Environment and Natural Resources Trust Fund
2021 Request for Proposal

General Information

Proposal ID: 2021-326

Proposal Title: Assessing Impacts of Boat Waves on Minnesota Lakes

Project Manager Information

Name: Jeffrey Marr

Organization: U of MN - St. Anthony Falls Laboratory

Office Telephone: (612) 624-4427

Email: marrx003@umn.edu

Project Basic Information

Project Summary: Characterize boat wakes and propeller wash and the effects of each on shorelines, bottom sediment, aquatic vegetation, and overall water quality in Minnesota lakes.

Funds Requested: $420,000

Proposed Project Completion: 2024-06-30

LCCMR Funding Category: Water Resources (B)

Project Location

What is the best scale for describing where your work will take place?
> Region(s): Central

What is the best scale to describe the area impacted by your work?
> Statewide

When will the work impact occur?
> During the Project and In the Future

Narrative

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

This project will evaluate impacts of boat-generated waves and propeller wash on Minnesota lakes and shorelines. Motorboat activities on inland lakes is a major recreational pastime in Minnesota and includes fishing boats, ski boats, wakeboarding boats, and large pontoons. All watercraft generate waves associated with the displacement of water by the boat hull. The waves interact with sediment and vegetation on the lake bottom and shoreline. Over the last 15 years, a new class of boat has emerged - wake enhancing watercraft or wakesurfing boats. These boats are engineered to create a massive wake nearly twice the size of a typical motorboat - large enough to allow surfing directly behind the boat. The tremendous wave energy produced by these boats appears to result in increases in sediment erosion, damage to aquatic vegetation and damage to shorelines. The large engine generates a powerful jet that penetrates deep into the lake, likely deeper than typical motorboats, potentially resulting in disruption of the lake bottom sediments and damaging aquatic vegetation. Presently, little data exist on impacts of large waves and propeller wash on lake bottom sediment and water quality, and how the impacts of boat-generated waves compare to wind-driven waves.

What is your proposed solution to the problem or opportunity discussed above? i.e. What are you seeking funding to do? You will be asked to expand on this in Activities and Milestones.

This project will generate data characterizing the waves and propeller wash produced by motorboats and quantify the impact on shorelines, lake bottoms, and aquatic vegetation. Field research will be supported by citizen scientists from our partner network (see Support Letters). Activity 1 will characterize the wave energy and propeller wash generated by individual boats covering a range of boat types including a wakesurfing boat. Velocity and pressure sensors will be deployed at various distances from the shoreline to characterize wave energy and turbulence within the water column. Wave monitors with synchronized photo capture of boat activity will be deployed to generate a long-duration record of boat-generated waves. Here, wind speed and direction will be used to differentiate wind driven waves from those caused by boats. Data will be collected on lakes covering a range of depths, shoreline slopes and lake bottom sediments types. Activity 2 will utilize the research facilities of the St. Anthony Falls Laboratory and will examine how the measured wave and propeller wash energies impact sediment and aquatic vegetation. The laboratory environment is an ideal location for examining complex water-sediment-plant interaction with advanced sensors and cameras and will allow the development of science-based guidance for boat operation.

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

This project will provide much needed scientific data for state and county leaders, lake associations, the marine sports industry and the general public to guide the safe expansion of wake surfing and other motorized watercraft while providing protection for Minnesota's most important asset – our lakes and rivers. We target the following outcomes:
 - Data to inform watercraft operational guidance including recommended distances from shoreline for operating enhanced wake boats to minimize shoreline and bottom erosion, damage to property, and maintain safety for all.
 - Data to inform the recommended lake depth for watercraft operation including wake boats.

Activities and Milestones

Activity 1: Field measurements of boat wakes and propeller wash under typical operational conditions and different bottom geometries.

Activity Budget: $163,222

Activity Description:

Field tests will be conducted on natural lakes with representative shoreline and bottom conditions. Three lakes will be identified for the study ranging in bottom sediment, lake size/depth, and shoreline slopes. Long-term wave and boat monitoring stations will be installed at each study site that will include sensors to capture wave height, wind, and photographs of boat activity over the summer/fall field campaign. The objective is to determine the range of wave activity typically produced at the study site. Additionally, focused test campaigns will be carried out using three common motorboats and an array of wave characterization technologies placed in the near-shore region. During the focused studies, boats will be driven parallel to shoreline under a range of operational conditions. Boats will include a deep-hull walleye fishing boat, a ski boat, and a ballasted wake boat. Velocity and pressure sensor arrays will be positioned in the water column near shoreline to record wave energy and turbulence associated with each boat type. The energy associated with propeller wash will also be studied. Project partners associated with several lake associations will help identify study sites, locate and operate test motorboats, and provide local communication about the testing results.

Activity Milestones:

Description	Completion Date
Field campaign design - long-term monitoring & focused studies on boat waves/propeller wash.	2021-08-31
Execute field campaign - long-term monitoring and boat evaluation	2022-10-31
Preliminary analysis of field data	2023-02-28

Activity 2: Laboratory research evaluating boat-generated wave energy/prop wash on sediment and aquatic vegetation.

Activity Budget: $187,441

Activity Description:

Laboratory studies will be carried out using the research flumes and tanks of the St. Anthony Falls Laboratory. These experiments will provide the detailed information needed to establish appropriate boat operation guidelines (minimum depth, minimum distance from shore, etc). Scaled boat models in tow tanks will characterize hull wake/wave development, wave propagation, and wave energy impacts on shorelines for different lake bathymetry profiles. Scaled models will also be used to characterize the impacts of propeller wash on lake beds for varying water depths and sediment types. Wave flumes will be used for near full-scale studies of wind and boat induced waves impacts on nearshore lake sediment, beaches, and vegetated shorelines. The flume experiments will include the effects of wave damping from submerged and emergent aquatic plants, and the potential for waves to uproot aquatic plants. The scaling methods of lab tests will be carefully considered such that results can be scaled up and appropriately applied to Minnesota lakes and lake sediments.

Activity Milestones:

Description	Completion Date
Experimental design completed and facility configurations completed - ready for testing	2022-03-31
Completion of experiments and data collection for laboratory studies	2023-06-30
Analysis of laboratory data	2023-12-31

Activity 3: Development of results, project summaries, and guidance documents.

Activity Budget: $69,337

Activity Description:

Data collected from the field and laboratory campaigns will be analyzed and summarized into actionable recommendations. We will determine the range of wave energies produced by motor boats over typical recreational seasons. We will also determine characteristics of waves and propeller wash produced by common motorboats and how characteristics change under different boat speeds and distances from shoreline, different lake bottom slopes, and lake depths. Data will be synthesized into recommendations that decision-makers may use to develop policy or use within training courses on watercraft operation. SPECIFIC GUIDANCE MAY INCLUDE: a) recommended distances from shoreline for operating enhanced wake boats to minimize shoreline and bottom erosion, damage to property, and how to avoid creating unsafe conditions for others, and b) recommended lake depth and/or lake size for operating wake enhancing watercraft. KNOWLEDGE TRANSFER: Research will be submitted for publication in at least one peer reviewed journal. Working with our partner network, we will develop a concise project summary and recommendations written for watercraft operators, lake managers and other stakeholder groups. The research will be presented to practitioners at the MN Water Resources Conference held annually in St. Paul, MN.

Activity Milestones:

Description	Completion Date
Development of concise Project Summary for distribution	2024-03-31
Analysis of data and development of draft recommendations	2024-03-31
Submission of article for review in peer-reviewed journal; Final Report to LCCMR	2024-06-30

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Jeffrey Forester	Minnesota Lakes and Rivers Advocates	Provide connection to specific lake associations. Help identify field sites and citizen scientists. Help locate boats that can be used in testing. Assist in Knowledge Transfer and distribution of findings. Mr. Forester is the Executive Director of MN Lakes and Rivers Advocates.	No
Kimberly Hill	University of Minnesota - SAFL & Department of Civil, Environmental and Geo-Engineering	Associate Professor Hill is Co-PI and will guide field and laboratory research in all areas with special focus on characterizing the propeller wash and impingement on lake sediments. Hill is an expert in particle physics and sediment transport with applications to lake, reservoir, river, and pond environments.	Yes
William Herb	University of Minnesota - St. Anthony Falls Laboratory	Dr. Bill Herb is Co-PI and will oversee field and laboratory research characterizing boat-generated waves and interaction with sediment and vegetation. Herb is a Research Associate at SAFL and is currently leading an LCCMR-funded project studying wind-wave energy and nearshore fish habitat in Minnesota lakes.	Yes
Jessica Kozarek	University of Minnesota - St. Anthony Falls Laboratory	Dr. Jessica Kozarek is Co-PI and will oversee field and laboratory research characterizing boat-generated waves and interactions with sediment and vegetation. Kozarek is a Research Associate at SAFL and is Manager of the SAFL Outdoor StreamLab.	Yes
Lian Shen	University of Minnesota - SAFL & Department of Mechanical Engineering	SAFL Director and Professor Shen is Co-PI and will provide technical expertise to guide field and lab research on wave monitoring and characterization. Shen is a world expert in wave dynamics and simulations.	Yes
Joseph Shneider	Minnesota Coalition of Lake Associations	Provide connection to specific lake associations. Help identify field sites and citizen scientists. Help locate boats that can be used in testing. Assist in Knowledge Transfer and distribution of findings. Mr. Shneider is current President of the MN COLA.	No
Mathew Lueker	University of Minnesota - St. Anthony Falls Laboratory	Research Engineer: Review of wind driven wave effects Literature review for characterization of wakes from boat hulls and propellers to aid design of datalogging equipment. Experimental design for laboratory testing. Analysis and reporting. Lueker is lead hydraulic modeler at SAFL with over 15 years of project experience.	Yes
Jeffrey Marr	University of Minnesota - St. Anthony Falls Laboratory	SAFL Associate Director is PI and will serve as project manager for the effort. He will provide technical and managerial guidance to all Activities. Marr will also coordinate the partner network, citizen science participation, and stakeholder interactions.	Yes

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this be funded?

The project is of interest to many levels of governance in the state including local lake associations, city and county boards, MNDNR and the state legislature. The results of this project will be published in peer-reviewed literature, as

LCCMR and UMN project reports, and presented at local conferences including the Minnesota Water Resources Conference. All data and findings will be provided to the project sponsor and interested state agencies. A concise project summary and recommendations will be developed for watercraft operators and MN citizens that can be distributed to stakeholder groups.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Enhancing Spawning Habitat Restoration in Minnesota Lakes	M.L. 2017, Chp. 96, Sec. 2, Subd. 08e	$294,000
MAISRC Subproject 21.2: Field Validation of Mulitbeam Sonar Zebra Mussel Detection	M.L. 2017, Chp. 96, Sec. 2, Subd. 06a	$0
Conserving Minnesota's Native Freshwater Mussels	M.L. 2014, Chp. 226, Sec. 2, Subd. 05k	$350,000

Project Manager and Organization Qualifications

Project Manager Name: Jeffrey Marr

Job Title: Associate Director of Engineering and Facilities

Provide description of the project manager's qualifications to manage the proposed project.
Marr is a licensed professional civil engineer (Minnesota) and the Associate Director of Engineering and Facilities at SAFL. He received his BS (1996) and MS (1999) from the University of Minnesota, Department of Civil Engineering and has been a member of SAFL professional research staff for over 20 years. Marr will serve as Project Manager and Principal Investigator for this project. His research expertise is in the areas of hydraulics and sediment transport including river and delta systems, deep water gravity currents, and reservoir/lake sedimentation and erosion. Marr manages SAFL's Applied Research and Engineering team, a 13 member team that supports ongoing faculty research and carries out applied research with public and private sponsors. Marr is an experienced project manager and principal investigator, having managed large infrastructure projects such as the $16M renovation of SAFL and $8.5M construction of the UMN Wind Research Facility at UMore Park in Rosemount, MN. Marr has also managed many multi-investigator applied research projects.
For this current project, two factors are especially important to the success of the effort. The first, is to recognize that this topic of recreational boating and environmental impact carries with it a variety of perspectives and viewpoints. It is critical to acknowledge both the economic importance and broad recreational enjoyment of boating as well as the delicate linkages within complex environmental systems such as lakes and rivers. The project team understands these contexts and has the experience to carry out robust, unbiased research for the benefit of multiple viewpoints. Second, the data and outcomes of the work are sought by many different stakeholder groups. The project team is experienced in publicly funded and applied research such as this proposed project and we are committed to broad and clear distribution of our findings to these stakeholder communities.

Organization: U of MN - St. Anthony Falls Laboratory

Organization Description:
SAFL is an interdisciplinary fluid mechanics research facility of the College of Science and Engineering at the University of Minnesota. SAFL research focuses on environmental, energy, and health challenges. SAFL is well instrumented for the study of waves and erosion and for the study of interactions between fluid mechanics and biota with expertise and equipment for measuring flow and turbulence at a range of scales including acoustic Doppler velocimeters (ADVs). The experimental portion of this project is centered at SAFL because of the data collection systems that allow for the careful positioning of instrumentation (http://www.safl.umn.edu/services/measurements) with sub mm accuracy. SAFL also has a sediment laboratory to characterize lake bed shoreline sediments.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Jeffrey Marr		Project Manager and PI			27%	0.09		$14,689
William Herb		Co PI			27%	0.84		$90,693
Jessica Kozarek		Co PI			27%	0.84		$90,294
Kimberly Hill		Co PI			27%	0.12		$23,689
Lian Shen		Co PI			27%	0.02		$10,476
Matthew Lueker		Lead engineer for field and laboratory research			24%	0.78		$63,105
Benjamin Erickson		Technical support of field deployment and lab research			24%	0.14		$11,169
Christopher Milliren		Engineering design and fabrication of instrumentation			24%	0.28		$19,310
Undergraduate Student		Support field and lab research			0%	0.5		$16,428
							Sub Total	**$339,853**
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
	Tools and Supplies	Instrumentation and sensors for confinuous field monitoring	data mast, solar panel, cabling, weather station for measurement of wave height and velocity in field campaign					$20,000
	Tools and Supplies	Instrumentation and sensors for focused monitoring	data mooring, power supplies, velocity probes, turbidity meter for field campaign					$18,000
	Tools and Supplies	Diver costs and supplies	Diver tank and supplies for staff diver to support deployment of field sensors.					$2,000
	Tools and Supplies	Hull Wake Model	fabrication of scale model boat hull and towing mechanicals					$10,900

	Tools and Supplies	Propeller Wake Model	motors, shaft and prop for modeling of prop wash in lab					$11,000
	Tools and Supplies	Littoral (Plant) Interaction	plants and substrate for laboratory experiments on wave-plant interactions					$9,500
							Sub Total	**$71,400**
Capital Expenditures								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
	Conference Registration Miles/ Meals/ Lodging	Conference registration	registration for MN Water Resources Conference to present results of work					$1,000
	Other	car rental	Rental of vehicle to travel to field sites for ACTIVITY 1 field campaign					$6,000
							Sub Total	**$7,000**
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
							Sub Total	-
Other Expenses								
		Cell phone model data contract	data plan to allow remote download and backup of field data.					$900
		Report production costs	Final summary report produced and distributed to project stakeholders					$847

							Sub Total	$1,747
							Grand Total	$420,000

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
-			**State Sub Total**	-
Non-State				
In-Kind	Unrecovered F&A	Support of SAFL facilities where research will be conducted.	Secured	$231,000
			Non State Sub Total	**$231,000**
			Funds Total	**$231,000**

Attachments

Required Attachments
Visual Component
File: [c8165863-333.pdf](c8165863-333.pdf)

Alternate Text for Visual Component
The Visual Component shows three research activities associated with the project. First, in the upper right is an image of a recreational watercraft to remind the reviewer that this project is focused on measuring environmental impacts from motorboats. The upper left is titled, "Field measurement of boat-generated waves in shoreline zone" and is a graphic of a sloped shoreline zone with waves of different heights impacting the shoreline. Bottom sand and gravel are shown as are aquatic vegetation. The lower right graphic is titled, "Field measurements of prop wash on lake bottoms". The graphic is a schematic of the propeller wash generated by a large boat engine. The wash is projected down toward the lake bottom and may impact aquatic vegetation, fish or sediment. The bottom left schematic is titled, "Laboratory and field measurements of waves/prop wash on sediment and aquatic vegetation". The graphic is two images illustrating examples of laboratory-based research with UMN researchers shown in the images. At the bottom of the Visual Component is the logo of the St. Anthony Falls Laboratory, University of Minnesota.

Optional Attachments
Support Letter or Other

Title	File
Letter of Support_Christmas Lake Homeowners Association	[f8715490-473.pdf](f8715490-473.pdf)
Letter of Support_Lake John Association	[49f0ee28-af6.pdf](49f0ee28-af6.pdf)
Letter of Support_Gull Chain of Lakes Association	[153ff14d-61a.pdf](153ff14d-61a.pdf)
Letter of Support_Greater Lake Sylvia Association	[5ddc2b16-0d2.pdf](5ddc2b16-0d2.pdf)
Letter of Support_Lake Minnewashta Preservation Assoc	[4570b79a-b99.pdf](4570b79a-b99.pdf)
Letter of Support_SafeWakes for Minnesota Lakes	[270763d5-a4e.pdf](270763d5-a4e.pdf)
Letter of Support_Minnesota Coalition of Lake Associations	[6df6dac6-fa2.pdf](6df6dac6-fa2.pdf)
UMN Administrative Approval Letter	94aaed40-068.pdf
Letter of Support_MN Lakes and Rivers Advocates	[56c8990b-d54.pdf](56c8990b-d54.pdf)
Letter of Support_Whitefish Area Property Owners Association	[e93ab350-3ba.pdf](e93ab350-3ba.pdf)

Administrative Use

Does your project include restoration or acquisition of land rights?
> No

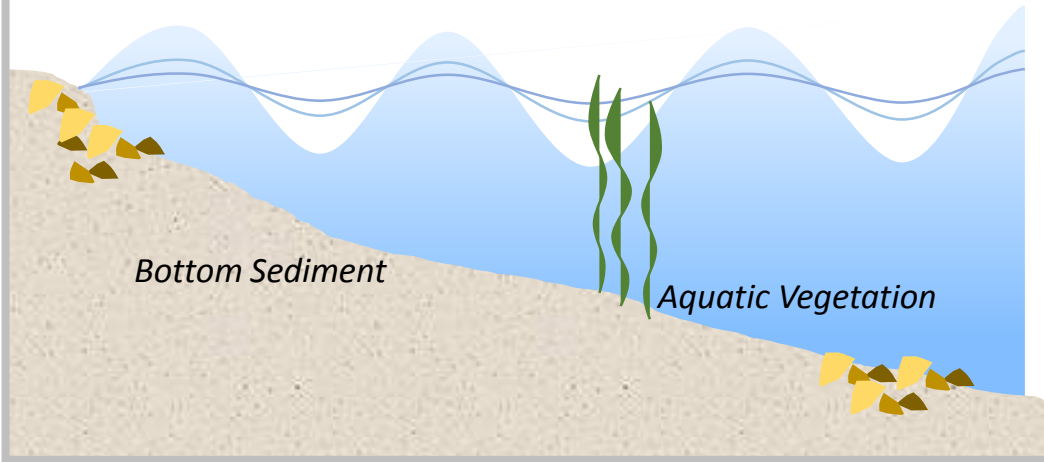**Does your project have patent, royalties, or revenue potential?**
> No

Does your project include research?
> Yes

Does the organization have a fiscal agent for this project?
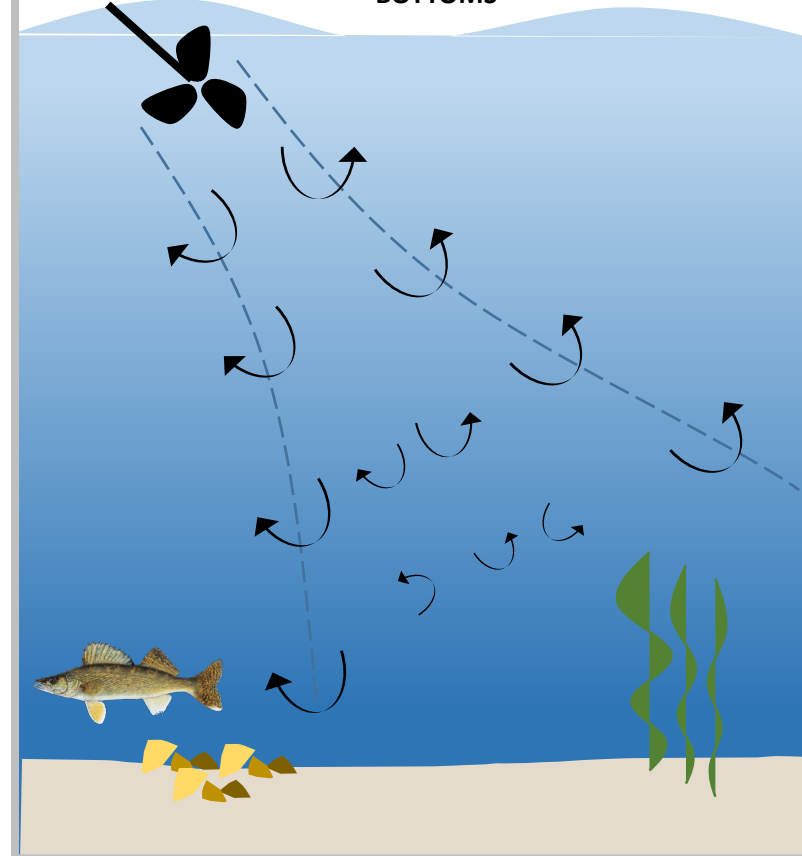> Yes, Sponsored Projects Administration

FIELD MEASUREMENT OF BOAT-GENERATED WAVES IN SHORELINE ZONE

Bottom Sediment

Aquatic Vegetation

LABORATORY AND FIELD MEASUREMENTS OF WAVES/PROP WASH ON SEDIMENT AND AQUATIC VEGETATION

FIELD MEASUREMENT OF PROP WASH ON LAKE BOTTOMS

ST. ANTHONY
FALLS LABORATORY

UNIVERSITY OF MINNESOTA

Driven to Discover℠