Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-076

Proposal Title: Predicting Winter Fish Kill Risk in Minnesota Lakes

Project Manager Information

Name: Ted Ozersky

Organization: U of MN - Duluth - Large Lakes Observatory

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Project Basic Information

Project Summary: This project will develop a model of under ice oxygen depletion and predict the likelihood of winter anoxia and fish kills across thousands of Minnesota lakes.

ENRTF Funds Requested: $592,000

Proposed Project Completion: June 30, 2030

LCCMR Funding Category: Fish and Wildlife (D)

Project Location

What is the best scale for describing where your work will take place?

Statewide

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.

Under ice oxygen depletion (anoxia/hypoxia) is one of the main causes of fish kills in Minnesota lakes. Beyond directly causing fish mortality, winter deoxygenation can also increase internal nutrient loading, leading to harmful algal blooms, water quality degradation, and loss of ecosystem services.

While drivers of summer-time oxygen depletion are well understood and routinely modelled, the processes controlling winter anoxia remain poorly constrained. This knowledge gap limits the ability to predict the likelihood of winter kills across lakes and undermines effective fish population management through mitigation actions and adaptive management practices. Rapidly changing winter conditions and evolving land use and water quality in Minnesota increase uncertainty around winter anoxia risk, making historical records of winter fish kills an increasingly unreliable guide to future risk.

This project will integrate existing and new data to develop predictive models of winter deoxygenation across thousands of Minnesota lakes. Our model will be developed into an online dashboard, providing resource managers and the public with lake-specific assessment of winterkill risk. The resulting tool could support both immediate interventions, such as targeted aeration, and longer-term adaptive management decisions aimed at reducing vulnerability to winter anoxia, such as changing stocking and take practices.

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

The ultimate goal of this project is to develop a fishkill risk prediction tool for thousands of MN lakes.

This will be accomplished by compiling existing oxygen observations from sources including our DNR Sentinel Lakes partners, MN counties, and the scientific literature. These data will be supplemented with continuous oxygen sensor deployments in 10 representative MN lakes, to obtain the high-resolution data needed for reliable models. Data on water and sediment chemistry will also be collected to help understand drivers and consequences of winter anoxia.

The oxygen results will be combined with information on lake basin shape (morphometry), water chemistry, and winter weather conditions to develop models of oxygen depletion and likelihood of anoxia.

The model will be used to predict the risk of under-ice anoxia and winter kills for thousands of lakes across Minnesota, using information on lake properties and local meteorological conditions. The model could be used to predict if a particular lake is likely to develop anoxia, and to examine how Minnesota's lakes may respond under future change scenarios.

We will work closely with project partners to communicate the results of our work and disseminate findings through scientific conferences and publications and through outreach to the public.

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 addresses LCCMR priorities in Resiliency, Water, and Fish & Wildlife by improving understanding of winter oxygen dynamics in Minnesota lakes. The results will support prediction and mitigation of hypoxia and winter fish kills, and improve assessment of water quality risk. The tools developed will help resource managers prioritize lakes for fish kill monitoring under Minnesota Statutes 103G.216 and 103G.2165 and guide proactive management. Applications include activating aeration systems before critical oxygen thresholds are reached, identifying lakes where aeration systems are most needed, and informing adaptive fisheries and water quality management, including nutrient load reduction and stocking practices.

Activities and Milestones

Activity 1: Generate winter dissolved oxygen and environmental variable database from existing data and new deployments

Activity Budget: $306,007

Activity Description:
This activity will generate a comprehensive database of winter dissolved oxygen (DO) and related environmental conditions from lakes representative of Minnesota systems. We will compile existing data and conduct targeted field measurements to fill key gaps.

Existing sources include continuous DO sensor deployments from Minnesota DNR Sentinel Lakes and discrete winter DO profiles collected by the Minnesota DNR and county monitoring programs. Additional data will be compiled from the scientific literature. A graduate student will work with the DNR, counties, and project personnel to assemble and standardize these records into a unified dataset.

We will supplement existing records with deployments of DO, temperature, and light sensors in 10 lakes selected to fill gaps in lake types and winter conditions, including variation in morphometry, trophic status, and geographic location across Minnesota.

The dataset will also include lake morphometry, temperature structure, water and sediment chemistry, and winter climate metrics such as ice cover duration, precipitation, and winter severity. In instrumented lakes we will characterize physical, chemical, and biological processes regulating oxygen transport and consumption during winter. These data will support development of empirical and mechanistic models of under-ice oxygen dynamics and fish kill risk.

Activity Milestones:

Description	Approximate Completion Date
Identify and compile existing DNR, county, and literature dissolved oxygen and relevant environmental data	June 30, 2028
Deploy sensors, and collect water/sediment chemistry data from 10 MN lakes over 2 years	September 30, 2029
Compile existing and new data into a single database to enable modelling of under-ice oxygen	October 31, 2029

Activity 2: Develop models of winter DO depletion and anoxia and fish kill risk

Activity Budget: $198,960

Activity Description:
This activity will use the DO dataset built under Activity 1 to develop statistical and mechanistic models linking lake characteristics and meteorological conditions to winter oxygen depletion and risks of anoxia.

We will develop statistical models that relate DO depletion rates and anoxia occurrence to lake morphometry, water quality, and winter severity. Using meteorological data, these models will generate predictions of oxygen depletion and risk across diverse lakes. To develop statewide winter anoxia risk maps, we will leverage existing water quality datasets from partners at MN DNR and MN PCA to upscale model results from study lakes to lakes throughout Minnesota.

In parallel, we will construct dynamic models that account for key processes regulating the oxygen mass balance, including sediment and water respiration, photosynthesis, and physical mixing that transports oxygen and other substances in the water. The models will provide a detailed view of lake oxygen dynamics throughout the winter and will

be tailored to individual lakes using their morphology and local conditions. These models will be used to test the sensitivity of oxygen concentrations to climate and management scenarios.

The combined set of models will produce statewide winter anoxia risk maps and a scenario-testing framework for management interventions.

Activity Milestones:

Description	Approximate Completion Date
Develop and validate multivariate statistical models linking lake and watershed characteristics to oxygen depletion	December 31, 2029
Develop and calibrate a mechanistic reaction-transport model for oxygen dynamics.	December 31, 2029
Identify risk of anoxia and sensitivity of oxygen to specific meteorological and location factors	April 30, 2030

Activity 3: Develop publicly available winter anoxia risk maps and publications to share findings with natural resources managers

Activity Budget: $87,033

Activity Description:
The objective of this activity is to disseminate findings and tools developed under Activity 2 to natural resources managers and scientists.

Geospatial datasets (i.e., maps) and associated metadata will be created for winter anoxia risk across Minnesota and be made publicly available through the Minnesota Natural Resources Atlas (mnatlas.org). Anoxia risk maps will be updated annually to reflect increased accuracy of statistical models and interannual differences in winter and meteorological forecasts. We will solicit feedback on these online tools from our project partners to ensure that information is being communicated effectively.

In addition to our final project report, we plan to develop at least three manuscripts based on our findings for publication in peer-reviewed scientific journals. Outputs include winter anoxia risk maps for winter 2028/2029 and 2029/2030 and scientific publications. Success will be evaluated through usage of geospatial datasets (via Google Analytics built into the Minnesota Natural Resources Atlas) and manuscript downloads and citations.

Activity Milestones:

Description	Approximate Completion Date
Create code for Winter 2028/2029 anoxia risk forecast	July 31, 2028
Refine code to create Winter 2029/2030 anoxia risk forecast	July 31, 2029
Submit final project report to LCCMR and 3 manuscript(s) for publication in scientific journals.	June 30, 2030

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Sergei Katsev	University of Minnesota Duluth, Large Lakes Observatory	Prof. Katsev is a physicist and geochemist with the UMD Large Lakes Observatory. He has 20+ years of experience in field characterizations and dynamic modelling of lake water columns and sediments, to predict nutrient and oxygen levels. He will oversee model development and collection and analysis of physical samples.	Yes
Chris Filstrup	University of Minnesota Duluth, Natural Resources Research Institute	Dr. Christopher Filstrup is a limnologist with the University of Minnesota's Natural Resources Research Institute and Director of the Central Analytical Laboratory. His research focuses on biogeochemistry and aquatic ecosystem responses to climate and environmental change. He will be responsible for upscaling anoxia risk models and disseminating project findings.	Yes

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.
Partner engagement: this project is being developed in collaboration with MN DNR (see letter of support) and in consultation with MN PCA. The anoxia models and fishkill risk map that we will produce have clear and immediate implications for fisheries and water quality management, including compliance with MN statutes 103G.2165 and 103G.216 (Development of fish kill response protocol and Reporting fish kills in public waters). We will meet with project partners throughout the project to seek advice on our approach, interpretation of findings, and to ensure that project findings are useful to management purposes. We will host a project kickoff meeting in Year 1, as well as project wrap-up meetings in each of Years 2 and 3.

Peer-reviewed publications and presentations: results of this project will be of interest to a wide range of researchers and natural resource managers in Minnesota and beyond. We will share our findings through scientific publications in the peer-reviewed literature and through presentations in regional and international scientific conferences such as the MN Water Resources Conference, Association for the Sciences of Limnology and Oceanography (ASLO), Society of Freshwater Science and the North American Lake Management Society (NALMS). We expect that at least three scientific publications and four presentations will be produced.

Data availability: All data will be made freely available and publicly accessible through online data repositories, such as the Environmental Data Initiative (EDI) or the Data Repository of the University of Minnesota (DRUM). All datasets will include fully documented metadata to facilitate use of data products. Data will be made freely available and publicly accessible upon publication of peer-review manuscripts or within two years of project completion.
Winter anoxia risk maps generated through this project will be distributed through the Minnesota Natural Resources Atlas (mnatlas.org), an established public platform for geospatial natural resource data. Maps will include metadata and documentation and will be updated annually as models are refined and new winter and meteorological data become available. GIS layers of winter anoxia risk maps will also be hosted on the Minnesota Geospatial Commons for permanent archiving and public availability. Dataset availability will be maintained after the project using existing University support mechanisms.

Public outreach: Findings from this project will be of interest to the general public and especially to recreational fishers. We will leverage our existing relationships with journalists and work with the University of Minnesota Duluth, Large Lakes Observatory, and Natural Resources Research Institutes' Communications Specialists to coordinate media inquiries and to develop stories on various platforms (newsletters, online media) related to this project. We will also

communicate the findings through ongoing outreach efforts such as the Large Lakes Observatory's Science on Deck events.

Funding acknowledgment: We will acknowledge the Environment and Natural Resources Trust Fund (ENRTF) through use of the trust fund logo or attribution language on project print and electronic media, publications, signage, and other communications and outreach following requirements detailed in the ENRTF Acknowledgment Guidelines.

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 work be funded?
Project activities, including data collection, data analysis and interpretation, and tool development, will be completed during this project. Institutional funds will be used to fund products that are developed afterwards, such as publications or scientific presentations. Data will be archived on online repositories through University of Minnesota for data preservation and public accessibility at minimal cost. Project partners have a long history of collaboration and will continue to collaborate after this project as part of typical job duties. If new research directions are developed from LCCMR's investment in this project, partners will seek new funding from other grant opportunities.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Changing Winters and Game Fish in Minnesota Lakes	M.L. 2022, , Chp. 94, Art. , Sec. 2, Subd. 04d	$238,000

Project Manager and Organization Qualifications

Project Manager Name: Ted Ozersky

Job Title: Associate Professor

Provide description of the project manager's qualifications to manage the proposed project.
Dr. Ted Ozersky is an Associate Professor of Biological Limnology at the Large Lakes Observatory, University of Minnesota Duluth. He is an expert in lake biogeochemistry and biology and an internationally recognized researcher in the winter ecology of lakes. He has conducted research on dozens of frozen lakes across North America and has led training workshops in winter field methods. Through this work, he has developed the specialized expertise required to conduct safe and effective winter field operations under a wide range of lake and ice conditions.

Dr. Ozersky has directed multiple winter research projects, including large multi-institutional and international collaborations. He has extensive experience supervising technical staff, graduate students, and postdoctoral researchers, and coordinating research activities across institutions. His work regularly involves deploying and maintaining lake sensor systems, coordinating field campaigns, collecting and analyzing water and sediment samples, and integrating large ecological datasets.

He has a strong record of communicating research results to both scientific and applied audiences. His work has been disseminated through peer-reviewed publications, conference presentations, collaborations with state agencies, and public outreach through media and community engagement.

In this project, Dr. Ozersky will coordinate activities among project participants and collaborating agencies, co-supervise

graduate students and postdoctoral researchers, oversee field operations and laboratory analyses, and help lead the dissemination of project findings.

Organization: U of MN - Duluth - Large Lakes Observatory

Organization Description:
The project will be conducted at the Large Lakes Observatory (LLO) and the Natural Resources Research Institute (NRRI) at the University of Minnesota Duluth (UMD). LLO is an internationally recognized freshwater research center focused on the ecology, chemistry, and physics of lakes. NRRI is a state-chartered applied research institute that develops science-based tools to support sustainable management of natural resources.

The laboratories of Drs. Ted Ozersky, Sergei Katsev (LLO), and Chris Filstrup (NRRI) provide the infrastructure and technical capacity required to complete the project. The co-PIs' laboratories maintain field gear and specialized instrumentation for deployment of oxygen, temperature, and light sensors and for collection of water and sediment samples. Dr. Ozersky's laboratory will contribute dozens of sensors from existing inventories at no cost to the project, an estimated $80,000 in in-kind support.

LLO and NRRI provide extensive laboratory and analytical facilities for preparation and analysis of water and sediment samples, allowing most analyses to be conducted in-house. Dr. Katsev's group maintains the computational infrastructure required for model development and analysis, while NRRI provides expertise in geospatial tools needed to develop interactive fish kill risk maps. UMD's graduate programs provide a strong training environment for students participating in the project.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
PI, Dr. Tedy Ozersky, LLO		Ozersky will be responsible for coordinating the project across all 3 project activities, including student, postdoc and staff supervision, field and lab operations, modelling, product dissemination, and reporting.			26.8%	0.24		$44,493
Co-I, Dr. Sergei Katsev, LLO		Katsev will be responsible for developing statistical and mechanistic models of anoxia (Activity 2) and will assist with creating the winter DO database (Activity 1) and dissemination of findings (Activity 3)			26.8%	0.24		$50,522
Co-I, Dr. Chris Filstrup, NRRI		Filstrup will be responsible for upscaling anoxia risk models to Minnesota lakes (Activity 2) and will assist with creating winter DO database (Activity 1) and disseminating findings (Activity 3).			26.8%	0.24		$34,418
Jerry Henneck, Civil Service Tech, NRR		Henneck will assist with sensor fabrication and deployment (Activity 1) and with upscaling anoxia risk models to Minnesota lakes (Activity 2).			24.4%	0.24		$27,395
Kristofer Johnson, IT Professional, NRRI		Johnson will be responsible for generating anoxia risk geospatial datasets and disseminating data online (Activity 3) and will assist with geospatial modeling of anoxia risk models (Activity 2).			26.8%	0.16		$15,450
Shawnee McMillian, Civil Service Tech, NRRI		McMillian will be responsible for assisting with sensor deployment and sample collection (Activity 1).			24.4%	0.16		$14,782
Civil Service Tech, LLO		A civil service technician (to be named) at LLO will assist with water and sediment sample preparation and analysis (Activity 1)			24.4%	0.24		$16,828
Postdoc		The postdoctoral researcher (to be named) will work with project PIs to develop the DO database (Activity 1) and construct statistical and mechanistic models of anoxia (Activity 2) and contribute to disseminating results (Activity 3)			20.7%	2		$156,170
Master's Graduate		A MS graduate student will work with project PIs and other personnel to help develop the DO database and collect, analyze, and interpret water quality and			41.4%	0.62		$68,813

Research Assistant		sediment chemistry results (Activity 1), as well as contributing to dissemination of results (Activity 3). The % benefits calculation includes tuition remission.						
							Sub Total	**$428,871**
Contracts and Services								
Lab analyses at UMD LLO	Internal services or fees (uncommon)	Water and sediment samples will be analyzed at PI Ozersky's Biological Limnology lab at LLO. Water analyses and sediment will include forms and concentrations of major nutrients, dissolved and particulate organic carbon, and chlorophyll.				0		$42,736
GIS lab services at NRRI	Internal services or fees (uncommon)	The NRRI GIS Lab is supported in part by a small hourly fee charged to projects in order to cover infrastructure and software licenses. This is applied to projects that use either GIS or web/application development services. The rate is $7.16 per hour and is applied to the percent				0		$1,432
PME and In Situ	Service Contract	PME and In Situ will provide sensor calibration services to ensure oxygen, temperature, and conductivity sensors are operating according to specs.				0		$10,000
University of New Hampshire	Service Contract	Water samples will be analyzed for major ion and methane concentrations at the Water Quality Analysis Laboratory at UNH.		X		0		$30,600
							Sub Total	**$84,768**
Equipment, Tools, and Supplies								
	Equipment	Sensors: depth and conductivity data loggers (20)	We will purchase depth and conductivity sensors for the sensor moorings (top and bottom of mooring) to depth-reference other observations and measure conductivity, which affects water mixing and distribution of oxygen (Activity 1).					$20,002
	Tools and Supplies	Supplies - NRRI	field supplies (e.g., notebooks, batteries, mooring hardware, field gear) in Years 1 and 2 (Activity 1).					$2,000
	Tools and Supplies	Mooring supplies	Weights, line, buoys, airtags and other miscellaneous items needed to					$5,000

			securely deploy and service sensor moorings (Activity 1).					
	Tools and Supplies	Field and lab supplies LLO	Miscellaneous field and lab supplies needed for sample collection and storage by the Ozersky lab, including auger blades, ice shelter, propane tanks for heaters, sample containers, filters, lab glassware, tape, printable labels and field sheets, etc. (Activity 1).					$7,004
							Sub Total	**$34,006**
Capital Equipment								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Approximately 30 trips to 10 study lakes across the state to deploy and service moorings and collect water and sediment samples by 3 people. Request includes costs of estimated mileage, per diem food, and accommodations at university-determined rates.	Travel to study lakes to deploy sensors, and then download data, and service the sensors twice/year. Additionally, 5 annual visits to each lake to collect water samples and water column profiles needed for developing statistical and mechanistic models of anoxia (Activity 1 and 2)					$32,171
							Sub Total	**$32,171**
Travel Outside Minnesota								
	Conference Registration Miles/ Meals/ Lodging	Travel by 4 project personnel to North American conferences in Years 2 and 3 of the project to disseminate project results (Activity 3). Estimate includes Google search for flights, conference registration, and GSA per diem for 4 nights and five days, using Vancouver, BC as a representative conference host site.	Project personnel will present the results of this research to aquatic science and management conferences (e.g., Association for the Sciences of Limnology and Oceanography, National Lake Management Society, Society for Freshwater Science).	X				$12,184

							Sub Total	**$12,184**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$592,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Contracts and Services - University of New Hampshire	Service Contract	Water samples will be analyzed for major ion and methane concentrations at the Water Quality Analysis Laboratory at UNH.	These analyses are not conducted at UMD and UNH service is the most affordable option for these analyses.
Travel Outside Minnesota	Conference Registration Miles/Meals/Lodging	Travel by 4 project personnel to North American conferences in Years 2 and 3 of the project to disseminate project results (Activity 3). Estimate includes Google search for flights, conference registration, and GSA per diem for 4 nights and five days, using Vancouver, BC as a representative conference host site.	Out of state travel is requested as there are no similarly large-scale conferences of this type in Minnesota.

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
In-Kind	UMN unrecovered indirect costs are calculated at the UMN negotiated rate for research of 54% modified total direct costs.	Indirect costs are those costs incurred for common or joint objectives that cannot be readily identified with a specific sponsored program or institutional activity. Examples include utilities, building maintenance, clerical salaries, and general supplies. (https://research.umn.edu/units/oca/fa-costs/direct-indirect-costs)	Secured	$573,280
In-Kind	MN DNR	In-kind support through 120 hours of staff time and expertise worth $5,971 and oxygen and temperature loggers/equipment worth $60,000	Secured	$65,971
			State Sub Total	**$639,251**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**$639,251**

Total Project Cost: $1,231,251

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: c4297009-328.pdf

Alternate Text for Visual Component

Visual description of problem (prediction of winter fish kills), proposed approach (combine existing data with new field sampling across MN to develop models of oxygen depletion), and outcome (winter fish kill prediction tool)...

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
Ozersky - Transmittal Letter	8d39486f-eb4.pdf
DNR support letter	adf5729b-aad.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

Yes, I understand the UMN Policy on travel applies.

Does your project have potential for royalties, copyrights, patents, sale of products and assets, or revenue generation?

No

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

N/A

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

N/A

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

No

Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?

No

Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care, treatment, education, training, instruction, or recreation to children")?

No

Provide the name(s) and organization(s) of additional individuals assisting in the completion of this proposal:

umdspa@d.umn.edu; jaco2565@d.umn.edu

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

Yes, I understand