Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-134

Proposal Title: Salt Threatens Minnesota Water Quality and Food Webs

Project Manager Information

Name: Mark Edlund

Organization: Science Museum of Minnesota - St. Croix Watershed Research Station

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Project Basic Information

Project Summary: Salt levels are rising in Minnesota lakes, but the biological impacts are poorly understood. We determine how salt damages water quality and food webs and how to save our lakes.

Funds Requested: $1,174,000

Proposed Project Completion: 2020-06-30

LCCMR Funding Category: Water Resources (B)

Project Location

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

Region(s): Central, Metro,

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.

We don't know how salt affects our lake water quality and food webs. Minnesota's lakes are under threat from an invisible enemy — increasing chloride levels from road salt and other sources like water softeners and fertilizer. And not just in urban areas, but also outstate Minnesota where population growth threatens the very reason people want to live there — our lakes and streams. Past LCCMR funding helped identify the causes of salinization and fine-tune winter deicing, but the effects of salt on food webs and water quality, especially clarity and algae, remain largely unknown. Unlike other pollutants, chloride doesn't break down in the environment. Instead it accumulates to levels toxic to animals and plants, and alters how lakes stratify and how frequently top and bottom waters mix to restore oxygen to colder, deeper layers. We will show how chloride impacts what matters most to Minnesotans — lake biology and water quality — using intensive lake surveys combined with historical tracking of salinization effects and lake simulations to identify tipping points where salt does irreparable damage. Only by knowing these linkages and specific thresholds beyond which lake quality and food webs suffer, can we inform policy and prioritize lakes for protection.

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.

We will show how salt affects the health of our lakes using:
1) intensive lake survey along a gradient of salinization to determine how nutrient cycling, noxious algae, and food webs have been altered
2) historical analysis to determine when, why, and how much salt has changed water quality and food webs
3) lake simulation and experiments to understand how salinity alters lake mixing, bottom-water oxygen, and phosphorus cycling
4) communication of results and solutions to lake users and resource managers on how to protect lakes

Lakes suffering from salt pollution are often our greenest lakes, rich in nutrients and choked with algae. Is this a consequence of how the lake is responding to the salt as lake mixing changes, or are excess nutrients simply linked to watershed inputs? We will disentangle these drivers of poor water quality.

Impairment for salt is based on chloride, an ion potentially toxic to freshwater animals. Daphnia, or waterfleas, are sentinels for chloride impacts and serve as keystone species that graze on algae to clear the water and are critical food sources supporting fisheries. We will show how chloride-induced changes in waterflea species reflect the food web health in Minnesota lakes.

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?

First, this project will determine chloride tipping points that lead to poor lake water quality and food web disruption, and so guide lake protection. Second, it will determine how and when our lakes became salinized to limit further degradation. Third, it will identify lakes and food webs that have resilience to salinization and should be conserved. Finally, it will link ecological processes, experiments, and lake simulations to determine ways to enhance and preserve water quality in salinized lakes. All elements are critical for preserving lake resources in the face of increasing chloride pollution.

Activities and Milestones

Activity 1: Measure differences among lakes under varying threat of salinization with intensive monitoring

Activity Budget: $482,090

Activity Description:
We will measure water quality and food webs monthly for two years in 15 lakes located throughout Central Minnesota and the Metro and grouped in five 3-lake clusters. High frequency monitoring buoys will be deployed in all lakes to record water-column temperature, oxygen, and chloride every 30 minutes. Five lakes (Tanners, Parkers, Powderhorn, Little Johanna, Henry) are “impacted”, with chloride levels 500-1000% above background concentrations. Five lakes (Medicine, Bde Maka Ska, Beaver, Wabasso, Uhlenkolts) are “at risk” showing chloride approximately 200% above background levels, and five lakes (Minnetonka, Cedar, Phalen, Josephine, Smith) are “least impacted” but still show chloride 50-100% above background.

Molecular analyses will be used to characterize lake food webs. We will isolate 300 Daphnia pulicaria clones (~20 per lake) and survey for genes correlated with chloride tolerance. Daphnia pulicaria, a keystone waterflea species, maintains water clarity by controlling algae and serves as preferred forage for recreational fisheries. We will also characterize each lake’s cyanobacteria using molecular tests to determine if genetic diversity of noxious algae is also correlated with chloride tolerance. Threshold changes in water quality and food web genetic diversity will define chloride tipping points for Minnesota lakes.

Activity Milestones:

Description	Completion Date
Measure nutrients, salinity, algae, zooplankton, and lake behavior for two years in 15 study lakes	2020-04-30
Use molecular tools to analyze lake food webs for chloride tolerance	2020-06-30

Activity 2: Use sediment cores to reconstruct the history and threat of salinization

Activity Budget: $472,955

Activity Description:
Every lake accumulates sediments that record its history. We will collect sediment cores from 15 study lakes and determine when and how much they have changed in response to salinization—their food webs, biology, nutrient and chloride levels—by analyzing multiple chemical and biological indicators. We will date each core with natural radioisotopes, then reconstruct historic food webs using zooplankton remains, reconstruct past chloride and nutrients using diatoms and existing monitoring data, and reconstruct historic algae using fossil pigments and other indicators past productivity. We will test whether increasing chloride causes reductions in the abundance of good keystone waterflea species, degrades the food web, and leads to poor water quality.

When salty snowmelt enters lakes, it flows downward and smothers the bottom, depleting the oxygen, releasing phosphorus, and turning lakes green with noxious algae. We will experiment in the lab on short sediment cores to test how different levels of salt and dissolved oxygen affect sediment release of phosphorus. We will also replicate these experiments with potassium acetate, an alternative to chloride road salt, to see if it is less harmful.

Activity Milestones:

Description	Completion Date
Measure changes in sediment internal nutrient loading in salinized lakes	2020-06-30
Compare historical changes in water quality, salinity, and food webs in 15 study lakes	2020-06-30
Collect, date, and analyze sediment cores from 15 lakes	2020-06-30

Activity 3: Identify critical salinity thresholds to stabilize the food web: reduce algae blooms and protect resilient food webs

Activity Budget: $218,955

Activity Description:
Lake and genetic simulation tools coupled with experiments will help solve the lake salinization crisis. We will mathematically simulate dense salty layers in lakes that cause low-oxygen bottom waters to determine critical thresholds of road salt or potassium acetate that cause density layers to form. This gives watershed managers scientifically based targets for reducing deicer applications and fixing lakes.

We determine resilience of lake food webs to salinization by measuring genetic relatedness of Daphnia populations among lakes. Study lakes are grouped into clusters, allowing us to explore how chloride-impacted lakes will exchange genes at different spatial scales. We will identify waterflea populations that have "desired" genes and how likely these genes will be transported to other lakes, increasing lake resilience to increasing chloride—in short, this activity will determine which lakes are at risk for water quality and food web collapse and how we can fix them.

Through reporting, presentations, and outreach (lake associations, MPCA, Road Salt Symposium, MN Groundwater Association), we will spread our findings to help communities stop salt pollution before it threatens our favorite lakes and fisheries.

Activity Milestones:

Description	Completion Date
Develop reports, factsheets, and outreach to inform managers and Minnesotans on protecting their threatened lakes	2020-06-30
Use lake and genetic modeling tools to determine lake and food web resilience to salinization	2020-06-30

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?

This project will determine chloride tipping points that lead to water quality and food web degradation, measure how and when lakes were salinized, identify lake and food web resilience to chloride, and test impacts of deicing alternatives. This information is needed at state and local levels to guide lake management and protection. We build on previous ENRTF funding and leverage collaborations with other research groups, agencies, and stakeholders. Through reporting, presentations, and outreach (newsletters, MPCA, Road Salt Symposium, MN Groundwater Association), we will spread our findings to help communities stop salt pollution before it threatens our favorite lakes and fisheries.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Determining Risk of a Toxic Alga in Minnesota Lakes	M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 06f	$200,000
Tracking and Preventing Harmful Algal Blooms	M.L. 2016, Chp. 186, Sec. 2, Subd. 04a	$500,000

Project Manager and Organization Qualifications

Project Manager Name: Mark Edlund

Job Title: Senior Scientist

Provide description of the project manager's qualifications to manage the proposed project.

1. Education

Ph.D. 1999 University of Michigan, (Natural Resources & Environment)
M.S. 1992 University of Michigan, (Natural Resources)
B.S. 1987 University of Minnesota (Biochemistry)

2. Positions

2007- Sr. Scientist, St. Croix Watershed Research Station, Science Museum of Minn.
2002-07 Assoc. Scientist, St. Croix Watershed Research Station, Science Museum of Minn.
2000-02 Ass't. Scientist, St. Croix Watershed Research Station, Science Museum of Minn.
2004- Adjunct Professor, Water Resources Science/Earth Sciences, U of Minnesota
1987-99 Research Ass't I, Center for Great Lakes and Aquatic Sciences, U of Michigan

3. Research Expertise

Aquatic biology, limnology, paleolimnology, and phycology; environmental drivers of ecological change; lake sediment records to understand short- and long-term environmental change. 20-yr record of federal, state, and local project management to get results.

Current Research:

- Biomonitoring of lakes in Great Lakes region National Parks
- Water quality in Lake of the Woods
- Understanding and predicting harmful algal blooms (HABs)

4. Publications (of more than 100)

Strock, K.E., Saros, J.E., McGowan, S., Edlund, M.B. and Engstrom D.R. 2019. Response of boreal lakes to changing wind

strength: Coherent physical changes across two large lakes but varying effects on primary producers over the 20th century. Limnology and Oceanography https://doi:10.1002/lno.11181
Edlund, M.B., Schottler, S.P., Reavie, E.D., Engstrom, D.R., Baratono, N.G., Leavitt, P.R., Heathcote, A.J., Wilson, B. and Paterson, A.M. 2017. Historical phosphorus dynamics in Lake of the Woods (USA-Canada) – Does legacy phosphorus still affect the southern basin? Lake and Reservoir Management 33: 386-402.
Edlund, M.B., Almendinger, J.E., Fang, X., Ramstack Hobbs, J., VanderMeulen, D.D., Key, R.L. and Engstrom, D.E. 2017. Effects of climate change on lake thermal structure and biotic response in northern wilderness lakes. Water 9(9),1-34

Organization: Science Museum of Minnesota - St. Croix Watershed Research Station

Organization Description:
The Science Museum of Minnesota (SMM) is a private, non-profit 501(c)3 institution dedicated to encouraging public understanding of science through research and education. The St. Croix Watershed Research Station the environmental research center of the SMM with the mission “we do the science that helps make our rivers and lakes clean” through research and outreach. The SCWRS supports an active year-round program in environmental research and graduate-student training, guided by a dedicated in-house research staff with direct ties to area universities and colleges. It collaborates closely with federal, state, and local agencies with responsibility for managing the St. Croix and upper Mississippi rivers and is a full partner with the National Park Service for resource management in parks of the western Great Lakes region. Its research has played a central role in setting management policy for the St. Croix and Mississippi rivers, for establishing water-quality standards for Minnesota lakes and for developing long-term monitoring plans for the National Park Service.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Edlund/Senior Scientist		Sediment Analysis, Water Quality, Diatom Analysis			45.5%	1.5		$174,600
Heathcote/Senior Scientist		Water Quality, DNA, environmental statistics			45.5%	0.75		$79,660
Myrbo/Assistant Scientist		Water and Core sampling, Core experiments, Outreach			45.5%	1.5		$152,775
Ulrich/Assistant Scientist		Lake Modeling			45.5%	0.99		$93,629
Field and Laboratory Technician		Field work and lab analyses			45.5%	1		$45,300
Science Communication Specialist		Outreach and social media			0%	0.1		$12,000
							Sub Total	**$557,964**
Contracts and Services								
University of Oklahoma	Professional or Technical Service Contract	Collection and analysis of 300 Daphnia clones @ $320 per clone ($96,000; University of Oklahoma or competitive bid)		X		0		$96,000
University of Regina	Professional or Technical Service Contract	Lab analysis of pigments samples: Algal pigment analysis: 225 samples @ $150 ($33,750)				-		$33,750
University of Minnesota	Professional or Technical Service Contract	Lab analysis of Daphnia DNA: 300 samples @ $40 ($12,000; University of Minnesota or competitive bid)				-		$12,000
University of Minnesota	Professional or Technical Service Contract	Lab analysis of Cyano DNA: 16S water sample DNA sequencing: 75 samples @ $150 ($3,000; University of Minnesota or competitive bid)				-		$3,000

							Sub Total	**$144,750**
Equipment, Tools, and Supplies								
	Tools and Supplies	Lab/Field supplies	Lab/Field supplies (bottles, reagents, preservatives, consumables, duplicate field gear for AIS prevention - $18,000)					$18,000
	Tools and Supplies	Monitoring buoy supplies	Component sensors for constructing and installing monitoring buoys on 15 lakes					$67,500
							Sub Total	**$85,500**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Water Quality and sediment core sampling ($12,345), 84 days, 2 field crew, 11,340 miles, 14 days in hotel	Water Quality and sediment core sampling					$12,345
	Conference Registration Miles/ Meals/ Lodging	MN Lake Conference Outreach (i.e., Minnesota Water Resources Conference), formal presentation + booth for dissemination of project results results, 3 in-state conferences at $800 each	formal presentation + booth for dissemination of project results results					$2,400
							Sub Total	**$14,745**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**

Other Expenses								
		Lab analysis of water samples: TN/TP, DIN/SRP, DOC, DIC, chlorophyll a, chloride: 420 samples @ $187 ($78,540) (unit prices for analysis at SCWRS)	Lab analysis of water samples					$78,541
		Lab analysis of sediment samples: 210-Pb (dating): 15 cores @ $2,500 ($37,500) (unit price for analysis at SCWRS) loss-on-ignition: 15 cores @ $800 ($12,000) (unit price for analysis at SCWRS) Sed P: 15 cores @ $1,875 ($28,125) (unit price for analysis at SCWRS) Diatoms: 15 cores @ $4,500 ($67,500) (unit price for analysis at SCWRS) BSi: 15 cores @ $825 ($12,375) (unit price for analysis at SCWRS) Core incubations: 27 treatments @ $5,000/treatment ($135,000)	Lab analysis of sediment samples					$292,500
							Sub Total	**$371,041**
							Grand Total	**$1,174,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Contracts and Services - University of Oklahoma	Professional or Technical Service Contract	Collection and analysis of 300 Daphnia clones @ $320 per clone ($96,000; University of Oklahoma or competitive bid)	This project involves a partnership with University of Oklahoma. Larry Weider's lab is the only facility with the capacity to clone and analyze Daphnia to address the food web questions we test in this proposal. **This is a single source contract.**

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
In-Kind	All indirect project costs are provided in-kind by the Science Museum of Minnesota (federal indirect rate 40.09% on all direct costs = $480,206)	In-kind contribution of indirects	Pending	$480,206
			Non State Sub Total	**$480,206**
			Funds Total	**$480,206**

Attachments

Required Attachments

Visual Component

File: 06ac72e7-fcf.pdf

Alternate Text for Visual Component

Salt levels are rising in Minnesota lakes, but the biological impacts are poorly understood. We determine how salt damages water quality and food webs and how to save our lakes

Optional Attachments

Support Letter or Other

Title	File
Institutional letter of support, Science Museum of MN	60166516-f1e.pdf
SF990, Institutional tax exempt form	3aad2c1f-434.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?

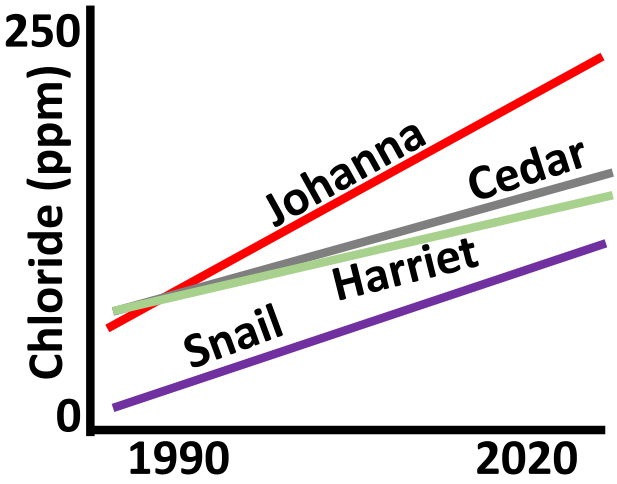
Yes

Does the organization have a fiscal agent for this project?

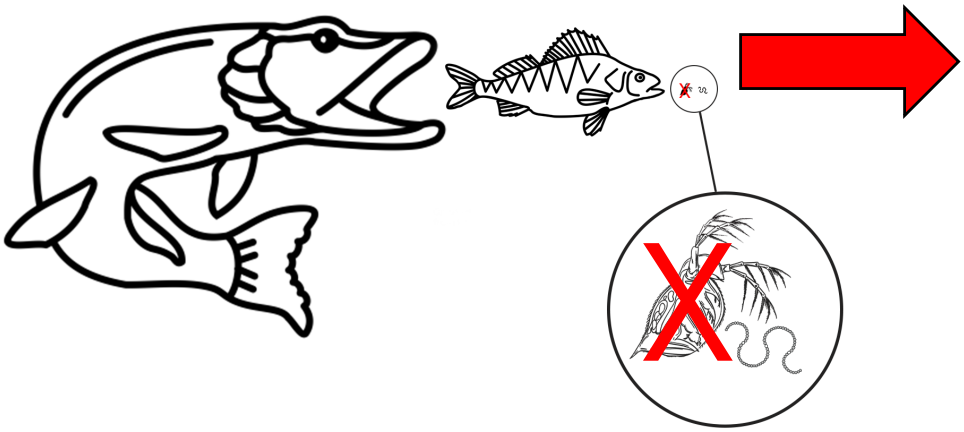
No

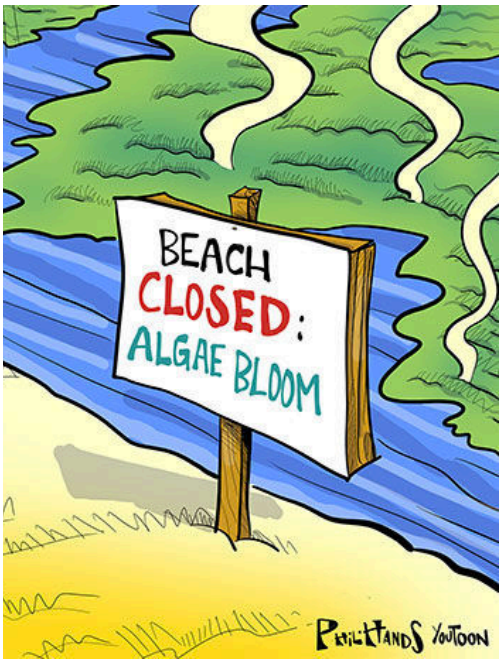
Environmental and Natural Resources Trust Fund (ENRTF)
2021 Main Proposal
Project: Salt threatens Minnesota water quality and food webs

Minnesota lakes are getting saltier



Saltier water disrupts the aquatic foodweb…





…and degrades water quality

How much salt is too much for aquatic life? What can cities do differently to protect our lakes?