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## EDITORIAL

# A Bold Step Forward: Ecosystem Forecasting, Integrated Observing Systems, and International Field Years for the Great Lakes

By any measure, the Laurentian Great Lakes are one of the earth's greatest treasures and the Nation's single most important aquatic resource from an economic, geographic, international, ecological, and societal perspective. Many, increasingly complex challenges lie ahead for the Great Lakes. The Great Lakes continually face extremes in natural phenomena such as storms, erosion, high waves, high and low water levels, and climate variability. Further population growth will lead to an increase in conflicting user demands and complexity in management issues. The one thing that we can predict with near certainty is that the Great Lakes ecosystem will continue to change and the challenges for effective use and management will only increase. We should ask ourselves: Is the scientific and management community ready to meet these long-term challenges?

I contend that we can. In the early 1970*s* when Lake Erie was declared dead, the solution, based on best available science, was relatively clear: nutrient loading must be reduced. The issues are more complex now. Our ecological understanding and technological know-how have greatly improved since the 1970*s*, and now is the time to take some bold steps forward. We can no longer be satisfied with single-issue resolutions. The long touted "ecosystem approach" must now be rigorously applied in the Great Lakes.

To meet the challenges of the future and move us toward an ecosystem approach, I believe we must:

1) Develop genuine ecosystem forecasting capability through focused research
2) Develop an Integrated Great Lakes Observing System
3) Conduct a second grand-scale, multi-agency, ecosystem-level research program on the Great Lakes – IFYGL-2.

One of the principal justifications for Great Lakes research is improved understanding of the ecosystem. Recent interest in the concept of **Ecosystem Forecasting** (Clark *et al.* 2001; NOAA 2001; CERN 2001) highlights the need to develop and implement the capability for *timely and continuing* predictions of the impacts of chemical, biological, and physical changes on ecosystem structure and function. Ecosystem forecasts could help to improve decision-making for coastal stewardship, mitigate the impacts of natural events and human activities, reduce impacts of natural hazards, enhance communication between scientists and managers, and provide more effective science direction and cross-disciplinary integration. Ecosystem forecasting in the Great Lakes should span a range of predictions from physical factors such as the occurrence of hypoxic water to ecological characteristics such as fish productivity.

In the Great Lakes, we already make forecasts of wind waves, ice cover, water levels, surface temperatures, currents, and marine meteorology. We should strive to make forecasts of the impacts of extreme natural events, societal pressures, and climate variability on ecosystem processes and create the next generation of lake management tools. Building the ability to forecast the cumulative effects of multiple stressors is one of ecology's most significant challenges.

To develop ecosystem forecasting, research scientists, coastal users, and management decision-makers must work together to identify and focus the types of forecasts required, as well as the time and space scales of interest. Some types of ecosystem forecasts may be made with statistical analyses. Other forecasts will require research-enhanced quantitative ecosystem understanding, particularly relative to biological-physical-chemical interactions on a lake-wide basis and over a range of time and space scales. Process-level ecological models and novel forecasting methodologies will need to be developed using focused research, published data, and data from integrated observing systems. To develop forecasting capabilities, our research will need to be re-focused at prediction rather than explanation.

The Great Lakes community is well poised to take leadership in developing ecosystem forecasts for coastal environments. Existing data, methods, models, and understanding are sufficient for "first generation" forecasting for a limited number of important ecological issues but perhaps only with relatively wide confidence limits. Research can be directed at expanding the types of predictions and narrowing the confidence limits, but will face the challenges of ecological complexity, data management, and definition of the useful scales of forecasts and forcing functions.

In parallel to developing ecosystem forecasting, we need to develop an integrated **Great-Lakes Observing System** that allows the Great Lakes community to track and identify changes in the ecosystem. Understanding and forecasting changes in an ecosystem require baseline and continuing observations on natural scales of variability to identify perturbations and changes, to put current trends into a historical framework, differentiate true ecosystem change from natural variance, and to provide a context for predicted changes. Presently, the ability to monitor the rapid changes in the Great Lakes is relatively poor.

A few observing systems do exist in the Great Lake such as satellite remote sensing, water levels, meteorological stations, shore-based monitoring at industrial and municipal water intakes, and ship-based observations. But, we do not have in place a set of real-time monitoring instruments spaced throughout the Great Lakes collecting identical information at identical time and space scales. One could envision a network of state-of-the-art buoys in each of the lakes designed to detect changes in the biological, chemical, meteorological, and physical conditions at enhanced time and space resolution. A fundamental goal of a Great Lakes Observing System should be to incorporate existing and new observing systems into a standard data management realm and to provide real-time data accessibility through the internet to meet the increasing demand for real-time information. Buoy locations and sensor types would be based on forecast operational needs, relevance to scientific data collection, availability of receiving stations, and relevance to the general public.

We should follow the approaches outlined in various Coastal Global Ocean Observations Systems recommendations (e.g., Ocean U.S. 2003) and also assess user needs. An interagency plan for system development and operations should be developed. The Great Lakes could be used as a national example of regional coastal observing systems.

The first and only International Field Year for the Great Lakes (IFYGL) was conducted over 30 years ago in 1972–1973. It was the largest coordinated, multi-institution aquatic research program ever carried out in the Great Lakes. The work from that program resulted in hundreds of publications. Information gained from the IFYGL program still resonates in our understanding and management of the Great Lakes. IFYGL was a significant step forward in our understanding of the physics of large lakes, but lake chemistry and biology were minor components. Since then, it has become apparent that lake chemistry, biology, and physics do not operate independently on the lakes, and an ecosystem approach should be adopted. Our scientific capabilities and the need for this type of science have greatly expanded over the last 30 years. Also, our technological, analytical, modeling, and institutional arrangements and cooperation have significantly improved since then. It is time to renew the IFYGL approach. The IFYGL was largely a 1-year field effort and many papers have pointed out that is was an "unusual" year. We now recognize the importance of interannual variations in large-scale driving forces. Therefore the International Field Years for the Great Lake (IFYGL – 2) must be 3–5 years in duration to capture and indeed better understand these large (time and space) scale driving forces. For example, a whole-lake ecosystem study over a period of a several years is required to discover the contributing factors and make future forecasts of hypoxia in Lake Erie. This could be accomplished with a well-planned IFYGL-2.

These three recommendations will require planning, interdisciplinary and international collaboration, more effective communication and information dissemination, resources, integration among forecasting goals, user needs, observing systems and ecosystem-level research, and a great deal of long-term commitment by key agencies in the region**.**

The Great Lakes region has a history of leading the nation in innovative management strategies and has provided a large-scale testing ground for new science and management. For example, the Great Lakes led the nation in nutrient control management in the 1970s, contaminant cleanup, international and ecosystem-based approaches to management, and invasive species control strategies. It is time for the Great Lakes community to take another bold step forward.

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