 10 years from now, you still need to know where it is going to grow well based on the climate at that time, but it's got all these additional challenges of trying to get from here to there. It's got to disperse to that new location, it's got to establish a new population, and reach reproductive age. We're trying to model all these things," McGill explained. "I think we're learning that it's a lot harder to predict 10 or 20 years into the future than it is to predict 100 or 200 years into the future. To predict 10 or 20 years into the future, you must take all the details into account about on how it gets there, how it grows up, and when it grows up."



CHANGES IN WHERE THE COMMON LOON, an important symbol of Maine for the tourism industry, will live due to climate change in 2070. Yellow areas show no change. Orange areas show declines of about 50%. Red areas show declines closer to 100% (extirpation). Large parts of Maine and Vermont are expected to see substantial declines in Loon populations.

BRIAN MCGILL, Professor of Ecological Modeling, School of Biology and Ecology holds a joint appointment at the Sen. George J. Mitchell Center for Sustainability Solutions at the University of Maine. Building some of the first mechanistic models of shifts in species ranges in response to climate change, McGill leads the Barracuda project, which officially began in September of 2020.

Bailey McLaughlin, a UMaine Ph.D. student working on Barracuda, grew up on Long Island — where her dad is a part-time shell fisherman — exploring the different corners of the marine environment. Over the years, McLaughlin has seen that system change when she goes back home. "I got hooked on using science as a tool to understand the environment, which was interesting to me from the ecology side but also because the traditions of my family were tied to that landscape," McLaughlin said.

Now working within terrestrial ecosystems, McLaughlin is helping to aggregate data for target organisms (e.g., trees, birds, agricultural crops) as well as climate and data layers that will be used to help create these short-term forecasts. "We need occurrence data, but we also need additional information for the mechanistic model, so we're also getting more species-specific data about life history, like population and age-to-maturity data, to understand more so how these specific species might respond," McLaughlin explained. Upon completion, these models of species ranges will become a series of maps through time estimating where a species may be living 5, 10, 15, 20 years from now, or where species can and cannot become established.

Barracuda also aims to understand the cultural evolutionary process of adaptation — another new area of study — particularly for rural communities. For example, if one farmer does something a little different to respond to climate change, and it works, that behavior may spread throughout the community. Barracuda will develop national scale maps detailing which peoples and parts of the country are more likely and less likely to adapt to climate change. This mapping technique is novel, and will help policymakers locate areas that might have resilience to climate change.

Barracuda views socioeconomic and ecological climate adaptation through a spatiotemporal data science lens. This viewpoint is aided by a computer science team that is developing new spatiotemporal data tools and creating tools that are easier for ecologists and social scientists to use. McGill commented, "The conversation about climate change adaptation is really different than it was 10 years ago. The number of people noticing the concrete impact of climate change on their lives has grown in the past couple of years, especially those who work outdoors for their livelihood (e.g., farming, hunting, conservation, tourism)."

Barracuda also seeks to understand what is going to be the most useful way to communicate these projections within the real arena. Barracuda hypothesizes that this next-level-of-modeling — predicting the movement of organisms, mapping them, and making them available — will be useful to individual farms as well as county or state-level policymakers.

"In my experience," McGill explained, "maps are just this great language. You have a meeting, you're talking, and maybe you're talking different languages or talking past each other, and then you put up a map and it just makes things concrete and tangible. I think the human brain is wired to think about maps, and that we all have this innate ability to navigate maps. I think maps are — the technical term is a boundary-spanning object — an object that goes across groups, and transmits information and makes connections across groups. I think maps are a key communication tool for complex data, which is part of why we have a strong spatial emphasis throughout the whole project."

Barracuda's Workforce Development component focuses on spatiotemporal data and data science. Data science is currently one of the most rapidly growing careers. A special emphasis is on the spatiotemporal aspects of data — it's not just what happened but where and when it happened. Barracuda is making training in spatiotemporal data science a key focus, from high school-level to graduate students as well as training faculty who can train others.

"This goes back to how the grant started with a focus on training in data science. There's a huge demand, but the supply of data science workers must come from universities doing training, but it's a relatively new field, so we're still developing capacity to do that training. EPSCoR grants are designed to improve the research capacity of the universities they fund as well as the teaching capacity. We're excited to expand our ability to train more people in the workforce to use data science tools," McGill said. "Increasingly interdisciplinary research and data science are really critical pieces to climate change adaptation, and also to solving all of society's big problems."

NEW FACULTY HIRE

By Attis Bielecki, ME EPSCoR Student Writer

Chaofan Chen

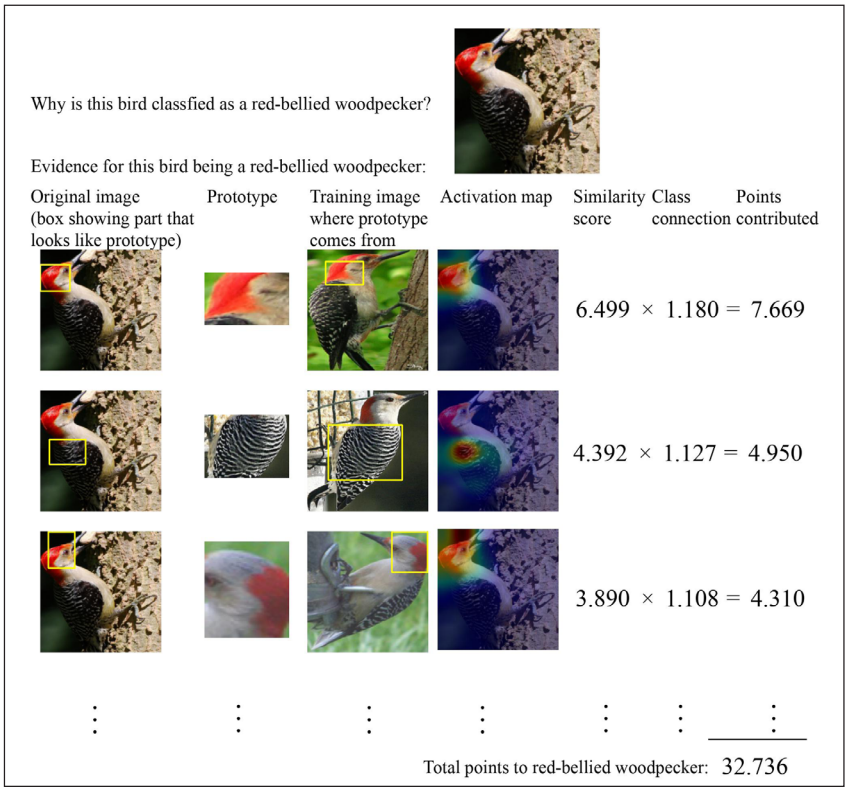
DR. CHAOFAN CHEN is an Assistant Professor at the University of Maine in the School of Computing and Information Science. He joined the National Science Foundation EPSCoR RII Track-1 award, Maine-eDNA, in September 2020. With his Ph.D. in computer science from Duke University, he is guiding data science activities on the Maine-eDNA program. He also finds himself rapidly learning about biology and bioinformatics, which he hopes will help him develop a wide array of machine learning tools for analyzing and understanding environmental DNA (eDNA).

"The field of machine learning involves training a model, which is essentially a computer program, to perform a particular task by showing the model lots of examples, so that the model can learn from those examples," Chen described. "For instance, we could train a model to recognize birds by showing the model lots of pictures of birds, and also telling the model that some of these birds are sparrows and others are seagulls. We will train the model to the point where we can remove the labels and the model is able to properly identify the bird without being told what kind of bird is in the photo."

The areas of artificial intelligence (AI) and machine learning are very broad, but Chen has concentrated his efforts. "My specific focus is called 'explainable AI' or 'interpretable machine learning," Chen explained.

The research into the application of machine learning with eDNA analysis is still in the early stages of development. Chen has started by collecting and training machine learning models on publicly available data, and will eventually use the data collected by Maine-eDNA researchers. Chen believes that this work will help the Maine-eDNA program gain insight into eDNA and lead to novel AI tools that will help with environmental monitoring.

CHEN'S GOAL IS TO MAKE MODELS MORE UNDERSTANDABLE TO HUMANS. For example, instead of simply classifying a photo of a bird as that of a sparrow, the model would also be able to tell people why it classified the photo as a sparrow and not another kind of bird. Chen hopes to apply these human-interpretable machine learning models to analyzing eDNA data. For example, researchers could train a human-interpretable machine learning model to predict if an eDNA sample came from polluted water or clean water. Such a model would not only allow Maine-eDNA personnel to develop an eDNA application that can monitor water quality, but also provide reasons (based on the presence or absence of certain eDNA signals) for why the model predicted that the water is polluted.



Maine-eDNA Faculty Launch New Class

By Attis Bielecki, ME EPSCoR Student Writer

In 2021, a new graduate class in the Ecology and Environmental Sciences program at the University of Maine, led by assistant professors Andrew Rominger and Erin Grey, found great success in informing students around environmental DNA (eDNA). Rominger and Grey recently joined UMaine with financial support from the National Science Foundation EPSCoR RII Track-1 grant, Maine-eDNA. The class, titled "Fundamentals of eDNA," provided an excellent starting point for graduate students' education on the subject, along with many flexible ways for the students to approach their learning.

The goal of the class was to take a little over 20 graduate students from varying backgrounds and give them the tools to not only take in information relating to eDNA but also to produce new insights with the use of eDNA.

To help support these goals, plenty of methods were tried. For example, in-depth lectures were delivered on topics such as learning how to properly extract eDNA, and hands-on work was interwoven covering related topics. Rominger explained, "Since we want [the students] to not only be comfortable in a conversation relating to eDNA, and to actually produce new insights, we had to make sure we were trying a more hands-on approach, which took up about 50% of the course.

"THE HANDS-ON PART OF THIS CLASS was often open-ended projects where we would group students with other students that had similar interests in the uses of eDNA," Rominger said. "Once we grouped them together we worked on things like the best ways to extract DNA from the environment, or exploring how we can quantify the details of an ecosystem through a single population or collection of populations. These approaches were often done through presentations that the students constructed; some even created websites for their specific projects." - Rominger

For the lecture half of this class, there were often guest speakers, such as professor of anthropology Darren Ranco and molecular ecologist, Karen James. These invited guest speakers introduced the students to research being conducted with eDNA and provided more insight into how a specific student's research discipline may be applied to the Maine-eDNA program as a whole.

From the perspective of the students, this class was a great opportunity. Graduate research assistant Phoebe Jekielek, found it to be a highly beneficial experience. "This course was very approachable no matter what level you were at, and I think that it was approachable because there were many directions to go with it, along with remote access making it easy to get to," Jekielek commented.

Rominger himself reflected on the class by saying, "The students being as involved in this class as they were was probably the biggest contributing factor to its success. It was amazing to see the level of enthusiasm they brought to each class and how they applied themselves, even if there may have been a little Zoom burnout. Erin Grey is definitely a close second, she was so critical in making this a success."

Although Zoom has its limitations, the platform helped to increase the availability of Rominger and Grey's class and has allowed students to revisit classes through recordings as needed. Rominger clarified, "Zoom was actually necessary because the students were dispersed across multiple campuses in Maine. When we do this class again in the fall, we plan on having a third of the students being remote while the rest are in-person."

Rominger and Grey's innovative curriculum has helped to increase the interest in the broad study of eDNA. Through the process of teaching the new concept of eDNA to future researchers, this has become a class worth emulating by the many ways it has encouraged the students to get involved.

Overcoming the Unpredictable

How one summer outreach program adapted in the face of COVID-19 restrictions

By Bhavana Scalia-Bruce and Marcella Silver

CAITLIN MCGUIRE, a fourth year Elementary Education undergraduate student at the University of Maine, found herself facing an overwhelming challenge as a direct result of the COVID-19 pandemic. Over the past few years, she has been working with Laurie Bragg, the Maine EPSCoR Outreach and Program Manager, and Sarah Sparks, a 4-H Science Professional with University of Maine Cooperative Extension, to develop curriculum to pilot lessons with the 4-H Summer Learning Series.

The University of Maine Cooperative Extension 4-H Summer Learning Series offers free, hands-on, virtual workshops geared toward students ages 5-18. Unfortunately, when COVID-19 came on scene, UMaine Cooperative Extension 4-H and EPSCoR were initially unable to hold workshops in-person.

Summer learning loss, also known as "summer slide," is the decline in achievement that occurs in youth between the end of the school year to the beginning of the new school year. One of the reasons these outreach programs are so important is because they help combat summer slide. "Summer slide particularly impacts the opportunity gap for young people who may not have access to summer programs and enrichment," Sparks said. "Programs such as this, that are free or low cost and held in local communities so access is easy for everyone, help to mitigate this by engaging young people in hands-on STEM experiences." So allowing COVID-19 to halt the Summer Learning Series was not an option in the minds of McGuire, Bragg, and Sparks.

Thanks to modern technology, they were able to improvise with remote sessions in the summer of 2020. These virtual workshops allowed youth to engage in science from the safety of their own homes. All the supplies that would have been used in-person were sent to participants' homes.

McGuire, Bragg, and Sparks worked to enhance the original framework that was developed for virtual workshops held in the summer of 2020 in order to build an even more successful approach that was applied during the summer of 2021.

Each of the three lessons developed included students reading a science picture book followed by a virtual discussion to stimulate conversation. Students also completed activities relating to science (such as creating an ecosystem in a bag) on Zoom. All of the activities directly correlated to ensuring that students gained exposure to science.

Bragg came up with the idea for these virtual lessons after watching a video of NASA astronauts reading children's books in space. She decided to start organizing a film project that has researchers from Maine EPSCoR grants reading children's books geared toward their respective areas of expertise. McGuire and Bragg also worked together to compile a list of STEM-related children's books. Some examples of these books are "Seeing Symmetry" by Loreen Leedy; "Over and Under the Pond" by Kate Messner; and "Flow Spin Grow (Looking for Patterns in Nature)" by Patchen Barss.

McGuire spent time during the spring 2021 semester in a fourth-grade classroom for her degree program's education requirements and saw first hand how STEM education is severely lacking in classrooms. "I feel strongly that it is imperative to expose children to STEM as much as possible," McGuire said. "Programs such as 4-H and Maine EPSCoR strive to create opportunities and outreach to get students involved."

Despite the COVID-19 pandemic, the hard work and dedication of personnel such as McGuire, Bragg, and Sparks has allowed Maine EPSCoR to ensure students continue to get exposure to STEM learning through resources such as UMaine Cooperative Extension 4-H.

New Faculty Hire

ERIN GREY is an Assistant Professor at the University of Maine in the School of Biology and Ecology. She has a Ph.D. in Ecology and Evolution from the University of Chicago and more recently she was an Associate Professor of Biology at Governor State University. Grey came to UMaine to conduct research under Maine EPSCoR's Maine-eDNA program as a new faculty hire in January 2021.

Grey's research looks into the application of environmental DNA (eDNA) within coastal regions, and focuses on how people are affecting the ecosystems. For example, she looks at how the use of shipping ports impact the environment around them as well as the species that call those waters home. Grey said, "I'm using eDNA to understand how coastal ecosystems are changing, and also developing new eDNA tools to increase the number of species that we can detect."

Commercial ships are specifically important because they often travel far, sometimes even around the globe. This provides an ideal opportunity for species such as barnacles or green crabs to latch on and travel to a different ecosystem.

"We try to simulate how that process might happen on a global scale, but there's a lot of uncertainty, so we want to see how our simulations may be right or wrong," Grey mentioned. "We went to commercial ports and collected eDNA that would show us if we're right to believe that two different ports connected by a lot of shipping traffic will share biodiversity characteristics."

While most of the commercial ports that were studied were within the United States, Grey did gather data from ports in other countries like Belgium, Argentina, Australia, and Singapore, to name a few. This will allow researchers to not only find similarities in ecosystems in these far away ports, but to also keep track of possible invasive species.

While some of Grey's work prioritizes the global application of eDNA, she also has an interest in applying eDNA techniques to crustaceans in the Gulf of Maine. For example, blue crabs from southern coastlines are moving up north due to Maine's warming waters.

Harmful invasive species may be what comes to mind when discussing blue crab, but Grey suggests that assumption isn't fully understood yet. Grey stated, "It could become an invasive species when the waters start warming up more, but right now we're not sure if it'll be harmful, or possibly even helpful."

It is possible that there may be some positives that can result from this introduction of blue crab. Grey pointed out, "People do love to eat blue crab down south and in the Gulf of Mexico, so it could become a fishery species here in Maine. But we still need to focus on how big of an impact the crab itself will have."

NSF EPSCOR TRACK-1 GRANTS 1980-2021

$538M New R&D Funding from NSF EPSCoR Supported Research Centers

$175M Add-on Grants from NSF-Funded Track-1 Research*

1,564 Scientific Journal Publications

1,183 Statewide Undergraduate Research Internships

491 Major Research Collaborations

372 Statewide High School Research Internships

37 Patents, Products, Companies Created

46 New Faculty Hires

* during the Track-1 award period.

Emily Pierce (Ph.D. student, UMaine) uses a long sampling pole with Kai Alger (EPSCoR intern, UNE) and Benjamin Rico (EPSCoR intern, UMaine)

Photo by Markus Fredrich

CURRENT NSF EPSCOR GRANTS IN MAINE

Track-1: Molecule to Ecosystem: Environmental DNA as a Nexus of Coastal Ecosystem Sustainability for Maine (Maine-eDNA) ($20M)

Applying eDNA approaches to understand coastal ecosystem dynamics across spatial and temporal scales.

- 3 new faculty hires at UMaine
- 5 postdoctoral researchers
- 22 graduate students

Track-2: Leveraging Intelligent Informatics and Smart Data for Improved Understanding of Northern Forest Ecosystem Resiliency (INSPIRES) ($5.1M)

Building a digital framework to better assess, understand, and forecast complex forest changes

- Cross-jurisdictional with Maine, New Hampshire, and Vermont (Led by UMaine)

Track-2: Harnessing Spatiotemporal Data Science to Predict Responses of Biodiversity and Rural Communities under Climate Change (BARRACUDA) (2.0M)

Understanding how communities of plants and animals, including forest plants and wildlife, diseases and their vectors, and agricultural crops, will respond to climate change.

- Cross-jurisdictional with Maine and Vermont (Led by UMaine)

Track-2: The Visual Database: A Large-Scale Point-of-View Video Database for Vision Research ($3.0M)

Creating a database of 240+ hours of diverse, first-person video in order to support cognitive science, neuroscience, computer vision, and humanities research.

- Cross-jurisdictional with Maine, Nevada, and North Dakota (Led by Bates College)

Track-2: Genomic Ecology of Coastal Organisms (GECO): A Systems-Based Research and Training Program in Genome-Phenome Relationships ($1.8M)

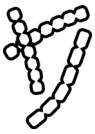
Developing a GECO research and training program to advance understanding of the genetic bases of organismal responses to natural environments

- Cross-jurisdictional with Maine and New Hampshire (Led by UNH)

Track-2: Single Cell Genome-to-Phenome: Integrating Genome and Phenome Analyses of Individual Microbial Cells in Complex Microbiomes ($6.6M)

Improving tools for the isolation of microbes to understand the molecular composition of microbial communities

- Cross-jurisdictional with Maine, New Hampshire, and Nevada (Led by Bigelow Laboratory)



Track-2: Computational Methods and Autonomous Robotics Systems for Modeling and Predicting Harmful Cyanobacterial Blooms

Developing robotic testing methods to monitor for harmful cyanobacterial blooms in water resources.

- Cross-jurisdictional with Maine, New Hampshire, and South Carolina (Led by Dartmouth)

Track-4: FY 2019-20 Diffuse Optical Imaging for Early Detection of Diabetic Polyneuropathy ($162K)

Using imaging techniques to generate heat maps capable of highlighting markers for diabetic polyneuropathy

- Target partner: Boston University BOTLab

Track-4: Advanced Control Strategies for Floating Offshore Wind Farms ($96K)

Finding strategies that best harness wind energy while reducing costs for floating wind farms

- Target partner: National Wind Technology Center

MAINE EPSCoR

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Orono, ME 04469-5717

RETURN SERVICE REQUESTED

Maine State EPSCoR Committee:

Maine EPSCoR is overseen by the Maine Innovation Economy Advisory Board, a statewide steering committee of individuals from Maine's education, research, and business communities and state government. The board is under the auspices of Maine's Office of Innovation.

Maine-eDNA students practice collecting water samples. *Photo by Grayson Huston*

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