

**Environment and Natural Resources Trust Fund
2010 Request for Proposals (RFP)**

LCCMR ID: 021-A3

Project Title:

Physics to Fish: Lake Superior Ecosystem Health Transects

LCCMR 2010 Funding Priority:

A. Water Resources

Total Project Budget: \$ \$512,480

Proposed Project Time Period for the Funding Requested: 3 years, 2010 - 2013

Other Non-State Funds: \$ \$1,316,000

Summary:

Repeated measurements of lake components (physics to fish) along a transect in Lake Superior will assess ecosystem health in response to environmental stresses, e.g. climate change, invasive species, water quality.

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Sponsoring Organization: Large Lakes Observatory, UMD

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Location:

Region: NE

County Name: Cook

City / Township:

_____ Knowledge Base	_____ Broad App.	_____ Innovation
_____ Leverage	_____ Outcomes	
_____ Partnerships	_____ Urgency	_____ TOTAL

Project Title: Physics to Fish: Lake Superior Ecosystem Health Transects

I. Project Statement: A multi-disciplinary team of scientists at UMD will use new state-of-the-art instrumentation deployed from the RV Blue Heron to establish ecosystem health transects in Lake Superior. The three-year program of transects across the western arm of Lake Superior will be repeated six times during the ice-free season, during which a full range of ecosystem properties, from physics to fish (physical properties of the water column, aquatic chemistry, and the entire food web from bacteria, through algae, plankton, and fish), will be sampled and measured. When completed, these transects will provide the best monitoring information and most complete baseline data yet available for assessing the ecosystem health of Lake Superior. They will be invaluable for identifying ecosystem shifts as they occur in response to stresses such as climate change, invasive species, and human activities.

Specifically, we will establish a comprehensive, integrative program of measurements of ecosystem health that will meet the following goals and products:

- Determine the presence and impact of invasive species in the coastal and deepwater regions of western Lake Superior
- Define the interaction between coastal and offshore waters in response to seasonal and year-to-year changes in lake circulation, water quality (including contaminants), food web abundance and diversity, and fish communities
- Provide the first integrated assessment of the ecosystem health of the western arm of Lake Superior, using concurrent measurements of the entire system, from physical properties to fish populations, and everything in between
- Integrate our sampling and measurements with those of the 2011 field program of the Lake Superior Coordinated Science Monitoring Initiative, part of the Lake Superior Bi-national Monitoring Program

Lake Superior is Minnesota's largest water resource, providing drinking water to many communities in Minnesota, hosting major shipping activity, sustaining a strong and recovering fishery, and providing an attractive focus for recreation and tourism. The lake is enduring multiple stresses that threaten it, including climate change, invasive species, continuing inputs of legacy and present-use contaminants, and long term trends of increasing nitrate and declining phosphorus. Various monitoring efforts are underway, but none operates in an integrated, ecosystem-structured way. The effort proposed here will avoid duplicating past and ongoing monitoring activities, while greatly enhancing our grasp of ecosystem trends and changes.

II. Description of program results:

Result 1: Invasive species distribution

Budget: \$100,240

Sampling of the ecosystem (bacteria, phytoplankton, zooplankton, and fish) at high resolution (in space and time) of coastal and offshore waters. This information will provide the most detailed analysis yet of the distribution and abundance of invasive plankton and fish and their relation to water quality. It will also allow assessment of how the effects of invasive species change with time. Cruises in 2010 will establish the current status of invasive species in light of new Ballast Water Treatment provisions that will soon become effective.

Specific Deliverable:

Report on newly identified invasive species
Distribution map of known invasive species

Completion Date:

December each year
December 2012

Result 2: Spatial analysis of ecosystem components

Budget: \$ 175,000

Digital mapping of ecosystem components from physical properties to fish abundances (and all of the chemistry and biology in between) along the project transect. Six evenly-spaced, three-day cruises each year will extend from ice-off (April) through early November to examine affects of seasonal and year-to-year variability on spatial distributions. The two-dimensional (distance and depth) vertical profiles will help with the analysis and visualization of the information.

Specific Deliverable:

Completion Date:

Digital visualizations of ecosystem component distributions

December 2011 & 2012

Result 3: Ecosystem health assessment
100,120

Budget: \$

Create the first comprehensive and integrated assessment of all components of the Lake Superior ecosystem (from physical properties to fish abundances) at the same time. This assessment will identify ecosystem trends and progress toward the L. Superior Lake Management Plan (LaMP).

Specific Deliverable:

Report on recent ecosystem trends relative to historic records
Analysis of progress towards LaMP targets

Completion Date:

December 2012
December 2012

Result 4: Integrate 2011 measurements into LaMP

Budget: \$ 137,120

Multi-agency snap-shot monitoring, structured as part of LaMPs, rotate field measurements among the lakes every five years. We will coordinate the middle year of this project (2011) with the Superior LaMP effort. Our measurements are timed and spaced in better alignment with ecosystem functioning than the five-year LaMP cycle and will provide essential seasonal perspective.

Specific Deliverable:

Standardize sampling and interpretive protocols
Complete LaMP segment of monitoring program

Completion Date:

March 2011
December 2011

III. PROJECT STRATEGY

A. Project Team/Partners

UMD LLO: Robert Hecky (project management and data integration); Steve Colman (project management and ship logistics); Jay Austin (physical limnology); Stephanie Guildford (phytoplankton abundance, productivity); Elizabeth Minor (biochemistry, carbon cycling);
UMD Biology: Donn Branstrator (zooplankton ecology); Randall Hicks (microbial diversity and ecology, DNA analyses); Tom Hrabik (fish abundance and ecology)

B. Timeline Requirements

We propose three years of measurements and monitoring along the project transect in Lake Superior. The middle year, 2011, is designated by the Lake Superior Bi-national Lake Monitoring Program (LaMP) as the year for field measurements (once every five years), part of its monitoring cycle. This project supports and strengthens that initiative as well as other ongoing monitoring efforts.

C. Long-Term Strategy

The proposed transects are intended to form the baseline for long-term monitoring and study of ecosystem processes and changes. We either hold current grants or have active applications for funding from the National Science Foundation, Sea Grant, and other external sources. These projects serve different purposes with different schedules, but all relate to the ecosystem of Lake Superior and all would benefit from baseline data. Ideally the baseline established in this proposal would be repeated in the future at 5 to 10 year intervals. The results of this proposal will be integrated with the **Center for Global Great Lakes Data Analysis, Synthesis and Modeling** database being established July 2009 with a grant from the University of Minnesota Institute on Environment. The data will be made available both in text and visualizations on the Center's ongoing website, and it will be used in ecosystem models developed by the center.

Project Budget

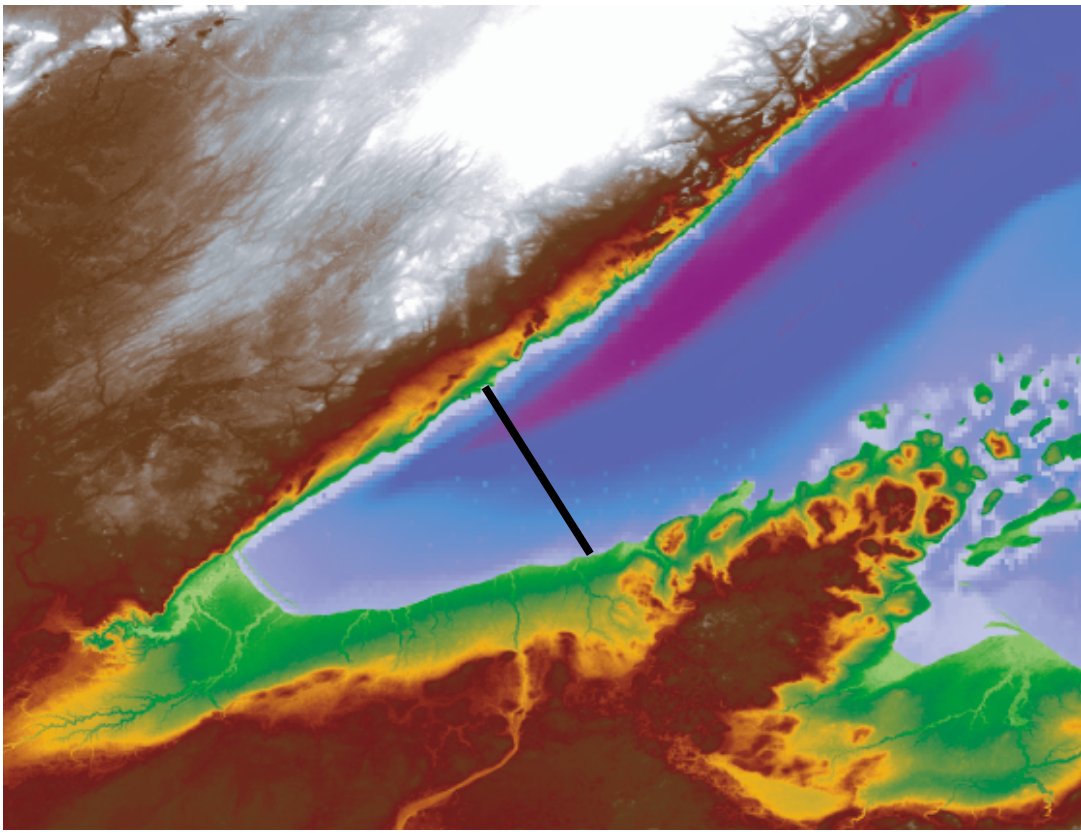
IV. TOTAL PROJECT REQUEST BUDGET (3 years)

<u>BUDGET ITEM</u>	<u>AMOUNT</u>
Personnel:	
Chemical Laboratory Technician (1 mo/y@\$4500/mo+benefits @36%; 3 yr)	\$ 18,360
Biological Lab Technician (2 mo/y @\$3500/mo+benefits@36%; 3 yr)	\$ 28,560
DNA Lab Technician (4 mo/y@\$4000/mo+benefits @36%; 2 yr)	\$ 43,520
Data and Graphic Analyst (2 mo/y @ \$4000/mo +benefits @ 36%; 3 yr)	\$ 32,640
Contracts:	\$ -
Equipment/Tools/Supplies:	\$ -
Acquisition (Fee Title or Permanent Easements):	\$ -
Travel:	\$ -
Additional Budget Items:	
RV Blue Heron 18 days per year at \$5800/d for 3 yr	\$ 313,200
Laboratory and analytical supplies	\$ 76,200
TOTAL PROJECT BUDGET REQUEST TO LCCMR	\$ 512,480

V. OTHER FUNDS

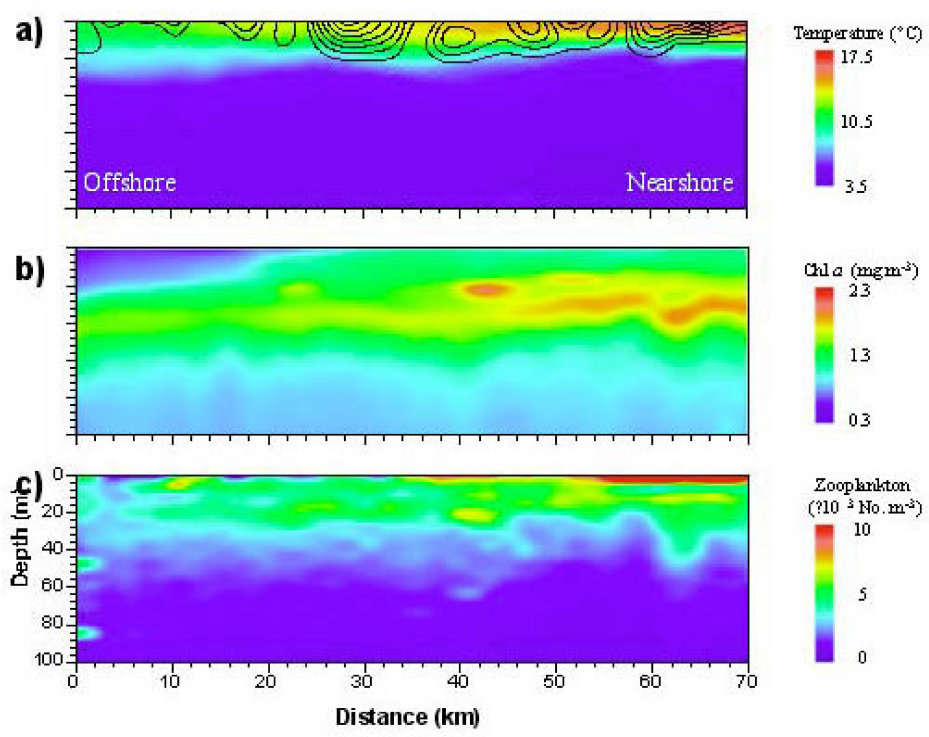
<u>SOURCE OF FUNDS</u>	<u>AMOUNT</u>	<u>Status</u>
Other Non-State \$ Being Applied to Project During Project Period:		
Two National Science Foundation (NSF) Grants (J. Austin; E. Minor)	\$ 566,000	<i>Secured</i>
NSF Grant (submitted February 09 Hrabik, Guildford, Branstrattor, Hecky)	\$ 400,000	<i>Pending</i>
Minnesota Sea Grant (Guildford, Branstrattor, Hrabik, Hecky)	\$ 200,000	<i>Pending</i>
Minnesota-Wisconsin Sea Grant (Guildford)	\$ 150,000	<i>Pending</i>
Other State \$ Being Applied to Project During Project Period:		
University of Minnesota Institute on Environment Grant (R. Hecky)	\$ 400,000	<i>Secured</i>
In-kind Services During Project Period:		
Eight Investigator salaries (one mo each/y) in each of 3 years + benefits@36%	\$ 228,480	<i>Secured</i>
Remaining \$ from Current Trust Fund Appropriation (if applicable):	\$ -	
Funding History: First years of two NSF grants listed above to Austin and Minor	\$ 1,300,000	

Digital elevation model of western Lake Superior (right). Shoreline is at the boundary between green and blue; the project transect, about 30 km long, extends between Two Harbors and Port Wing.



Six transect cruises will be conducted each year, each of three days duration, evenly spaced through the ice-free season. On each cruise, two nights will be devoted to trawling for fish (one night coastal and one offshore) to determine community composition, sizing, diets, samples for contaminant analysis, and calibration of remote sensing devices. The outgoing transect will deploy a Triaxus towed vehicle for continuous monitoring of physical water-column structure and characterization of the phytoplankton and zooplankton communities by repeatedly traversing the water column from surface to near bottom. The returning transect will provide high-resolution depth profiles of temperature structure, water chemistry, plankton and bacterial sampling, and primary productivity at 10 stations on the transect while continuously estimating abundance and size of fishes using calibrated remote sensing methods.

Eastern Lake Superior Transect 7/99



An exaple of transect data from eastern Lake Superior (left, M. Zhou, unpublished data). A) Temperature (color); contour lines are currents into or out of the page; B) Chlorophyl-a, a measure of pytoplankton photosynthesis; C) Zooplankton density.

Co-Project Manager Qualifications

Steve Colman is a Professor of Geological Sciences and Director of the Large Lakes Observatory at the University of Minnesota Duluth (UMD), having also had a productive research career with the US Geological Survey in Woods Hole, MA. He has published more than 100 scientific articles in leading journals, including *Science* and *Nature*. He currently holds two large grants from the National Science Foundation. He has won several scientific awards and has served as an officer or on the steering committees for many national and international scientific organizations. He has successfully managed a previous LCCMR-funded project, begun in 2006 and now drawing to a close.

Robert Hecky joined UMD and LLO in 2007 as a McKnight Presidential Endowed Professor for Lake Ecology. Previously he served as a research scientist with the Canadian Government for 27 years and then held the United Nations University Research Chair for African Great Lakes at the University of Waterloo (Canada). In 1996 he received the Hutchinson Medal for Outstanding Research Career from the American Society of Limnology and Oceanography and in 2006 received the Rigler Award from the Canadian Society of Limnologists for Outstanding Contributions to Canadian freshwater science. He has nearly 200 scientific publications one of which was recently chosen as one of the top 100 scientific discoveries of 2008 by *Discover* magazine. He currently also serves as a Canadian Commissioner for the Great Lakes Fisheries Commission.

Organization Description

The **Large Lakes Observatory** (LLO) is a research institute at the University of Minnesota Duluth. It is the only institute in the country dedicated to the study of large lakes throughout the world. We focus on the global implications of our investigations in areas such as aquatic chemistry, circulation dynamics, geochemistry, acoustic remote sensing, fish ecology, plankton dynamics, sedimentology, and paleoclimatology. LLO's research ranges from lakes in the East African Rift Valley and Central Asia, to the Great Lakes of North America. 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.

The LLO operates the largest university-owned research vessel in the Great Lakes, the R/V Blue Heron, 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 allowing a unique capacity for observing Lake Superior. This equipment includes a SeaBird 911+ CTD and Carousel sampler for determining temperature, salinity, chlorophyll concentration, transparency, dissolved oxygen content and pH of the water column as well as sampling water at desired depths using Niskin bottles. Acoustic Doppler Current Profiler (ADCP) as well as a Triaxus are invaluable for mapping physical conditions along transects. The ADCP is used to measure current speed and direction in 2 m increments throughout the water column while the ship is underway. The Triaxus is a towed vertically undulating vehicle with an extensive instrument package that can measure temperature, salinity, chlorophyll concentration, transparency, dissolved oxygen content and plankton size and distribution. Biological sampling gear includes plankton nets and a 60' Stauffer midwater trawl with a trawl sonar system. It also supports bioacoustic systems for remote sensing of fish populations. Although LLO is the lead organization on this proposal, researchers from other parts of the University of Minnesota Duluth and the University of Minnesota Twin Cities will be involved in the collaborative research proposed.