Rationale and Needs for Basic Research by Academic Institutions on the Laurentian Great Lakes and Other Large Lakes of the World

Thomas C. Johnson
Large Lakes Observatory
University of Minnesota Duluth

A small number of large lakes distributed across the continents make up a surprisingly high percentage of the world's surface potable water. The Laurentian Great Lakes of North America, Lake Baikal, in Russia, and the great lakes of the East African Rift Valley (Tanganyika, Malawi, Victoria, Kivu, Edward and Albert) alone comprise more than two thirds of the fresh water on the surface of our planet. As our supply of fresh water continues to dwindle due to increased use and pollution, these lakes will undoubtedly be viewed as potential reservoirs of convenience. How will these ecosystems respond to major withdrawals of water? How are these great lakes responding to global climate change, including warming, more frequent storms, and ozone depletion? In order to answer these and other important questions, we need to understand some basic aspects of these lakes. What is the seasonal cycle of life in these lakes? How much does this cycle vary from year to year? How have these lakes evolved over the past century? To what extent has this evolution been the result of natural processes versus human influence? What has been the natural variability in lake ecosystems over the past several thousand years, and what caused it? How does water mix and get moved from one part of the lake basin to another? How fast does this happen and, if a major pollutant were accidentally introduced to the lake, where would it go? Unfortunately the answers to these fundamental questions are not yet at hand. Basic research on the large lakes of the world lags far behind similar research on the oceans. We know far less about the biology and physics of Lake Superior than we know about these aspects of the Indian Ocean. Our nation's freshwater inland seas, as well as those on the other continents, are invaluable resources that are in dire need of major new research initiatives.

Knowledge gained from research on large lakes provides us with important new insights into an aquatic realm that has existed for thousands, and in some lakes, millions, of years. The lakes span a tremendous range of latitudes, from the subpolar Great Bear Lake in the Northwest Territories of Canada to Lake Victoria in equatorial Africa. Their range of ages, water chemistry, and biota provide unparalleled opportunity for both comparative and highly focused research activities of aquatic ecosystems on a grand scale. These lakes provide isolated habitat where new species of fish and invertebrates have evolved. The abyss of Superior and other large lakes is surprisingly dynamic, with occasional storms passing through that scour the lake floor and expose the bottom dwelling communities to intense currents, even in water depths of several hundred meters. The behavior of the plankton is complex and surprisingly varied from one year to the next, for reasons that still elude us. Sediments that accumulate on the floor of the deep basins tell a fascinating story of how climate and the lake ecosystems have changed through time.

<u>Basic research on the world's large lakes provides more than the wonder of discovery, however; it serves as the basis for assessing human impact on large-lake ecosystems, and for developing sound policy for managing and protecting these invaluable bodies of fresh water as our global environment evolves</u>. Many large lakes of the world straddle international boundaries where differences in regulations concerning everything from waste discharge to commercial fisheries make management of these resources especially difficult. The African great lakes, for example, are essential resources that actually lead to improved regional governance, because the lakes are recognized as strong elements of the regional economies. This contributes to the larger effort of building stability and economic cooperation in East Africa. Having sound science as the basis for policy decisions is key to serious international negotiation.

<u>There appears to be a major mismatch between the importance of the nation's freshwater inland seas and the level of support they are receiving from NSF</u>. Despite the importance of the large lakes of the world, the current level of NSF funding for basic research on them is extremely low, typically less than 1% of what is spent on ocean sciences in any given year. Science infrastructure in some sectors of the Great Lakes academic community is dwindling. The University of Michigan has terminated its operation of the UNOLS vessel, R/V Laurentian. The only other UNOLS vessel in the Great Lakes, the R/V Blue Heron, has only 22 days funded by NSF in 2002. This costs $88K, in stark contrast to approximately $35M that NSF is spending on ocean-going research vessels in 2002. None of the $22K is for basic research - the ship time is only for instrumentation testing and an REU (Research Experience for Undergraduates) project. The lack of research activity and infrastructure on the other great lakes of the world is even more severe than in North America. It is time to invest more of NSF's budget into basic research on large lakes.

An NSF-funded workshop on the Science of Freshwater Inland Seas (SOFIS) was held in Duluth, Minnesota on July 14 - 16, 2002. The purposes of the workshop were to define the current research needs, and to develop an implementation plan that was realistic in scope and would insure the establishment of a healthy, productive and sustained research program on large lakes of the world. Attendance at the workshop was limited to 20 scientists from academic institutions from throughout the United States and Canada (Table 1). Participants were selected to achieve a balance of disciplinary expertise, and widespread geographic representation, both in terms of research areas (e.g., North and South America, Asia, Africa) and of institutional affiliation. Our objective was to represent the needs and concerns of the large lakes research community as a whole, to foster its growth, and to engender a new era of discovery in the largest and most diverse freshwater ecosystems on the planet.

Table 1. Participants at the Large Lakes Science Workshop (The SOFIS Working Group)

Name	Affiliation	Interests
Tom Johnson, co-convenor	Univ. Minnesota Duluth	Sedimentology, paleoclimate

Paul Baker, co-convenor	Duke Univ.	Geochemistry, paleoclimate
J. Val Klump, co-convenor	Univ. Wisconsin Milwaukee	Geochemistry, nutrients
David K. Rea, co-convenor	Univ. Michigan	Sedimentology, oceanography
Sarah Green, co-convenor	Michigan Technological Univ.	Chemical limnology
Hans Paerl	Univ. North Carolina	Nutrients, estuarine ecology, limnology
John Janssen	Univ. Wisconsin Milwaukee	Fish ecology
Sally McIntyre	Univ. California Santa Barbara	Physical limnology
Joe Niebauer	Univ. Wisconsin Madison	Physical limnology, oceanography
Elise Ralph	Univ. Minnesota Duluth	Physical limnology, oceanography
James McManus	Oregon State University	Geochemistry, oceanography
Jonathon Cole	Inst. Ecosystems Studies	Microbial ecology, carbon cycles
Bob Sterner	Univ. Minnesota Twin Cities	Zooplankton ecology, nutrients
Bob Hecky	Univ. Waterloo	Nutrient dynamics, tropical limnology
Noel Urban	Michigan Technological Univ.	Geochemistry, carbon/nutrient dynamics
David Jude	Univ. Michigan	Fish Ecology
Chris Scholz	Syracuse Univ.	Seismic stratigraphy, sedimentology
Jim Churchill	Woods Hole Oceanographic Inst.	Physical oceanography
Ray Weiss	Scripps Inst. Oceanography	Chemical oceanography
John Swenson	Univ. Minnesota Duluth	Physical/sedimentary dynamics

A workshop report is being completed for NSF and for distribution to the ocean and large lakes research community. It will summarize our current state of knowledge, including recent accomplishments and identification of important gaps in our knowledge of large lakes systems. The report will provide key examples of exciting new scientific breakthroughs and opportunities for new discovery in the scientific realm, and major recommendations for immediate implementation of a much-needed new initiative in freshwater research.

Fascinating new discoveries and accomplishments have come out of the last decade of basic research on large lakes of the world. Some examples: (1) A superb model of lakewide circulation dynamics has been generated for Lake Michigan that provides perhaps the best predictive capability that we have for any great lake, in terms of lake response to climate forcing. (2) We have learned that Lake Victoria, the largest lake (by area) in Africa, dried up completely during the last ice age. This means that most of the ca. 500 endemic species of cichlid fish that are found in this lake evolved in just the past 14,000 years – the most rapid rate of vertebrate evolution ever reported. (3) We have learned that large eddies, on the order of 3- 5 miles across, are pervasive throughout Lake Superior in all seasons, and probably play a major role in the lake's circulation dynamics. This will completely rewrite the book on how to predict where nutrients, plankton and pollutants are dispersed throughout the basin.

The large lakes community needs sustained funding for:

- investigator-driven, individual research projects on the biology, chemistry, geology and physics of large lakes
- multi-investigator, large research initiatives, some involving sustained (multi-year) time-series measurements of key environmental parameters
- research vessel operations
- new instrumentation, including "ocean" observatories and autonomous underwater vehicles
- fellowship support for graduate students who will comprise the next generation of scientists and government managers of large lakes ecosystems.

Proposals submitted to NSF for basic research on the large lakes of the world normally do not compete well with proposals for oceanographic research. The workshop participants believe that this is due in part to the inherently regional scope of a large lakes proposal, as opposed to most ocean proposals that can legitimately claim global significance with little further explanation. (However we suspect that oceanographic proposals would not fare as well as they do at NSF if they had to compete for a common pool of funds, with sub-atomic physicists, nanotechnologists and molecular biochemists.)

The rationale for more basic research on large lakes, and the needs of the community, are very much the same as that for the oceanographic community. However in view of the difficulty to compete favorably with oceanographers for a common pool of funds, <u>the workshop participants advocate the establishment of a separate budget of $10M per year in the Geosciences Directorate at NSF for large lakes research</u>. Whether this constitutes a separate program or sub-program in one of the divisions of GEO is best determined by the NSF administration, but we believe that this budget should be overseen by its own manager and panel of peer reviewers. This very modest level of funding (by oceanographic standards) would greatly strengthen the level of research and education on the Laurentian Great Lakes and other large lakes of the world, and would attract proposals from scientists not only in the Great Lakes region but from the oceanographic community at large. A strengthened academic research program would nicely complement the needs and applied/basic research activities in the Great Lakes region that are undertaken by state and federal government agencies such as the EPA, USGS, NOAA and the state departments of natural resources.