FINAL REPORT

DEC 16 2002

1999 Project Abstract
For the Period Ending June 30, 2002

TITLE: Assessing Lake Superior Waters Off the North Shore
PROJECT MANAGER: Prof. Thomas C. Johnson
Mailing Address:
ORGANIZATION: Large Lakes Observatory
ADDRESS: University of Minnesota Duluth
Duluth, MN 55812
WEB SITE ADDRESS: www.d.umn.edu/cse/llo.html
FUND: $100,000 the first year and $100,000 the second year of this appropriation are from the trust fund, and $200,000 is from the Great Lakes protection account
LEGAL CITATION: ML 1999, Chapt. 231, Sec. 16, Subd. 12(g).

APPROPRIATION AMOUNT: $400,000

Reseach results and dissemination

The Large Lakes Observatory of the University of Minnesota has established benchmark data on the phytoplankton communities, nutrient chemistry, temperature and currents in western Lake Superior based on a timeseries of measurements from moored instruments at selected stations along the north shore from Duluth to Split Rock between 1999 and 2001. A database of these results has been established at the LLO and, through publications, is being made available to the scientific community and the public.

The annual catch of fish that can be sustained by Lake Superior ultimately depends on primary production of organic matter by phytoplankton (single-celled algae and other plants) in the sunlit surface waters. Our work shows that biological productivity in Lake Superior is much more variable in space and time (both seasonally and, more interesting, inter-annually) than previously thought. This makes biological productivity difficult to quantify using ship-based methods. Our results, based on time-series measurements from moored instruments, suggest that biological productivity may be two- to three- fold higher on an annual basis than reported by previous studies. If true, this is of great significance for fisheries management. In addition, our work suggests that Lake Superior, and by inference other large temperate lakes, are net sources of CO_2 to the atmosphere, so we cannot rely on these lakes to help remediate the problem of increasing atmospheric CO_2 and global warming.

Further work is needed for rigorous assessment of biological productivity and carbon cycling in Lake Superior. An understanding of basic physical, chemical, and biological processes is needed for assessment and prediction of the lake's response to future environmental stresses. We are continuing to develop innovative and cost-effective monitoring programs to assess these key environmental parameters and anticipate receiving significant federal and funding for such work in the coming years.

Date of Report: December 11, 2002
LCMR Final Workprogram:
Date of Workprogram Approval:
Project Completion Date: June 30, 2002

LCMR Work Program 1999

I. PROJECT TITLE: Assessing Lake Superior Waters Off the North Shore

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Total Biennial Project Budget:

$LCMR:	$400,000	**$Match:**	$0
-$LCMR Amount Spent:	$394,851	**-$Match Amount Spent:**	$0
=$LCMR Balance:	$ 5,149	**=$Match Balance:**	$0

A. Legal Citation: ML 1999, Chapt. 231, Sec. 16, Subd. 12(g).

Appropriation Language: $100,000 the first year and $100,000 the second year of this appropriation are from the trust fund, and $200,000 is from the Great Lakes protection account to the University of Minnesota, Duluth for a pilot program to establish benchmark data for Lake Superior. Expenses may not include capital cost for a research vessel. This appropriation is available until June 30, 2002, at which time the project must be completed and final products delivered, unless an earlier date is specified in the work program.

II. and III. FINAL PROJECT SUMMARY

The Large Lakes Observatory of the University of Minnesota has established benchmark data on the phytoplankton communities, nutrient chemistry, temperature and currents in western Lake Superior based on a timeseries of measurements from moored instruments at selected stations along the north shore from Duluth to Split Rock between 1999 and 2001. A database of these results has been established at the LLO and, through publications, is being made available to the scientific community and the public.

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IV. OUTLINE OF PROJECT RESULTS

Result 1. Purchase equipment needed for research cruises. Construct moorings.
LCMR Budget: $97,198
Amount spent: $ 97,171
Balance: $ 27

Completion date: 1 September 1999.

Result 2. Research cruises September 1999 (1x3 days Blue Heron; 1 day Noodin)
LCMR Budget: $16,456
Amount spent: $16,421
Balance: $ 35

Completion date: 1 October 1999.

Result 3. Analysis of data and samples; refinement of research strategies for 2000. Budget
LCMR Budget: $14,328
Amount spent: $14,328
Balance: $ 0

Completion date: 1 April 2000

Result 4. Research cruises May through September 2000 (9 days Blue Heron; 10 days Noodin).
LCMR Budget: $55,886
Amount spent: $55,886
Balance: $ 0

Completion date: 1 October 2000

Result 5. Analysis of results and samples
LCMR Budget: $94,917
Amount spent: $94,917
Balance: $ 0

Completion date: 1 April 2001

Result 6. Research cruises May through September 2001 (8.5 days Blue Heron; 9 days Noodin)
LCMR Budget: $49,586
Amount spent: $49,586
Balance: $ 0

Completion date: 1 October 2001

Result 7. Analysis of results and samples; evaluation of data and preparation of publications and reports.

LCMR Budget: $71,629
Amount spent: $66,542
Balance: $ 5,087

Completion date: 30 June 2002

Final analyses were completed at lower cost than initially anticipated.

V. DISSEMINATION

Our results are being published in scientific journals. This brings our work to the attention of the scientific community, aids in refining our research direction, and reaffirms the status of the University of Minnesota as a world leader in studies of lake processes. In addition, we are making data summaries available through the LLO website; one of our long-term goals is development of a system to provide information continuously about the interior of Lake Superior (i.e. a "fish's eye-view") over the World Wide Web.

Publications include:

Baehr, M.M. and J. McManus "The measurement of phosphorus and its spatial and temporal variability in western Lake Superior." Journal of Great Lakes Research. Submitted July 2002.

Heinen, E.A. and J. McManus. "Carbon and nutrient cycling at the sediment-water boundary in western Lake Superior." Journal of Great Lakes Research. Submitted September 2002.

McManus, J., E.A. Heinen, M. M. Baehr. "Hypolimnetic oxidation rates in Lake Superior: Role of dissolved organic material on the lake's carbon budget." Limnology and Oceanography Submitted May 2002, revised version submitted November 2002.

Ralph, E.A., 2002. "Scales and structures of large lake eddies." Geophysical Research Letters, in press.

Erik Heinen 2002. M.S., Water Resources Science, University of Minnesota "Carbon and Nutrient Cycling in Western Lake Superior" 128 pp.

Several other manuscripts are in preparation at this time.

Presentations at scientific meetings:

Baehr, M.M., M. Jones, and J. McManus. 2002. The spatial and temporal distribution of phosphorus in Western Lake Superior, Ocean Sciences Meeting, Honolulu, HI, February, 2002.

Heinen, E.A., J. McManus, E.A. Ralph, R. Sterner, and S. Grosshuesch. 2002. Carbon and nutrient cycling in a coastal freshwater system: Western Lake Superior. Ocean Sciences Meeting, Honolulu, HI, February, 2002.

Heinen, E.A., J. McManus, P.J. Hommerding, S. Grosshuesch, and K. E. Kolbeck. Benthic carbon and nutrient recycling in western Lake Superior. IAGLR meeting, Green Bay, WI, June 2001.

VI. CONTEXT

A. Significance:

Lake Superior is undergoing significant environmental change.

- Dissolved nitrate levels have steadily increased since the early part of this century, causing a major shift in the ratio of nutrients available to phytoplankton.
- Exotic species of fish and invertebrates continue to be introduced to the lake from merchant vessels.
- Atmospheric deposition of mercury and other heavy metals continues to affect the food web of the lake.
- Global climate change associated with greenhouse gasses will undoubtedly impact the lake.

No long-term baseline data are available on the state of the lake's ecosystem.

Only one comprehensive study of the lake was ever conducted, in 1973 by the Canada Centre for Inland Waters (CCIW). We continue to have contact with CCIW scientists and will work toward collaborative examination of our results in the context of their modern and historic data. The EPA has a monitoring program in the lake, but it has undergone much change and downsizing in its five years of existence. We will study parameters (plankton, currents, nutrient dynamics) that are not measured by the EPA but are essential for understanding the lake system and assessing its fisheries. Throughout this project, we will coordinate our efforts with EPA scientists from the Mid-Continent Ecology Division Laboratory in Duluth (as well as scientists from the EPA Regional Office in Chicago), developing strategies for complementary work that maximize the scientific benefit of our research.

Such information is needed as societal impact on the Superior system intensifies.

- High-density housing is being developed along the lakeshore.
- Shipping activity, including cruise liners, is increasing.
- Demands for Lake Superior water will arise within federal and international courts as aquifers in the southwestern United States become depleted.

Legal decisions are often strongly influenced by high quality environmental data that clearly distinguish natural variability of a system from changes caused by human activity. Now is the time to quantify the extent of natural variability in the Lake Superior system.

The information collected has other direct benefits.

- Commercial and sport fisheries are fundamentally limited by the amount of plant growth (phytoplankton productivity) in the lake. This is analogous to the limit placed on the number of cattle that can be raised on an acre of ranch land by the quality and quantity of available grasses. We know very little about the level and variability of phytoplankton productivity in Lake Superior.
- The fate of pollutants discharged to the lake from urban centers (e.g. the benzene spill from Superior in 1992 or the accidental discharge of 500,000 gallons of raw sewerage from Duluth in 1996) depends strongly on the water currents that transport and disperse them into the open lake.

Prospects for future funding of this program are good.

Based on this pilot study we should have a sufficient database, scientific publications, and science spin-offs to justify seeking long-term support. Potential sources for this support include the National Science Foundation, the EPA, and the National Oceanic and Atmospheric Administration.

B. Time: Rigorous evaluation of processes occurring in Lake Superior requires observations during uninterrupted ice-free seasons. Because the 1 July 1999 start-date for LCMR funding precludes a full season's monitoring work during 1999, we are planning our major field efforts for calendar years 2000 and 2001. This requires that the project extend beyond the normal 2 years of the LCMR biennium. We project that our fieldwork will be completed by October 2001, and that analyses and data processing, evaluation, and dissemination will be completed by June 30, 2002.

C. Budget Context: An LCMR grant of $250,000 in 1997, matched by $914,000 in federal funds ($700,000 from the National Marine Fisheries Service and $214,000 from the National Science Foundation), allowed purchase and renovation of the

research vessel to be used in this project. National Science Foundation equipment grants ($430,000 matched by $260,000 from the U of M VP for Research), provided for purchase of shipboard and shore-based laboratory equipment needed for many of the measurements to be undertaken in this project. In addition, the LLO has received funding from Minnesota SeaGrant (total of $300,000 from 1996 through 2000) for studies of lake circulation as well as lake floor topography and sediments in western Lake Superior. The National Science Foundation is also providing funding to the LLO (total of $900,000 from Sept 1997 through August 2002) for examination of the influence of the Keweenaw Current on circulation and transport processes in central Lake Superior as part of the Keweenaw Interdisciplinary Transport Experiment on Superior (KITES). KITES is the largest NSF-funded research program ever on Lake Superior, now involving scientists from 10 institutions. LLO researchers (Ralph, Brown) were among the core of scientists who defined the scientific goals of KITES and selected Lake Superior as the study area. The proposed LCMR research project will benefit from the additional information provided by these complementary studies, which do not examine biological and water column processes in the western arm of the lake. We emphasize that the shiptime budget covers only the daily costs associated with operating a research vessel: crew salaries, fuel, insurance, routine maintenance, etc. None of the requested funds will be used for capital costs for the ship.

VII. COOPERATION

1. Prof. Erik T. Brown, Large Lakes Observatory (water chemistry)
2. Prof. James McManus, Large Lakes Observatory (sediment traps, nutrient dynamics)
3. Prof. Elise A. Ralph, Large Lakes Observatory (water temperature and currents)
4. Prof. Robert Sterner, Dept. of Ecology, Evolution and Behavior, Twin Cities Campus (plankton ecology)

VIII. LOCATION: Western Lake Superior waters adjacent to St. Louis, Cook and Lake Counties.