Project Title: **ENRTF ID:**   **120-BH**

Cascading Effects of Ice-Cover on Summer Water Quality

Category: H. Proposals seeking $200,000 or less in funding

Sub-Category: B. Water Resources

Total Project Budget: $ 191,000

Proposed Project Time Period for the Funding Requested: June 30, 2023 (3 yrs)

Summary:

This project will determine the importance of variable ice cover conditions in controlling harmful cyanobacteria, phosphorus cycling, and oxygen distribution in Minnesota lakes.

Name: Lesley   Knoll

Sponsoring Organization: U of MN

Job Title:

Department: Itasca Biological Station

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          Lake Itasca   MN   56470

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Web Address:

Location:

Region: Statewide

County Name: Statewide, Anoka, Clearwater

City / Township:

Alternate Text for Visual:

The visual highlights our goals: 1) examining how variable ice conditions influence water quality, 2) creating a website with real-time data, and 3) offering programs at Itasca State Park.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%

PROJECT TITLE: Cascading effects of ice-cover on summer water quality

I. PROJECT STATEMENT

   Records indicate recent years with more extreme meteorological conditions, such as warmer winter and spring air temperatures, are leading to shorter ice cover duration on lakes that may extend to warmer waters during the summer. **We aim to determine the importance of year-to-year differences in ice cover conditions on summer water quality in a diverse set of Minnesota lakes**. Cyanobacteria (blue green algae) blooms are noxious and cause unsafe, unsightly, and undesirable conditions in our lakes. Sometimes we find high cyanobacteria concentrations in lakes not typically considered at risk for algal problems (e.g., forested, protected). Two factors that are likely playing roles in their increased abundance are excess nutrient levels, especially phosphorus, and warmer surface waters. Both surface water temperatures and phosphorus are predicted to be influenced by changing ice cover duration.

Our project will use existing MN DNR Sentinel Lakes data and new data to assess how years with extreme vs typical ice cover duration across a range of lake types:
   - influence the amount of phosphorus and oxygen in bottom-waters in the summer (activity 1)
   - influence the amount of harmful cyanobacteria in the summer (activity 1)

Findings in activity 1 will enable us to:
   - identify which lake and watershed types are more vulnerable to changing ice conditions (activity 2)
   - make recommendations to lake managers (e.g., MN DNR, MN PCA, lake associations) on lake and watershed management strategies (activity 2)
   - share findings and streaming data via displays with over 500,000 public visitors (activity 3)

   We hypothesize that shorter ice cover duration will negatively influence water quality and ultimately, fish habitat, by increasing summer lake surface water temperatures and cyanobacteria dominance, reducing oxygen in the deep parts of lakes, and increasing phosphorus release from lake sediments. More phosphorus can fuel additional algal growth to create a feedback loop decreasing overall water quality. We currently cannot predict how variable ice cover duration and changing water temperatures influence these key lake variables and which lake types (deep, large, shallow, agricultural, urban, etc.) may be sensitive to or buffered by extreme conditions.
   Lakes in the first two activities are: (Sentinel Lakes italicized, NSF equipment in underlined lakes) Cedar Bog (Anoka Co.), *Carlos* (Douglas Co.), Elk (Clearwater Co.), *Greenwood* (Lake Co.), Itasca (Clearwater Co.), *Madison* (Blue Earth Co.), *South Center* (Chisago Co.), and *Trout* (Cook Co.). The third activity, showing streaming data, will use the underlined lakes.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1 Title: Investigate how variable ice cover conditions affect summer water quality

Description: It was historically difficult to study late winter and early spring because of unsafe ice conditions. We will use new sensor technologies that allow us to collect information remotely. Our project will leverage: 1) data from six MN DNR Sentinel Lakes and two additional lakes, and 2) recent infrastructure funding to Knoll and Cotner from the National Science Foundation ($391,050).
   When ice-out occurs earlier, surface waters may warm faster and stay warmer over the summer. In turn, lakes may stratify into distinct layers earlier with overall longer and stronger stratification during the summer. This type of change in stratification may provide an ideal environment for enhanced phosphorus accumulation and oxygen

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depletion in deep-waters as well as increased cyanobacteria in surface waters. We will use automated sensors to define stratification start and end dates, quantify stratification strength, and monitor deep oxygen conditions.

ENRTF BUDGET: $101,900

Outcome	Completion Date
1. Collect water samples (900) and phytoplankton samples (40)	*September 2022*
2. Maintain temperature/oxygen sensors (some managed by UMN and some by MN DNR)	*June 2023*
3. Analyze 940 samples in the laboratory	*December 2022*

Activity 2 Title: Predict the lake and watershed types that are sensitive to extreme ice conditions and make recommendations to lake managers on management strategies

Description: We will use existing and new data on 8 lakes (up to 15 years of data) to develop models. The models can be used to predict trends across Minnesota and identify which lake and watershed types may need modified management strategies. For example, water quality for some lake types or lakes in certain watershed types may be more sensitive to variable ice conditions than others and knowing this will benefit management and help prioritize conservation efforts. We will use our results to provide recommendations to lake managers (e.g., MN DNR, MN PCA, lake associations) by highlighting at-risk lake and watersheds types.

ENRTF BUDGET: $29,000

Outcome	Completion Date
1. Collate data (new and historical)	*February 2023*
2. Develop predictive models to understand the role of variable ice conditions on summer water quality by lake type	*June 2023*
3. Provide recommendations on best management strategies	*June 2023*

Activity 3 Title: Use streaming lake data for website and public outreach displays/programs

Description: We will create a public website showing streaming data on three lakes. Anglers in particular are often interested in lake temperature and how it changes with depth and over the season. Our website will provide this and other water quality values. We will also create displays with streaming data for the visitor centers of Itasca State Park (Clearwater Co.) and Cedar Creek Ecosystem Science Reserve (Anoka Co.). Both reach a large annual audience of public and K-12 visitors (500,000+ Itasca, 10,000+ Cedar Creek). Public programs will complement established relationships with Itasca State Park.

ENRTF BUDGET: $60,100

Outcome	Completion Date
1. Create website with streaming data	*July 2021*
2. Create educational displays with streaming data from website	*July 2021*
3. Offer public programming to the 500,000+ annual visitors of Itasca State Park	*June 2023*

III. PROJECT PARTNERS AND COLLABORATORS: James Cotner (co-investigator), University of Minnesota; Casey Schoenebeck (partner), Minnesota DNR; Gretchen Hansen (partner), University of Minnesota

IV.   LONG-TERM IMPLEMENTATION AND FUNDING: Our proposed project will provide data and models for water quality (MN PCA) and fish management (MN DNR) in Minnesota. We will leverage existing projects, equipment, and infrastructure that are part of the Sentinel Lakes Program and a NSF award to Knoll and Cotner.
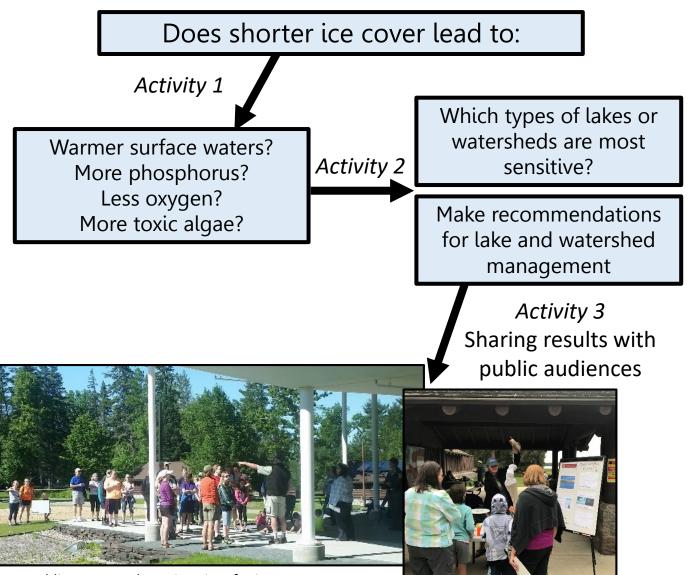
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Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: Lesley Knoll
Project Title: Cascading effects of ice-cover on summer water quality
Organization: University of Minnesota
Project Budget: $191,000
Project Length and Completion Date: 3 years, June 2023
Today's Date: 3/14/19

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET		Budget	Amount Spent	Balance
BUDGET ITEM				
Personnel (Wages and Benefits)		$ 122,000	$ -	$ 122,000
Graduate student assistant: $58,000 (62% salary, 38% benefits during the academic year - includes tuition) (87% salary, 13% benefits during the summer); One semester plus the summer at 50% FTE for years 1 and 2. Will assist with sampling, data analysis, and lead lab analysis efforts.				
Undergraduate student: $21,000 (100% salary, 0% benefits); One student at 27% FTE (annual). 14 weeks at 40 hours per week during the summer for 3 years. Will assist with sampling and outreach efforts while gaining in-depth training in both areas.				
Support staff: $43,000 (77% salary, 23% benefits); 50% FTE. Will develop website and educational display information.				
Professional/Technical/Service Contracts				
Phytoplankton identification and analyses for 8 lakes sampled 5 times - Phycotech, Inc. 40 samples @ $400 = $16,000. Phycotech was selected because of established relationships with the Sentinel Lakes Program.		$ 16,000	$ -	$ 16,000
Equipment/Tools/Supplies				
Surface water sample analyses for chlorophyll; dissolved and particulate carbon, nitrogen, and phosphorus for 2 years (60 samples per year for each analysis type) : $8,000		$ 24,000	$ -	$ 24,000
Sample bottles and filters for 2 years (200 of each per year): $1,000				
Software and licenses for educational display = $5,000				
Materials for educational displays (monitors, mounting hardware, signage) = $10,000. Monitors are permanently mounted as part of educational displays.				
Capital Expenditures Over $5,000				
		$ -	$ -	$ -
Fee Title Acquisition				
		$ -	$ -	$ -
Easement Acquisition				
		$ -	$ -	$ -
Professional Services for Acquisition				
		$ -	$ -	$ -
Printing				
		$ -	$ -	$ -
Travel expenses in Minnesota				
Travel for field work to Itasca Field Station (from Twin Cities) and lodging at the station: PI/graduate student/undergraduate travel (0.58 per mile): 15 round trips over 3 years = $4,000 Lodging for undergraduate: 14 weeks per year for 3 years = $14,000 Lodging for graduate student/PI: 10 weeks per year for 2 years = $11,000		$ 29,000	$ -	$ 29,000
Other				
		$ -	$ -	$ -
COLUMN TOTAL		$ 191,000	$ -	$ 191,000

SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: Indirect Costs (54% MTDC) associated with this proposal	secured	$ 94,000	$ -	$ 94,000

Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	Amount legally obligated but not yet spent	Budget	Spent	Balance
		$ -	$ -	$ -

Does shorter ice cover lead to:

Activity 1

Warmer surface waters?
More phosphorus?
Less oxygen?
More toxic algae?

Activity 2

Which types of lakes or watersheds are most sensitive?

Make recommendations for lake and watershed management

Activity 3
Sharing results with public audiences

Public programs by University of Minnesota Itasca Biological Station at Itasca State Park

Why this matters to Minnesotans

LOCAL

The good old Minnesota winter is losing its bite

By Mary Lynn Smith Star Tribune | DECEMBER 1, 2017 — 9:14PM

Northern lakes are losing their ice cover at an accelerating rate

By Ron Meador | 02/08/2019

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Water Worries: Investigating Toxic Water On Minnesota Lakes

Blue-Green Algal Blooms Cause Dog Deaths, Sickness In Kids

Nikki Davidson, Anchor/Reporter, ndavidson@kqdsfox21.tv
Adam Jagunich, Photojournalist, ajagunich@kqdsfox21.tv
POSTED: 11:19 PM CDT Jul 06, 2016

Project Manager Qualifications and Organization Description

Education
Ph.D.   2011   Miami University, Oxford, OH (Ecology, Evolution, and Environmental Biology)
M.S.   2004   Michigan State University, East Lansing, MI (Fisheries and Wildlife)
B.S.   2001   Miami University, Oxford, OH (Botany, magna cum laude)

Professional Experience
2018-present   *Adjunct Assistant Professor*, Dept. of Plant and Microbial Biology, University of Minnesota
2016-present   *Station Biologist*, University of Minnesota Itasca Biological Station and Labs (Lake Itasca, MN)
2012-2015   *Director of Research and Education*, Lacawac Sanctuary Field Station (Lake Ariel, PA)

Relevant Publications to Proposal
Block, B., B.A. Denfeld, J.D. Stockwell, G. Flaim, H.P.F. Grossart, **L.B. Knoll**, D.B. Maier, R.L. North, M. Rautio, J.A. Rusak, S. Sadro, G.A. Weyhenmeyer, A.J. Bramburger, D.K. Branstrator, and S.E. Hampton. 2019. The unique methodological challenges of winter limnology. *Limnology and Oceanography Methods* 17: 42-57 doi: 10.1002/lom3.10295

Knoll, L.B., C.E. Williamson, R.M. Pilla, T.H. Leach, J.A. Brentrup, and T.J. Fisher. 2018. Browning-related oxygen depletion in an oligotrophic lake. *Inland Waters* 8: 255-263.

Pilla, R.M., C.E. Williamson, J. Zhang, R.L. Smyth, J.D. Lenters, J.A. Brentrup, **L.B. Knoll**, and T.J. Fisher. 2018. Long-term trends in water temperature and thermal stratification in two small lakes resulting from browning-related decreases in water transparency. *Journal of Geophysical Research: Biogeosciences*: 123. doi: 10.1029/2017JG004321.

Richardson, D.C., S.J. Melles, R.M. Pilla, A.L. Hetherington, **L.B. Knoll**, C.E. Williamson, and others. 2017. Transparency, geomorphology, and mixing regime explain variability in trends in lake temperature and stratification across northeastern North America (1975 – 2014). Water 9: 442. doi:10.3390/w9060442

Knoll, L.B., A. Morgan, M.J. Vanni, T.H. Leach, T.J. Williamson, and J.A. Brentrup. 2016. Quantifying pelagic phosphorus regeneration using three methods in lakes of varying productivity. *Inland Waters* 6: 509-522.

Brentrup, J.A., C.E. Williamson, W. Colom-Montero, W. Eckert, E. de Eyto, H.P. Grossart, Y. Huot, P. Isles, **L.B. Knoll**, T.H. Leach, C.G. McBride, D. Pierson, F. Pomati, J.S. Read, K.C. Rose, N.R. Simal, P.A. Staehr, and L.A. Winslow. 2016. The potential of high-frequency profiling to assess vertical and seasonal patterns of phytoplankton dynamics: An extension of the Plankton Ecology Group (PEG) model. *Inland Waters* 6: 565-580.

Knoll, L.B., E.J. Hagenbuch, M.H. Stevens, M.J. Vanni, W.H. Renwick, J.C. Denlinger, R.S. Hale, and M.J. González. 2015. Predicting eutrophication status in reservoirs at large spatial scales using landscape and morphometric variables. *Inland Waters* 5: 203-214.

Knoll, L.B., O. Sarnelle, S.K. Hamilton, C.E.H. Kissman, A.E. Wilson, J.B. Rose, and M.R. Morgan. 2008. Invasive zebra mussels (Dreissena polymorpha) increase cyanobacterial toxin concentrations in low-nutrient lakes. Canadian Journal of Fisheries and Aquatic Sciences 65: 448-455.

Organization Description
The proposed research will be performed at both the UMN Itasca Field Station and the University of Minnesota Twin Cities campus. The field station was established in 1909 and has a long and successful history of supporting field-based biological research. The University of Minnesota is a large and renowned public institution producing cutting-edge research products.