Maine EPSCoR FY24-29 NSF EPSCoR RII Track-1
Proposal Development Process Phase I – Research Concept Papers

1) Proposed Research Focus:		**Microbial Bioprocessing and Bioengineering**			
2) Primary Contact Person:					
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3) Suggested/Potential Key Senior Personnel:					
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4) Intellectual Merit:

A. ***Need****: a brief statement of the research problem/need to be addressed, and why it is urgent for Maine to address this problem/need now (how it is currently limiting the state's capacity/research competitiveness).*

Microbes and microalgae are at the core of a rapidly growing 'blue' economy. Microbes and microalgae are being applied and employed in processes ranging from cell factories for natural biochemicals to large-scale, solution-based applications for addressing climate change challenges. Basic research and scientific innovation are key to supporting the continued growth of this 'blue' economic revolution, especially for Maine with its extensive coastline and its emergent marine innovation sector.

Maine's participation in the 'blue economy' is primarily focused on fisheries, aquaculture, and other marine product development. Under this umbrella, marine microbial organisms can provide a multiplier effect for the 'blue economy'. Marine microbial and microalgal processes and products can provide significant value-added benefit to this growing multibillion-dollar industry. There is also substantial evidence that points to novel biochemical processes occurring in microbes and microalgae that could revolutionize the utility of marine microorganisms that this project aims to explore. Maine currently lags behind other New England states who have been focusing on these non-fishery blue economy activities. Nevertheless, Maine's access to an array of both native and non-native microorganisms through the National Center for Marine Algae and Microbiota (NCMA) provides unique leverage and opportunity to understand the building blocks of microbial biological function and its products. With EPSCoR funding we would be able to substantively expand on our current efforts and to see that knowledge transferred to the commercial sector.

B. ***Research Goal & Objectives:*** *describe the overall project goal to address this problem/need, and the related research objectives.*

The overarching goal of this research program is to stimulate a wide-ranging basic and applied research program based on microbes and microalgae. The resulting research would be the foundation for innovation-based advances in the 'blue' economy and its application to solutions for important societal problems.

Research objectives are to:

1) Develop a microbial science cluster/network in Maine including researchers, engineers, and entrepreneurs.
2) Identify the relevant microorganisms and develop the methodology for use of produced biochemicals produced in bioremediation processes (e.g., nutrients, microplastics and industrially important metals).
3) Develop microbe-based 'green molecule' chemistry to replace synthetic molecules currently in use in a wide range of sectors such as pharmaceuticals, nutraceuticals, biomedical, human food production systems, and aquaculture feed systems.
4) Research the basis for mineralization in microbes that are able to concentrate and precipitate important elements (e.g. phosphorus, carbon, silica and strontium) from dilute solutions.
5) Design an economically and environmentally sound infrastructure to support the production of microbial and microalgal products that can be leveraged by partners throughout Maine.
6) Develop an accessible database of novel natural products, physiological capabilities, and functions in microbes and algae held in the NCMA collection that can be accessed by researchers throughout Maine

and the world.

C. ***Research Actions:*** *describe a few specific key research actions that could be implemented to meet the objectives. Withhold any information deemed sensitive, given this form will be shared with the community.*

Specific research actions:

1) Screen NCMA collection for polysaccharide content and profiles, as polysaccharides have been implicated in antimicrobial, antiviral, anticancer function.
2) Develop processes for microbe/algal feed in finfish aquaculture.
3) Identify specific transporters for critical elements from microbial DNA/RNA using bioinformatics and test their functionality and utility using transgenics/production in model systems.
4) Engineer infrastructure and develop processes to enable the efficient retention/production microbial products.

D. ***Priority:*** *indicate how this research would address national priorities (*FY2022 budget request to Congress, White House 2021 R&D priorities memo*) and state priorities (*Maine Economic Development Strategy 2020-2029, 2017 Maine Innovation Economy Action Plan*).*

National Priorities:

1) Climate change solutions: Innovation in clean-energy technology and infrastructure; nature-based climate solutions for mitigation and adaptation.
2) Catalyze research and innovation in critical and emerging technologies: leverage existing national and state assets; initiate innovative biotechnology solutions through research into understudied microbes that have a potentially valuable capacity for novel processes.
3) National Security and economic resilience: marine microbes and algae are highly productive, can create products 'on-demand' and thus are not part of an extractive economy but rather a biomanufacturing economy.

State Priorities:

1) This research would leverage existing state resources, the emerging Maine bio-economy, Maine's expertise in marine research, and the bountiful marine eco-system to develop an array of solutions and products that will empower the Maine research and entrepreneurial ecosystems.
2) This research aligns with Maine priority for bio-based 'manufacturing' but utilizes marine resources.
3) The types of jobs created by these activities would be higher paying technical jobs, in line with Maine's priority to increase pay.
4) The research will provide solutions to climate change at the same time as stimulating other applications-based solutions to an array of challenges.
5) Microbes and microalgae can inherently be part of a circular economy. This research would support local job creation, attract new talent and capital to Maine, and stimulate innovation by focusing on existing in-state assets (NCMA)

5) Broader Impacts:

E. ***In-state collaborations****: describe potential for collaborations within Maine (considering diverse participants from institutions of higher education, PUIs and community colleges, as well as productive partnerships between Maine's academic institutions and governmental, non-profit, and commercial or industrial sectors).*

Below are some potential collaborators on this EPSCoR project in the state, many of which we are already conversing with in this general space.

HiEd: MMA (L. Whitney, S. Baer, R. Kimball), UM-Orono (S. Brawley, Schwartz, MARINE Program faculty), USM (I. Levine), Colby College (A. Bates, W. King), Bowdoin College (C. Roesler),
PUI/CC: SMCC (C. White, B. Tarbox)
Federal: USDA-NCWMAC (G. Burr)
Industry: Beacon Analytical LLC (T. Fan), Field Bioprocess (D. Sisitsky), New England Ocean Cluster

F. ***Regional/national collaborations****: describe potential for collaborations among regional and national EPSCoR jurisdiction-based organizations, and/or partnerships with nationally recognized centers of R&D activity, such as federal and industrial R&D laboratories, NSF-sponsored research centers, and academic institutions with nationally recognized research capabilities*.

Below are potential collaborators at the regional/national level, only with the faculty at the University of Mississippi School of Pharmacognosy have we had conversations.

Regional: BioMade (UNH – bioplastics from algae), C-AIM (RI – ecology/enabling technologies),
National: School of Pharmacognosy (Mississippi – EPSCoR state)

G. ***Economic development****: describe potential for economic development in Maine.*

Nationwide the microbial and microalgal sector is a very fast-growing, multibillion-dollar economic activity, supported by extensive research funding at the US federal level from a diversity of agencies (e.g., DOE, DOT, USDA, NSF). Maine has the potential to benefit from this momentum. There are already key resources in Maine (e.g., UMaine-ScratchPad, Gulf of Maine Ventures, New England Ocean Cluster, etc.) that have interests in or connections to microbial and microalgal bioprocessing and bioengineering. There is a strong microbial and microalgal academic research community in Maine. There are new companies (e.g., Field Bioprocess) and potential for more leverage from investments in the aquaculture sector (e.g., microbes/microalgae in finfish feed for aquacultured species). Maine has invested heavily in growing its entrepreneurial capacity through development of incubator/accelerator resources within the state, which will provide effective opportunities for the microbe/microalgal research community to translate their research into economic growth for Maine. Six years ago, MTI funded an Algal Cluster planning grant; the macroalgae portion has expanded greatly, now there is potential for the microbe/microalgae section to advance.

H. ***Workforce Development****: describe potential for statewide workforce development in this research area (e.g., support for faculty and student teams that include women, minorities underrepresented in STEM, and persons with disabilities that will result in a strong, quantifiable impact on the STEM workforce; may also consider support for students who are in the first generation of the family to attend college, or those from economically disadvantaged or rural populations).*

There is a great deal of interest and examples of 'environmental workforce development' in Maine (e.g., Focus Maine and Biobased Maine). In addition, the National Center for Marine Algae (NCMA) at Bigelow Laboratory offers training short courses to academics and professionals attracting students from around the country and the world; ~70% of students are women and first-generation college students. Further, Bigelow has made connections and partnerships within the region (e.g., SeaAhead based out of Boston; UMaine-ScratchPad; Gulf of Maine Ventures @ GMRI) that can facilitate further workforce development. The outreach of these different entities promises to facilitate a diverse STEM workforce. Specific actions would be to 1) build local human capacity to support the long-term growth of the microbial/microalgal sector of the blue economy, and 2) develop training opportunities and strategies to build the fundamental capacity and success of the microbe/microalgae industry in Maine with consideration paid to engage underrepresented groups.

I. ***Infrastructure****: describe potential to provide infrastructure (e.g., physical and/or cyber) that grows the state's academic research and education capacity.*

There are already some foundational infrastructure elements at state institutions (e.g., Bigelow Laboratory-NCMA, CAI, WHH; University of Maine; Gulf of Maine Research Institute; Maine Maritime Academy – METEL Laboratory) that would serve as nucleation centers for new infrastructure and research such as this EPSCoR proposal. There is also evidence for diverse (i.e., both academic and private) interest and support for microbial/microalgal bioprocessing and bioengineering in Maine; those interests remain largely 'discrete' rather than part of a network. This funding would not only create the network but would facilitate growth of research and education capacity and infrastructure through improved communication and more efficient use of resources.