Environment and Natural Resources Trust Fund
2019 Request for Proposals (RFP)

Project Title: **ENRTF ID: 166-D**

Ecological Coatings to Mitigate Proliferation and Spread of Invasive Species

Category: D. Aquatic and Terrestrial Invasive Species

Sub-Category:

Total Project Budget: $ 401,000

Proposed Project Time Period for the Funding Requested: June 30, 2021 (2 yrs)

Summary:

We propose to develop innovative coatings containing a revolutionary antifouling ecological molecule: these coatings will contribute to stop the proliferation and the spread of aquatic invasive species.

Name: Mikael Elias

Sponsoring Organization: U of MN

Title:

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Innovative, Ecofriendly Coatings stops the Proliferation of Aquatic Invasive Species on Surfaces and Boats and Limit their Spread.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%
____ If under $200,000, waive presentation?			

PROJECT TITLE: Ecological Coatings to Mitigate Proliferation and Spread of Invasive Species

I. PROJECT STATEMENT

Biofouling is a natural process in which aquatic organisms attach to structures, boats, docks, and anchors. Not only does it have an economic impact on coastal industries, but it is also a medium for the spread of numerous invasive species in Minnesota waters. It is our goal to fight against biofouling, and the damage it causes, by developing a new and biologically advanced generation of coatings. These coatings will significantly reduce the proliferation and spread of invasive aquatic organisms.

Biofouling is a spontaneous process in which aquatic organisms (e.g. bacteria, diatoms, algae, protozoan, sponges, mussels) colonize on the surface of submerged objects. This natural process affects ships, pipes, port infrastructures, and water treatment plants. Biofouling allows for the proliferation and spread of aquatic invasive species, providing passage for the invasion of new places when structures are moved from a one body of water to another one. Of particular concern are the aquatic invasive species such as Zebra mussels. Zebra mussels have spread throughout the Great Lakes, parts of the Mississippi River, and other rivers and inland lakes. Despite the efforts of the department of natural resources, they continue to spread in Minnesota causing damage to the environment. Economical drawbacks caused by maintenance of pipes clogged by Zebra mussels is estimated to cost $60 million annually in the Great Lakes. Additionally, this invasion is estimated to have cost industrial plants $3.1 billion from 2008-2018 (US State Department website). Current methods for controlling the spread of these organisms (cleaning boats, structures, use of pesticides) are cumbersome and possibly unsafe due to the need for cleaning stations, the toxicity of cleaning substances, and foremost their lack of efficacy. **Therefore, there is a need for new strategies to fight the proliferation and spread of invasive mussels across Minnesota.**

Here, **we propose to develop a highly innovative, ecologically safe antifouling coating** that will prevent the adhesion of macroorganisms to object surfaces. To achieve these objectives, we will take advantage of our recent discovery of 100% biological and eco-friendly molecules that make surfaces less adhesive to invasive aquatic species. These biological molecules haves a tremendous potential for translated research in numerous fields, and were recently recognized by the University of Minnesota with an Early Innovator Award given to Dr. Elias. Our initial pilot and field testing experiments on Lake Superior, in the Duluth-Superior Harbor (DSH), confirmed that coatings containing these eco-friendly molecules were not fouled by aquatic organisms. In addition, our compounds were found to outperform other widely used coatings. Our eco-friendly coating has the potential to reduce the proliferation and spread of invasive aquatic species by minimizing the possibilities of transferring them to new bodies of water when ships, pleasure craft, portable docks, and anchors and their chains are transferred to new bodies of water.

In collaboration with key strategic stakeholders in the field, including the Duluth Seaway Port Authority, a Minnesota company (AMI Consulting Engineers), a biotechnology company (Gene&GreenTK), our group has a unique collection of skills, expertise, knowledge and contacts to perform the field testing, develop the coatings, and collect the data that are necessary to transfer this technology to the market.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Optimize the ecological antifouling coatings **ENRTF Budget: 165,000$**

We will optimize our coating formulation to improve efficacy, stability, and durability of the coating. Tests will be performed in the lab in water, and in water from the DSH. The goal is to make coating formulations containing our enzymatic biofouling inhibitors that are as durable as the best coatings on the market (2 years).

Outcome	Completion Date
1. Improve the coating antifouling properties	November 1, 2019
2. Improve the coating durability	June 30, 2020

Activity 2: Conduct field experiments in the Duluth-Superior Harbor (DSH). **ENRTF BUDGET: 236,000$**

In these field tests, we will perform a comparative study of the ecological coating with the highest performance coatings on the market, and measure the adhesion of aquatic invasive species such as zebra mussels to these coated surfaces. Sample coupons (steel, fiberglass) will be taken out of the harbor and analyzed after 3,6,10, and 16 months.

Outcome	Completion Date
1. Sample preparation and installation in the harbor	July 30, 2020
2. Sampling and analysis of the samples.	June 30, 2021

III. PROJECT PARTNERS:

A. Project Team/Partners

The project will be carried out by a strong team that covers complementary areas. Collectively, the team covers environmental science, biology, and engineering expertise. The teams consists of a Biochemistry assistant professor, Mikael Elias, and biology professor Randall Hicks. Mikael Elias discovered the biofilm inhibitory molecule, while Randall Hicks has extensive expertise in microbiological processes underlining biofouling, and has performed field experiments in the DSH for many years. The team will also benefit from an already established collaboration with the Duluth Seaway Port Authority, a Minnesota company (AMI Consulting Engineers), and a French company (Gene&GreenTK) that will provide key feedback and contacts with other stakeholders. Letters of support from our partners will be sent to the LCCMR.

A. Partners receiving ENRTF funding

Name	Title	Affiliation	Role
Mikael Elias	Assistant Professor, PhD	University of Minnesota	Principal Investigator
Randal Hicks	Professor, PhD	University of Minnesota	Co-investigator

B. Partners NOT receiving ENRTF funding

Name	Title	Affiliation	Role
David Daude	CSO, PhD	Gene&GreenTK	Collaborator

IV. LONG-TERM- IMPLEMENTATION AND FUNDING:

Our initial pilot and field testing experiments on Lake Superior, in the Duluth-Superior Harbor (DSH), confirmed that our coatings containing these eco-friendly molecules were not fouled by aquatic macroorganisms, and outperformed existing coatings. We now propose to take advantage of our competitive advantage (i.e., novel, potent, patent protected biofouling inhibitor) to investigate the properties of this coatings over long (2 years) field studies in real conditions. This innovative project may lead to a viable solution that increases the maritime shipping industry efficiency and economy by using an eco-friendly coating to protect the maritime transportation infrastructure not only in Minnesota but worldwide, a problem that costs the U.S. Navy over $6 billion annually, and at least $200 billion annually overall in the U.S. alone. Cost-effective mitigation strategies will be invaluable to our State and beyond by reducing the proliferation and helping mitigate the spread of undesired, or invasive species from a body of water to another while moving pleasure craft, portable docks or anchors. Such a product will be a new asset to help preserve our environment. We, and now other firms and stakeholders we have contacted (Gene&GreenTK), and The Duluth Seaway Port Authority), feel that the future potential of this innovative technology is enormous.

V. TIME LINE REQUIREMENTS: This project will take 24 months to carry out as described above. Thereafter, it is expected that the products of the project to be handed off to state agencies and the private sector.

2019 Detailed Project Budget

Project Title: Ecological Coatings to Mitigate Proliferation and Spread of Invasive Species

IV. TOTAL ENRTF REQUEST BUDGET *2* **years**

BUDGET ITEM *(See "Guidance on Allowable Expenses", p. 13)*	**AMOUNT**
Personnel: Mikael Elias, project manager, PI: 8% time; (75% salary; 25% benefits) 1 month/year (summer) for 2 years . Dr Elias will be in charge of the completion of all project activities.	$ 28,500
Personnel: Randall Hicks, co-PI: 8% time; (75% salary; 25% benefits) 1 month/year (summer) for 2 years	$ 31,500
Personnel: Postdoc Researcher: (82% salary, 18% benefits); 100% FTE for 1 year. Funds are requested for 2.0 year to support a postdoctoral fellow to fulfill activity 1 and 2.	$ 120,500
Personnel: Postdoc Researcher: (82% salary, 18% benefits); 100% FTE for 1 year. Funds are requested for 2 years to support a postdoctoral fellow to fulfill activity 1 and 2.	$ 120,500
Professional/Technical/Service Contracts: coupons, coupons holders, and coupons installation in the Duluth Superior Harbor to perform the experiments proposed in activity 2. Involves the hiring of professional divers.	$ 30,000
Equipment/Tools/Supplies: Funds are for producing and optimizing presticide-degrading materials for lab testing, as well as routine lab supplies (chemicals, flasks, pipetters, disposable plasticware, for example test tubes and petri plates, as well as media needed for production of molecular biology reagents made in the lab).	$ 40,000
Equipment/Tools/Supplies: Core facility costs (DNA sequencing and protein production): will cover costs associated with the production of our biofouling inhibitor and with 'reading' the DNA of microbial communities in experiments to determine success of experiments	$ 30,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 401,000

V. OTHER FUNDS *(This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)*

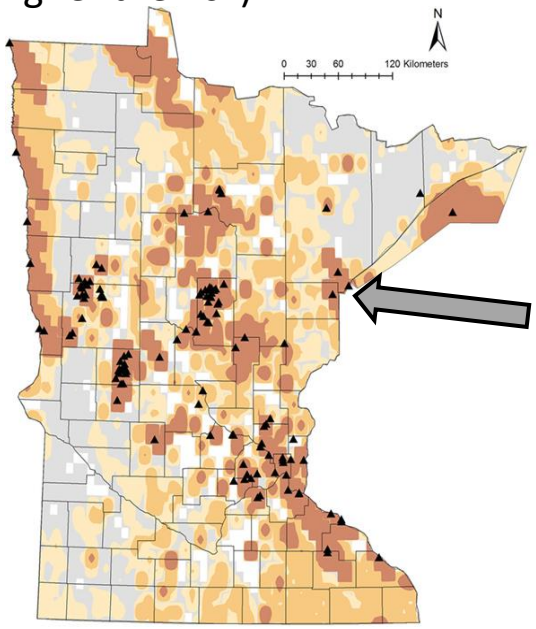
SOURCE OF FUNDS	**AMOUNT**	**Status**
Other Non-State $ To Be Applied To Project During Project Period: *Indicate any additional non-state cash dollars secured or applied for to be spent on the project during the funding period. For each individual sum, list out the source of the funds, the amount, and indicate whether the funds are secured or pending approval.*	$ -	*Indicate: Secured or Pending*
Other State $ To Be Applied To Project During Project Period: MnDrive Initiation funding to Mikael Elias and Randall Hicks to perform preliminary field testing and development of anticorrosion and antifouling coatings.	$ 296,276	*Secured*
In-kind Services To Be Applied To Project During Project Period: The University of Minnesota does not charge the State of Minnesota its typical overhead rate of 54% of the total modified direct costs.	$ 216,540	*Secured*
In-kind Services To Be Applied To Project During Project Period: BioTechnology Institute Pilot Plant fee waiver. Since the PIs are members of the BioTechnology Institute, this project will have the entry fee waived for the use of the facilities to prepare pesticides-degrading biocatalysts to be used in this proposal. The project will only be charged for materials used in production and the hourly wages of the staff at the facility that they work on this specific project.	$ 15,000	*Secured*
Remaining $ From Current ENRTF Appropriation: *Specify dollar amount and year of appropriation from any current ENRTF appropriation for any directly related project of the project manager or organization that remains unspent or not yet legally obligated at the time of proposal submission. Be as specific as possible. Indicate the status of the funds.*	$ -	

Ecological Coatings to Mitigate the Proliferation of Invasive Species

Mikael Elias, Randall Hicks

Aquatic invasive mussels spread *via* fouled boats and structures to new bodies of water

Statewide problem: Presence of zebra mussels (▲ in 2015) and risk of spread (the darker, the higher the risk)



Duluth-Superior Harbor: location of our field testing

From Kanankege et al., 2018

Our proposal: **<u>Ecological, superior performance coating that renders surfaces improper for adhesion, proliferation and transfer of aquatic invasive species to new bodies of water</u>**

Ecological antifouling molecule

Invasive species-free surfaces

Management: The research team will include Prof. Mikael Elias, Prof. Randall Hicks. Prof. Elias will be the project manager. The team assembled has unique, and complementary, skills necessary to achieve the goals of the project. The specific expertise of each team member is described below.

Prof. Mikael Elias, PI, is an Assistant Professor in the Department of Biochemistry, Molecular Biology and Biophysics at the University of Minnesota. Elias has over 10 years of research experience on enzyme interfering with bacteria, producing 4 patents and >30 articles on this topic alone, including in prestigious journals (*JACS*, *Nature, PNAS*) and extensive know-how in protein engineering where he pioneered methods, such as the use of ancestral methods. He will invest most of his time on the project, and perform experiments and data analysis. Additionally, he reviews data and meets with laboratory personnel on a daily basis to promote the projects. He also prepares the dissemination of results, such as the proposed conference and publications. As the PI of the project, Dr. Elias will oversee the entire project, design the experiment plans, and draft the project reports.

Prof. Randall Hicks, co-PI is a Professor of Biology at the University of Minnesota Duluth (UMD). Dr. Hicks is an environmental microbiologist who studies the diversity and productivity of aquatic microbial communities, and the survival and virulence of pathogenic microbes in these communities. This work has taken him to the bottom of different great lakes using a manned submersible, to Russia, Africa and various oceans, but his current research is focused on the North American Great Lakes. He has published over 40 scientific journal articles and book chapters. Dr. Hicks brings several decades of organizational experience and expertise ranging from heading a large academic department (UMD Biology; 1998-2006), organizing an international scientific conference (IAGLR 2011), to directing a university center (UMD Center for Freshwater Research and Policy; 2007-2011).

Organization: the University of Minnesota has several missions: improve lives through research, education, and outreach. The University possess extensive facilities that ensure high research performance. In particular, for this project:

• Biotechnology Resource Center: (http://www.bti.umn.edu/brc/index.html) A wide variety of bench-scale to pilot scale fermenters is available, up to 500L, and will be used in this project to produce cost-effective biomaterials.

Elias Lab: 1,800 sq. ft. of renovated research space is dedicated to Dr. Elias. This space is located on the 1st floor of the GortnerLab Building, on the St Paul campus. Elias's office space is adjacent to the laboratory. The lab contains all of the necessary equipment for molecular biology, biochemistry, protein production and purification, enzyme kinetics, and crystallography. Numerous facilities are available, such as microplate readers, spectrophotometers, scintillation counters, fplc, liquid nitrogen storage, -80 freezers, incubators/shakers, autoclave, as well as 4 and -20 rooms.

Hicks Lab: Dr. Hicks's research laboratory is located in the research wing of the Swenson Science Building (SSB 171) on the University of Minnesota Duluth campus. In addition to research laboratories, this wing has special rooms for culturing, epifluorescence microscopy, tissue culture, work with radioisotopes, equipment rooms, cold rooms, and variable temperature rooms. There is a support room on each floor that has an autoclave, dishwasher, and pyrogen-free Milli-Q water system. Dr. Hicks's laboratory (~1,200 ft2) is equipped for research in the areas of microbial ecology, organic geochemistry, and molecular biology and includes computers and special software for genetic and phylogenetic analyses. The Department of Biology is well equipped for microbiological, limnological, and molecular biology research. In addition, his laboratory and this project have access to DNA sequencing facilities at the University of Minnesota Biomedical Genomics Center and the Minnesota Supercomputing Institute for analysis of DNA sequence data generated by this project.

The Northeast-Midwest Institute oversees the operation of the Great Ships Initiative ballast water testing facility in Superior, WI. These facilities include laboratories to test new ballast water treatment technologies at the bench-scale and mesocoms, a full-scale, on-land testing facility, and scientific labs to process samples.

The collective research, organizational, and administrative experiences of the project team members and the resources available to this project from the University of Minnesota should ensure the successful completion of the proposed project goals.