Great Lakes Issue Identification Workshop

January 20-21, 2003

Lurie Engineering Center
University of Michigan
Ann Arbor, MI

Sponsored by

NOAA/Center for Sponsored Coastal Ocean Research
NOAA/Great Lakes Environmental Research Laboratory
Cooperative Institute for Limnology and Ecosystems Research

GREAT LAKES ISSUE IDENTIFICATION WORKSHOP
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INTRODUCTION

On January 20 – 21, 2003 the NOAA Center for Sponsored Coastal Ocean Research (CSCOR), NOAA Great Lakes Environmental Research Laboratory (GLERL), and the Cooperative Institute for Limnology and Ecosystem Research (CILER) co-hosted a Great Lakes Issues Identification Workshop at the University of Michigan in Ann Arbor. The **focus of this workshop** was to identify major issues within the Great Lakes that fit within the overall goals of NOAA-CSCOR. This brief report summarizes the **results of this workshop** and will form the basis of any RFP that may subsequently be developed by CSCOR for a future Great Lakes Program. For purposes of program scale, past CSCOR programs have totaled approximately $1 million in funding over a five-year time period.

The CSCOR Coastal Ocean Program (COP) is a federal-academic partnership providing predictive capabilities for managing coastal ecosystems. The typical goals of a COP regional ecosystem study are to:

- Support NOAA's ecosystem and resource responsibilities.
- Foster collaboration between NOAA, universities, and states.
- Provide a path leading to operational or management products.

Projects funded through this program are typically those that span several disciplines with many investigators and are large scale and model based.

From 1998 through 2002 CSCOR, along with NSF-CoOP, GLERL, EPA Great Lakes National Program Office (GLNPO), and National Water Research Institute in Canada (NWRI) sponsored the Episodic Events Great Lakes Experiment (EEGLE) program (www.glerl.noaa.gov/eegle) in Lake Michigan. The focus of this program was nearshore-offshore transport and transformation of biogeochemically important materials and their impact on a whole lake scale.

The **Great Lakes Issue Identification Workshop goal** was to identify and prioritize a list of Great Lakes research issues compatible with CSCOR's goals and mission and to provide scientific information to assist decision makers in meeting the challenges of managing our nation's coastal resources (see http://www.cop.noaa.gov/). CSCOR targets critical issues that exist in the nation's estuaries, coastal waters, and Great Lakes. CSCOR translates its findings into accessible information and the transfer of technology to coastal managers, planners, lawmakers, and the public. Its aim is to create near-term and continuous improvements in environmental decisions affecting the coastal ocean and its resources.

WORKSHOP SYNTHESIS

By any measure, the Laurentian Great Lakes are one of the earth's greatest treasures. They contain about 18 percent of the world's surface freshwater supply and over 80 percent of the U.S. supply. The Great Lakes provide drinking water to over 40 million U.S. and Canadian citizens and water quality is thus an exceptionally important concern for the region. The

Great Lakes also provide a locus for industry, tourism and a commercial and recreational fishery – the recreational fishery alone is valued at $4 billion annually.

Pressures associated from these multiple demands had devastating consequences on the Great Lakes and were epitomized by a declaration in the early 1970s that "Lake Erie was dead." Currently, the lakes are recovering from these devastating human impacts and water quality conditions have improved tremendously. The 1972 Great Lakes Water Quality Agreement between the U.S. and Canada set target loads for phosphorus that are calculated to restore the biological integrity of the Great Lakes ecosystem. The Great Lakes led the nation in the 1970s in nutrient control management and contaminant cleanup as well as in international and ecosystem-based approaches to management and control strategies of invasive species. Phosphorus targets were largely achieved by the early 1980s and contaminant levels continue to decrease or level off.

However, based on data collected over the past few years, the participants at the workshop agreed that new and continuing water quality and ecosystem health issues persist within the lakes and remain a challenge to managers.

Over the past 15 years the rate of species invasion into the Great Lakes has accelerated with substantial impacts on food webs and cycling of nutrients. The benthic food web and associated processes are very different from the 1980s and earlier. The most obvious example of these changes resulted from the introduction of zebra mussels (*Dreissena polymorpha*) in the early 1990s. They fundamentally altered energy transfer and nutrient cycling in the lakes and have been identified as a primary cause of the appearance of hazardous algal blooms of *Microcystis*, increased depletion of oxygen, and increased water clarity with resultant blooms of benthic macrophytes, such as *Cladophora*. In addition to the stresses associated with the zebra mussel invasion, the coastal areas of the lakes are being impacted by continuous changes in land use. These issues are now common in several areas including Saginaw Bay, Green Bay and Lake Erie. Also, there has been a massive reduction in *Diporeia* (a benthic amphipod and critical fish food) in several of the lakes. The strategy developed to manage the lakes by titrating phosphorus loads to set levels of chlorophyll did not anticipate or include alteration of key processes in this ecosystem.

Given these recent perturbations and changes in community structure, the nutrient management strategy for the Great Lakes needs to be reexamined from a total ecosystem perspective.

While scientists, resource managers, and the public struggle to improve and sustain the quality of the Great Lakes by balancing the needs of multiple users, similar problems occur in other coastal areas.

Can we successfully manage ecosystems on the scale of the Great Lakes?

The models used in the 1970s to set nutrient input levels were first generation, but proved successful in forecasting lake response into the 1990s. Some recent data may imply that lake phosphorus concentrations are diverging from predictions. We now have a better understanding of how ecosystems work and need to improve the models by adding better physics, refined chemical and biological processes, incorporate the upper food chain, and importantly add new ecological components which were not present in the 1970s. Improved hydrodynamic models are now able to provide reliable information on lake circulation, transport of nutrients, and system-wide thermal structure. The importance of episodic events, land-lake coupling, and fundamental changes in nutrient dynamics and food webs need to be incorporated into a next generation of lake management tools. Concurrently, the validity of state-of-the-art models needs to be evaluated to test the validity and robustness of their outputs. This can be done in hindcast and forecast modes. Extensive databases, derived from research and monitoring programs that often extend back into the 1970s, can be used to test hindcast simulations. Furthermore, reasonably good meteorological data from approximately the past 50 years is available to drive circulation and thermal simulations.

RECOMMENDATIONS

The **consensus of this workshop** is that a new concerted research effort is needed to examine the impacts of recent ecological changes in the Great Lakes on water quality.

Proposals should be solicited to develop environmental forecasting tools for assessing and predicting changes in water quality and its consequences to the food web of the Great Lakes. Questions/issues identified at the workshop that should have priority include:

- Whether recent ecosystem changes have compromised eutrophication controls.
- Connections between water quality and undesirable ecosystem events such as taste and odor problems, harmful algal blooms, hypoxia, and fish die-offs.
- Impact of landscape changes on material fluxes across the land-lake interface.
- The effect of the benthic community on nearshore-offshore cycling and transport of materials.
- The role of physical processes (episodic events, interannual variability, and climate change) on basin ecology.
- The role of benthic-pelagic coupling in controlling key ecosystem processes.
- An examination of ecological resiliency in non-steady state environments.

The Great Lakes ecosystem is the most clearly definable regional entity under NOAA's purview and mission responsibilities, contains a suite of environmental stresses common to all coastal systems, and has a long history of bi-national and interagency partnerships and collaborations. Thus, the Great Lakes have the greatest potential for success in testing any regional approaches and for the development of ecosystem forecasting tools.

WORKSHOP PROGRAM

The workshop was opened by a presentation from John Wickham describing COP goals and the format of the regional programs that they support. This talk was followed by a series of five invited presentations on topical areas important to the lakes. The presentations were given by senior investigators familiar with those areas and were intended to represent examples of new approaches and programs of appropriate scope, and as a place to begin the workshop discussions. Complete copies of the presentations have been posted to the web sites *http://www.glerl.noaa.gov/eegle/products/COP_workshop_2003* and *http://www.ciler.org/news*.

- *Extending NOAA's Prediction and Assessment Mission to Coastal and Marine Ecosystems – Don Scavia, NOAA-COP.* This presentation focused on ecological forecasting and current efforts to incorporate this concept into ecosystem planning.

- *Land-Margin Interactions: Three Venues Subject to Major Changes – Val Klump, University of Wisconsin-Milwaukee*. This presentation focused on developing a coastal research theme similar to NSF-LMER (Land-Margin Ecosystem Research) with emphasis on examining the roles of rivers, upwellings, etc. on coastal ecology. Management products would include improved predictions of alewife for salmon stocking decisions. This type of program would be a follow-on to EEGLE, building on information acquired in that project.

- *Potential CSCOR Projects: Major Issues in Lake Erie Research – Gerald Matisoff, Case Western Reserve University*. This presentation described a potential Lake Erie program that would focus on food-web changes and impacts, and include research on other major NOAA-COP interests such as hazardous algal blooms and hypoxia. This program would build on a large Lake Erie database and current EPA programs focused on the cause of phosphorus increase and hypoxia. The fisheries management products would be different, but still notable. Lake Erie has large signal-to-noise in many areas of interest. Large gradients would provide a major challenge for optical work and satellite-based algorithm development; massive sediment resuspension would provide a test for EEGLE products.

- *Retrospective (1953-2002): Hydrodynamic Modeling for Lake Erie – Dmitry Beletsky, University of Michigan and David Schwab, NOAA Great Lakes Environmental Research Laboratory*. This presentation discussed developing a retrospective analysis of one (or more) of the Great Lakes covering the past 45 years using well-calibrated hydrodynamic models to hindcast thermal structures, circulation and waves. These models would provide a means of isolating other major processes during major transition events (phosphorus load reduction, infestation of zebra mussels, etc.) and provide a framework for conducting detailed examination of a major ecosystem restoration.

- *Remote and in situ Optical Methods for Characterization of Ecosystem Level Physical and Biogeochemical Processes in the Great Lakes – Oscar Schofeld, Rutgers University and Steve Lohrenz, University of Southern Mississippi*. This presentation focused on opportunities for optical studies to improve algorithms for Great Lakes remote sensing products – this could be a part of a larger theme as well. The talk also described potential developments in observing systems that would facilitate additional *in situ* measurements offering opportunities to examine, synoptically, teleconnections among the lakes.

After these presentations and some plenary discussions, the workshop participants split into three workgroups with a common charge – to discuss the items that were presented and to identify new themes for Great Lakes research that addressed important research issues compatible to the goals and format of a COP regional program.

Workgroups met several times in the issues format where each group had representatives on all disciplines, and discussions focused on specific topical areas. Then, participants re-formed into new groups along disciplinary lines to continue to hone potential hypotheses and objectives. The three workgroup summary reports are presented below.

WORKGROUP SUMMARIES

WORKGROUP E – 1 / ECOLOGISTS

Chaired by Doran Mason, NOAA Great Lakes Environmental Research Laboratory

1. Issues

- Water quality issues return – hypoxia, *Microcystsis* blooms, *Cladophora*, avian botulism, coastal contaminants.
- Impacts of changes in community structure on taste/odor, food webs, fisheries.

2. Overarching Questions

- To what extent are recent changes in physics, chemistry, and ecology, independently or interactively, contribute to the degradation of water quality?
- What is the appropriate external phosphorus and nitrogen loading given recent changes to the Great Lakes?

3. Working Hypothesis

- Weather and climate induced the change in water quality.
- Increased loadings (change in land use) contributed to the water quality degradation.
- Ecosystems responses resulted from change in internal cycling processes.
- Changes in food web structure have resulted in altered rates and pathways of nutrient and energy flow.

4. Critical Program Elements

- Status and trends
- Retrospective analysis (refine field and modeling projects)
- Causes and consequences to fisheries yields and human health

- Prediction of potential future states

5. Other Issues Developed

   - What science do we need to support decision making (clean-up/de-listing) for Areas of Concern (AOCs)?
   - Apparent de-coupling of nutrients to traditional measures of primary production and implications to fish production (hypothesis: increased benthic production responsible for apparent disruption).
   - Habitat change and changes in the trophic transfer of energy (question: how has habitat change restructured the pathways of energy flow?).
   - Land-lake margin study – energy/nutrient balance; origin, fate and recycling of nutrients; shunting materials offshore. (What are the ground water inputs?)

WORKGROUP P – 2 / PHYSICAL

Chaired by David Schwab, NOAA Great Lakes Environmental Research Laboratory

Solicit proposals related to:

1. Assessing, understanding, and predicting changes in water quality and consequences to the food web of the Great Lakes

   - Effect of benthic community on nearshore-offshore cycling and transport of materials.
   - Impact of landscape changes on material fluxes across the land-lake interface.
   - Examine whether recent ecosystem changes have compromised eutrophication controls.
   - Impact of physical processes (episodic events, interannual variability, and climate change) on basin ecology.
   - Connection between water quality and fisheries productivity and/or environmental health.
   - Connections between water quality and undesirable ecosystem events (harmful algal blooms, hypoxia, and fish die-off).
   - Role of benthic-pelagic coupling in controlling key ecosystem processes.
   - Examination of ecological resiliency in non-steady state environments.

2. Study effects of changes in habitat (wetlands, shoreline, and mussel reefs), particularly in coastal margins, on ecosystem structure and function.

3. Develop tools to characterize and predict temporal and spatial variability in Great Lake systems/processes.

WORKGROUP C – 3 / CHEMICAL

Chaired by Peter Landrum, NOAA Great Lakes Environmental Research Laboratory

There is a need to generate a test case of an ecological forecasting system(s) that can be used and validated. The Great Lakes should serve as a test site for developing ecological forecasting systems. The Great Lakes have been identified as sensitive systems that show responses earlier than observed in coastal systems and there has been a substantial research program designed to model the ecosystem or major components of the system. Thus, the pieces should be in place to build the platform for an ecological forecasting system or systems.

The group thought that a good way to prioritize a set of research issues was to develop a matrix that included issues, management controls (decision points) and science requirements.

1. Priority Great Lakes Issues

   - Fish productivity – need to understand energy (metabolic energy) and mass flow.
   - Fish consumption advisories – need to examine sources.
   - Contaminants – what role do contaminants play in the system today? What will be the impact of new persistent contaminants such as polybrominated diphenylethers? Do the non-persistent bioactive compounds such as pharmaceuticals (a recently identified potential contaminant problem) play a substantial role in the Great Lakes?
   - Hypoxia.
   - Pathogens – such as avian botulism.
   - Harmful/nuisance algal blooms – does the relative proportion of nutrients drive the system e.g. for harmful algal blooms and nuisance species? Can predictability be developed for blooms or for change in species composition in the algal species?

2. Management Decision Points

   - Comparative lake assessments – detect long-term changes; examine spatial variability; and improve sensing technology. Determine teleconnectivity in lakes – to what extent are lakes responding to larger scale functions?
   - Water quality – need to understand physics, nutrients and loads. Also water quality is tied directly to water quantity issues that will impact ecology.
   - AOCs continue to be problems and even with the Great Lakes Legacy Act it will not be possible to address all the problems. What is the impact of each AOC on the ecosystem function and fish consumption advisories? Can we establish an approach to set priorities to focus the Great Lakes Legacy Act funds to address cleanup of the sites with the most impact on the ecosystem?
   - Role of episodic events on ecological processes.
   - Impact of changing land use patterns on ecology.

- How dose nearshore-offshore coupling affect the ecology of the Great Lakes – this issue is tied directly to the impact of changing land use patterns and impacts in the coastal ecosystem.

3. Science Needs (Unfortunately there was not adequate time to couple science needs with identified issues.)

- Develop carbon and nutrient budgets for each of the lakes.
  - *The carbon and nutrient budgets need to be tied together.*
  - *Develop coupling to remote sensing to augment budgets and productivity measurements.*
  - *Improve satellite algorithms for one or more of the lakes incorporating a ground truth field program.*
- Quantitatively determine the primary productivity of each lake.
  - *What are the temporal and spatial scales that are required to interpret the productivity of the system?*
- Improve our understanding and quantification of the forcing functions in order to develop better ecological models.
  - *Can we develop the minimally necessary information required to develop an ecological model for ecosystem forecasting? This may be issue dependent and could be accomplished through a comparative lake study that makes use of retrospective analysis.*
  - *What types of models are available to serve as a test base for ecological forecasts (phosphorous models, silica models)?*
- Through the collection of cores make a calculation of sediment sink terms, resuspension and remobilization for a variety of chemical constituents.
  - *Use long cores to look at long-term changes in the lake to sort out natural and anthropogenic components of change.*
- Use persistent chemicals as tracers of ecosystem processes regulating fate and transport.

4. Comments on Ecological Models

- Models need to be adaptive.
  - *Need to allow for improvements over time.*
  - *Need to be sensitive enough to detect changes in system.*
  - *Should be readily available and run frequently to look for deviations from predictability.*

5. Comments on Lake Erie as a Site for the COP Program

- Pros
  - *Politically visible.*
  - *Relatively fast response – thus models developed for this system will be both challenged since changes will happen quickly and verifiable since changes will occur*

at relative time scales that can be detected to insure that the models are functioning properly.
- *Lake Erie has been a historical symbol of the health of the Great Lakes.*
- *Models are in place or available for developing a foundation e.g., the Great Lakes forecasting system.*
- *The Lake Erie ecosystem is strongly influenced by external processes.*

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- *There are multiple issues, several of which are likely interconnected.*
- *Lake Erie is a very complex system compared with the other lakes.*
- *The Lake Erie ecosystem is strongly influenced by external processes.*

APPENDIX 1 — AGENDA

GREAT LAKES ISSUES WORKSHOP AGENDA
JANUARY 20-21, 2003

Monday, January 20

GM Conference Room – 4th Floor Lurie Engineering Center

1:00 – 1:15	Convene and Welcome
1:15 – 1:30	COP Goals and Supported Programs — John Wickham
1:30 – 2:30	Briefings on Potential Themes
	Ecosystem Forecasting — Don Scavia
	Nearshore / LMER / EEGLE — Val Klump
	Optical Opportunities — Oscar Schofeld and Steve Lohrenz
2:30 – 3:00	Refreshment Break
3:00 – 4:00	Briefings on Potential Themes
	Lake Erie — Gerald Matisoff
	Forty Year Retrospective — Dmitry Beletsky and David Schwab
	Other?
4:00 – 4:15	Charge to Workgroups

Johnson Conference Rooms – 3rd Floor Lurie Engineering Center

4:15 – 5:30	Workgroup Discussions (Issues: Groups 1-3)
5:30	Adjourn
6:00	Dinner – Boulevard Room, Pierpont Commons

Tuesday, January 21

Johnson Conference Rooms – 3rd Floor Lurie Engineering Center

7:00 – 8:15	Continental Breakfast

GM Conference Room – 4th Floor Lurie Engineering Center

8:15 – 9:00	Plenary – Review Workgroup Discussions – New Ideas

Johnson Conference Rooms – 3rd Floor Lurie Engineering Center

9:00 – 10:30	Workgroup Discussions (Issues: Groups 1-3)
10:30 – 11:00	Refreshment Break
11:00 – 12:00	Workgroup Discussions (Disciplines – Groups P, E, and C)
12:00 – 1:00	Lunch

GM Conference Room – 4th Floor Lurie Engineering Center

1:00 – 1:30	Plenary – Review Workgroup Discussions – New Ideas

Johnson Conference Rooms – 3rd Floor Lurie Engineering Center

1:30 – 3:00	Workgroup Discussions (Issues: Groups 1-3) Draft Reports
3:00 – 3:15	Refreshment Break

GM Conference Room – 4th Floor Lurie Engineering Center

3:15 – 4:00	Plenary – Review Workgroup Discussions
4:00	Wrap-Up and Adjourn

APPENDIX 2 — LIST OF PARTICIPANTS

Participant	Affiliation	Email Contact	Discipline	Workgroup
Allan, David	U of Michigan	*dallan@umich.edu*	Ecologist	E – 2
Bedford, Keith	Ohio State U	*bedford.1@osu.edu*	Physical	P – 3
Beletsky, Dmitry	U of Michigan	*dima.beletsky@noaa.gov*	Physical	P – 1
Bence, James	Michigan State U	*bence@msu.edu*	Ecologist	E – 1
Carrick, Hunter	Pennsylvania State U	*hjc11@psu.edu*	Plankton ecologist	E – 2
Charlton, Murray	CCIW	*murray.charlton@cciw.ca*	Nutrients	C – 2
Eadie, Brian	NOAA – GLERL	*brian.eadie@noaa.gov*	Biogeochemist	C – 1
Fahnenstiel, Gary	NOAA – GLERL	*gary.fahnenstiel@noaa.gov*	Phytoplankton ecologist	E – 2
Freedman, Paul	Limnotech, Inc.	*pfreedman@limno.com*	Environmental engineer	E – 3
Heath, Robert	Kent State U	*rheath@kent.edu*	Nutrients	C – 3
Johengen, Thomas	U of Michigan	*johengen@umich.edu*	Nutrients	C – 2
Kerfoot, W. Charles	Michigan Tech U	*wkerfoot@mtu.edu*	Ecologist	E – 2
Klump, Val	U of Wisconsin	*vklump@uwm.edu*	Biogeochemist	C – 2
Landrum, Peter	NOAA – GLERL	*peter.landrum@noaa.gov*	Aquatic contaminants	C – 3 Chair
Lesht, Barry	ANL	*bmlesht@anl.gov*	Sediment transport	C – 3
Lohrenz, Steve	U of So Mississippi	*steven.lohrenz@usm.edu*	Bio Oceanographer	E – 3
Mason, Doran	NOAA – GLERL	*doran.mason@noaa.gov*	Fisheries ecologist	E – 1 Chair
Matisoff, Gerry	Case Western Reserve U	*gxm4@po.cwru.edu*	Biogeochemist	C – 1
Meadows, Guy	U of Michigan	*gmeadows@engin.umich.edu*	Physical	P – 3
Meadows, Lorelle	U of Michigan	*lmeadows@engin.umich.edu*	Physical	P – 3
Peacor, Scott	Michigan State U	*scott.peacor@noaa.gov*	Ecological modeler	E – 2
Rao, Ram	CCIW	*ram.yrao@odin.cciw.ca*	Physical	P – 2
Scavia, Don	NOAA – CSCOR	*don.scavia@noaa.gov*	Ecological modeler	E – 1
Schwab, David	NOAA – GLERL	*david.schwab@noaa.gov*	Physical	P – 2 Chair
Vanderploeg, Hank	NOAA – GLERL	*henry.vanderploeg@noaa.gov*	Zooplankton	E – 1
Wickham, John	NOAA – CSCOR	*john.wickham@noaa.gov*	Physical	E – 2