

**Environment and Natural Resources Trust Fund
2012-2013 Request for Proposals (RFP)**

Project Title:

ENRTF ID: 139-I

Evaluating Lake Superior's Health in a Changing World

Topic Area: I. Water Resources

Total Project Budget: \$ 600,000

Proposed Project Time Period for the Funding Requested: 3 yrs. July 2013 - June 2016

Other Non-State Funds: \$ 485,000

Summary:

Lake Superior is undergoing dramatic changes—less ice, warmer summers, more invasive species. Using advanced field technologies, we will evaluate how these impact the natural capital of this incomparable resource.

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Sponsoring Organization: U of MN - Duluth

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Location

Region: NE

County Name: Cook, Lake, St. Louis

City / Township:

<input type="checkbox"/>	Funding Priorities	<input type="checkbox"/>	Multiple Benefits	<input type="checkbox"/>	Outcomes	<input type="checkbox"/>	Knowledge Base
<input type="checkbox"/>	Extent of Impact	<input type="checkbox"/>	Innovation	<input type="checkbox"/>	Scientific/Tech Basis	<input type="checkbox"/>	Urgency
<input type="checkbox"/>	Capacity Readiness	<input type="checkbox"/>	Leverage	<input type="checkbox"/>	Employment	<input type="checkbox"/>	TOTAL <input type="checkbox"/> %

Project Title: Evaluating Lake Superior's Health in a Changing World

I. Project Statement:

Lake Superior is among Minnesota's greatest natural resources. Shipping, recreation and tourism on the lake stimulate Minnesota's economy. It provides drinking water to thousands, and it symbolizes our natural heritage. The lake seems timeless, but recently it has been changing dramatically. For example:

- Surface summer water temperatures have increased by 5°F over the past 30 years, some of the most rapid change observed on the planet;
- Average ice cover on the lake over the past 15 years is 2-fold lower than the long-term average;
- The lake's nutrient content is changing markedly, with nitrate increasing 5-fold since 1900;
- The lake is increasingly affected by invasive species (spiny water flea, zebra mussels; etc);
- The lake's biological productivity is decreasing, providing less food for fish;
- While lake trout and herring have recovered from mid-20th Century decimation, lake herring populations rise and fall dramatically from year to year.

We do not fully understand the reasons for these changes, or complex interactions among them. Yet we need such an understanding to protect and foster this resource during a time of unprecedented change.

A team from the U of M and the DNR will use state-of-the-art techniques to evaluate the lake's behavior in this rapidly changing temperature regime. Ship-based observations (using the research vessel *Blue Heron*) will focus on two transects across the western arm of Lake Superior. These results will be complemented with data obtained using an autonomous underwater glider and moored profiling instruments (purchased with National Science Foundation—NSF—grant support). These new unmanned technologies provide cost-effective measurements at more places and times than possible with labor-intensive ship operations. Our plan (see graphic) includes:

- a. Shipboard sampling (from 5 to 10 depths at 12 locations occupied 4 times in 2014 and in 2015) to measure nutrients, pH, carbon, oxygen, temperature, particle abundances and composition, activity of photosynthetic and other pigments. We will also measure primary productivity, carbon and nutrient cycling using sediment traps and abundances species of algae, zooplankton, and fish.
- b. Use of an autonomous underwater glider for measurements of temperature, chlorophyll and other pigments, oxygen and water clarity. This unmanned device, which can be released and recovered from small boats, is programmed to "swim" repeatedly from surface to bottom as it navigates across the lake, and can provide results in near-real time via satellite telephone.
- c. Moored profilers to be deployed from Fall 2013 to Spring 2016. Several times daily they unspool and float upward to record profiles of temperature, oxygen, nitrate, currents, chlorophyll and other biologically important pigments, and water clarity, also providing real time data. They provide year-round observations, including under ice measurements never previously made in Lake Superior.

No prior large lake study has included the breadth of measurements, the geographic range, and the span of seasons we propose.

II. Description of project activities:

Result 1: Abundance and distribution of native and invasive species

Budget: \$167,018

Observed warming may affect growth of invasive and native species. For example, lake herring often reproduce more efficiently in warm years, but the mechanism for is unknown. We will provide detailed analyses of native and invasive plankton and fish responses to changing lake conditions.

Specific Outcomes:

1. Report on newly identified invasive species;

Completion Date:

December each year

- | | |
|---|---------------|
| 2. Distribution map of known invasive species; | December 2015 |
| 3. Training of a master's student in biology at UMD | May 2016 |

Result 2: Snapshots of current ecosystem health

Budget: \$327,244

Physical, chemical and biological results from shipboard sampling, the autonomous glider, and profiling moored instruments will be used to create a comprehensive assessment of the western Lake Superior ecosystem needed to understand responses to ongoing change.

Specific Outcomes:

Completion Date:

1. Report on seasonal changes in the lake ecosystem;
2. Maps and data cross sections displaying results
3. Real time modeling of lake circulation for public use.

February 2015 & 2016
February 2015 & 2016
December 2015

Result 3: Evaluation of previous ecosystem conditions

Budget: \$ 86,044

Identification of historic ecosystem trends using archived samples from sediment traps and surface sediment cores. Anticipated results: historic arrival of invasive species (spiny water flea); past changes in fish feeding habits; past changes in nutrient and carbon cycling; comparison with meteorological data.

Specific Outcomes:

Completion Date:

1. Report on recent ecosystem trends relative to historic records;
2. Distribution map showing timing of arrival of invasive species.

December each year
December 2015

Result 4: Public outreach

Budget: \$19,694

We will maximize impact of our work by coordinating with ongoing Minnesota Sea Grant efforts.

Specific outcomes:

Completion date:

1. Updates through social media outlets;
2. Interviews between mass media and project investigators;
3. Short videos on websites & YouTube channels;
4. Sea Grant newsletter stories and/or press releases.

ongoing
ongoing
Winter 2015
Spring 2014, 2015, 2016

III. Project Strategy:

A. Project Team/Partners

Requesting Trust Fund support: U of M Duluth Large Lakes Observatory: Erik Brown (project management, carbon & nutrient cycling); Jay Austin (physical processes, moored and autonomous instruments); Robert Hecky (aquatic ecology, data integration); Stephanie Guildford (phytoplankton abundance, nutrient distributions); Elizabeth Minor (biochemistry, carbon cycling); Richard Ricketts (ship operations; logistics); **UMD MN SeaGrant:** Jeff Gunderson; Sharon Moen (public outreach); **UMD Biology:** Donn Branstrator (zooplankton ecology); Tom Hrabik (fish ecology); **U of M Twin Cities Ecology, Evolution and Behavior:** Robert Sterner (biological productivity; data management); **Providing services at no cost: DNR Duluth Office:** Don Schreiner (fish population dynamics);

B. Timeline Requirements

Three years of funding (July 2013 through June 2016) will allow work on the lake over two full field seasons (2014 and 2015) with supplemental observations in fall 2013 and spring 2016.

C. Long-Term Strategy and Future Funding Needs

Our goal is to understand the lake's complex responses to stresses, such as changing thermal structure and arrival of invasive species, and to use that knowledge to aid in refining management strategies. We will coordinate these efforts with those of other organizations including: LaMP, USEPA, MNDNR, USGS. We will extend long-term datasets resulting from earlier work supported by NSF, SeaGrant and LCCMR.

2012-2013 Detailed Project Budget

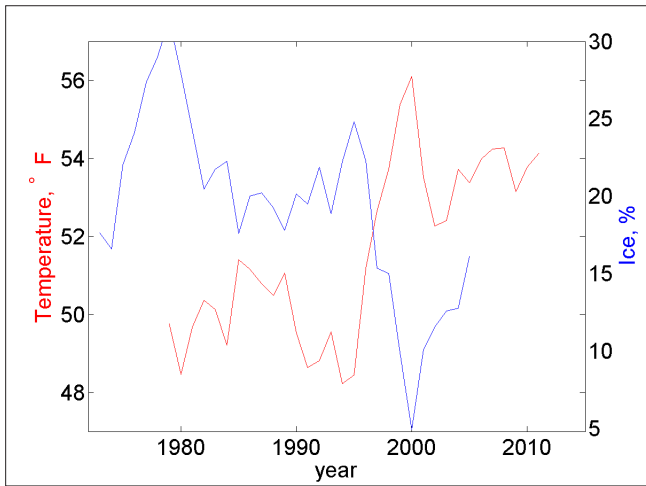
IV. TOTAL ENRTF REQUEST BUDGET 3 years

<u>BUDGET ITEM</u>	<u>AMOUNT</u>
Personnel: includes fringe benefits--41.3% for technicians and specialists, 18.49 % for academic year graduate student, 26.1% for summer graduate students, and 7.61% for undergraduates.	
Chemical Field/Lab Technician (1.5 month/yr)	\$ 22,006
Biological Lab Technician (2 months/yr)	\$ 35,110
Mooring and glider technician (1 month/yr)	\$ 18,525
Lake dynamics modelling technician (1 month/yr)	\$ 18,525
Public outreach specialist (1 month/yr)	\$ 19,694
Graduate student (1 academic year including tuition fellowship of \$12,612/yr)	\$ 30,596
Graduate student summer appointments in 2014 and 2015 (Five students for 12 weeks)	\$ 58,511
Undergraduate student summer help in 2014 and 2015. (Four students for 12 weeks)	\$ 20,661
Equipment/Tools/Supplies:	
Field sampling and laboratory supplies. Includes: batteries, chemical reagents, C-14, glass and teflon bottles, calibration standards, mooring anchors, fittings and wire for moored systems, maintenance and calibration of field instruments	\$ 39,122
Travel:	
Mileage for U of M Twin Cities employees to join Duluth-based field programs	\$ 1,200
Additional Budget Items:	
Shiptime 11 days per year. Day rate = \$8850. Covers costs of fuel, crew salaries, insurance, basic maintenance, meals.	\$ 292,050
Laboratory analyses: organic carbon, nutrients, pH, photosynthetic pigments, C:N, stable isotopes, ~600 samples	\$ 30,000
Satellite telephone for instrument control and data transfer. Mooring: 25 min/day for 750 days. Profiler: 60 min/day for 48 days. \$0.65 per minute.	\$ 14,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND \$ REQUEST =	\$ 600,000

V. OTHER FUNDS

<u>SOURCE OF FUNDS</u>	<u>AMOUNT</u>	<u>Status</u>
Other Non-State \$ Being Applied to Project During Project Period:		
National Science Foundation support to Austin, Brown, Minor, Hecky Guildford for purchase of moored profileers available to this study	\$ 485,000	current
National Science Foundation grants to Austin for ongoing study of Lake Superior ice dynamics complementary to this project. \$100,000	\$ -	current
Minnesota SeaGrant support to Guildford, Minor, Sterner, Hrabik, Branstrator for Lake Superior projects that will complement proposed LCCMR project activities. \$285,000	\$ -	current
Great Lakes Observing System support to Austin for Lake Superior moored instrument deployment that will provide a broader context for this project. \$100,000	\$ -	current
Great Lakes Maritime Research Institute support to Branstrator for ballast water invasive species study that complements this project. \$50,000	\$ -	current
Other State \$ Being Applied to Project During Project Period:		
In-kind Services During Project Period:		
LLO/UMD commits 12 days shiptime (\$8850/day) to the project	\$ 106,200	
LLO/UMD will provide small boats as needed for deployment of underwater glider	\$ 4,000	
Eight Investigator's time in each of 3 years. Investigators are enthusiastic about this project and are willing to work on it, especially during the summer, without compensation.		
Remaining \$ from Current ENRTF Appropriation (if applicable):	\$ -	
Funding History: Support from 7/11 to 7/13	\$ -	

Evaluating Lake Superior's Health in a Changing World

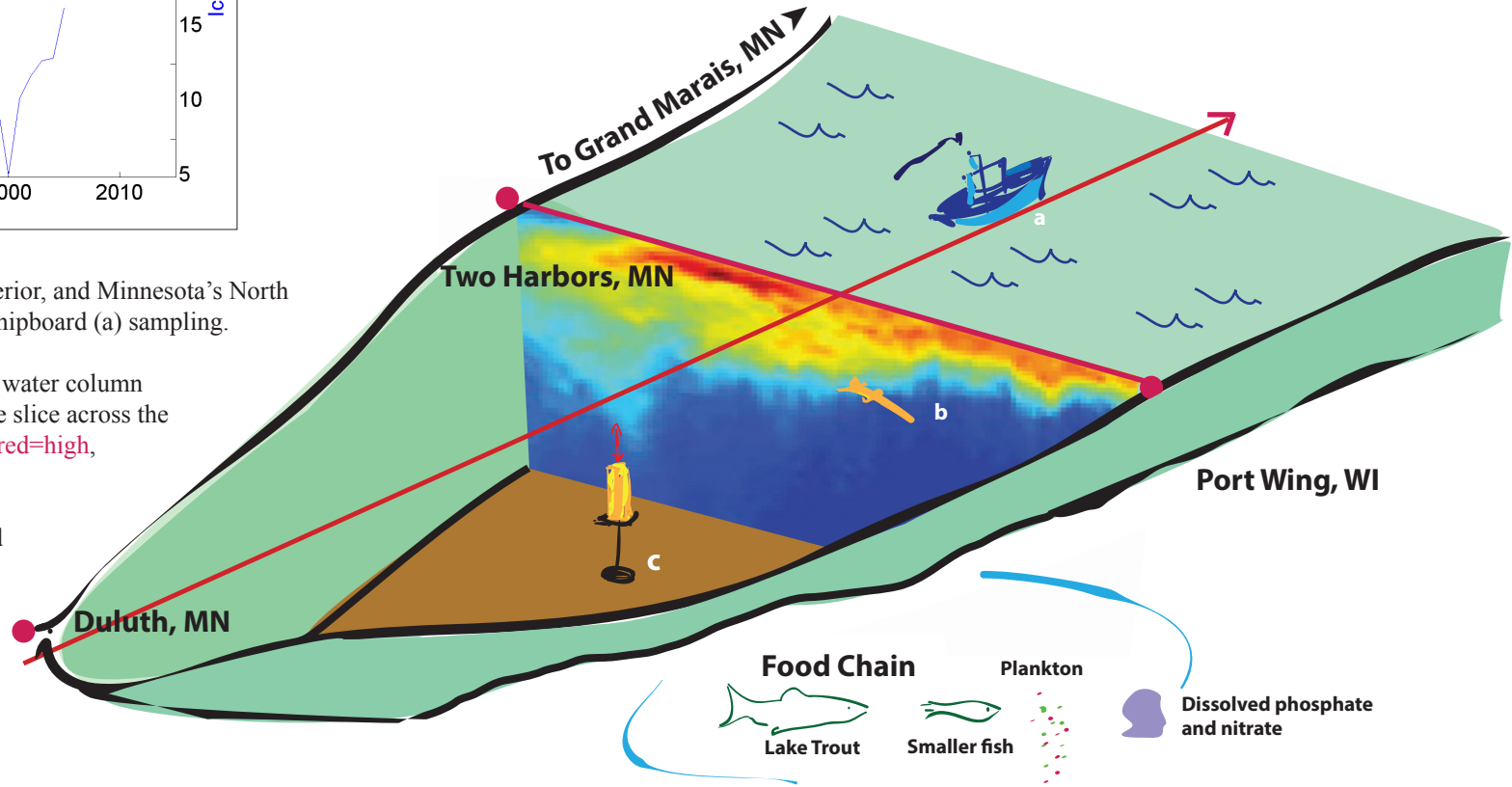


Lake Superior average summer *temperatures (red)* have increased in recent years, in conjunction with declining winter *ice cover (blue)*. Ice reflects the sun's energy in winter setting conditions for more warming during the following summer.

Schematic map of western Lake Superior, and Minnesota's North Shore. **Red lines** show transects for shipboard (a) sampling.

The underwater glider (b) makes full water column measurements of lake conditions. The slice across the lake shows chlorophyll abundances (**red=high**, **blue=low**) on 9/4/11.

Moored profilers (c) will be deployed year-round, including under ice in winter. Several times daily they will record profiles of environmental parameters between the surface and 50 m water depth.



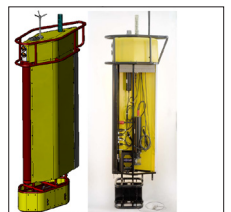
a
Research Vessel Blue Heron. This ship was purchased with LCMR support in 1997, and has support U of M research that has garnered \$14.3 million in external support.



b
UMD's underwater autonomous glider (purchased with NSF support). This device allows our research to cover far more of lake than possible with labor-intensive ship-based studies.



c
UMD's new moored profilers (presently being purchased with NSF support). This system measures and records ecological parameters far more often than possible with ship operations.



Project Manager Qualifications

Erik Brown is a Professor of Geological Sciences and Acting Director of the Large Lakes Observatory at the University of Minnesota Duluth (UMD). He has published more than 70 scientific articles in leading journals, including *Science* and *Nature*. He currently holds grants from the National Science Foundation, the Environmental Protection Agency, and the International Continental Drilling Program. He has won several scientific awards and has served on committees for national and international scientific organizations. He was involved with a highly successful LCMR-funded project, undertaken in 1999-2002 under the direction of Thomas Johnson.

Organization Description

The **Large Lakes Observatory** (LLO) is a research institute at the University of Minnesota Duluth. LLO was established in 1994 to make systematic use of oceanographic techniques in lake studies. We have grown (currently 10 faculty members) to have a global outlook and an international reputation with field programs and collaborators on 6 continents. In addition to housing a vibrant graduate program (we have attracted students from Malawi, Tanzania, Uganda, Ghana, China, Malaysia and the Netherlands), LLO provides unique research opportunities to undergraduates; in the past few years UMD undergraduates have participated in field programs in Indonesia, Mexico, Malawi, as well as on Lake Superior. Close ties have been formed with institutes in Canada, Uganda, France, Norway, Kyrgyzstan, Kenya, Nicaragua, Malawi, Tanzania and England, as well as with many universities within the United States. We are working to understand how lakes function, how they behaved in the past, and what will happen to them in the coming years.

The LLO operates the largest university-owned research vessel in the Great Lakes. The R/V Blue Heron was purchased with LCMR support in 1997, and is the only member of the University National Oceanographic Laboratory System (UNOLS) on the Great Lakes. The ship is outfitted with state-of-the-art research equipment that provides unique capabilities for observing Lake Superior. Although LLO is the lead organization on this proposal, researchers from other parts of the University of Minnesota Duluth, the University of Minnesota Twin Cities, and the Minnesota Department of Natural Resources will be involved in the collaborative research we propose.