UMS Research Reinvestment Fund (RRF)
Annual Report of Activities

UMS Board of Trustees Meeting
March 18 & 19, 2018

Executive Summary

The objective of the UMS Research Reinvestment Fund (RRF) is to strengthen research, development and commercialization activities that are tied to Maine businesses and industries that are critical to the future of Maine. The RRF program focused the first three years of its activities filling the commercialization pipeline by establishing a portfolio of research and development projects with strong commercialization potential. In its fourth year of funded activities the RRF program has placed a far greater emphasis on accelerating research commercialization. This report highlights notable outcomes of new and cumulative activities within the three funded initiatives of the RRF program established by the UMS Board of Trustees:

I. Competitive Grant Funding to UMS Researchers Initiative

- Since 2015, the RRF Program has received 389 proposals from UMS researchers spanning all seven campuses. A total of 133 projects have been competitively selected by the RRF Advisory Board for awards totaling $5.1M. As the State's flagship university for research, UMaine spearheaded 119 of these projects, with other system campuses taking the lead on 14 projects and being actively involved as Co-Investigators on another 28 projects. Funded projects primarily reside in the Aquaculture and Marine Sciences, Biotechnology, and Environmental Technologies sectors.

- RRF funded grantees have submitted 131 follow-on grant applications to funding agencies, of which 49 were selected for awards, bringing in a total of $14,758,416 in external funding. The management of the competitive grant program as well as direct support to grantees in their pursuit of follow on grants is provided by professional staff from the Office of the Vice President for Research and Dean of the Graduate School (OVPRDGS).

- Establishing collaborations amongst campuses and with non-UMS facilities is a required component of funded RRF grant projects and as a result, a total of 151 external entities were included as project partners, many of which reside within the private sector and are Maine-based businesses.

II. Infrastructure Support to the Business Development Enterprise Initiative

- The Office of Innovation and Economic Development (OIED) has focused its business development activities on sector specific strategies for the forestry and marine/aquaculture industries. Grants totaling nearly $5 million were awarded in the past two years to develop a roadmap for the forest economy and implement emerging technologies in that sector. Two companies announcing plans to expand cross-laminated timber manufacturing in Maine, with nearly $50 million invested, were directly related to this work. These companies are expected to create approximately 200 jobs.

- Through the Alliance for Maine's Marine Economy, OIED is a convener of private industry and public sector efforts to develop and implement new technologies and provide infrastructure for growth. As a result of winning a $7 million state bond RFP, the Alliance has recently awarded funds for capital projects for such as seafood and lobster processing, fish aquaculture and seaweed production. These funds also leveraged an additional $7+ million in additional investment.

- Five projects involving 14 faculty, staff and students are part of the new Maine Innovation, Research and Technology Accelerator (MIRTA). These projects have high potential for successful commercialization as start-ups or licenses to existing Maine companies. Funded by the Research Reinvestment Fund, the accelerator is an intensive 16-week program and guides participants through customer discovery, market analysis, intellectual property analysis, and business model development that will result in a commercialization plan with a strategy for bringing their research to market.

- An effort to help grow and create jobs across the state of Maine, the Innovate for Maine Fellows program helps early-stage, scaling and growing innovation-based companies throughout Maine connect with talent while at the same time demonstrating to students that there are opportunities to do meaningful and exciting work in the state. The program prepares students to collaborate with

companies on innovation projects that accelerate company growth and give students a paid, meaningful, hands-on internship experience.

- To date, the program has served 168 companies with 162 Fellows representing 29 colleges and universities.

- In addition, RRF funded graduate and undergraduate students participated in projects with strong commercial application and private sector partners gaining direct hands on experience connecting their education to problem solving to career.

III. Infrastructure Support to the Research Enterprise Initiative

- RRF funding has enhanced the capacity of units within the OVPRDGS to serve faculty and researchers across the UMS research enterprise in their pursuit of external funding.

- The Office of Research Administration (ORA) at UMaine now handles grant administration for the Orono, Machias, and Fort Kent campuses of UMS. During FY 2017 a total of $56,926,782 was received by the flagship from extramural sponsors, a 13% increase over that of FY 2016 ($50,369,625). The number of proposals submitted was significantly greater than the previous year (573 vs. 500 in FY 2016, a 15% increase).

- The Grant Development Office (GDO) oversees the RRF internal grants program, provides direct grantwriting assistance to individuals and teams, and develops and delivers grantsmanship training for faculty and staff. Since FY 2015, the GDO has had a direct hand in securing $24,344,279 in external funding and has conducted 41 separate grantwriting offerings to 784 faculty, staff, graduate and undergraduate students.

- Grant writing projects currently underway with support of the GDO that will have statewide impact include:

    - $8,000,000 proposal to the Harold Alfond Foundation to support the Engineering Education and Design Center;

    - $12,500,000 proposal to NSF for an INCLUDES scale up project related to increase diversity in STEM;

    - and a $20,000,000 proposal to NSF EPSCoR in collaboration with Bigelow Laboratory for Ocean Science, other UMS campuses, and industry partners to investigate environmental DNA (eDNA) technical applications in the context of the economic future of Maine's coast.

Plans for the upcoming year:

- Increase faculty education/grant writing support for commercialization, industry partnership, and large grants.

- Continue competitive grant programs to develop new research, commercialization, and workforce development projects and enhance criteria related to private sector engagement, investment, and advancement outcomes.

- Compete an additional round of Phase II Accelerator Grants that provides faculty release time and funding for consultants to accelerate commercialization outputs.

- Conduct targeted outreach to University of Southern Maine for research, development, and commercialization collaborations.

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I. Competitive Grant Funding to UMS Researchers Initiative

The competitive grants program supported by RRF provides funding for research, development, and commercialization projects to seed larger initiatives that are tied to advancing aspects and sectors of Maine's economy. Measurable outcomes of seed grant investments include: the attraction of additional extramural funding, the provision of meaningful hands on experiences for undergraduate and graduate students within the UMS, and the movement of basic and applied research to commercialization. Several of the funded research and development initiatives within the RRF portfolio have generated new and impactful private sector engagements, investments and advancements between commercial businesses and the UMS research community. By creating collaborations and partnerships with the private sector, economic and workforce development activities are being accomplished in designated economic sectors that benefit the State of Maine and beyond. Final funding decisions for the RRF competitive grants programs are made by the RRF Advisory Board whose membership is comprised of faculty and administrators from UMS campuses as well as representatives from the private sector and the Maine Technology Institute (MTI) (See Appendix A for a current membership roster of the RRF Advisory Board). The RRF Competitive Grants program is managed and administered by the Grant Development Office within OVPRDGS.

Composition of the RRF grant portfolio and new programs

Since June 2015, the RRF Program has received 389 proposals from UMS researchers spanning all seven campuses. Of these applications, a total 133 projects have been competitively selected by the RRF Advisory Board for awards totaling $5.1M in grant funding. As the State's flagship university for research, UMaine spearheaded 119 of these projects, with other system campuses taking the lead on 14 projects and being actively involved as Co-Investigators on another 28 projects. Funding programs created by the RRF Advisory Board include Seed Grants (4 rounds, 41 funded projects), Planning Grants (rolling basis, 13 funded projects), Graduate Assistantship Grants (3 rounds, 34 funded projects), Undergraduate Assistantship Grants (3 rounds, 35 funded projects), and Interdisciplinary Undergraduate Research Collaboratives (1 round, 4 funded projects).

Special emphasis on research commercialization for Year 4 competitive grant programs

A new RRF Phase II Accelerator program was launched in winter 2017 with the goal of identifying projects within the existing RRF funding portfolio that could achieve measurable commercial outputs after a 16 week time frame (Spring 2018 semester) with an infusion of technical assistance and funding. Potential outputs from the Phase II Accelerator program include starting a company, licensing UMS technology to an existing company, filing a patent, or forming an extended research collaboration with an external partner. Five accelerator projects were selected by the RRF Advisory Board for the pilot of this program. Project teams commenced activities in January 2018, weekly coaching sessions with Accelerator staff have been established, and deliverables are expected by May 2018. (See Appendix B for a listing of the grants and abstracts).

The solicitation for the fourth round of RRF Seed Grants (Fall 2017) placed a strong emphasis on commercialization. A total of 39 applications were received from UMS researchers, of which the RRF Advisory Board selected 10 for funding, along with 1 additional Accelerator grant. (See Appendix C for a listing of the grants and abstracts).

Lastly, in addition to the established graduate and undergraduate assistantships that enable UMS students to perform impactful research, development, and commercialization projects, a new student award program was created to foster interdisciplinary collaborations fueled by the work of teams of undergraduates under the supervision of faculty. The past rounds of the Interdisciplinary Undergraduate Research Collaboratives (IURC) program funded 4 teams of UMS undergraduate student researchers. In the third round competition of the RRF Student Awards (Fall 2017) a total of 45 applications were received from UMS researchers, of which the RRF Advisory Board selected 22 for funding. These awards were comprised of: 9 Graduate Assistantships; 9 Undergraduate Assistantships; and 4 Interdisciplinary Undergraduate Research Collaboratives (See Appendix D for a listing of the grants and their abstracts).

Stimulation of Grant Activity: Follow-On Grant Submissions and Awards

To date, RRF funded grantees have submitted 131 follow-on grant applications to external funding agencies, of which 49 were funded totaling $14,758,416 in additional external research dollars.

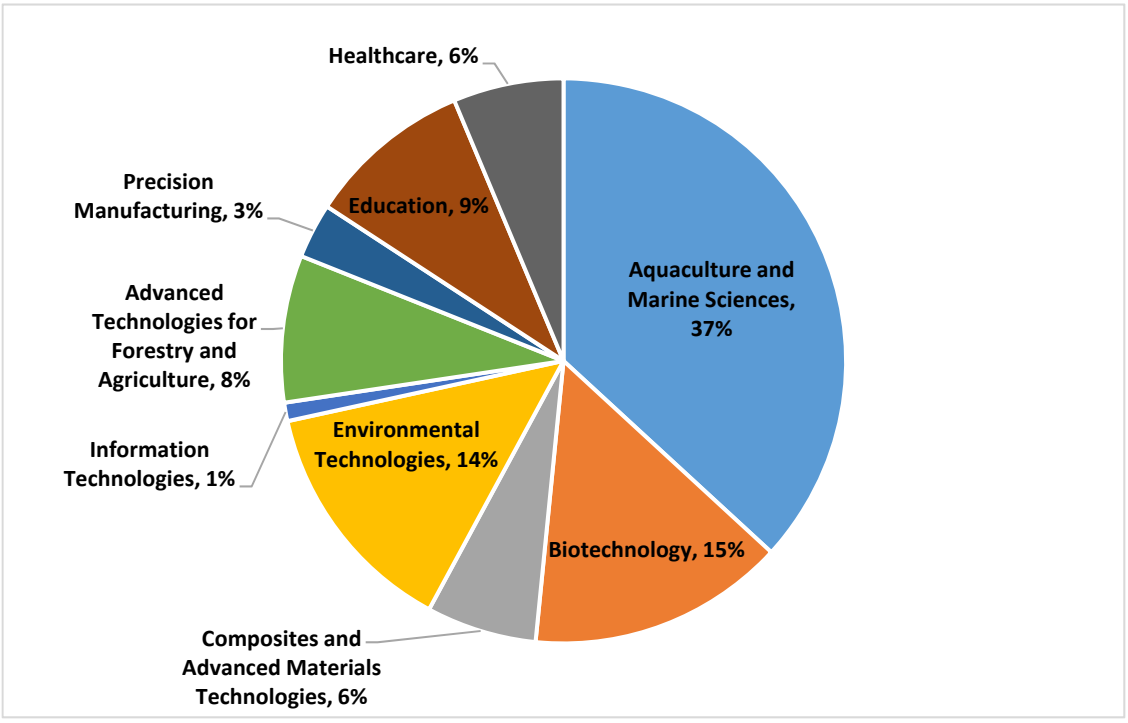
Table I: Follow-On Grant Submissions and Awards

Report Year	Submitted	$Submitted	Awarded	$Awarded	$Matched	Planned	$Planned
1	3	$7,175,212	1	$9,948	0	0	0
2	63	$23,599,816	17	$8,402,299	$8,050,000	7	$4,450,000
3	65	$41,752,629	31	$6,346,169	$2,071,124	62	$18,335,227
Total	**131**	**$72,527,657**	**49**	**$14,758,416**	**$10,121,124**	**69**	**$22,785,227**

Private Sector Investment, Engagement and Advancement in Maine Economic Sectors

In recognition of the fact that successful commercialization of University-based research requires engagement and relationship building with external partners, applicants to the RRF are required to collaborate with private sector businesses and other key stakeholders to accelerate UMS lead technology transfer activities that benefit Maine industries and enhance Maine's economic well-being. As a result of this programmatic focus on external engagement, ***a total of 151 external entities have served as project partners (several on multiple projects), many of which reside within the private sector and are Maine-based businesses.*** As shown in Chart I, funded projects primarily reside in the Aquaculture and Marine Sciences, Biotechnology, and Environmental Technologies sectors. Funded projects in the Education, Forestry and Agriculture, and Composites and Advanced Materials Technologies sectors have also shown signs of growth.

Chart I: Economic Sector Breakdown for RRF Funded Projects



Examples of private sector relationships that have been stimulated by RRF program support include:

- Sappi North America
- IDEXX
- Hodgdon Yachts
- Lyman Morse
- Hinckley Yachts
- Saber
- Thermwood Corporation
- Elder Technology Labs
- Mobility Technologies
- Specialty Materials
- Pemaquid Oyster Company
- AquaLine
- Constellation Consortium
- Fiberlean Technologies
- Betulium
- Acadia Harvest
- Maine Coast Sea Vegetables
- Maine Fresh Farms
- Cooke Aquaculture
- American Unagi
- Mook Sea Farm
- Thermoelectric Power Systems LLC
- Maine Marine Composites, Stryker Orthopedic
- Ready Seafood Company
- Innovation Natural Resource Solutions LLC
- General Dynamics Bath Iron Works.
- Stora Enso
- Innovasea Systems Inc.
- Beacon Analytical Systems
- Twin Rivers Paper Company

Exemplar Seed grants that embody the mission of RRF:

Liquid-Infused Paper Substrates for Biomedical Applications
RRF funded a 12 month Seed Grant project for $83,233
Industry Sector: Forestry/Biotechnology
PI: Caitlin Howell (Chemical and Biomedical Engineering, UMaine)
Engagement: SLIPS Tech, Inc., Sharklet Technologies, Inc, Sappi-Warren Release Papers
Private Sector Investment: $93,300 in committed funding from Sappi North America to continue the project
Advancement: Patentability and commercial assessment pending

Unmanned Aerial Systems: Supporting development / training on UAV applications for Maine businesses and state agencies
RRF funded a 12 month Seed Grant project for $99,363
Industry Sector: Education/Aviation
PI: Thomas Abbott (University of Maine at Augusta)
Engagement: Civil Air Patrol, Maine Forest Service
Advancement: Infrastructure development for Unmanned Aircraft Systems operational center for UAS certification

Sustainable Bio-conservation Technology for Aqua-feed Production and Waste Management
RRF funded a 12 month Seed Grant project for $92,487
Industry Sector: Aquaculture
PI: Andrei Alyokhin (UMaine)
Engagement: Acadia Harvest Inc., Franklin, ME
Federal Investment: $44,024 NSF SBIR small business subaward from commercial partner – Acadia Harvest Inc; $64,110 proposal submitted to NOAA Sea Grant; $500,000 planned to USDA
Advancement: As a result of this project, Acadia Harvest has opened a pilot plant that now employs three people in Waldoboro.

Development of Intrac™: A Weight Bearing and Fitness Tracking System for Assistive Devices
RRF funded a 12 month Seed Grant project for $82,899
Industry Sector: Precision Manufacturing/Healthcare
PI: Vincent Caccese (UMaine)
Engagement: Mobility Technologies (in the process of forming)
Federal Investment: Submitted $950,000 NIH STTR small business proposal to commercialize the technology
Advancement: This project will help support and fund a new small Maine tech business in Brunswick, ME.

Novel Fire Resistant Low Formaldehyde Emitting Fiberboard Panels Made from Deadwood, Residuals and Nanocellulose
RRF funded a 12 month Seed Grant project for $100,000
Industry Sectors: Forestry/Advanced Materials
PI: Mehdi Tajvidi (UMaine), Douglas Bousfield (UMaine)
Engagement: FiberLean Technologies; Composite Panel Association; Betulium; USDA
Federal Investment: $322,528 funding proposal submitted to the US Endowment for Forestry and Communities
Advancement: Industry partnerships established for potential technology transfer

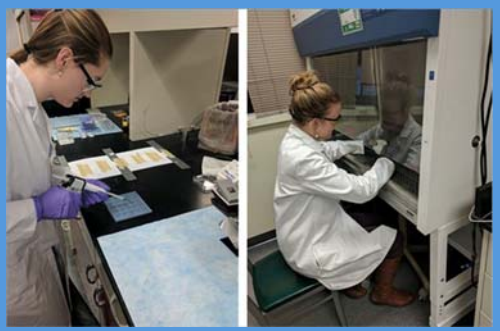
ACCELERATED OUTPUT

LIQUID INFUSED PAPER SUBSTRATES FOR NEW BIOMEDICAL APPLICATIONS

PRINCIPAL INVESTIGATOR: DR. CAITLIN HOWELL

Dr. Caitlin Howell joined the UMaine faculty ranks as an Assistant professor of Chemical and Biomedical Engineering in spring of 2016, where she brought with her a research background in biological surface interactions along with industry connections and a drive for commercialization. She submitted and was awarded her first RRF Seed Grant in 2017 in the amount of $83,233 for *Liquid Infused Paper Substrates for New Biomedical Applications*. This critical seed funding allowed her to conduct the necessary basic research to prove her concept, and demonstrate the game-changing advantages that her technology enabled in the Point of Care (POC) paper diagnostics market to Sappi-Warren Release Papers research unit. The demonstration was a great success, and in the Fall of 2017 Sappi-Warren committed an additional $93,000 in funding to support ongoing research and development of this innovative technology that has the potential to revolutionize the paper-based medical diagnostics industry, a market estimated to be worth $2.2 Billion. Along the way, Dr. Howell also managed to involve ten different students on this project (8 undergraduate, 1 graduate, and 1 high school student), and in doing so providing them invaluable educational and research experiences on a technology that has immense commercial potential.

In recognition of her work in this area, and to further accelerate the commercialization of her paper diagnostic technology, Dr. Howell's project was selected for the Spring 2018 RRF Phase II Accelerator Program. As part of this program, her research team will be involved in the customer discovery process and meet with actual customers to explore the most promising pathways for integrating their release-paper microfluidic platforms into current and future POC medical diagnostic devices. In addition, the ongoing partnership with Sappi-Warren will be leveraged to explore potential technology transfer pathways to transition this UMaine supported technology into the marketplace.



Undergraduate bioengineering students Abby Weigang (left) and Chloe Lilly (right) conducting experiments as full time co-op students supported by this project

ACCELERATED OUTPUT

PROTOTYPE DEVELOPMENT FOR DETECTION OF WINE AND BEER SPOILAGE YEASTS

PRINCIPAL INVESTIGATOR: DR. LAURIE CONNELL

In 2013, Dr. Laurie Connell first developed the idea to apply technology she developed to track harmful marine algal blooms to solve a very different problem detecting microorganism contamination in the beer and wine industry. Dr. Connell's team prepared a commercial development plan to address technical, market and funding challenges on the pathway to introducing this new product. With support from a $25,000 Maine Technology Institute technology transfer grant, the team spoke with more than fifty companies to understand their need for a better solution to current methods. This early market research lead to a RRF Seed Grant for $68,361 in the Fall of 2015, which supported early product development and testing with Allagash Brewing Company. This RRF grant was also leveraged as match for additional MTI technology transfer funding for technical development. During this period, one of the largest producers and distributors of wine in the world (Constellation Consortium) was contacted to explore interest in this technology. This outreach proved successful as it led to a partnership and additional funding from Constellation Consortium in the amount of $78,000 for continued product development at UMaine. Additionally, the research team commenced work with a Maine based company (Beacon Analytical Systems) for prototype development and eventual product manufacturing.

Dr. Connell's project was selected for the Spring 2018 RRF Phase II Accelerator Program and in the recent Round 4 Seed Grant competition as well. This funding will support ongoing activities related to final product commercialization and sales efforts. Specifically, the team is now poised to develop a license agreement and initiate beta testing with Constellation Consortium and Beacon Analytical, finalize patent protection, and obtain ISO product certification to facilitate initial product sales.

InstaProbe

Prototype instrument for detecting wine and beer spoilage utilizing proprietary florescent probe technology developed by UMaine researchers.

Phase II Accelerator Program:

To facilitate commercialization activities a new RRF Phase II Accelerator program was approved by the RRF Advisory Board and commenced in January of 2018. This program is designed to capitalize on previously funded RRF projects, and advance selected projects from basic and applied research and development stages to a stage that can realize measurable commercialization outputs in the short term. The Accelerator is an intensive 16-week program that includes five teams (one per selected Accelerator project) that will guide the participants through market analysis, intellectual property analysis, and business model development that will result in a commercialization plan with a strategy for bringing the research to market. Possible outputs will include starting a company, licensing to an existing company, filing a patent, or forming an extended research collaboration. Through weekly learning cycles, teams will determine how to position and develop their research for commercialization success. Technical assistance for the Phase II accelerator teams is provided by professional staff from the Office of Innovation and Economic Development (OIED) and the Office of the Vice President for Research and Dean of the Graduate School (OVPRDGS)

Public Engagement, Publication, and Student Involvement

RRF related student involvement, public engagement, and publications have increased dramatically since the beginning of the program. In particular, 322 students were involved in RRF-related research activities in Year 3 alone, averaging 3 students per funded project. Table II summarizes publication, presentation, and student involvement outcomes.

Table II. Publications, Presentations and Student Involvement

RRF program year 2015:
Publications: -
Presentations given: 1
Student participants: -

RRF program year 2016:
Publications: 32
Presentations given: 36
Student participants: 35

RRF program year 2017:
Publications: 84
Presentations given: 152
Student participants: 322

Total:
Publications: 116
Presentations given: 189
Student participants: 357

ACCELERATED OUTPUT

BEEHIVE ACTIVITY MONITORING SYSTEM

PRINCIPAL INVESTIGATOR: DR. NURI EMANETOGLU

Bees pollinate up to 80% of US crops, including blueberries and other crops important to the Maine economy. However, the last decade has seen an increasing rate of beehive colony collapse disorder, which resulted in a 44% loss of the honey bee colonies nationwide during the 2015-2016 season. To contend with this growing problem, there is an increasing need within the agricultural industry for beehive activity monitoring systems that can provide real-time and actionable information to the farming community at an affordable price.

To address this critical need, a team of researchers and students lead by Dr. Nuri Emanetoglu at UMaine have developed an innovative approach for monitoring colony collapse disorder that utilizes Doppler radar. Their research first began in 2015 with the support of a Maine Department of Agriculture grant for $25,355, which allowed the team to build and deploy two early stage radar systems for feasibility testing. The success of this early work was then leveraged to secure an RRF Undergraduate Assistantship award for $6,970 to construct five beta systems for further system development, testing and refinement at beehives located at UMaine. By the end of Summer of 2017, the team had successfully demonstrated that their concept was technologically sound as well as affordable at $100/unit, which is considerably less than other commercially available units. Dr. Emanetoglu subsequently met with OIED staff in the Fall of 2017 to file an invention disclosure and initiate the patent protection process and commercialization of their technology.

Dr. Emanetoglu and his team were selected to be part of the Spring 2018 RRF Phase II Accelerator Program, where they are now focused on accelerating the commercialization of their beehive activity monitoring system through small business formation and/or establishing a licensing agreement to Maine based companies. Undergraduate researchers are actively involved in this project.

Impactful Student Research Experiences

The following are representative examples of funded RRF projects in which UMS students have played a key role in advancing research, development, and commercialization projects important to Maine's economy:

Increasing the Value of Maine's Lobster Fishery by Improving Shell Quality and Meat Yield

Industry Sector: Aquaculture and Marine Sciences
PI: Rick Wahle (UMaine)
Undergraduate Student: Abby Shaughnessy
Description: This project supported UM Marine Science major and Honors College student Abby Shaughnessy to undertake preliminary experiments that informed proposal development for a larger grant from NOAA. Abby successfully executed 7 week-long trials including an experiment over the course of the summer that involved research on a total of 168 lobsters. The rearing chambers and all lobsters were supplied by Ready Seafood. Abby's senior capstone and Honors College thesis is on track to be completed in May 2018.

Before Pangea Geoheritage Corridor

Industry Sector: Education
PI: Douglas Reusch (University of Maine at Farmington)
Undergraduate Student: Bryce Neal
Description: The goal of this project is to conduct geological research in the western Maine mountains (the Rumford allochthon) to uncover the nature and history of Maine's continental crust, and ultimately produce an improved geologic map of this area based on a modern evaluation of lithologic and structural data. This project will support the student's senior year research project, in which he will utilize drone-acquire images to produce a detailed outcrop map of ledges on the southwest side of Bald Mountain and near the summit of adjacent Saddleback Mountain. This outcrop mapping will constitute an important component of the Bryce's professional development.

Low-Cost Breathing Simulator for Medical Training

Industry Sector: Biotechnology
PI: Caitlin Howell (UMaine)
Undergraduate Student: Jordan Tremont
Description: In this work, a low-cost, adaptable breathing and auscultation simulator was designed and developed based on clinical data and quantitative fluid-flow modeling. This project supported Jordan's research (B.S. Bioengineering, UMaine 2018) as she builds her skillset in medical simulation technologies in preparation for a career in biomedical engineering. The immediate result will be proof-of-concept for a new approach to creating low-cost medical simulations. The longer-term result has been the creation of a new student led start-up company (Zephyrus) that is seeking to commercialize the technology funded by this project.

SmilePartners: Oral Health as an Economic Development Strategy

Industry Sector: Healthcare
PI: Becca Boulos (University of Southern Maine)
Graduate Student: Lyvia Gaewsky
Description:
SmilePartners is a collaborative initiative that has partnered with local organizations to provide dental care to residents of Greater Portland. Specifically, residents who do not have access to care due to lack of insurance, high out-of-pocket costs for treatment, and those that are unfamiliar with the dental system. This project is supporting Lyvia's research as she will be assisting with launching the SmilePartners cohorts, conducting literature reviews, and researching employer sponsorship development. The goals are to provide participants the confidence needed to save for dental care, to navigate the dental system independently, and to have oral health restored to preventative status and maintained through a newly created dental home.

An Integrated Approach to Realizing the Value of Maine's Forest Resources

Industry Sector: Forestry and Agriculture
PI: Adam Daigneault (UMaine)
Graduate Student: Erin Huss
Description: This project aims to develop a more systematic method to integrate the myriad market research associated with the forest products industry within the University of Maine System. Researchers at the University of Maine's School of Forest Resources and the University of Southern Maine's Maine Center for Business and Economic Research are collaborating to develop an integrated approach to realizing the value of Maine's forest resources. Erin has begun to develop the spatial database with information related to land use and land cover (including conservation areas), historical forest product harvests and prices, forest growing stock by species, mill locations, employment, land values and taxation rates, recreation sites and water quality.

Field and Laboratory Trials to Examine Growth and Survival of a New Bivalve Culture Candidate in Maine: Arctic Surfclams, Mactromeris polynyma

Industry Sector: Aquaculture and Marine Sciences
PI: Brian Beal (University of Maine at Machias)
Undergraduate Students: Alex McCarthy, Rory Morgan
Description: This project funded two undergraduate students who worked at the Downeast Institute (DEI), the Marine Science Field Station of the University of Maine at Machias. The students became familiar with the culture and

STUDENT INVOLVEMENT

Modeling Bacterial Circulation on Maine Mudflats

Principal Investigator: Dr. Damian Brady
Graduate Student: Gabrielle Hillyer

Dr. Damian Brady applied for Research Reinvestment Funding to support a graduate student on his research project studying the impact of bacteria in mudflats on the Medomak River in Waldoboro, Maine. The levels of bacteria in the mudflats can have a profound impact on clamming activity. Data for his project has been collected by a Lagrangian Drifter, which was designed by Gabrielle Hillyer, the RRF-supported graduate student, and NOAA's Jim Manning. The funding for the drifter design and materials also came from support through the RRF program. These "bucket drifters" are packed with scientific instruments that take the measure of the tides— which helps to better understand the dynamics of the estuary's ability to flush out harmful bacteria that can close clam flats for a mandatory nine-day period. The drifter has been deployed over 25 times, which has provided a wealth of data in variable situations.

Gabby Hillyer takes readings from her bucket drifters.

Much of the project's emphasis has been on engaging key stakeholders. Gabby Hillyer has been working closely on her drifter deployments with commercial clammer Glen Melvin (Chair of the Waldoboro Shellfish Committee). Before even beginning data collection, Hillyer interviewed eight clammers who had expertise in the area.

ACCELERATED OUTPUT

THE MAINE FOREST ECOSYSTEM STATUS AND TRENDS (FOREST) APP

PRINCIPAL INVESTIGATOR: DR. ERIN SIMONS-LEGAARD

An outbreak of eastern spruce budworm expanding south from Quebec is a major threat to Maine's forest economy, leading to a potential outbreak that could cause annual losses of nearly $400,000 and 600 jobs from the forest products sector. In addition, recent stakeholder meetings with forest managers in Maine have identified a lack of spatial information about forest resources as a key barrier to the planning and prioritization of management actions. In order to maintain a leading role in a global forest economy, forest landowners and managers need access to timely, affordable and relevant geospatial data to improve decision making and capitalize on emerging markets.

To combat these growing threats and address the needs within a critical economic sector in Maine, Dr. Erin Simons-Legaard and her research team in the school of forestry at UMaine utilized support from a RRF Seed Grant (Spring 2016 for $75,748) to develop an innovative web-based resource mapping system called the Maine Forest Ecosystem Status and Trends (ForEST) App. Their unique approach utilizes machine learning methods for analyzing remote sensing Landsat data and is capable of producing superior decision making results at substantially lower cost than currently available products. As a result of this seed grant, the research team was able to leverage this work and secure additional funding from the USDA in the amount of $96,147 for further development and refinement of the ForEST App. The App now has a fully functional back end hosted on a server maintained by the UMaine Advanced Computing Group and the core functionality of the web interface is complete, with data visualization, navigation, and downloadable features.

Dr. Legaard and her team were selected to be part of the Spring 2018 RRF Phase II Accelerator Program, where they are now poised to evaluate the commercialization potential of the ForeEST App as well as a larger suite of remote sensing products.

maintenance of Arctic surfclam larvae and juveniles, and participated in routine hatchery operations involving cleaning tanks, rearing algae, spawning adults, and rearing surfclam larvae and juveniles. Students worked closely with Downeast Institute personnel on a daily basis, and met weekly with DEI's Executive Director, Dianne Tilton, where they discussed the economic and workforce development aspects of the work. Students also participated in their own research projects where they engaged in laboratory and field trials to examine features associated with survival and growth of cultured surfclam juveniles. Since the RRF project was funded, additional funds were secured from NOAA. This award will extend activities to five commercial field sites in eastern Maine over the next two years. The ultimate goal is to discover commercial-scale methods to grow cultured surfclams to a commercial size.

Northern Maine Wood Turtle Population Survey

Industry Sector: Education
PI: David Putnam (University of Maine at Presque Isle)
Undergraduate Student: Gannon Pratt
Description: The goal of this project was to conduct field surveys on the endangered wood turtle (*Glyptemys insculpta*) along the rivers and streams of northern Maine's working forest. This project funded an undergraduate research assistant, Gannon Pratt, who assisted with the field survey and compiled the results which he will present at a regional conference in the spring of 2018. In addition to supporting Gannon, this work also involved thirteen undergraduate students from two UMS campuses who participated in the fieldwork, and two undergraduate students from Mongolia who contributed to the single most productive day of the wood turtle survey. The students forged relationships with Maine Department of Inland Fisheries and Wildlife biologists, private forestland owners/managers, and Department of Environmental Protection personnel that will provide a supportive professional network when they enter the job market.

Visible and Infrared Imaging Spectroscopy for High Resolution Mapping and Health Assessment of Maine's Forest and Agricultural Resources

Industry Sector: Forestry and Agriculture
PI: Peter Nelson (University of Maine at Fort Kent)
Graduate Student: To be recruited
Description: A graduate student will be recruited in spring 2018 to scale up existing airborne imaging spectroscopy data combined with high resolution ground-based spectral measurements applied to multiple vegetation, agricultural and forest targets. The goal is to integrate ground-based spectral scanning/chemical analysis and data mining of hyperspectral images into a pipeline for detection of specific, user-generated targets (eg. specific plants, pathogens, stress signals, etc.) for Maine's economically important natural resource sectors and elsewhere for competitive research applications. This project leverages existing collaborations between UMFK and UMaine researchers and with NASA.

II. Infrastructure Support to the Business Development Enterprise Initiative

The Research Reinvestment Fund provides funding to support UMS capacity to serve in the areas of business partnerships, technology transfer and commercialization leading to economic development. The RRF funding supplements existing programs and is integrated with the Maine Economic Improvement Fund and other similar programming. In addition to funding specific projects through grants, the supported programs help faculty gain experience, and add capacity to expand UMS's contribution to the overall economic development ecosystem of the state.

RRF is a tool that coincides with and is leveraged by several campus and statewide initiatives aimed at strengthening the economic development ecosystem. These include the following:

- *Targeted Initiatives by UMaine and UMS Administration*. The *Commercialization Working Group (CWG*) was a year-long effort initiated by UMaine's President Susan Hunter to "move to an enhanced level of leadership focus and modernized policies, processes and structure" as they relate to industry engagement and the commercialization of research. CWG's efforts culminated in the launch of the UMaine *Innovation and Economic Development Council* (IEDC), which first met in January 2018 and has established short and long-term goals in five key areas to promote growth in commercialization and business development.

- *Maine Technology Institute (MTI)*: MTI is an industry-led, Maine state-funded, nonprofit corporation offering funding to Maine private companies, universities and non-profit organizations to support R&D leading to commercialization. UMS has historically been an integral partner to MTI and works directly with many MTI funded companies. MTI also provides funding on a competitive basis to UMS commercialization projects. RRF funds are sometimes leveraged as matching funds for MTI grants. The 2017 MTI Strategic Plan calls for increased and more systematic collaboration between MTI and UMS.

- *State Support for R&D*: In June 2017, Maine citizens voted to support a $50M R&D bond to be administered by the Maine Technology Institute and distributed on a competitive basis through the Maine Technology Asset Fund (MTAF). UMS was a partner on nearly $10 million of MTAF proposals submitted with industry partners in the state.

- *Private Support*: The Harold Alfond Foundation has demonstrated interest in supporting commercialization of research through recent gifts to UMaine and UMS. The Foundation gave its first significant R&D gift to UMaine to support the Alfond W2 Ocean Engineering Lab and has demonstrated interest through recent gifts in supporting to UMS's efforts to bring research products to market. In addition, Alfond funded $100k to UMaine for developing best practices for accelerating commercialization.

In addition to current state development initiatives, the following drivers unique to the UMS ecosystem merit consideration:

- UMaine, through external grants, state-bonds and private funding, has strategically invested in people and facilities – such as the Advanced Structures and Composites Center, the Advanced Manufacturing Center, the Process Development Center and the Aquaculture Research Center, which directly relate to the Maine economy and allow for companies to access resources and research results to be developed further along the commercialization continuum.

- Trends in grant program availability and expectations have prompted faculty to consider commercialization and industry engagement to increase proposal competitiveness, look for alternate sources of funding, and pursue learning opportunities.

- The collaboration between University of Southern Maine and UMaine Office of Innovation and Economic Development (OIED) has begun to introduce efficiencies in technology transfer and is increasing opportunities for collaboration among faculty and access UMS resources among the business community.

Commercialization Working Group Outcomes

The Commercialization Working Group developed deliverables and outcomes that provide specific guidance and best practices that, while directed at commercialization in general, are directly applied to RRF funded projects and target the acceleration of economic development. The September 2017 CWG final report summarized the results of the group's work and outlined next step recommendations. The CWG work plan included four interrelated areas of focus:

1. *IP Portfolio Review*: CWG arranged for an external assessment of a portion UMaine's intellectual property assets for the purpose of developing action plans to advance those with the highest potential. This activity also tested the process and effectiveness of using contracted services for IP evaluation.

Outcomes: About 25% of the technologies evaluated were recommended for continued investment; about 25% were recommended against further investment; the remaining reports recommended investment with some reservations. The faculty response to the reports was generally positive; investigators appreciated the tangible feedback, which sparked further discussion and motivated greater faculty participation. This portfolio review was used to shape project specific RRF grant applications with stronger commercialization objectives.

2. *Research Foundation or Other Structure*: Assessment and recommendations for the development of an independent entity, such as a research foundation, to facilitate the movement of IP to market.

Outcomes: It was recommended that UMS should fully establish The University of Maine System R&D Foundation to support commercialization of research. The benefits of an independent foundation include:

- More flexible and specialized talent recruitment, retention, and compensation practices;
- More nimble product sales and payment practices;
- A vehicle for non-traditional, opportunistic investments and research and commercialization efforts; and
- Positioning UMaine/UMS for continued growth of institutional infrastructure.

Several technologies in the RRF funded portfolio could be accelerated to the market with an R&D Foundation capable of doing a start-up, limited production and early product sales.

3. *Stakeholder Feedback*: Surveys, interviews and focus groups were completed to assess the experiences and recommendations of Maine businesses and faculty. Focus groups were held in Jan/Feb 2017.

Outcomes:

- University leadership needs to develop and communicate a ***clear vision*** for commercialization and innovation and a plan for realizing that vision should be articulated.
- Maine business and industry partners highlighted the need for improved ***communication and marketing of services, improved service delivery, and a wider array of services***
- The faculty highlighted the need for ***clear policies, additional resources, and aligned incentives*** supportive of commercialization and innovation. Current challenges include:
    - Inconsistent understanding of the importance of public-private partnership to the land-grant mission;
    - Inconsistent understanding of the resources the university has in place to support commercialization;
    - Inconsistency in the recognition of knowledge transfer activities in the incentive structures (e.g., promotion and tenure criteria);
    - Insufficient resources (e.g., release time, monetary rewards, human resources) to support faculty engagement in commercialization activities;
    - Insufficient marketing of UMaine R&D resources to potential industry or agency partners.

4. *Best Practices*: CWG examined practices unique to UMS and at peer and aspirational institutions, identifying the following priority areas for initiating growth:

- Faculty engagement & incentives, including policy, IP revenue allocation, internal funding/incentive programs
- Tenure and promotion criteria
- Information sharing, communication
- IP evaluation and marketing
- Structure for ongoing prioritization, resource allocation

Innovation and Economic Development Council (IEDC)

One outcome of the CWG was the establishment of the Innovation and Economic Development Council to advise the President. It is charged with building a campus culture that supports commercialization activities, establishing priorities and carrying out initiatives to enhance and increase technology commercialization, industry engagement and economic development. IEDC began meeting in January 2018 and has established five priority areas with associated short- and long-term goals based on the CWG work. This council is made up of UMaine administrators, faculty, and staff and includes UMS Chief of Staff James Thelen. IEDC is reviewing and recommending improved practices and policies that are systemwide and thus will include systemwide involvement.

As indicated, RRF funding enhances and is leveraged by activities underway to expand UMS commercialization capacity in ways that go beyond the technology-specific project support.

IEDC Year 1-2 Priorities:

Culture
- Articulate a vision for commercialization at UMaine/UMS;
- Build a culture of innovation by creating a sense of urgency, building guiding coalitions and ambassadors, removing barriers and creating short-term wins.

Policy
- Update policies for compliance and risk mitigation;
- Create policies that incentivize faculty and enhance service to industry partners.

Organizational Structure
- Identify and enable existing staff to efficiently support commercialization (***including existing professional staff***); engage contractors and plan for new employees where needed to expand capacity;
- Operationalize an independent research foundation to enhance business development and commercialization.

Industry Engagement
- Revamp and enhance the process and options for companies to engage in sponsored research; provide tools and training for faculty;
- Create materials and systems for marketing research capacity.

Internal Resources
- Provide training and programs (***such as the RRF accelerator***) to enable faculty and staff to engage in commercialization;
- Adopt administrative tools and systems to enhance service to stakeholders;
- Advise the development and administration of institutional funding mechanisms (***such as RRF seed grants***) to accelerate commercialization, build the project pipeline and increase collaboration among campuses and with industry partners.

RRF – Integral to Support the Business Development Enterprise

RRF has served not only to increase the research capacity of UMS, but also to support project development at various points along the technology readiness continuum, attract industry partners and additional funding, accelerate commercialization and grow the business development infrastructure, with special emphasis on sectors critical to Maine's economy. This section of report outlines the following:

- The commercialization status of RRF grants, by sector;
- New technologies and commercialization outcomes
- Sector-specific response
    - Forest Products
    - Aquaculture
- Internal support: Innovation and commercialization initiatives
    - Faculty, staff and graduate student commercialization training
    - Technology acceleration grants and programming
    - One University – institutional collaboration
    - Tools and systems for service and efficiency

New Technologies, Licensing and Commercialization Outcomes

UMaine saw growth in the number of projects, licensing revenue and invention disclosures in FY17. Licensing revenue in FY18 through February 2018 is already much higher than for the entire year of FY17.

Number of Maine Projects since FY16

The University of Maine System continues to build on existing industry engagement mechanisms including company funded R&D and product development contracts. These projects provide companies with access to UMS faculty, staff and facilities. Projects with Maine companies with formal contracts totaled for each fiscal year:

- FY16: 233
- FY17: 271
- FY18: (through February 2018 only): 104

License Revenue

License revenue was $186,148 for FY17. License revenue to-date in FY 2018 exceeds $550,000. UMaine's technology pipeline has been filling up over the last 10 years, recognizing that many new technologies take an average of 10 years from lab invention to marketable technology. UMaine technology transfer manages more than 125 active commercialization projects, which range from initial patent application, ongoing R&D, early prototypes and field trials, initial market trials, and startup formation to licenses with mature companies.

Invention Disclosures and Patents

- In FY17, 26 notifications of new inventions were received and evaluated for technical readiness, commercialization potential and patentability, compared to 15 in FY16.
- 6 new U.S. patents were issued
- 5 new provisional patent applications were filed
- 7 non-provisional U.S. or PCT applications were filed

Commercialization Progress of RRF Funded Grants

UMaine OIED worked closely with the majority of RRF seed grant applicants and recipients. This work includes implementing intellectual property protection, developing commercial development plans, identification of commercial partners and leveraging additional investment funding from other sources in an effort to accelerate and advance commercial development.

The following are examples of which are progressing towards commercialization and leveraging RRF for industry engagement and business development.

Forest Products & Agriculture

2017 Seed Grant: Cross-Laminated Timber Demonstration Building Design and Cost Analysis
PI*:* James Beaupre
Engagement*:* Led to engagement with multiple land owners and municipalities; facilitated 2018 announcements by two companies, **LignaTerra** and **Smartlam**, to build CLT manufacturing facilities in Maine. Planning is underway for a Maine-based demonstration building to utilize manufactured CLT panels.
Advancement: Seed grant used as match for $455,000 EDA Mass Timber Commercialization Center (see table below). Both companies are progressing toward site selection and capital acquisition. UMaine continues to improve business attraction packages for CLT and other forest products in collaboration with communities and regional economic development leaders.

Biotechnology

2017 Seed Grant: Variable and High Porosity Nanocellulose Solid Forms for Biomedical Applications
PI: Michael Mason (UMaine Department of Chemical and Biological Engineering)
Engagement: UMaine School of Forest Resources, **Colorado Limb Consultants**
Advancement: Executive-level discussions began in January 2108 with large a device provider (facilitated by results of CWG portfolio assessment) on non-CNF devices of this type, with expectation of evaluation / sponsored research in CNF devices.

2015 Seed Grant: (relates to above): Development of additively manufactured highly porous implantable devices that promote post-surgical wound healing and a biological transcutaneous seal: Testing of implant material and internal pore geometry in a porcine model
PI: James Weber (Food and Agriculture, UMaine)
Engagement*:* **Stryker Orthopedic**
Additional Investment: Stryker Orthopedic in-kind funding
Advancement: Department of Defense proposal pending.

2017 Seed Grant: Cellulose Nanofibers: A Novel Adjuvant for Veterinary and Medical Applications
PI: Deborah Bouchard (UMaine, Aquaculture Research Institute)
Engagement: **Benchmark Animal Health**
Advancement: Currently under evaluation by Benchmark for a license option and funded research; UMaine will pursue funding and industry collaborations outside the Benchmark field of use in 2018.

2016 Seed Grant: Liquid-Infused Paper Substrates for New Biomedical Applications
PI: Caitlin Howell (Biomedical Engineering, UMaine)
Engagement: **SLIPS Tech**, **Sharklet Technologies**, **SAPPI Fine Paper North America**
Advancement: SAPPI sponsorship research; patentability and commercial assessment pending; RRF Accelerator participant.

Healthcare

2017 Seed Grant: Development of Intrac™: A Weight Bearing and Fitness Tracking System for Assistive Devices
Industry Sector: Healthcare
PI: Vincent Caccese (UMaine, Department of Mechanical Engineering)
Engagement: UMaine School of Social Work and Center for Community Inclusion and Disability Studies, USM Lewiston, Occupational Therapy Programs, **Mobility Technologies**
Advancement: Product line expansion for UMaine licensee and SBIR awardee Mobility Technologies.

2017 Seed Grant (relates to above): Eco-Sno Co-Design Project
Industry Sector: Healthcare
PI: Elizabeth DePoy (UMaine School of Social Work and Center for Community Inclusion and Disability Studies)
Engagement: UMF, Outdoor Recreation Business Administration, UMaine School of Social Work and Center for Community Inclusion and Disability Studies, UMaine Center on Aging. **Mobility Technologies**.
Advancement: Product line expansion for UMaine licensee and SBIR awardee Mobility Technologies.

Composites & Advanced Materials

2017 Seed Grant: Application of low-cost bio filled thermoplastics to 3D printed marine tooling
PI: Douglas Gardner (UMaine, Advanced Structure and Composite Center)
Industry Sector: Composites & Advanced Materials
Engagement: UMaine, School of Forest Resources, UMaine, ASCC, **Lyman Morse, Hinckley Yachts**, **Hodgdon Yachts**, **Sabre**, & **Thermwood Corporation**
Advancement: Used to leverage $300,000 from Oakridge National Laboratory; industry-sponsored projects continuing.

2017 Seed Grant: Turning Maine's Wood Fiber Resource into Renewable Food Packaging Systems
Industry Sector: Forest Products & Agriculture; Composites & Advanced Materials
PI: Mehdi Tajvidi (UMaine School of Forest Resources)
Engagement: UMaine, Department of Chemistry, UMaine ASCC, **Synthesis Group Minerals Technologies,** UMaine School of Food and Agriculture, USDA Forest Products Lab

Advancement: Leveraged grants from P3Nano, technology of interest to multiple licensees, including opportunities for Maine industry. Discussions underway.

2017 Seed Grant: Novel Fire Resistant Low Formaldehyde Emitting Fiberboard Panels Made from Deadwood or Wood Residuals and Nanocellulose
Industry Sector: Forestry/Composites
PI: Mehdi Tajvidi (Forest Resources, UMaine)
Engagement: Early discussions underway with a large global end-user, a Maine sawmill and large potential end-user licensees in building products and consumer goods.
Advancement: Patent application filed

2015 Seed Grant: Development of Structural Wood Plastic Composite Timber for Innovative Marine Applications
Industry Sector: Forestry/Composites/Aquaculture
PI: Douglas Gardner (Advanced Structures and Composites Center, UMaine)
Engagement: **Innovasea**
Advancement: Discussions underway to secure material supply agreement between Innovasea and a multi-national UMaine license & development partner.

Aquaculture

2015 Seed Grant: Energy Recovery Dehumidification (ERDH) for energy efficient increased drying capacity of high quality sea vegetables
Industry Sector: Marine/Aquaculture
PI: Peter Van Walsum (Chem & Bio Engineering/Forest Bioproducts Research Institute, UMaine)
Engagement: Nyle Corporation, Brewer Maine
Advancement: Discussions with three Maine sea vegetables companies. Nyle Corporation has expressed interest in developing commercial units for sale to Maine seaweed processors.

2015 Seed Grant: Sustainable Bio-conservation Technology for Aqua-feed Production and Waste Management
Industry Sector: Marine/Aquaculture
PI: Andrei Alyokhin (Biology and Ecology, UMaine)
Engagement: **Acadia Harvest**
Advancement: Additional Investment: Federal Small Business Innovation Research (SBIR) grants Phase I & II ($40,000 to UMaine) from USDA and NSF. Start-up/UMaine incubator tenant. Acadia Harvest is in the process of building an aqua-feed rearing facility to implement this technology in Waldoboro, Maine.

Environmental/Food Technologies

2015 Seed Grant: Prototype Development for Detection of Wine and Beer Spoilage Yeasts
Industry Sector: Food and Beverage, Environmental Science
PI: Laurie Connell (Marine Sciences, UMaine)
Engagement: Allagash Brewing, Portland, Maine; Constellation Brands, NY; Beacon Analytical System, Saco, Maine
Advancement: Additional Investment: Maine Technology Institute ($28,360); Constellation Consortium ($77,082). Partnership (license options) with Saco, ME, company Beacon Analytical Systems for future manufacturing of reagent kits. Estimated initial entry to market second half of 2018. Participating in the MIRTA RRF Accelerator.

TECHNOLOGY COMMERCIALIZATION: CELLULOSE NANOMATERIALS

Cellulose nanomaterials are a class of naturally derived particles with unique and highly desirable properties that have been known for decades, but due to the difficulty and expense of production, the materials have not been available to industry in quantities required for product development and commercialization. The UMaine Process Development Center generated a patent-pending solution to provide a cost-effective, scalable production technology for one class of these materials, cellulose nanofibrils (CNF). CNF is valued for its strength and barrier properties, among other characteristics, making it a perfect additive for pulp, paper and packaging applications. Other applications in composites, building materials, food, and biomedical applications are also in development. UMaine has supplied CNF to hundreds of companies and research institutions around the world and has licensed the production technology to several commercial partners, with more licenses underway for production and product applications.

Innovation & Commercialization Initiatives

OIED has been working on several initiatives to grow and accelerate innovation, industry engagement and commercialization activities at UMaine and at the other UMS campuses. These initiatives involve growing the pipeline of faculty, staff and students engaged in commercialization by providing them with the tools and training they need as well as by supporting acceleration of their projects. Several of the current and future, planned activities come from the efforts of the Commercialization Working Group (CWG). The improvements in these program areas are consistent with the UMS BOT priorities and the Research Reinvestment Fund Initiative. A summit was held in January 2018 to report out findings from the CWG and to present proposed activities.

Commercialization Training

Prior to the Research Reinvestment Fund initiative, commercialization training was provided in an ad hoc manner, mostly by working individually with faculty and staff who were involved in industry engagement and by encouraging them to attend incubator or community workshops.

Many faculty and staff are unsure of how to get started with commercialization and industry engagement opportunities. In order to grow activity, more faculty, staff and students need support and training to participate in industry engagement and commercialization opportunities, and thus OIED looked at ways to create a more systematic approach to training. OIED reviewed best practices at other universities to develop a comprehensive approach to meet the needs of UMS faculty and staff. Based on our experience in supporting faculty commercialization, in hosting workshops and events, and the survey of best practices, OIED has created a three-tiered approach with increasing levels of formality and commitment by the participants.

The first level is *Innovators MeetUp*, a regular, monthly, informal peer networking event. These discussions cover topics such as identifying commercial partners for your research, working with or creating a startup, licensing agreements, encouraging graduate student commercialization, and funding sources for projects. Some will include a guest such as a Maine Technology Institute representative or an industry representative to present research collaboration opportunities.

The second level is a more comprehensive training program. Working with the OVPRDGS office, OIED launched an Introduction to Commercialization workshop, encouraging RRF grant recipients as well as faculty and soft-money researchers hired within the past five years at UMaine to attend. In addition, OIED has developed a workshop series, UMaine/UMS Innovates, which will include two tracks: one for those who want to pursue a start-up company to commercialize their research and one for working with industry partners. Financial incentives are under development to encourage participation in the full series.

The third professional development level is the Maine Innovation, Research and Technology Accelerator (MIRTA). This initiative, described below, has the dual benefit of moving technologies closer to commercialization while also training faculty, staff and students in the commercialization process.

Timeline for activities:

Fall 2017:
Introduction to Commercialization workshop offered three times

Winter 2018:
MIRTA launched in January 2018 with first cohort of five RRF projects

Spring 2018:
Introduction to Commercialization provided at UMS campuses, first peer networking sessions

Summer 2018:
UMaine/UMS Innovates series starts with videoconferencing and local workshops

Commercialization Acceleration

As stated in its purpose, RRF provides infrastructure, planning and seed grants, and student assistantships in applied research and development that impacts Maine's economy and enables UMS faculty, professional staff and students to partner with private sector companies to accelerate commercialization. Figure 1 shows the distribution of seed grants awarded through 2018 along the research commercialization continuum.

However, the current timeline for commercialization can be long without focused attention to moving both the business/economic and research aspects of a project forward, and commercialization assistance has historically been provided on an individual project basis, which can be inefficient. UMaine OIED, working with the UMaine OVPRDGS office, has developed a new program within RRF to accelerate and streamline this process. RRF seed grant recipients, along with any recipients of undergraduate and graduate student awards, were invited to apply for participation in the accelerator pilot.

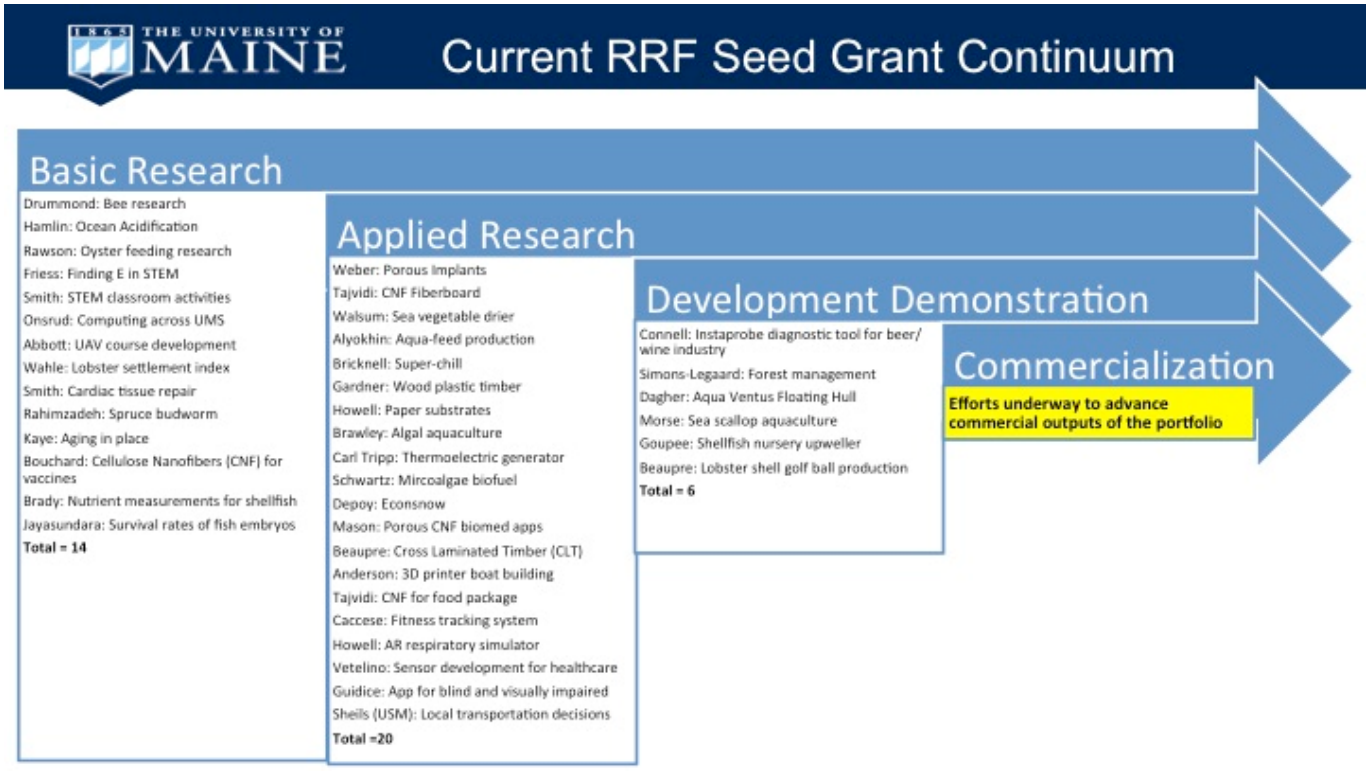


Figure 1- Seed grants through FY18 *Connell project was selected for funding in both the 1st and 4th rounds

MIRTA is designed to advance selected projects from basic and applied research and development stages to a stage that can realize measurable commercialization outputs in the short term. The accelerator is an intensive 16-week program and guides participants through customer discovery, market analysis, intellectual property analysis, and business model development that will result in a commercialization plan with a strategy for bringing their research to market.

The teams meet with OIED staff to develop a work plan and homework to make measurable progress toward commercialization every week. Through these weekly cycles, teams will determine how to position and develop their research for commercialization success. Each team is also matched with a group of mentors who provide advice at key points of the accelerator. At least one person from each team is required to dedicate at least 20 hours per week to participation in the accelerator and executing their commercialization work plan. RRF funds are used for prototyping, meeting with potential customers, market analysis and intellectual property protection. In addition, OIED staff worked with the Maine Technology Institute to open a special MTI seed grant round for the participants in the accelerator, using the RRF funds as match in their MTI proposals, which, if awarded, will allow the teams to continue their commercialization work after the accelerator ends. Possible outputs include starting a company, licensing to an existing company, or forming an extended research collaboration.

The current spring 2018 cohort consists of five teams:

Beverage (Wine and Beer) Spoilage Detector
Near real-time instrument for detection of microorganisms to avoid ruined product.
PI: Laurie Connell, School of Marine Sciences, with Connell Lab staff Corey Hirn and Leslie Astbury
RRF: 2015 Seed Grant and 2018 Seed Grant
Other funding*:* MTI seed grants, industry contract
IP: Patent application in process
Industry partners*:* Beacon Analytics, Saco, Maine; Constellation, NY; Allagash Brewing, Portland, Maine
Possible outcomes: license to industry partner

Low-Cost Geoinformatics for Forests
Near real-time mapping of forest characteristics for improved forest management.
PI*:* Erin Simons-Legaard, Kasey Legaard, Aaron Weiskittel, all from School of Forest Resources and staff from UMaine Advanced Computing Group
RRF: 2016 Seed Grant
IP: Software licensing
Industry relationships: Maine forest landowners
Possible outcomes: license to end users or start-up company

Microfluidics Platform Technology for Biomedical Applications
Lower cost and environmentally-friendly point of care diagnostics
PI: Caitlin Howell, biological engineering, with staff Matt Talbot, and students Amber Boutiette and Bailey Corliss
RRF: 2016 Seed Grant
Other funding: Industry contracts
IP: Patent analysis in process
Industry Partners: SAPPI, Westbrook, Maine
Possible outcomes: license to already identified existing Maine companies and a start-up

Early Diagnosis and Treatment of Peripheral Neuropathy
Device to detect neuropathy much earlier than current methods.
PI: Kristy Townsend, School of Biology & Ecology; Rosemary Smith, electrical engineering; students Magdalena Blaszkiewicz and Michael Small
RRF: Round 1 & Round 2 Undergraduate Assistantship
IP: Patent analysis in process
Industry relationships: Mount Desert Island Biological Laboratory, Bar Harbor, Maine
Possible outcomes: start-up company or license to an existing company

Bee Hive Activity Monitoring System
Monitoring system that is an early warning tool against colony collapse disorder.
PI: Nuri Emanetoglu, electrical engineering; Herbert Aumann, electrical engineering; Frank Drummond, School of Biology & Ecology; student Berkay Payal.
RRF: Round 1 Undergraduate Assistantship
Other funding: National Science Foundation
IP: Provisional patent application in process
Industry relationships*:* State of Maine apiarist
Possible outcomes: start-up company or license to an existing company

The combination of commercialization training, RRF awards and MIRTA (Accelerator Training) creates a stronger pipeline and pathway leading to increased ongoing industry R&D projects, commercialization and economic development. The pathway builds upon existing OIED business development and start-up supports including licensing, business incubation and entrepreneurship support (figure 2), with the goal of increased licensing, industry collaborations, and jobs created and retained.

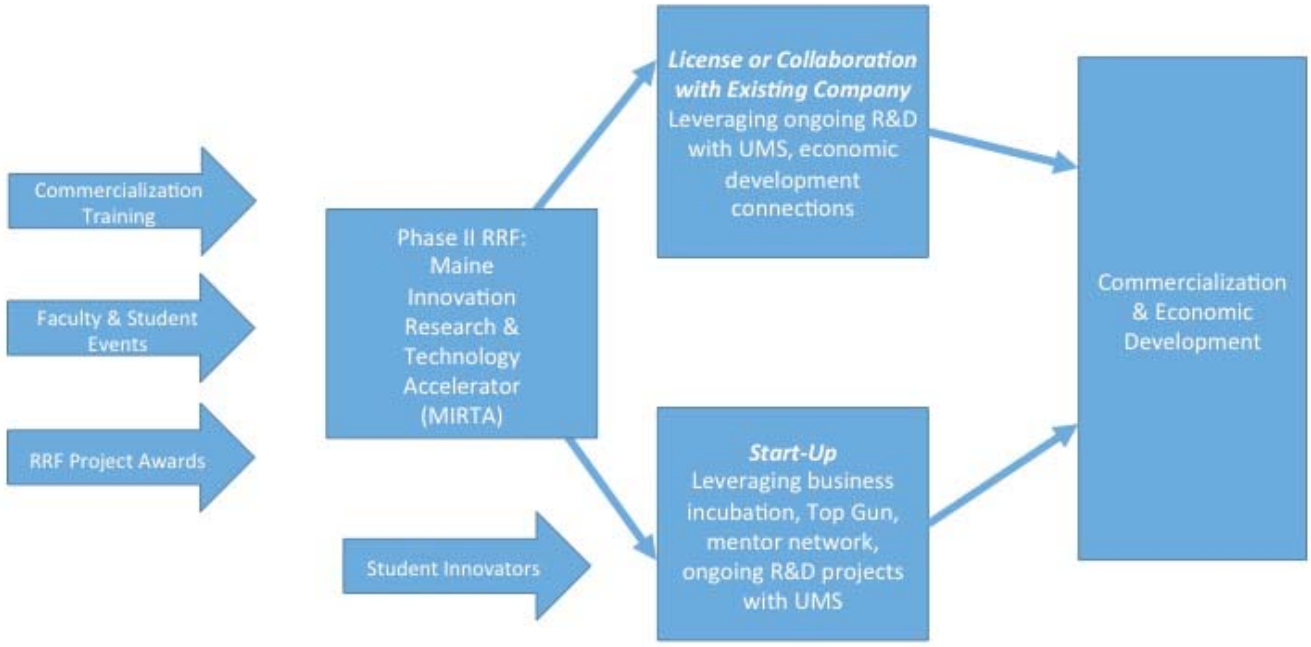


Figure 2 Research Commercialization Supports

Timeline for activities:

Fall 2017:
RFP for MIRTA released

Spring 2018:
MIRTA taking place January-May

Fall 2018:
RFP released and pre-proposal support for next round of MIRTA

Business Development Infrastructure – Responding to Maine's Most Pressing Needs and Opportunities

OIED has limited resources, but has built programs and access to UMS resources and assets. By connecting with the Maine economic development ecosystem including companies, trade associations, state agencies and local communities, OIED facilitates both opportunistic connections and strategic collaborations. Since the RRF program began, there have been several significant developments in the Maine economy that changed the climate and opportunity for business development. RRF operational funds supplement the existing resources to increase engagement and accelerate commercialization.

In addition, UMaine's Commercialization Working Group that was tasked to assess activities related to technology commercialization and industry engagement completed its work and identified several areas for improvements to grow industry engagement and commercialization. Because of these two developments, OIED has focused its efforts to grow the business development enterprise infrastructure on 1) sector partnerships and 2) systems and processes to grow industry engagement.

Forest Sector Focus

Maine Forest Economy Growth Initiative

The Maine Forest Economy Growth Initiative (MEFGI) is one of the most comprehensive economic development efforts in the history of Maine. With the closure of six pulp and paper mills in Maine in just a two-year period, Maine has seen not only the economic disaster from the businesses and jobs lost in those communities, but also the loss of markets for nearly 25% of the annual wood harvest. The Maine congressional delegation, working with the US Department of Commerce, initiated the Economic Development Assessment Team (EDAT) process during the summer of 2016 to develop opportunities and federal program assistance to revitalize the forest economy and the communities most affected by the closures, while pursing economic opportunities to take advantage of the available wood and the brownfield sites left from the closed mills. The EDAT process led the Maine Forest Products Council, the Maine Professional Loggers Association, the Maine Woodland Owners, the Maine Development Foundation and the University of Maine to form a unique collaboration between the private companies, trade associations and the public sector to develop a *Vision and Roadmap for Maine's Forest Economy.* Several EDA, USDA, DOE grants have been awarded in Maine and to UMaine to specifically focus on industry support, forest species supply, modeling emerging technology commercialization, workforce assessment, community and stakeholder engagement, and business attraction and recruitment. MEFGI is run by an industry-led executive committee and seven subcommittees that include private sector companies, trade associations, land owners, state agencies, and communities (see Appendix E for more information on the Vision and Roadmap for Maine's Forest Economy).

CLT R&D AND RRF EFFORTS HELP WITH BUSINESS ATTRACTION

In February 2018, two companies with a desire to manufacture Cross-Laminated Timber (CLT) announced plans to locate manufacturing in Maine, one in Millinocket and the other in a location to be determined. These opportunities were a direct result of multi-year R&D projects by UMaine's Advanced Structures and Composites Center, an RRF grant to develop a CLT demonstration project, a site-location information package developed by OIED staff, and the relationships developed between UMaine and these companies.

Since the Advanced Structures and Composites Center began researching mass timber innovations using Maine wood species, OIED business development staff helped convene the Roadmap advisory group and a variety of industry partners including construction companies, architects and sawmill owners to develop a strategy to attract CLT manufacturing to Maine to commercialize these technologies. Staff also worked with Maine & Company, the Department of Economic and Community Development, Our Katahdin and other partners to implement the strategy. The two announcements represent an estimated $50 million investment in the state with the potential to create 200 jobs and demonstrate how the process is working.

UMaine and USM are partners in the formation of this statewide project. UMS faculty and staff participate in all of the committees and our expertise is sought in all facets of the programs as illustrated in figure 3. UMS faculty and staff serve as PIs/Co-PIs on multiple grants funding different elements of the vision and roadmap for Maine's forest economy. In addition, EDA also funded a roadmap for Maine's Bioproducts Sector to advance biobased manufacturing, marketing Maine's biobased assets to investors in new technologies and processes, and providing technical assistance to Maine forest products manufacturers and users in the implementation of new biobased technologies. It is anticipated that the cost analysis, technology assessment and market research component of the project could place one or more mills into the production of cellulosic sugars, with 195 or more jobs created.

Phase one of the broader vision and roadmap for Maine's forest economy has focused on examining global market opportunities, wood fiber availability and transportation. Phase two will focus on analyzing subsectors of opportunity, combined heat power energy opportunities, evaluation and demonstration of emerging technologies, and developing a marketing plan for the business starts, expansion and attraction for Maine. The USM EDA University Center, managed by USM Center for Business and Economic Research (CBER) has been in place for more than 20 years. The most recent grant now includes UMaine as a formal partner, with an expanded mission to include technology transfer and industry support- focused on the forest sector. The Center partners with UMaine's School of Forest Resources, the Margaret Chase Smith Policy Center and OIED in this five-year grant awarded in 2016, focused on providing market analysis, workforce analysis and technology development support for the forest products industry.

The RRF efforts of UMaine including the Office Innovation and Economic Development and individual RRF grants to specific technologies are directed at this overall strategic effort.

UMS External Awards Aligned with this Forestry Sector Effort

Agency	Title	Applicant	UMS PIs	Amount
EDA	Bioproducts Roadmap	Biobased Maine & UMaine	Ward (UM), Pendse (UM), Wallace (USM)	$519,000
EDA	University Center	USM/UMaine	Wallace (USM), Ward (UM), Kelly (UM), Shaler (UM), Rubin (UM)	$582,000
EDA	Forestry Roadmap Phase I	UMaine & Maine Forest Products Council	Weiskittel (UM), Ward (UM), Beaupré (UM)	$996,000
EDA	Forestry Roadmap Phase II (pending)	UMaine & Maine Forest Products Council	Weiskittel (UM), Ward (UM), Beaupré (UM)	$1,000,000
MTI	Forestry Roadmap Phase I	UMaine & Maine Forest Products Council	Weiskittel (UM), Ward (UM), Beaupré (UM)	$250,000
MTI	Forestry Roadmap Phase II (pending)	UMaine & Maine Forest Products Council	Weiskittel (UM), Ward (UM), Beaupré (UM)	$250,000
EDA	Mass Timber Commercialization Center	UMaine	Edgar (UM), Herzog (UM), Beaupré (UM), Shaler (UM)	$455,000
DOE	Northeast Combined Heat and Power Center	UMaine & UNH	Dvorak (UM), Ellis (UM), Dunning (UM)	$2,000,000

RRF Awards Aligned with this Forestry Sector Effort

RRF Type	Title	PI and Partners
RRF Seed Grant 2017	Cross-Laminated Timber Demonstration	Beaupré (UM), Shaler (UM), Nagy (UM), Wallace (USM)
RRF Seed Grant 2017	Application of Low-Cost Bio Filled Thermoplastics to 3D Printed Marine Tooling	Gardner (UM), Crandall (UM), Anderson (UM), Lyman Morse, Hinckley Yachts, Hodgdon Yachts, Sabre, Thermwood Corporation
RRF Seed Grant 2017	Nanocellulose Forms for Biomedical Applications	Mason (UM), Tajvidi (UM), Colorado Limb Consultants
RRF Seed Grant 2017	Renewable Food Packaging (using nanocellulose)	Tajvidi (UM), Bousfield (UM), Gramlich (UM), Gardner (UM), Nayak (UM), Synthesis Group Minerals, USDA Forest Products Lab
RRF Seed Grant 2016	forEST Application	Simons-Legaard (UM), Legaard (UM), Weiskittel (UM), Maine Forest Service, US Forest Service
RRF Seed Grant 2016	Detecting and Assessing Spruce Budworm Forest Defoliation over Maine	Rahimzadeh (UM), Weiskittel (UM), Nelson (UMFK), University of New Brunswick, University of Quebec
RRF Seed Grant 2015	Structural Wood Plastic Composite Timber for Marine Applications	Gardner (UM), Han (UM), Innovasea, Stora Enso
RRF Seed Grant 2015	Fire Resistant, Low Formaldehyde Emitting Fiberboard	Tajvidi (UM), Bousfield (UM), USDA Forest Products Lab

Adding Capacity for Strategic Outreach and Rapid Response

Leveraging federal funding with state match is fundamental to increasing industry engagement and commercialization. Utilizing the EDA University Center grant and the EDA Mass Timber Commercialization Center grant, UMaine has hired a new forestry business development manager to reach out to industry partners to build R&D relationships, collaborate on emerging technology opportunities, and attract new business to the state. In addition, the DOE Combined Heat Power Combined (CHP) will offer real solutions to today's energy issues: supporting economic development through improved energy efficiency, increased energy resiliency, and lower energy costs. The team of experts at the University of Maine and the University of New Hampshire will be working together to promote cost-effective energy systems in both states.

Aquaculture/Marine Sector Focus - The Alliance for Maine's Marine Economy

In 2015, the Darling Marine Center and OIED used an RRF planning grant, *Building Campus and Community Connections to Advance Research Development and Communication for Maine's Marine Economy,* to organize a group of Maine's private and nonprofit marine and aquaculture related organizations to apply for a $7 million State of Maine Marine Jobs and Economy Bond. The outcome was the formation of the Alliance for Maine's Marine Economy, and the successful award of $7 million in funds matched by more than $7 million for capital construction and equipment located at both companies and non-profit organizations, including UMaine and UMM's marine field station, the Downeast Institute. The goal of the bond and the resulting Alliance is to spark economic development in the marine sector. Much like the forest sector losses of mills and the industry's response to alternative uses, the commercial fisheries sector has seen reduction in wild catches and catch limits on historically economically important species. At the same time, new markets and emerging technologies in the aquaculture sector are creating significant new opportunities for Maine's working waters and waterfronts.

The Alliance is a 10-year project with continually expanding participation of private companies. The Alliance is in the formative stage of developing a vision and road map for the Maine's marine economy parallel to the forest economy project. Currently, USM's EDA Center with trade associations and UMaine staff is leading a workforce assessment (See Appendix F for 2017 Highlights).

The Alliance builds on the long history of UMS support of the marine/aquaculture sector. This effort brings strategic focus to the historic and current activities and better positions UMS to respond to needs. UMS resources at Orono, Machias and the Darling Marine Center are seeing modernization at a critical time in this sector's evolution. Bond funded improvements at the Darling Marine Center and the UMM Downeast Institute directly support aquaculture businesses, while the new Orono-based FishLab will focus on aquatic animal health and disease challenges faced by both wild fisheries and aquaculture. In addition, the Focus Maine partnership has selected aquaculture as a target for their business development activities, which align with UMS aquaculture R&D and business incubation programs at the Darling Marine Center, the Center for Cooperative Aquaculture Research and the UMM Downeast Institute.

A review of RRF funded R&D and commercialization shows a concentration of efforts for this sector as well.

AQUACULTURE R&D AND RRF EFFORTS HELP WITH BUSINESS ATTRACTION

In early 2018, two companies announced their plans for commercial production of Atlantic Salmon using land-based recirculation systems. This technology is very similar to the land-based technology utilized at the UMaine Center for Cooperative Aquaculture Research in Franklin, Maine. Both companies have reached out to UMaine for assistance with workforce and future R&D. RRF funded grants are already addressing needs such as alternative feed production and rapid detection of egg fecundity. The two companies plan to employ hundreds, and the combined investments in Bucksport and Belfast are expected to near $750 million.

RRF Seed Grants Aligned with this Aquaculture/Marine Sector Effort

RRF Type	Title	PI and Partners
RRF Seed Grant 2018	Supporting Maine's Sea Scallop Aquaculture Industry	Morse (UM)
RRF Seed Grant 2018	Shellfish Nursery Upweller	Goupee (UM)
RRF Seed Grant 2018	Lobster Golf Ball Production	Beaupré (UM)
RRF Seed Grant 2018	Predicting Bad Eggs: Survival Rates of Fish Embryos for Aquaculture	Jayasundara (UM)
RRF Seed Grant 2017	Cellulose Nanofibers for Veterinary & Medical Applications (aquaculture)	Bouchard (UM), Bricknell (UM)
RRF Seed Grant 2017	Improving Maine's Coastal Infrastructure Upgrade Decisions	Brady (UM), Strong (UM), Wilson (USM), Maine DEP, Portland Water District, Friends of Casco Bay
RRF Seed Grant 2016	Advancing Algal and Invertebrate Aquaculture	Brawley (UM), Kogson (UM), Redmond (UM), Maine Coast Sea Vegetables, Maine Fresh Sea Farms, Wholesale Marine Worms
RRF Seed Grant 2016	Forecasting Value of American Lobster Settlement Index	Wahle (UM), Beal (UMM), Brady (UM), NOAA
RRF Seed Grant 2015	Effects of Ocean Acidification on Reproduction in American Lobsters	Hamlin (UM), Bouchard (UM), McRae (UM), MDI Biological Laboratory
RRF Seed Grant 2015	Increased Drying Capacity of High Quality Sea Vegetables	Van Walsum (UM), Nayak (UM), Belding (UM), Martinez (USM)
RRF Seed Grant 2015	Sustainable Aqua-Feed Production and	Alyokhin (UM), Bernard (UM), Acadia Harvest
RRF Seed Grant 2015	A Novel Approach to Prevent Super-Chill in Atlantic Salmon	Bricknell (UM), Bouchard (UM), USDA National Cold Water Marine Aquaculture Center, Cooke Aquaculture
RRF Seed Grant 2015	Development of Tools for Measuring the Costs of Feeding and Food Utilization in Eastern Oysters	Rawson (UM), University of New England, Maine Aquaculture Innovation Center

Serving all sectors with small resources requires efficiency

Both of these statewide initiatives have required focused attention from UMaine's and USM's industry engagement and economic development efforts and have led to opportunities to accelerate the technology commercialization in these sectors. It is notable that RRF grants to UMS institutions see a concentration of forest and marine applications. The concentration of economic development partners and industry participation involved in these two initiatives allow OIED to perform business development more efficiently and robustly.

Systems and Processes to Grow Business Development

Enhanced Industry Engagement

The contracting process is often a source of delay and tension between universities and industry partners. By Q2 2018, UMaine will launch a new process for engaging with industry that provides information upfront and a menu of options appropriate for the project. In addition, information will be made available to both industry and faculty that clearly explains the process and expectations for both parties. This new model of engagement is expected to reduce the time required to negotiate and execute projects, and increase the satisfaction of internal and external collaborators.

Integrated, Accessible Real-Time Information Management System

OIED is in the process of selecting a new system for customer relationship management (CRM) software to streamline industry project management, intellectual property management and business development. Faculty and staff who work on industry projects will be able to view their projects and track contacts with Maine companies. In addition, OIED will be able to use this information to reach out strategically to companies who already have a UMS connection to share information on other UMS R&D resources that may be of assistance.

These contacts, along with the targeted list of companies from historical activity that was developed last year, future MTI grant recipients and applicants, and companies in the targeted forestry products and aquaculture/marine sectors form the core of OIED's business outreach strategy. Formal outreach is underway to promote three types of potential interactions: supporting company R&D needs, marketing UMS technology transfer and developing workforce through internships and fellowships.

Timeline for activities:

Fall 2017:
Phase one implementation of forestry sector vision and roadmap, formal outreach with forestry sector, outreach with aquaculture sector to identify needs, OIED review of new systems for industry engagement

Spring 2018:
Formal outreach program to MTI grant recipients and companies with existing relationships, implementation of new industry contract templates, forestry business development staff hired and ongoing business outreach

Summer/Fall 2018:
Implementation of CRM business development system, Phase two coordination of forestry sector innovation and economic development, ongoing coordination of aquaculture sector innovation and economic development

Outreach to UMS Campuses

As part of the One University initiative, OIED has been tasked with expanding technology transfer and commercialization capacity throughout UMS and expanding industry engagement and partnerships. UMaine and the University of Southern Maine entered into a memorandum of understanding for shared business development services and commercialization initiatives between the campuses. Over the last year, the collaboration has led to regular, systematic intercampus collaboration on economic development initiatives. USM provided dedicated office space to OIED in March 2017, with the expectation that the collaboration will continue and expand.

Under USM direction, OIED assumed responsibility for USM intellectual property management, patent licensing, industrial contracting and activities related to increasing and enhancing commercialization at USM. This generated efficiencies by eliminating a ½ FTE and made additional services and resources available to USM. It also increased the awareness of both teams of the capabilities and resources available at each campus, and introduced opportunities to promote collaboration among faculty. Activities this year include the migration of the USM intellectual property portfolio and related agreements into the OIED IP management system, and assistance with USM contract negotiation and execution as requested. Additionally, OIED conducted outreach to a number of USM faculty to promote commercialization of their work and to facilitate the next stages of product development. Armed with a better understanding of USM and UMS needs, a goal for spring and summer 2018 is to identify staffing requirements to address business development needs at USM.

To date, outreach at the other UMS campuses has focused on innovation internship opportunities. An effort to help grow and create jobs across the state of Maine, the Innovate for Maine Fellows program helps early-stage, scaling and growing innovation-based companies throughout Maine connect with talent while at the same time demonstrating to students that there are opportunities to do meaningful and exciting work in the state. This program provides students from all of the System campuses with Innovation Engineering training, exposure to entrepreneurial events, and connects them with Maine's most exciting, growing companies and business leaders. The program prepares students to collaborate with companies on

innovation projects that accelerate company growth and give students a paid, meaningful, hands-on internship experience. To date, the program has served 168 companies with 162 Fellows representing 29 colleges and universities.

In spring 2018, OIED staff is working with several faculty and staff across the System to recruit students for the Innovate for Maine program. Additionally, staff is visiting some of the campuses to engage with students and faculty around industry partnerships, with a focus on internship opportunities. In addition, we are exploring partnerships with USM to provide the Innovate for Maine model for new internship programs they are developing.

OIED staff met with the Chief Academic Officers of the UMS campuses in summer 2017 to share information about how OIED can directly support innovation efforts at their campuses, including industry contracting and intellectual property management. In addition to continued general outreach and internship engagement, future plans include connecting with UMS faculty who participated in projects that received RRF awards to help explore commercialization opportunities for their work. In addition, there are plans to offer training and workshops on all campuses. OIED also plans to leverage the new UMS Academy to provide online training for faculty, staff and students at the UMS campuses.

Timeline for activities:

Summer 2017:
Meeting with Chief Academic Officers regarding innovation support

Spring 2018:
Intern recruiting and outreach visits on campus, Introduction to Commercialization provided at UMS campuses

Summer/Fall 2018:
Plan for regular outreach activities/support developed with UMA, UMF, UMFK and UMPI; innovation and commercialization workshops provided both on campus and via new UMS Academy system

Conclusion

This report of activities is obviously much broader than the activities supported by RRF funding. The RRF funding provides a tool and extra resources to focus on priorities. Challenges remain for the System to continue to grow in the research and economic development space as outlined in the report of the Commercialization Working Group activities. While the initial RRF program focused on research & development in the seven MEIF sectors plus healthcare, business and tourism, it is clear that economic development requires attention to workforce development as well.

The UMaine Office of Innovation and Economic Development has been charged with collaborating with USM to expand commercialization and private sector engagement. As USM has been assessing their strengths and capabilities, they have introduced the concept of "social innovation" into the lexicon, which has stimulated robust discussion on how to identify and accelerate these projects. This topic was discussed at the January 2018 Innovation Summit hosted by Chancellor Page.

UMS provides OIED with $200,000 year in RRF funds to support staff for technology transfer, commercialization and coordination to other campuses. The actual expenditures were less than that amount, with unspent funds returned to the System. Use of these funds going forward requires an updated strategy mindful of USM's social innovation concept, needs of the other campuses, sector strategies and priorities identified to grow commercialization and industry engagement.

III. Infrastructure Support to the Research Enterprise Initiative

Grant Development Office

The Grant Development Office (GDO) is a unit within the OVPRDGS that provides proposal development support for large grant applications; high profile programs with system wide and statewide impact; signature areas of excellence; proposal resubmissions; and early career faculty grant submissions. Services to faculty and researchers include grant writing support, review and critique of proposal narratives, funding opportunity searches and alerts, project management of inter-institution proposal writing teams, and conducting a variety of grant writing workshops. The GDO aims to enhance grant-seeking activities and facilitate internal and external collaborations to promote a culture of research excellence and extra-mural funding success. RRF funding supports three FTE professional staff positions to provide hands-on support to faculty pursuing external funding and building research, development, and commercialization initiatives. As part of the program enhancement activities that the RRF Advisory Board approved for Years 4 & 5, a Large Center Development Associate positon was created to increase grant writing activity for multi-year multi-million dollar research commercialization grants involving multiple internal and external stakeholders.

Examples of grant writing projects currently underway include: $8,000,000 proposal to the Harold Alfond Foundation to support the Engineering Education and Design Center; $12,500,000 proposal to NSF in April 2018 for an INCLUDES scale up project related to increase diversity in STEM; and a $20,000,000 proposal to NSF EPSCoR in August 2018 in collaboration with Bigelow Labs, other UMS campuses, and private sector partners to investigate environmental DNA (eDNA) in the context of Maine's economic future.

The coordination of the RRF competitive grant program is facilitated by GDO staff. This includes the management of the InfoReady grant portal that houses program announcements, receives proposal submissions from UMS researchers, and enables RRF Advisory Board members to review and score applications. GDO staff also consult with applicants to review their internal proposals and work with grantees in their pursuit of the RRF program requirement of securing follow on grants.

GDO Testimonials

"You both brought a level of expertise and counsel that left me impressed and confident in our collective ability to meet the stringent requirements demanded by the NSF...From an organization that would not have been able to pull this off without your help, thank you."
~ Fred Brittain, Associate CIO-Multi-Campus Operations: UMS, COO: University of Maine at Farmington

"The Grant Development Office was an integral partner in the successful 2017 proposal to the US Department of Commerce's Economic Development Administration (EDA). This award, received by UMaine in September 2017, will enable much needed waterfront improvements to expand research, workforce development and business incubation capacity at UMaine's marine laboratory, Darling Marine Center. GDO staff worked closely with faculty and staff at the DMC and allied units to pitch the proposal concept to the EDA program officer in fall 2016, and shepherded the proposal through to successful submission in March 2017. This six-month process required coordinating science and support staff statewide. Without the GDO, successful submission of a proposal of this magnitude - $1.5M request, matched by $1.5M in state and internal funds - would have been much more difficult."
~Dr. Heather Leslie, Director, Darling Marine Center

"As a new faculty member, the Grant Development Office has been invaluable in helping me navigate the submission process in nearly every federal grant I have written so far. Luke Doucette and Jason Charland took the time to understand my research interests and capabilities when I first arrived, and since then have frequently contacted me with calls that fit my research program. With these RFPs or others that I find, Luke has always been available to help me understand the dense language and numerous requirements when I need it, and even drafts packages for me with all the components I will need to write, saving me hours of time that I can then spend improving upon my proposal itself. He then reads through what I have written and makes helpful comments, often using his own extensive grant writing experience, particularly with the Department of Defense, to add more targeted language or streamline a concept description.

Beyond this, the workshops that the team has put on for us faculty to increase our knowledge of the various federal funding mechanisms has definitely increased and diversified the number of proposals that I have submitted. I appreciate having such a proactive Grant Development Office on campus, and am certain that my productivity is significantly increased because of them."
~Dr. Caitlin Howell, Assistant Professor of Chemical and Biomedical Engineering, University of Maine

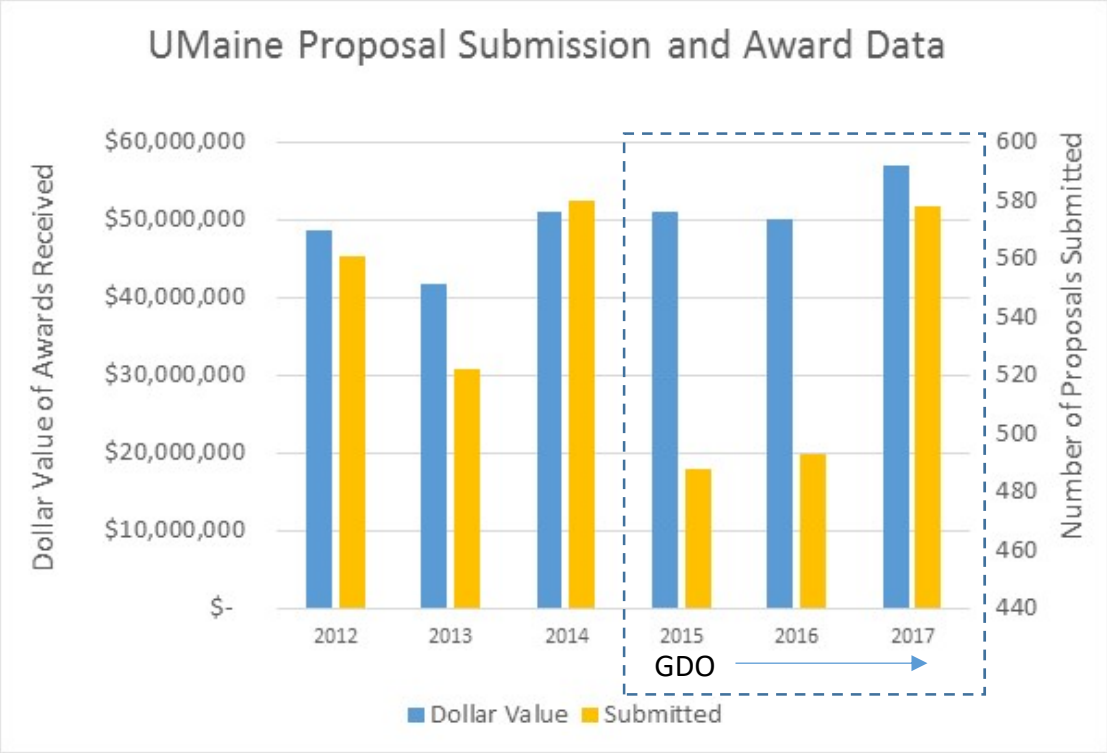
"Thanks so much, you folks are awesome. I've written dozens of small grants in the past and it is generally like submitting to a "dark hole". Not so with your office, and much appreciated!"
~Dr. Patsy Thompson Leavitt, Assistant Professor of Nursing, University of Southern Maine

Proposal Submissions
With regard to impact on grant proposal submissions, since its inception in FY2015 the GDO has provided consultative assistance to faculty and researchers in the submission of 183 proposals to sponsors requesting a total of $146,772,619. Of the proposals submitted, 44 are still pending a decision and 29 have been funded for a total $24,344,279.

The following list represents notable funded grants the GDO staff had a direct hand in supporting during FY2017/2018:

1. "Technology Maturation of Wireless Harsh-Environment Sensors for Improved Condition-Based Monitoring of Coal-Based Power Generation", US Department of Energy/National Energy Technology Laboratory, PI: Mauricio Pereira da Cunha, Award: **$2,500,000**
2. "Investing in Waterfront Infrastructure to Power Maine's Economy Through Applied Research & Development, Workforce Training, and Business Incubation", US Department of Commerce Economic Development Administration, PI: Heather Leslie, Award: **$1,500,000**
3. "Interstitial Fluid Analysis: Feasibility Study for Use in Threat Exposure Monitoring", Department of Defense - Defense Threat Reduction Agency, PI: Rosemary Smith, Award: **$2,100,000**
4. "CAREER: Sound Production by Flow Induced Elastic Wave with Application to Phonation", National Science Foundation, PI: Xudong Zheng, Award: **$513,000**
5. "Youth Aspirations and Labor Market Perceptions in Rural Communities", USDA Agricultural and Food Research Initiative, PI: Mindy Crandall, Award: **$458,000**
6. "Collaborative Research: Predicting Controls of Partitioning Between Dissimilatory Nitrate Reduction to Ammonium (DNRA) and Dinitrogen Production in Marine Sediments", National Science Foundation, PI: Jeremy Rich, Award: **$480,000**
7. "Maine Mass Timber Commercialization Center", US Department of Commerce Economic Development Administration, i6 Regional Innovation Strategies Program, PI" Steve Shaler, Award: **$1,000,000**

Although many factors affect proposals submitted and awarded, since the GDO's inception both Total Dollar Value of Awards Received and Number of Proposals Submitted have trended in a positive direction.



Grantsmanship Training

The GDO has conducted 41 separate training sessions which have provided grant writing and professional development services to 784 faculty, staff, graduate and undergraduate students. Training and professional development offerings include workshops on writing competitive proposals to selected Federal programs as well as outreach and support for faculty commercialization training, new researcher orientation, guest lectures, and facilitation of grant writing groups. A sampling of trainings offered is included below.

GDO co-sponsored NSF Grant Writing Workshop

Faculty Commercialization Workshops: In collaboration with staff from OIED, the GDO provided 3 separate introductory workshops on research commercialization during the fall of 2017. The purpose of these workshops was to increase awareness of the different technology transfer pathways and services on campus that research faculty and staff can leverage to commercialize their research. A total of 29 people attended these workshops (19 Faculty, 9 Staff, 1 Graduate Student). Expansion of this offering to USM is planned.

Grants 101 Workshops: The GDO partners with the Fogler Library to conduct a two hour basic grantsmanship training called "Grants 101". The workshop is offered twice per semester covering such topics as: grant seeking strategies, how to analyze an RFP, and grant writing basics. Since FY2015, the GDO has provided a total of 17 workshops, which has included training to 367 members of the UMaine research community (164 Faculty, 119 Staff, 79 Graduate Students, 5 Undergraduate Students). Results from this project were presented at a national conference: Charland, J.C. and Bonnet, J.L. (2017). *Enhancing Grantsmanship Training Through Departmental Partnerships.* Concurrent session presented at the National Council of University Research Administrators (NCURA) Pre-Award Research Administration Conference, San Diego, CA, March 9, 2017.

USDA/AFRI Foundational Program Grant Writing Workshop: In partnership with Interim Associate Dean for Research, Jessica Leahy (College of Natural Sciences, Forestry, and Agriculture) the GDO has conducted multiple grant writing workshops and writing group sessions focused on the USDA AFRI Foundational Program. Early career faculty were targeted for this training to ensure their familiarity with this complex funding program. The workshop was inspired by Dr. Sonny Ramaswamy's (Director of the National Institute of Food and Agriculture) visit to UMaine encouraging the university to submit more grants to the foundational program. To date, 2 workshops and 2 writing sessions have been conducted and have trained 29 individuals (26 Faculty, 2 Staff, 1 Graduate Student). This training project will be presented at an upcoming regional NCURA conference in New Hampshire (Charland, J.C., Leahy J., and Doucette, L. (2018) *Preparing Early Career Faculty for Grantwriting Success for USDA NIFA/AFRI's Foundational Program.* Concurrent session presentation accepted for the NCURA Region 1 Spring Meeting, Portsmouth, NH, April 29 – May 2, 2018).

NIH Workshops: The GDO has conducted 2 workshops in 2017 focused on NIH programs designed to increase programmatic knowledge and agency mission requirements among the UMaine/UMS research community. As a result of these first workshop meetings, the GDO has also facilitated a follow-on writing group to provided further grant writing and development assistance to faculty pursuing NIH funding targets. A total of 50 faculty have been part of these workshops.

Department of Defense (DoD) Workshop and Outreach: In 2017, the GDO conducted the first ever workshop at UMaine focused on DoD funding opportunities. The workshop goals were designed to increase awareness of the different agencies within the DoD, what their respective funding programs included, how to craft a competitive proposal, and the importance of relationship building with program managers. A panel consisting of prior DoD awardees was available to share their experiences working with the military, as well as taking questions from the participants. This workshop was presented to a total of 34 attendees (21 Faculty, 7 Staff, 5 Graduate Students, and 1 Undergraduate Student).

NSF CAREER Workshops: Each spring, the GDO offers an NSF CAREER workshop to eligible UMaine junior faculty in disciplines supported by NSF. The workshop provides participants with an overview of the CAREER program, Broader Impacts activities on campus, and hosts a panel of successful NSF career recipients at UMaine. Since 2015, there have been 5 CAREER training workshops that have included 61 Faculty, and resulted in 25 submissions (this does not include current cohort of 14), and 4 successfully funded (Gill and Townsend 2017; Zheng 2016; Putnam 2015). The NSF CAREER award is one of the most prestigious NSF grants that faculty can receive and provides 5 years of dedicated funding linking the faculty's research and teaching together.

Office of Research Administration

The Office of Research Administration is a unit within the OVPRDGS that manages and administers extramural grants and contracts for UMaine, UMM, and UMFK. During FY 2017 a total of $56,926,782 was received from extramural sponsors, a 13% increase over that of FY 2016 ($50,369,625). The number of proposals submitted was significantly greater than the previous year (573 vs. 500 in FY 2016, a 15% increase). Indirect cost return for FY 2017 was considerably higher than FY 2016 ($8,768,079 vs. $8,041,760). UMaine is consistently ranked among the top 125 public universities for research through the NSF Higher Education Research and Development (HERD) Survey. UMaine's Carnegie Classification remains in the High Research Activity category.

Research Reinvestment Funds currently support three FTE staff and one graduate student at ORA. These positions detailed below enhance ORA's organizational capacity to process proposals, to review and negotiate new awards and to administer new and existing awards. This support reduces the administrative burden while increasing the investigator's ability to implement sponsored activities at the UMaine Orono, UMaine Machias and UMaine Fort Kent campuses. In addition, the UMaine ORA provides administrative support to select UMPI and UMS awards.

Megan Dill, a veteran UM employee, was hired in September, 2016 as a Grant Accountant. Megan's primary responsibility is entering into the MaineStreet Financial System the award budgets that are mutually agreed upon by UM and sponsors, giving investigators quicker access to sponsor funds. She has begun cross-training on the proposal review and submission process, thereby increasing ORA's ability to respond to high demand during sponsor driven proposal submission deadlines.

Shannon Johnson, a veteran UM employee, was hired in December, 2016 as Post Award Support Associate. She provides post award support to faculty and staff, including the processing of cost transfers, no cost extensions, change of investigator requests, reporting and award closeout. Her support allows the investigators to focus less time on administrative functions and more time on performing research.

Leisa Preble is an Administrative Specialist supporting both the Office of Research Administration and Research Compliance. Her continued support increases ORA and ORC efficiency by allowing staff to focus more on research administration and compliance related tasks and less on daily administrative tasks.

Dominic Piacentini, Graduate Assistant in ORA, works as a Grant & Contract Administrator and assists in the review and negotiation of grant and contract offers funded through extramural support. This includes the initial review through project account set-up. He also serves on internal ORA committees and is involved in special projects related to drafting guidance and policy. The importance of Dominic's role in award review cannot be understated. Awards are now processed in a timelier manner, which equates to project accounts being set-up sooner resulting in the office's ability to meet faculty and staff service expectations.

Associate Vice President for Research and Graduate Studies

David Neivandt, UMaine Associate Vice President for Research and Graduate Studies is supported 0.25 FTE by RRF funds to develop interdisciplinary and/or multidisciplinary research collaborations, serve as the faculty liaison for the ME EPSCoR office, administer faculty-related issues regarding graduate education, assist in moving key research and development areas forward, and make research connections between UMS campuses.

Activity highlights:

- Serves on the Operations Committee of the RRF Advisory Committee and co-led the development and implementation of the Seed Grant, Planning Grant, Graduate, Undergraduate Assistant, Phase II Accelerator, and Interdisciplinary Undergraduate Research Collaborative Grant competitions
- Serves as Executive Director of Maine's current NSF EPSCoR Track 1 award Sustainable Ecological Aquaculture (SEANET), a 5 year, $20M project (FY2014-2019)
- Aiding in the development of a new NSF EPSCoR Track 1 application in collaboration with Bigelow Laboratories with a thematic focus on Environmental DNA (eDNA). The proposal will be for a 5 year, $20M award (FY2019-2024).

Appendix A: RRF Advisory Board Members

Name	Title	Organization
Brian Beal	Professor of Marine Ecology	University of Maine at Machias
Martha Bentley	Director of Innovation Infrastructure	Maine Technology Institute (MTI)
Seth Berry	Vice President for International Business Development	Kennebec River Biosciences
Jason Charland (ex-officio)	Director of Grant Development	University of Maine
Doug Gardner	Professor of Forest Operations, Bioproducts and Bioenergy	University of Maine
Kody Varahramyan (Operations Committee)	Vice President for Research and Dean of the Graduate School	University of Maine
Mike Kinnison	Professor of Evolutionary Applications, School of Biology and Ecology	University of Maine
David Neivandt (Operations Committee)	Associate Vice President for Research	University of Maine
Kris Sahonchik	Director, Cutler Institute for Health and Social Policy	University of Southern Maine
Terry Shehata	Senior Policy Associate: Research and Economic Development/ MEIF Coordinator	University of Southern Maine
Rebecca Van Beneden	Director of the School of Marine Sciences	University of Maine
James Ward (Operations Committee)	Vice President of Innovation and Economic Development	University of Maine

Appendix B: Phase II Accelerator Grants

Principal Investigator	Partners	Project Title
Connell, Laurie (Marine Science, UMaine)	Maine Technology Institute	RRF Phase II Acceleration of beverage spoilage yeast test to market
Emanetoglu, Nuri (Electrical and Computer Engineering, UMaine)	Maine Technology Institute, Maine Agricultural Center	Bee Hive Activity Monitoring System: Phase 2
Howell, Caitlin (Chemical and Biomedical Engineering, UMaine)	Sappi North America	Patterned Release Paper Microfluidics as a Platform Technology in Biomedical Applications: Customer Discovery
Simons-Legaard, Erin (Forest Resources, UMaine)	UMaine Advanced Computing Group	Investing in Maine's future forest with high-value, low-cost geoinformatics
Townsend, Kristy (Biology and Ecology, UMaine)	Mount Desert Island Biological Laboratory	Early Diagnosis and Treatment of Peripheral Neuropathy
Visselli, Anthony (ASCC)	U.S. Department of Energy, National Renewable Energy Laboratory, Cianbro, Stantec	Design of Floating Wind Turbine Concrete Hull

1. Title: RRF Phase II Acceleration of beverage spoilage yeast test to market
PI: Connell, Laurie
Abstract: Our handheld, point-of-use (POU) instrument will provide the only near-instantaneous solution to detect certain environmental microbes from complex matrices with minimal sample preparation. The system is based on prior-art developed at UMaine funded through Federal, State, and Private sources. The initial target application is the detection of spoilage yeasts during wine or beer production, which provides an exceedingly attractive opportunity to commercialize this device. We have two strong private partners, Constellation Consortium (CC), as an end user, and Maine-based Beacon Analytical Systems (BAS) as a kit manufacturing and distribution partner. Potential sales for the wine spoilage yeast detection are estimated at $1million globally within five years. The prototype employs a new detection scheme that is ~200x more sensitive than previous methods and has the added benefit of using fewer reagents. An additional and highly desirable quality is discrimination between live-dead organisms, critical for wine and beer production management. The project requires further assistance in the steps to move toward market and production. This project will focus on 1) determination of appropriate licensing agreements; 2) test and assign appropriate disposable kit components; 3) develop supply streams; 4) determine kit price; 5) build prototype (already designed) for Beta testing; 6) Complete paperwork required for patent submission. Work 1-3 will be done in coordination with BAS.

2. Title: Bee Hive Activity Monitoring System: Phase 2
PI: Emanetoglu, Nuri
Abstract: A Doppler radar based bee activity monitor has been developed, which is placed closed to the hive entrance, without disturbing the bees. Based on a 10.5 GHz motion detector, the unit measures the total energy in the return signal due to Doppler signals from flying bees and records it. The activity indices derived from these measurements are compared with past activity levels of all hives in the apiary, as well as weather conditions, to infer bee colony health. The studies of Summer 2017, funded with an RRF Undergraduate Assistantship and an NSF REU grant, have proven the concept. An invention disclosure was filed with UMaine at the end of November. Two undergraduate students (one electrical engineering, one biology) are writing their honor's theses on the design and verification of the prototypes. The prototypes cost less than $100/unit, highly competitive with commercial systems, which cost more than $500. To bring this prototype to market, the following need to be done: (a) Market research and customer discovery, identifying potential customers' needs; (b) put instrument into a form factor that is usable by bee keepers, as identified in (a); (c) the radio links with the base station need to be completed; (d) secure funding for commercialization, once an appropriate strategy (start-up vs. licensing) is identified.

3. Title: Patterned Release Paper Microfluidics as a Platform Technology in Biomedical Applications: Customer Discovery
PI: Howell, Caitlin
Abstract: The purpose of this project is to identify and contact potential customers to explore and identify the most promising pathway(s) to the integration of release-paper microfluidic platforms into current and future point-of-care (POC) medical diagnostic devices. An ongoing industry-university collaboration between the Release Paper Group at Sappi North America and the Howell Lab in the Department of Chemical and Biomedical Engineering has identified

the breakthrough potential of patterned release paper, currently used primarily to add texture to fabrics, as a low-cost method of producing microfluidic channels for a wide range of applications in healthcare and pharmaceuticals. The next steps will be to reach out to potential customers such as IDEXX, Alere, and Katahdin Analytical Services to further develop this technology in a market-compatible direction. The project stands to significantly benefit Sappi North America (which currently employs 1,300 Mainers) and will enable the company to expand into a growing market and will demonstrate how academic-industrial partnerships can be used to help local industries innovate and grow.

4. Title: Investing in Maine's future forest with high-value, low-cost geoinformatics
PI: Simons-Legaard, Erin
Abstract: The forest products industry contributes nearly $8.5 billion annually to Maine's economy, and by some estimates this contribution could more than double with value-added processing, biodiversity offsets, forest carbon trading, and other ecosystem service credits. Realization of this potential will require adaptation of forest management strategies. Forest managers in Maine have identified a lack of spatial information on both timber and non-timber forest resources as a barrier to the planning and prioritization of management actions. Satellite remote sensing data are capable of providing near-real time mapping of forest attributes that are key to management decisions. The utility of available commercial products is limited, however, due to cost of production and reliability shortcomings. We have developed machine learning algorithms for application in remote sensing and geoinformatics that are highly adaptive and uniquely capable of addressing characteristic shortcomings of other methods. With computationally efficient software implementations that are currently under development, we plan to produce better data at lower cost than is currently available through commercial vendors. Our machine learning approach can produce a variety of products of high relevance to forest management problems, including tree species composition; intensity and time since last harvest/disturbance; estimates of volume, biomass, and carbon; and additional ecosystem services like wildlife habitat suitability. These products would provide an array of options for annual sales, and a number of forest products companies have already expressed interest in their purchase.

5. Title: Early Diagnosis and Treatment of Peripheral Neuropathy
PI: Townsend, Kristy
Abstract: We propose the creation and commercialization of a transdermal, microelectrode array for measuring nerve conduction of free nerve endings in the skin during the progression to diabetic neuropathy, in order to provide earlier and non-invasive detection and diagnosis; as well creation of an accompanying microneedle device for subdermal drug delivery using microfluidics, in order to provide therapeutic treatments to halt and reverse the neuropathy. Currently, peripheral neuropathy, or the dying-back of nerves in the skin and distal extremities, is a devastating condition affecting around 50% of diabetics, those treated with certain drugs (chemotherapy agents, antibiotics), and that also increases with aging. This painful and uncomfortable condition is met with no therapeutic options to halt or reverse the neurodegeneration. In addition, diagnosis of the condition occurs quite late in the disease process when large myelinated nerves die-back. Thus, earlier diagnosis and improved therapies to re-grow peripheral nerves would be a major advancement in the treatment of peripheral neuropathies, and that is the goal of the current project.

6. Title: Design of Floating Wind Turbine Concrete Hull
PI: Anthony Viselli (Advanced Structures and Composites Center, UMaine)
Sector: Engineering, Composite Technology
Partners: U.S. Department of Energy, National Renewable Energy Laboratory, Cianbro, Stantec
Abstract: The RRF funding will be used to complete final design engineering efforts of two VolturnUS floating concrete hulls that support 6MW offshore wind turbines. Offshore wind is Maine's largest untapped renewable resource with 156 GW of capacity within 50 miles of shore. Floating turbine technology is required to harness this huge resource because of the deep waters in the Gulf of Maine. The New England Aqua Ventus project consists of two x 6 MW units 2.5 miles South of Monhegan Island. This will be the first floating wind project in the US, and will position Maine to lead in a global industry expected to exceed $146 Billion in the US in the next decade1. The unique VolturnUS concrete hull technology developed and patented by UMaine has been shown to achieve a competitive commercial cost of electricity to 7.7 cents/kWh. The proposed project will leverage a $37M DOE grant in 2019 in addition to $123M of private investment to construct the demonstration project. The project will connect to the grid in 2020, create 1,500 Maine jobs, and allow the construction of larger commercial farms which will potentially bring billions of dollars to Maine and create thousands of Maine jobs.

Appendix C: Round 4 Seed Grants

Principal Investigator	Partners	Project Title
Beaupre, James (Foster Center for Student Innovation, UMaine)	Cape Seafood	Lobster Shell Golf Ball Production and Initial Beta Market Launch
Connell, Laurie (Marine Sciences, UMaine)	Beacon Analytical Systems, Constellation Consortium	Development Toward Commercialization of a Rapid Test for Beverage Spoilage Yeasts
Dagher, Habib (Advanced Structures and Composites Center, UMaine)	U.S. Department of Energy, National Renewable Energy Laboratory, Cianbro, Stantec	Maine-Based Construction and Assembly of Aqua Ventus Floating Hull
Giudice, Nicholas (Vemi Laboratory, UMaine)	Iris Network	Gaming Application for Multimodal Skill Acquisition (GAMSA): Improving Navigation and Independence for Blind and Visually Impaired People
Goupee, Andrew (Mechanical Engineering, UMaine)	Aquaculture Innovation Center, Pemaquid Oyster Company, Darling Marine Center	Optimization and Automation of a Shellfish Nursery Upweller
Howell, Caitlin (Chemical and Biomedical Engineering, UMaine)	Zephyrus Technology, Denham Ward (Maine Medical Center Research Institute)	Augmented reality respiratory simulators for combined visual and haptic medical training in low-resource settings
Jayasundara, Nishas (Marine Sciences, UMaine)	Cooke Aquaculture, Center for Corporate Aquaculture Research	Predicting bad eggs: developing a high throughput respirometry system to portend growth, hatching, and survival rates of fish embryos for the aquaculture industry
Morse, Dana (Marine Sciences, UMaine)	Maine Aquaculture Cooperative, Rachel Lasley-Rasher (University of Southern Maine), Hugh Cowperthwaite (CEI)	Supporting the development of Maine's sea scallop aquaculture industry
Sheils, Martha (New England Environmental Finance Center, University of Southern Maine)	MaineDOT, GEI Consultants Inc.	Local Transportation Decisions for a Resilient Future
Vetelino, John (Electrical and Computer Engineering, UMaine)	Saint Joseph's Hospital, James Moreira (UMaine Machia), Steven Quackenbush (UMaine Farmington)	Sensor Development/Adaptation to Improve Healthcare: A Partnership Between the University of Maine System and Saint Joseph's Hospital

1. Title: Maine-Based Construction and Assembly of Aqua Ventus Floating Hull
PI: Habib Dagher (Advanced Structures and Composites Center, UMaine)
Sector: Engineering, Composite Technology
Partners: U.S. Department of Energy, National Renewable Energy Laboratory, Cianbro, Stantec
Abstract: The RRF funding will be used to develop construction procedures which allow for the 8,000 tons VolturnUS floating concrete offshore wind turbine hulls to be produced in Maine. Offshore wind is Maine's largest untapped renewable resource with 156 GW of capacity within 50 miles of shore. Floating turbine technology is required to harness this huge resource because of the deep waters in the Gulf of Maine. The New England Aqua Ventus project consists of two x 6 MW units 2.5 miles South of Monhegan Island. This will be the first floating wind project in the US, and will position Maine to lead in a global industry expected to exceed $146 Billion in the US in the next decade. The unique VolturnUS concrete hull technology developed and patented by

UMaine has been shown to achieve a competitive commercial cost of electricity to 7.7 cents/kWh. The project will connect to the grid in 2020, create 1,500 Maine jobs, and allow the construction of larger commercial farms.

2. Title: Augmented reality respiratory simulators for combined visual and haptic medical training in low-resource settings
PI: Caitlin Howell (Chemical and Biomedical Engineering, UMaine)
Sector: Biomedical, Biotechnology
Partners: Zephyrus Technology, Denham Ward (Maine Medical Center Research Institute)
Abstract: Simulation-based learning is becoming a newly adopted standard for training medical professionals, immersing students in complex 'real-life' scenarios to facilitate clinical knowledge application and hands-on skill development. However, current training simulators are expensive, prohibiting access to those with limited budgets and forcing an end-user compromise between price and realism. In this project, we will begin to address this need by developing a novel low-cost augmented-reality (AR) simulator for remote medical training of pediatric respiratory conditions. Building off a patent-pending, low-cost simulation system developed and undergoing commercialization by Zephyrus Simulation, LLC, we will develop an augmented reality overlay to enhance simulation realism and add new layers of information. The smart phone-compatible AR overlay will consist of a virtual patient with interactive display, in which students can select through a variety of anatomical and physiological modules while dynamically interacting with the patient, providing context for pediatric respiratory pathologies and 'real-life' patient scenarios. By leveraging the expertise of bioengineering, virtual reality, spatial learning, nursing, and medical simulation experts, our team will create a new set of affordable, portable and information dense teaching tools accessible to all types of medical trainees, particularly those in low-resource settings.

3. Title: Supporting the development of Maine's sea scallop aquaculture industry
PI: Dana Morse (Marine Sciences, UMaine)
Sector: Aquaculture
Partners: Maine Aquaculture Cooperative, Rachel Lasley-Rasher (USM), Hugh Cowperthwaite (CEI)
Abstract: Maine's opportunity in the ear-hanging technique of scallop aquaculture is clear: a large domestic market for scallops, a need to diversify our working waterfronts along with strong brand recognition of Maine seafood. Results from field trials of scallop ear-hanging production show great promise. Further, there is an established network of fishermen, shellfish farmers, scientists and regulators, extension and others that are poised for expansion. The principal bottleneck in this expansion of scallop farming in Maine is access to specialized equipment; specifically a drill and a scallop washer for biofouling control. This project will address the commercialization goals of the RRF by providing existing and new producers with access to such equipment through cooperative-use agreements, providing producers with technical support and extension services, and allowing farmers to bring product to market.

4. Title: Optimization and Automation of a Shellfish Nursery Upweller
PI: Andrew Goupee (Mechanical Engineering, UMaine)
Sector: Aquaculture, Engineering
Partners: Aquaculture Innovation Center, Pemaquid Oyster Company, Darling Marine Center
Abstract: Shellfish aquaculture is rapidly growing in the State of Maine. Oyster aquaculture alone in Maine has increased nearly five-fold from 2011 to 2016, with harvest values of approximately $6 million as of 2016. However, shellfish farming could be significantly improved through advancement of the nursery technologies currently being employed in Maine shellfish farming. Achieving rapid growth of juvenile shellfish during the nursery phase is critical for the economic success of the shellfish aquaculture operation, as stunted growth can lead to greater time and resources spent nurturing the shellfish and an increased time to get the animals to market. Current rearing of juvenile shellfish is undertaken by using a simplistic device, called an upweller, which passes seawater containing ambient phytoplankton through a layer of juvenile shellfish in order to feed the animals. To that end, this work aims to design, develop and test a low-cost, 'smart' upweller that provides optimal flow patterns for feeding the shellfish, in addition to making adjustments in response to monitored flow rates and food content in order to maximize shellfish growth.

5. Title: Lobster Shell Golf Ball Production and Initial Beta Market Launch
PI: James Beaupre (Foster Center for Student Innovation, UMaine)
Sector: Aquaculture, Manufacturing
Partners: Cape Seafood
Abstract: In an effort to accelerate the commercialization of the lobster golf ball technology developed at the University of Maine, a start-up enterprise will be nurtured and built at UMaine. This technology takes advantage of waste lobster shell from the Maine lobster processing industry. Such a start-up will increase the technology value by presenting a complete turnkey business built around the technology and significantly decrease the startup risk by establishing the initial production and sales systems. In addition, the project will be used to build new jobs and provide the workforce development training to sustain and grow the enterprise**.**

6. Title: Predicting bad eggs: developing a high throughput respirometry system to portend growth, hatching, and survival rates of fish embryos for the aquaculture industry.
PI: Nishad Jayasundara (Marine Sciences, UMaine)
Sector: Aquaculture
Partners: Cooke Aquaculture, Center for Corporate Aquaculture Research
Abstract: Aquaculture is a multibillion-dollar global industry that is valued at ~$130 million dollars in Maine. Atlantic salmon farming is the highest valued (over $50 million) finfish aquaculture in the State. Maine salmon is a major contributor to the national salmon production and has tremendous potential to be a leader in the billion dollar global salmon industry. However, a critical bottleneck in salmon and other finfish aquaculture industry is the unpredictability of embryo survival rates. Additionally, wild Atlantic salmon are reared in hatcheries as part of this Endangered Species' recovery plan. Early prediction tools to portend egg survival and larval growth rates can dramatically improve early-life resource investment strategies and broodstock selection in culturing of these fish. Here, we propose to utilize a high-throughput respirometry approach utilizing a low-cost instrument we have built to measure embryo metabolic rates as a predictor of embryo survival and rapid-growth. The positive link between embryonic metabolic rate (MR) with embryonic survival and growth is well established in various fish species. In collaboration with industry partners, we aim to measure MR in salmon embryos and link to fitness measures (hatching, survival, and growth rates) in eggs from commercial and conservation hatcheries.

7. Title: Sensor Development/Adaptation to Improve Healthcare: A Partnership Between the University of Maine System and Saint Joseph's Hospital
PI: John Vetelino (Electrical and Computer Engineering, UMaine)
Sector: Biotechnology
Partners: Saint Joseph's Hospital, James Moreira (UMM), Steven Quackenbush (UMF)
Abstract: The goal of this proposal is to develop a partnership between University of Maine System researchers and Saint Joseph's Hospital to develop/adapt and commercialize sensors to detect/monitor diseases and/or medical conditions to improve public healthcare. A pilot project focused on motion sensors for an aging population was chosen to initiate the UMS-SJH partnership. Personnel in this project include SJH physicians, associates, and caregivers, UMS researchers in sensors and aging, an entrepreneurship professor in business, and selected undergraduate and graduate students. Prototype motion sensors will be designed and fabricated at UM and evaluated at SJH. Since sensor "friendliness" is critical to the project's success, SJH will obtain input from aging urban population groups while UMF and UMM will obtain input from aging rural population groups. It is anticipated that commercial products will result with economic benefits to UMS and the greater Bangor area. In that regard, Fil-Tech, LLC has shown an interest in licensing the sensor technology associated with motion sensors for an aging population.

8. Title: Gaming Application for Multimodal Skill Acquisition (GAMSA): Improving Navigation and Independence for Blind and Visually Impaired People
PI: Nicholas Giudice (Vemi Laboratory, UMaine)
Sector: Healthcare Technology, It, Computer Science
Partners: Iris Network

Abstract: One of the biggest challenges to educational, vocational, and social success for blind and visually impaired individuals is the inadequacy of current tools for teaching travel skills and technologies supporting independent navigation. This problem impacts the 30,000 people in Maine (and 12 million across the country) with visual impairment and contributes to the unacceptably low educational and vocational success of this demographic. This project proposes a novel solution for training of O&M skills using an innovative gamification approach called GAMSA. BVI clients will reinforce and practice O&M skills learned from physical O&M trainers by playing the GAMSA app when instructors are not physically available. The core gaming app will be developed at the VEMI Lab and evaluated by O&M professionals at the Iris Network.

9. Title: Local Transportation Decisions for a Resilient Future
PI: Martha Sheils (New England Environmental Finance Center, USM)
Sector: Climate Science, Policy
Partners: MaineDOT, GEI Consultants Inc.
Abstract: It is a challenge for Maine's municipalities to respond to long-term impacts of sea level rise and increased precipitation that threaten their economic viability. This pilot project develops a technical assistance process to help municipalities make informed decisions about their transportation infrastructure, and explores how the framework can be developed into a marketable service for Maine's environmental technologies sector. The objective is to bring the state-of-the art decision making framework called Transportation Risk Assessment for Planning and Project Delivery tool that was developed by the Maine Department of Transportation for state roads, bridges and culverts, to the municipal level. The TRAPPD framework provides a new approach to making risk and priority decisions about transportation infrastructure by incorporating ecological, hydrologic, and structural characteristics of the roads, bridges and culverts. The tool assesses the risks that could adversely affect projects' budgets, timing and safety, making it a useful tool to help field engineers decide which assets to upgrade, and why. Working with one municipality, New England EFC and its partners will assist municipal staff with the application of the tool, examine its efficacy to augment existing planning actions, gauge its acceptance and value to the municipality, and examine the market value of the service for delivery by Maine's environmental technologies sector.

10. Title: Development Toward Commercialization of a Rapid Test for Beverage Spoilage Yeasts
PI: Laurie Connell (Marine Sciences, UMaine)
Sector: Food Science
Partners: Beacon Analytical Systems, Constellation Consortium
Abstract: Our handheld, point-of-use instrument will provide the only near-instantaneous solution to detect certain environmental microbes from complex matrices with minimal sample preparation. The system is based on prior-art developed at UMaine funded through Federal, State, and Private sources. We have completed experiments and market research that must be accomplished before market consideration and commercialization. The initial target application is the detection of spoilage yeasts during wine or beer production, which provides an exceedingly attractive opportunity to commercialize this device. Potential sales for the wine spoilage yeast detection are estimated at $1million globally within five years. The prototype employs a new detection scheme that is ~200x more sensitive than previous methods and has the added benefit of using fewer reagents. An additional and highly desirable quality is discrimination between live-dead organisms, critical for wine and beer production management.

Appendix D: Round 3 Student Grants

Track 1 – Graduate Assistantships

Principal Investigator	Partners	Project Title
De Urioste-Stone, Sandra (Forest Resources, UMaine)	Penobscot Nation, University of New Hampshire	An Interdisciplinary Approach to Explore Risks Associated with Winter Ticks
Gardner, Allison (Biology and Ecology, UMaine)	UMaine	Impacts of climate change on the geographic range expansion of ticks and tick-borne disease in Maine
Hayes, Daniel (Forest Resources, UMaine)	UMaine Fort Kent	Evaluating LiDAR Tools for Large-area Enhanced Forest Inventory Applications in Maine
Hejrati, Babak (Mechanical Engineering, UMaine)	Eastern Maine Medical Center	A Novel Robotic Glove for Hand Assistance of Older Adults in Activities of Daily Living
Nayak, Balunkeswar (Food and Agriculture, UMaine)	US Forest Service, Twin Rivers Paper	Value-addition of cellulose nanofibers (CNF) by developing food packaging materials and assessment on food safety – II
Nelson, Peter (Biological and Environmental Sciences, UMaine)	UMaine	Visible and infrared imaging spectroscopy for high resolution mapping and health assessment of Maine's forest and agricultural resources
Nelson, Sarah (Forest Resources, UMaine)	US Geological Survey, National Park Service	Connecting the dots: determining temporal mercury flux via aquatic insects to avian predators in Acadia National Park
Ross, Lauren (Civil and Environmental Engineering, UMaine)	Cianbro, Engineer Research and Development Center (Army Corps)	Design and Model Testing of Concrete Modular Floating Breakwaters for Increased Coastal Protection
Roth, Amber (Forest Resources, UMaine)	UMaine Presque Isle, UMaine Fort Kent, Irving, Department of Inland Fisheries and Wildlife	Sustainable management of commercial forests for wood products and a globally threatened bird species

1. Title: An Interdisciplinary Approach to Explore Risks Associated with Winter Ticks
PI: De Urioste-Stone, Sandra (Forest Resources, UMaine)
Sector: Ecology, Biology
Partners: Penobscot Nation, University of New Hampshire
Abstract: Our proposal develops an interdisciplinary approach to understand whether perceived zoonotic disease risk in key stakeholder groups aligns with realized transmission risk from an iconic wildlife reservoir (moose) in Maine. This study will use a "One Health" model (i.e., "an integrated, holistic approach to understanding the intersections between disease dynamics, environmental drivers, livelihood systems and veterinary and public health") to analyze health risk and risk perceptions of winter tick (Dermacentor albipictus) zoonotic pathogens in moose (Alces alces). Moose carry several pathogens that cycle between canids and ungulates; some, including tick-borne diseases, can pose risks to people and livestock. Keeping recreationists (e.g., hunters) and other stakeholder groups accurately informed about health risks is critical for public health and responsible wildlife management. The economic significance may be one of the most pressing ones in Maine, given the important of moose for tourism (moose draw visitors to and within Maine for viewing and hunting purposes) and to Wabanaki tribes.

2. Title: Impacts of climate change on the geographic range expansion of ticks and tick-borne disease in Maine
PI: Gardner, Allison (Biology and Ecology, UMaine)

Sector: Ecology, Climate Change
Partners: UMaine
Abstract: The goal of our project is to investigate causal ecological and physiological mechanisms by which climate may alter human risk of exposure to tick-borne disease in Maine, and integrate these data with climate change projections for the State of Maine to develop predictive tick-borne disease risk maps. The blacklegged tick first appeared in Maine during the 1980s, and its geographic range expansion has been associated with a concomitant increase in the incidence of tick-borne disease. Recently, 58% of Acadia National Park visitors identified increased risk of exposure to vector-borne disease as a top concern among the potential consequences of climate change. This study will assess the current geographic distribution of the blacklegged tick and its key hosts. We will conduct field-based assays to investigate the effects of temperature patterns (e.g., cold shocks versus extended periods of cold) on off-host tick survival. Finally, we will develop a predictive spatial model of Lyme disease risk by integrating the field-collected data with climate change projections for the State of Maine.

3. Title: Evaluating LiDAR Tools for Large-area Enhanced Forest Inventory Applications in Maine
PI: Hayes, Daniel (Forest Resources, UMaine)
Sector: Forestry, Computer Science
Partners: UMaine Fort Kent
Abstract: Maine's economy depends heavily on its forest resource base: it accounts for over 6% of the total GDP and has an estimated total annual economic impact of $8-10 billion. The sound, scientifically-based management of the forest resource requires a significant investment in inventory programs. While traditional, ground-based inventory is expensive and imprecise, recent advances in remote sensing technology are revolutionizing the way in which forests are measured and monitored. In particular, Light Detection and Ranging, or LiDAR, technology allows for the development of high quality, Enhanced Forest Inventory (EFI) information over large areas efficiently and at lower cost relative to field-based methods. There is a fast-growing need for leveraging the growing collection of LiDAR data across Maine for usable and reliable EFI data products to support management and decision-making in the state's forest industry. A significant obstacle has been that basic, supporting research on the topic is lacking in three main areas, including remote sensing, forest mensuration and computer science disciplines. The goal of this project is to evaluate available LiDAR data sets and modeling techniques for their comparative efficacy in generating geospatial EFI information products useful for sustainable forest management in Maine.

4. Title: A Novel Robotic Glove for Hand Assistance of Older Adults in Activities of Daily Living
PI: Hejrati, Babak (Mechanical Engineering, UMaine)
Sector: Biotechnology, Aging
Partners: Eastern Maine Medical Center
Abstract: One of the major hand functions necessary for performing activities of daily living (ADL) and having independence in life is object manipulation, which is defined as the ability to grasp, lift, and release an object. The ability to grasp and release can deteriorate due to aging or aging-related conditions such as Parkinson disease, stroke, and arthritis. It has been reported that after the age of 60 years, there is a rapid decline in hand-grip strength by as much as 20-25%, and hand response latency increases about three times in older adults. The objective of this proposal is to design and fabricate a novel multi-fingered soft robotic glove for performing ADL by using Ionic Polymer-Metal Composites materials for the first time. The proposed soft robotic glove will be portable, unobtrusive, maneuverable, and capable of generating sufficient power to assist with grasping and releasing tasks in real-world settings such as home and community.

5. Title: Value-addition of cellulose nanofibers (CNF) by developing food packaging materials and assessment on food safety – II
PI: Nayak, Balunkeswar (Food and Agriculture, UMaine)
Sector: Forestry, Advanced Materials
Partners: US Forest Service, Twin Rivers Paper
Abstract: This application proposes funding request for research-based training of a RRF supported Doctoral student at UMaine. The student will continue engage in research and training in cross-disciplinary areas including food process engineering, cellulose nanocomposites and polymer science. The research component of this

proposal focuses on the antimicrobial behavior of CNF modified packaging materials in reducing bacterial adhesion and biofilm formation However, the complete and long-term scope of this research is to design CNF based films and coatings for various types of food products (low, medium and high moisture) to improve shelf-life during storage.

6. Title: Visible and infrared imaging spectroscopy for high resolution mapping and health assessment of Maine's forest and agricultural resources
PI: Nelson, Peter (Biological and Environmental Sciences, UMaine)
Sector: Forestry, Information Technology
Partners: UMaine
Abstract: Our goal is to integrate ground-based spectral scanning/chemical analysis and data mining of hyperspectral images into a pipeline for detection of specific, user-generated targets (e.g. specific plants, pathogens, stress signals, etc..) for Maine's economically important natural resource sectors and elsewhere for competitive research applications. A graduate student would improve this hyperspectral image processing capacity using existing imagery synergized with our current spectroradiometric and UAV-image acquisition capacity. The image processing would focus target sites with existing imagery from NASA contacts connected to key economically important crops, specifically forest resources flown by G-LIHT last year. The student would help develop new and better algorithms for mapping, utilizing to the very sensitive cameras and co-located additional datasets with high resolution reference data, which enables detecting problems (e.g. insects or disease) or positive signals (exceptional growth) in which managers could then act to either mitigate disease or stress or expand certain treatments found to be exceptionally beneficial.

7. Title: Connecting the dots: determining temporal mercury flux via aquatic insects to avian predators in Acadia National Park
PI: Nelson, Sarah (Forest Resources, UMaine)
Sector: Marine Science
Partners: US Geological Survey, National Park Service
Abstract: Mercury (Hg) is a globally distributed contaminant that biomagnifies through food webs and is highly toxic to fish, wildlife, and people, leading to fish consumption advisories in every US state. As a result of its widespread distribution, Hg is a serious concern for protected areas such as many national parks in the US, including Acadia National Park. The Dragonfly Mercury Project (DMP) enlists park staff or community partners who lead teams of citizen scientists in collection of dragonfly larvae for analysis in national parks, providing data for national-scale assessment of this neurotoxic pollutant. Although spatially extensive, the scope of the current research does not allow us to answer a key question for resource managers and human consumers: Do elevated concentrations of Hg in dragonfly larvae translate into their foodwebs and does this vary in time? This proposed research would broaden the temporal dimension of this research, determine the effects of life-history on concentrations in dragonfly larvae, and provide the opportunity to link with a project investigating bird diets and macroinvertebrates at Acadia National Park, which is scheduled to begin in summer 2018.

8. Title: Design and Model Testing of Concrete Modular Floating Breakwaters for Increased Coastal Protection
PI: Ross, Lauren (Civil and Environmental Engineering, UMaine)
Sector: Engineering, Advanced Materials
Partners: Cianbro, Engineer Research and Development Center (Army Corps)
Abstract: Sea level rise combined with stronger and more intense storms enhances coastal vulnerability. Confounding this general pattern, the Gulf of Maine is the most rapidly warming body of water on the planet, making Maine's coast uniquely susceptible to storm damage in the future. This study aims to investigate the design and testing of modular mobile concrete floating breakwater systems for coastal infrastructure protection from increased wave hazards generated by extreme windstorms along the US coast. Floating mobile breakwaters are an attractive engineering method to mitigate storm hazards as they are less intrusive to the environment and offer a more cost effective adaptation measure for coastal protection in a changing climate as sea levels rise in the near future.

9. Title: Sustainable management of commercial forests for wood products and a globally threatened bird species
PI: Roth, Amber (Forest Resources, UMaine)
Sector: Ecology, Forestry
Partners: UMaine Presque Isle, UMaine Fort Kent, Irving, Department of Inland Fisheries and Wildlife
Abstract: The Rusty Blackbird is a species of special concern in Maine and is globally threatened, having declined by more than 85% since the 1970s. Rusty Blackbirds nest in stunted or regenerating spruce-fir (softwood) stands in or near shallow wetlands across northern North America. Our goal is to provide guidance to landowners managing commercial forests with Rusty Blackbird breeding habitat. Our primary objective is to evaluate the effects of a range of silvicultural practices, from naturally regenerated stands to intensively managed planted stands, on Rusty Blackbird nest site selection and nest survival. This research fills an important gap in our understanding of best management practices for Rusty Blackbird breeding habitat in intensively-managed commercial forests.

Track 2 – Undergraduate Assistantships

Principal Investigator	Partners	Project Title
Beal, Brian (Marine Sciences, UMaine Machias)	Downeast Institute, Darling Marine Center	Field Trials to Examine Growth and Survival of a New Bivalve Culture Candidate in Maine: Razor clams, Ensis leei
Chapkis, Wendy (Women and Gender Studies and Sociology, University of Southern Maine)	All Art Media	Querying the Past Student Research Assistantship
Flanagan, Sara (Education and Human Development, UMaine)	UMaine	Responsive Reading: Improving Reading in Adolescents and Adults, Track 2
Gordon-Messer, Susannah (CI2Lab, University of Southern Maine)	N/A	Beyond the Tides: An Environmental Augmented Reality Game
Howell, Caitlin (Chemical and Biomedical Engineering, UMaine)	Zephyrus Simulations, LLC	Haptic Feedback Sensor Suite for AR-Enhanced Medical Simulators
Legaard, Kasey (Forest Resources, UMaine)	UMS Advanced Computing Group	Leveraging machine learning and high-performance computing to deliver the spatial data needed by Maine's forest industry
McGreavy, Bridie (Communication and Journalism, UMaine)	UMaine	Interdisciplinary Research for Decision Making about Dams in Maine
Roe, Judith (Biology, UMaine Presque Isle)	Department of Inland Fisheries and Wildlife	Undergraduate Capstone: Genetics of Freshwater Snails of Northern Maine
Strong, Aaron (Marine Sciences, UMaine)	Sea Grant, NOAA	Assessing the Economic Value of Maine's Coastal Tourism: The Ecosystem Services across Acadia National Park

1. Title: Field Trials to Examine Growth and Survival of a New Bivalve Culture Candidate in Maine: Razor clams, Ensis leei
PI: Beal, Brian (Marine Sciences, UMaine Machias)
Sector: Aquaculture
Partners: Downeast Institute, Darling Marine Center
Abstract: Thanks to funding over the past two years from the Maine Technology Foundation and Maine Aquaculture Innovation Center, razor clams, Ensis leei, have become a new culture candidate in Maine. Work at UMM's Marine Science Field Station at the Downeast Institute (DEI) has progressed on the hatchery phase of this deep-burrowing, suspension-feeding bivalve. Because this species commands $4-5 per pound from wild harvests, we are interested in undertaking commercial-scale production of juveniles. We are proposing pilot-scale nursery and field studies during May-August 2018 to examine factors affecting growth and survival of cultured razor clam

juveniles. The proposed work will be conducted in eastern Maine with our partner, the Downeast Institute and supported by a student researcher. The undergraduate student selected from the University of Maine at Machias will become a SEA Fellow, and participate in the public research forum to be held at the Darling Center in August 2018.

2. Title: Querying the Past Student Research Assistantship
PI: Chapkis, Wendy (Women and Gender Studies and Sociology, University of Southern Maine)
Sector: Northeast Humanities, New Media
Partners: All Art Media
Abstract: The purpose of this project, "Querying the Past: Maine LGBTQ History," is to preserve and make available the often-hidden history of LGBTQ Maine. The project involves the use of a variety of media including digital applications. Over the past two years, working with the Jean Byers Sampson Center for Diversity in Maine/USM Special Collections, and community partners, the project has collected two dozen audio oral histories with key figures in Maine's LGBTQ community and more than two hours of filmed material. In addition, student researchers have explored and analyzed material cultural artifacts in the Sampson Center's LGBTQ Collection. All of these materials are (or are being) digitized with an eye to using them as content in future online applications**.**

3. Title: Responsive Reading: Improving Reading in Adolescents and Adults, Track 2
PI: Flanagan, Sara (Education and Human Development, UMaine)
Sector: Education, Computer Science
Partners: UMaine
Abstract: Secondary students with or without a disability may lack the needed reading skills to exit high school prepared for competitive employment and daily living (e.g., paying bills, reading directions). The National Assessment of Education Progress suggests that approximately 28% of 8th graders in Maine are not meeting basic grade-level standards. Maine recognizes adult illiteracy as a state-wide concern for employment. Illiterate adults earn between 30 and 42% less than literate adults, are less likely to make gains in employment or have meaningful employment, and are less likely to go onto postsecondary education. Reading skills can be improved and supported through instructional technology, such as literacy software. The objective of this research is to develop Responsive Reading to remediate beginning reading in secondary students and adults using an age-appropriate software. Existing apps and software for beginning reading are heavily targeted towards young children in theme (e.g., Sesame Street) and features (e.g., excessive sound and animation).

4. Title: Beyond the Tides: An Environmental Augmented Reality Game
PI: Gordon-Messer, Susannah (CI2Lab, University of Southern Maine)
Sector: Climate Change, Computer Science
Partners: N/A
Abstract: Beyond the Tides is a student developed, location based, augmented reality (AR) game that educates Mainers on effects of climate change on oceans including rising sea levels, rising temperatures and increased ocean acidification. In a chose-your-own adventure style game, players take on different occupations (ex. builder, city planner, lobster boat captain) to see how their job decisions, economic futures and lifestyles will be changed as a result of climate change.
During the game, players interact with virtual characters, objects, and data as they move around their real-world location. At the end of the game, the player is provided a list of community engagement ideas, projects and local organizations working to combat climate change.

5. Title: Haptic Feedback Sensor Suite for AR-Enhanced Medical Simulators
PI: Howell, Caitlin (Chemical and Biomedical Engineering, UMaine)
Sector: Biotechnology
Partners: Zephyrus Simulations, LLC
Abstract: Simulation has become a useful tool in medical training, allowing students to realistically interact with a simulated patient in a safe, controlled environment. A significant component of simulation-based training is the opportunity for students to dynamically interact and communicate with a simulated patient, so they can run

through iterative clinical cycles of assessment, planning, intervention, and reevaluation. Current methods for providing students with this dynamic feedback require human actors (inconvenient), high fidelity manikins (expensive), or videos (non-immersive), thus, the requirements for creating these dynamic training environments do not currently meet the budgetary and personnel constraints of many low-resource, rural medical facilities. In this project, undergraduate student Daniel Lesko (Bioengineering Class of 2019) will work with an interdisciplinary team of Bioengineering, Electrical Engineering, Nursing, and Spatial Information faculty members, as well as a start-up commercial partner (Zephyrus Simulations, LLC) to design a cost-effective haptic sensor suite to monitor student interactions with a medical simulation manikin. The result will provide students with real-time, dynamic feedback while being immersed in a simulation experience

6. Title: Leveraging machine learning and high-performance computing to deliver the spatial data needed by Maine's forest industry
PI: Legaard, Kasey (Forest Resources, UMaine)
Sector: Computer Science, Forestry
Partners: UMS Advanced Computing Group
Abstract: Forest managers in Maine cite a lack of spatial information about forest resources (both timber and non-timber) as a key barrier to the planning and prioritization of management actions. Available commercial products are typically priced at levels that are viewed as too expensive by Maine landowners. More critically, available products suffer from systematic error originating from mapping algorithms or imperfections in reference data available to train mapping algorithms. To address the reliability shortcomings of current data products available to forest industry and forest researchers, we developed a machine learning method that is capable of minimizing both total and systematic error in estimates of forest attributes from satellite imagery. We would specifically like a student to lead the continued effort of producing map output from trained GA-SVM models.

7. Title: Interdisciplinary Research for Decision Making about Dams in Maine
PI: McGreavy, Bridie (Communication and Journalism, UMaine)
Sector: Energy, Communications
Partners: UMaine
Abstract: The goal of our project is to advance research that analyzes stakeholder needs for information, perceptions about dams, and news media coverage to support decision making about dams in Maine and New England. We will complete the following objectives to reach this goal: (1) expand collaborative partnerships with key dam stakeholders in
Maine; (2) understand how stakeholders perceive and make decisions about dams; (3) and analyze news media coverage about dam decision making.

8. Title: Undergraduate Capstone: Genetics of Freshwater Snails of Northern Maine
PI: Roe, Judith (Biology, UMaine Presque Isle)
Sector: Biology, Ecology
Partners: Department of Inland Fisheries and Wildlife
Abstract: There are ~40 species of freshwater snails in Maine. These snails have been inventoried occasionally over the past 150 years, and Ken Hotopp of Appalachian Conservation Biology has spearheaded a project to determine the current distribution of species in the Fish River Lakes system in northern Maine. One project goal is to compare this inventory with historical records of local naturalists who collected shells and documented observations in northern Maine lakes since the late 1800s. The presence of certain snail species can indicate the health of important natural resources.

9. Title: Assessing the Economic Value of Maine’s Coastal Tourism: The Ecosystem Services across Acadia National Park
PI: Strong, Aaron (Marine Sciences, UMaine)
Sector: Ecology, Tourism
Partners: Sea Grant, NOAA
Abstract: Ecosystem services provide a paradigm for using biophysical and social science to investigate and optimize the management of Acadia National Park. By quantifying the full suite of values provided to humans in

a system across various uses, ecosystem services provide a framework for a data-driven balance of diverse stakeholder priorities critical to economically beneficial management. Since May 2017, we have led a project to quantify the ecosystem services of Schoodic Peninsula and how they have changed since the development of Schoodic Woods. Preliminary results show that Schoodic Woods has increased both recreational and business opportunities in the area, as well as altered patterns of biodiversity. Building upon work this past summer and fall at Schoodic, we propose here to fully quantify the value of ecosystem services throughout ANP focusing on its greatest contributors: tourism, recreation, biodiversity and wildlife habitat, carbon storage, and water quality.

Track 3 – Interdisciplinary Undergraduate Research Collaboratives

Principal Investigator	Partners	Project Title
Blais, Joline (New Media, UMaine)	UMaine Presque Isle, SYRA	Maine Ag Data Monitoring App--Undergrad Interdisciplinary (Track 3)
Jayasundara Nishad (Marine Science, UMaine)	UMaine	High throughput predictive bioenergetics through statistical machine learning for big-data to assess biological responses to environmental stressors
King, Benjamin (Molecular and Biomedical Sciences, UMaine)	UMaine	Muscular Dystrophy Genomics Research Collaborative
Leslie, Heather (Darling Marine Center, UMaine)	UMaine Machias, University of Southern Maine	Track III: Coastal Ecosystem Science for Maine's Marine Economy & Coastal Communities

1. Title: Maine Ag Data Monitoring App--Undergrad Interdisciplinary (Track 3)
PI: Blais, Joline (New Media, UMaine)
Sector: Agriculture, Computer Science
Partners: UMaine Presque Isle, SYRA
Abstract: The goal of this project is to test hardware sensors for environmental monitoring in Maine year round agricultural systems including controls that integrate seamlessly with Maine farmer's production needs. We are seeking funding for 3- 4 undergraduate students across disciplines through an Interdisciplinary Undergraduate Research Collaboratives Program to test remote sensor hardware and provide supplemental support for the RRF Graduate Track proposal for "Maine Ag Data Monitoring App". This is a research and development project with urgent and direct application to Maine farm's through the Maine Technology Institute's Sustainable Year Round Agriculture (SYRA) Cluster Initiative. The SYRA Project Team has approached UMaine Electrical Engineering and UMaine New Media and Bill Seretta from the Maine Food Systems Innovation Challenge to collaborate on the program. Project will begin in September and end in April 2019.

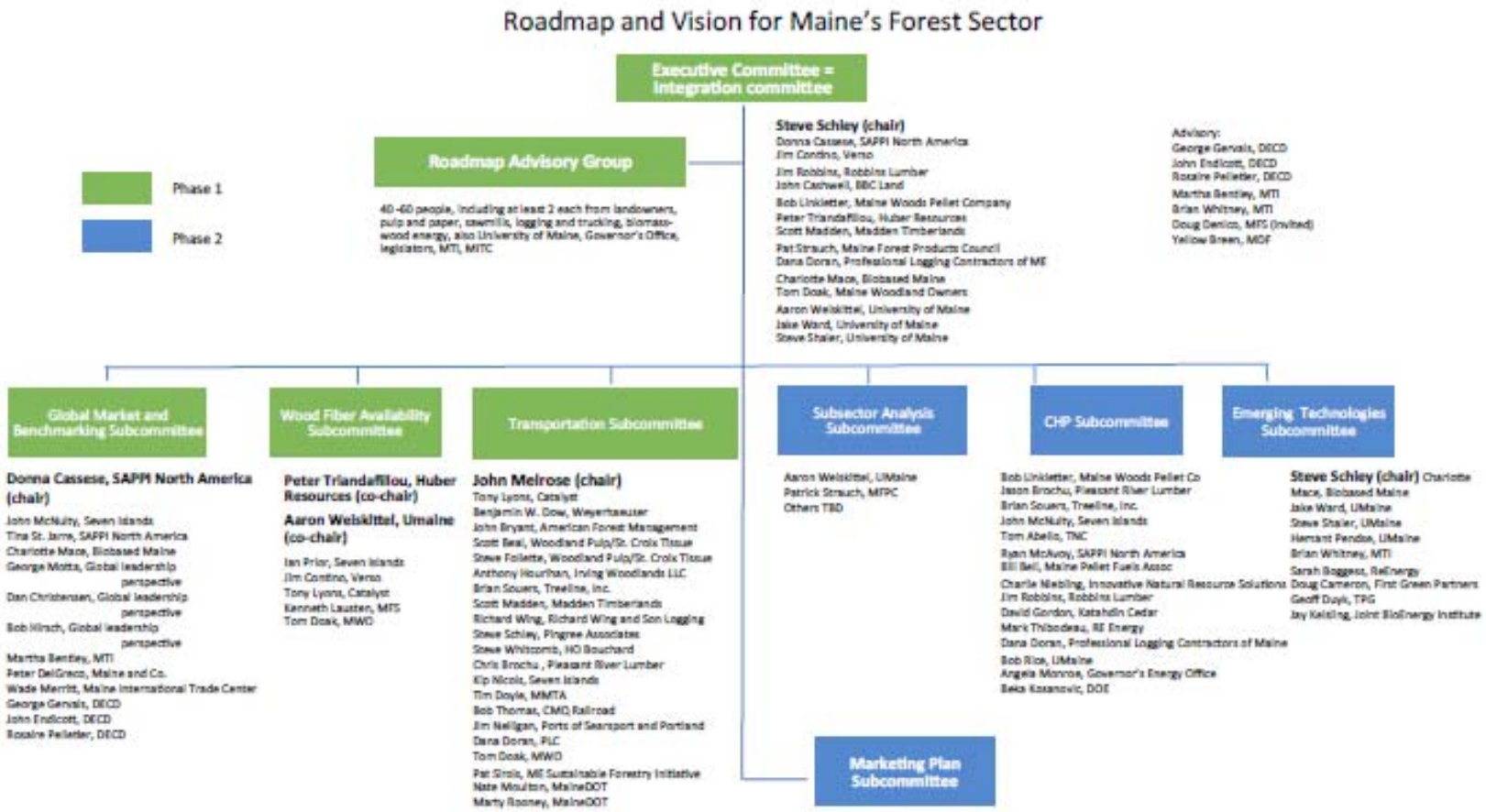
2. Title: High throughput predictive bioenergetics through statistical machine learning for big-data to assess biological responses to environmental stressors
PI: Jayasundara Nishad (Marine Science, UMaine)
Sector: Biology, Data Science
Partners: UMaine
Abstract: The goal of this research is to build a team of undergraduates to integrate biological sciences with big-data statistical approaches to develop a commercializable statistical tool that can predictively compute the capacity of an organism to maintain energy homeostasis when exposed to toxicants and other stressors (e.g., temperature). Once developed, the tool can be used as a predictive toxicity screening method, a critical need as highlighted by the US national toxicology program, especially in their grant solicitations. Undergraduates trained through this project will get direct hands-on experience in method development and experimental design in metabolic research, and big-data analytical methods. These will directly contribute to their further training as scientists and will significantly improve their analytical skills on big-data, a highly sought after attribute in the current job market.

3. Title: Muscular Dystrophy Genomics Research Collaborative

PI: King, Benjamin (Molecular and Biomedical Sciences, UMaine)
Sector: Healthcare, Genomics
Partners: UMaine
Abstract: Muscular dystrophy is a large group of debilitative diseases that result in weakened skeletal muscle and affect approximately 250,000 individuals in the US. Our interdisciplinary research collaborative seeks to discover the molecular mechanisms dysregulated in one form of muscular dystrophy by applying developmental biology, genomics and computational methods to characterize a novel zebrafish model developed at UMaine using CRISPR-Cas9. In one form of muscular dystrophy, individuals with mutations in GMPPB (GDPmannose pyrophosphorylase B) have variable muscular dystrophy phenotypes and ages of onset ranging from birth to adulthood and we hypothesize that this and other dystroglycanopathies are the result of defects in neuromusculoskeletal development. We propose to identify the molecular mechanisms that contribute to impaired muscle function in the novel zebrafish mutant bycomputationally modeling how networks of genes are dysregulated together to find critical regulatory genes.

4. Title: Track III: Coastal Ecosystem Science for Maine's Marine Economy & Coastal Communities
PI: Leslie, Heather (Darling Marine Center, UMaine)
Sector: Marine Science
Partners: UMaine Machias, University of Southern Maine
Abstract: Coastal ecosystems are of great value. They provide food and clean water, protection from coastal storms, and also are home to some of the most productive ecosystems on the planet, fueling seafood and tourism industries valued at more than $5B per year in Maine alone. To ensure a continued flow of benefit from healthy marine ecosystems to the communities and local economies that depend on them, we need knowledge of how these systems work. We also need to build capacity of the next generation of coastal ecosystem scientists, managers, and citizens. This Undergraduate Research Collaborative focused on Coastal Ecosystem Science will catalyze innovative ecosystem science of direct benefit to Maine's marine economy and coastal communities. It will also contribute to developing the next generation of marine scientists and managers, by enhancing the technical, communication, and collaborative skills of the students, researchers, and industry professionals engaged in these projects.

Appendix E: Vision and Roadmap for Maine's Forest Economy



Appendix F: Alliance for Maine's Marine Economy 2017 Highlights

Looking ahead

The capital investments enabled by the bond and matching funds is just the beginning. By leveraging existing capacity and working together to pursue new resources, the Alliance is:

- Catalyzing targeted infrastructure and workforce development investments that facilitate business development
- Accelerating product innovation
- Assessing and preventing risks to resource health
- Forecasting changes in product supply

Alliance partners have identified additional projects and contracts that will attract at least another $50M of additional private sector and federal grant dollars over the next 10 years, above and beyond the state bond funds. Together, this evolving portfolio of investments and expanded infrastructure and workforce capacity will ensure that Maine marine industries are able to innovate and adapt their business strategies to new opportunities and challenges as they emerge.

As part of this project and in recognition of the central role of Maine's public universities in Maine's marine economy, the University of Maine System has committed more than $2.3M in internal funds to this important effort.

Seawater treatment trials with new technology will develop more reliable, scalable organic nursery seed production to support Maine's seaweed industry. (Credit: Springtide Seaweed, LLC)

An invitation to all

The Alliance is open to all individuals, businesses and organizations that share the commitment to a future Maine where healthy marine ecosystems and coastal communities support a diversity of traditional fisheries, aquaculture and other marine-dependent industries.

To learn more about the Alliance, visit umaine.edu/alliance.

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A new aquaculture seaweed exchange will expand seaweed production, increase jobs and develop innovative new and value-added products. (Credit: Springtide Seaweed, LLC)

THE UNIVERSITY OF MAINE

Alliance for Maine's Marine Economy

2017 Highlights

Our motivation

Maine's ocean and coastal resources are the foundation of our coastal communities, contributing vital jobs and shaping our culture. Mainers pride themselves on the distinctiveness of their local communities, the prominence of owner-operated small businesses, and the rural and pristine character of much of our coast. Maine fishermen land the highest-value annual catch, including our iconic lobster fishery, of all East Coast states. Yet, Maine's marine environment and its marine markets are changing. Rising ocean temperatures and ocean acidification, shifting abundances of species, and fluctuating markets are creating both opportunities and challenges. Blessed with an incredibly productive marine ecosystem, clean water, access to an array of private, public and nonprofit research institutions, and a culture of ingenuity and hard work, Maine's marine economy has great promise for continued advancement. Commercial fishing and aquaculture industries, together with the increasing activity in seafood processing and value-added market development for Maine-based marine products, signal incredible potential for sustainable economic growth in the next decade.

Our mission

The Alliance for Maine's Marine Economy is a network of more than 20 Maine-based organizations dedicated to a vibrant marine economy for Maine. Our mission is to ensure that Maine seafood, fishing and aquaculture industries, and the natural and innovation ecosystems on which they depend are healthy and benefit Maine people.

The new construction of the marine research laboratory at the Downeast Institute, the UMaine-Machias marine field station. (Credit: Brian Beal)

Our partners

The University of Maine System (including the following UMaine entities): Darling Marine Center, Maine Sea Grant, School of Marine Sciences, Aquaculture Research Institute, Cooperative Extension, School of Food and Agriculture, Lobster Institute, Center for Cooperative Aquaculture Research, The Office of Innovation and Economic Development and the UM-Machias marine field station)

Maine Coast Fishermen's Association

Maine Aquaculture Association

Cape Seafood

Maine Aquaculture Innovation Center

Maine Lobster Dealers' Association

Maine Lobstermen's Association

Downeast Lobstermen's Association

Gulf of Maine Research Institute

University of New England

Maine Department of Marine Resources

Maine Technology Institute

Bigelow Laboratory for Ocean Sciences

Coastal Enterprises, Inc.

Island Institute

Maine Center for Coastal Fisheries

Downeast Institute for Applied Marine Research & Education

Maine Fair Trade Lobster

Cooke Aquaculture

Accomplishments to date

Since the Alliance's founding in May 2016, we have undertaken a transformative, ten-year, $14+ million initiative to foster development in Maine's marine sectors. Capital investments in public and private infrastructure will benefit the entire sector. On behalf of the state of Maine, the Maine Technology Institute (MTI) manages the finances of the Marine Economy and Jobs bond, and in partnership with the Alliance for Maine's Marine Economy, invested in seven capital projects and awarded eight competitive capital grants in 2017.

Top left: Seed ropes - mussel seed collected on coiled, pegged grow-out ropes to be used in breakthrough mussel raft technology at Pemaquid Mussel Farms, LLC. (Credit: Carter Newell)

Top right: Newly constructed submersible mussel raft without buoys, ropes, or nets. (Credit: Carter Newell)

Projects in 2017

The Alliance, working with the Maine Technology Institute, is enabling the following investments via the state bond funds and additional matching funds:

- $500,000 (match $800,000) for expansion of Maine Fair Trade Lobster, a seafood processing plant in Prospect Harbor (Hancock County)
- $150,000 (match $182,000) for lobster processing equipment at Cape Seafood in Saco (York County)
- $500,000 (match $1,200,000) for a feed barge for a new locally managed aquaculture facility in Downeast Maine owned by Cooke Aquaculture USA (Washington County)
- $650,000 (match $650,000) for improvements to the waterfront infrastructure at UMaine's Darling Marine Center in Walpole to support applied research, development and business incubation (Lincoln County)
- $2,000,000 (match $2,000,000) for the addition of laboratory and business incubation space at the marine science field station of the University of Maine at Machias, the Downeast Institute, in Beals (Washington County)
- $125,000 (match $125,000) for instrumentation to support Bigelow Laboratory's analytical services for Maine's wild-harvest and farm-raised seaweed industries (Lincoln County)
- $1,150,000 (match $1,650,000) for construction of an Aquatic Animal Health Facility at UMaine with high-level biosafety capabilities to study fish pathogens and help minimize health risks to Maine's wild and farmed fish stocks (Penobscot County)

Developing innovative lobster processing equipment will create new lobster products, customers and markets allowing Cape Seafood to process more lobster and employ more workers in Maine.

New technology will extend the shelf-life of fresh Maine lobster meat enabling Maine Seafood Ventures to generate revenue, create jobs and expand markets and production. (Credit: Curt Brown)

The Maine Technology Institute, in partnership with the Alliance, initiated a competitive Marine Economy Capital Grants Program:

- $44,328 (match $204,972) to Blue Hill Bay Mussels, LLC to commercialize remote settlement, a proven hatchery technology (Hancock County)
- $66,574 (match $75,000) to Coastal Enterprises, Inc. to increase the sustainable supply, quality, and diversity of farm raised sea scallops (Multiple locations)
- $100,000 (match $100,000) to Community Shellfish LLC to develop a dynamic and innovative aquaculture venue to grow shellfish on the Medomak River (Lincoln County)
- $400,000 (match $1,650,000) to Maine Seafood Ventures to expand markets for fresh Maine lobster by implementing the latest High-Pressure Processing technology (York County)
- $336,000 (match $1,897,228) to Mook Sea Farm to build a multi-purpose, state-of- the- art oyster facility (Lincoln County)
- $250,400 (match $540,000) to Pemaquid Mussel Farms LLC to continue development of submersible mussel raft technology to increase production of cultured mussels (Lincoln County)
- $180,000 (match $697,000) to Springtide Seaweed, LLC for the creation of a new aquaculture seaweed exchange to expand seaweed production (Knox County)
- $400,000 (match $1,150,000) to Shucks Maine Lobster Inc. to expand a lobster processing facility (Cumberland County)

For information on the Marine Capital Grants Program, visit the Maine Technology Institute at www.mainetechnology.org