International Field Year on Lake Erie (IFYLE) – 2005

7 February 2005

BACKGROUND

A long-term goal of NOAA is to provide enhanced ecosystem forecasts (both ecological and environmental) that would predict patterns of biological and chemical variables, as well as natural and human-induced changes to the system (e.g., extreme natural events, climate change, land and resource use, pollution, invasive species, fisheries impacts and interactive effects), across a variety of spatial and temporal scales. These forecasts ultimately should benefit coastal communities, including the Great Lakes, by providing the foundation for 1) improved decision-making for resource stewardship, 2) mitigation of potentially hazardous human activities, 3) reduced impacts of natural hazards, 4) enhanced communication between scientists and managers, and overall, 5) more effective prioritization of science, particularly across disciplines.

It is now well recognized that continued and new water quality and ecosystem health issues persist within the Great Lakes that are of concern to the user community and researchers, and which remain a challenge to Great Lakes resource management. These include, but are not limited to, harmful algal blooms (HABs), reduced oxygen availability (hypoxia/anoxia), and exotic species, all of which have the potential to negatively influence food web dynamics, native biodiversity, and biological production (e.g., fisheries yield). Clearly, development of tools to provide reliable forecasts of the Great Lakes ecosystem, and/or modular components of chemical, biological, or physical subsystems, would help resource agencies choose among potential management options.

To improve our ability to provide reliable ecosystem forecasts in the Great Lakes, NOAA-GLERL has been working toward development of an integrated (multi-agency), multidisciplinary research program for Lake Erie that deals with important management issues (e.g., harmful algal blooms, hypoxia/anoxia, fish production). Four attributes make Lake Erie ideal for piloting the development of an ecosystem-forecasting framework. First, although Lake Erie is a large system, it is small relative to other coastal marine systems and the other Great Lakes. In turn, comprehensive, yet cost-effective, field sampling can be performed to test hypotheses (i.e., tractable questions can be asked). Second, a wealth of historical monitoring and research data has been compiled for this system, which can be used immediately for model parameterization/calibration, validation, and ecological scenario testing. Third, several predictive physical and biological models exist for Lake Erie (Maumee River watershed-hydrology model; Lake Erie hydrodynamics model), or are ready to be tailored to Lake Erie (Saginaw Bay lower trophic level model). Finally, a large research and policy infrastructure (e.g., Lake Erie Millennium Group, Lake Erie LaMP) already exists, which will facilitate our effort to develop truly integrative, multidisciplinary programs aimed at conducting the needed research for ecosystem forecasting.

As a major step in developing this Lake Erie program, NOAA hosted a large, international workshop on March 4-5, 2004 to discuss three important Lake Erie issues that GLERL scientists thought were within the existing capabilities of the laboratory: 1) anoxia/hypoxia, 2) harmful algal blooms (HABs), and 3) coupling physics with forecasts of fish production. This workshop also provided an opportunity 1) for scientists to learn about ongoing Lake Erie programs by U.S. and Canadian agencies and academics; 2) to discuss facilitation of communication and collaboration among academicians and research agencies in Lake Erie; and 3) for improving the focus and approach of a coordinated Lake Erie research program whose long-term goal is the development of models and other tools to better understand and forecast changes in the Lake Erie ecosystem. A complete de-

scription of this workshops goals and accomplishments can be found at http://www.glerl.noaa.gov/rsch/erie/workshops/workshop_final2004.pdf)

This proposed Lake Erie research program for 2005, which we describe below, derives largely from research hypotheses, ideas, and needs generated at the 2004 Lake Erie Science Planning Workshop. In initiating this Lake Erie research program, we have tried to remember several important generalizations derived at the 2004 workshop:

1. The need for collaboration and coordination among agencies is critical. Efforts to build useful forecasting models will fail in the absence of inter-disciplinary approaches. Efforts aimed at maximizing integration, collaboration should be supported.
2. Encourage the development of a user-friendly database that would provide general access to the large inventory of historical data.
3. Continued efforts to bring scientists from multiple disciplines together to focus on specific issues are vital to development of a proper forecasting framework.
4. Sampling needs to be coordinated among agencies and scientists such that redundancy can be reduced and we can maximize information collected (e.g., ships might have space for additional researchers).

Efforts to develop multidisciplinary, integrative (multi-agency) research programs, which in the end, could improve our (the Lake Erie community's) ability to provide reliable ecological and environmental forecasts will benefit by adhering to these general guidelines in planning and conducting research (Brandt 2003).

Literature Cited

Brandt, S.B. 2003. A bold step forward: ecosystem forecasting, integrated observing systems, and international field years for the Great Lakes. J. Great Lakes Res. 29(3):373–374.

RESEARCH FOCI

In keeping with the previous 2004 Lake Erie Science Planning Workshop, this overall research program will focus on Hypoxia/Anoxia, Fish Recruitment, and HABs. However, in an effort to develop a more cohesive framework for the project, **Food Web Dynamics** will serve as the overarching theme of this research program, with each of the three previously identified research foci falling under that general umbrella (Figure 1). In this way, all research conducted as part of this integrative project should in some add to our ability to understand (and eventually forecast) food web dynamics, whether directly (e.g., explicit research on trophic interactions) or indirectly (e.g., research that improves our ability to model physical habitat, which ultimately will influence biota). Also note that, owing to other ongoing HABs investigations related to NOAA's NOAA Center of Excellence for Great Lakes and Human Health, HABs research (in the context of this program) will be of secondary importance relative to other components.

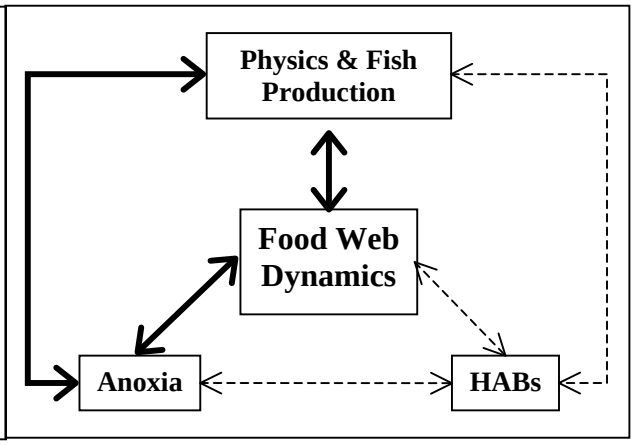

Figure 1. Conceptualization of the research framework that will guide the ILES field-sampling program during 2005. An emphasis will be placed on understanding food web dynamics across the lake, with a stress placed upon understanding linkages between hypoxia/anoxia, fish production, and overall food web dynamics (bold arrows). Linkages with HABs are of lower priority, given the NOAA Center of Excellence for Great Lakes and Human Health HABs program.

Research that provides obvious short-term contributions that could help understand (or forecast) one of more of these linkages is highly encouraged. Research with longer-term application also is of interest, provided that the research is couched in this broader (food web) context. Owing to the nature of the money supporting this overall research program, it is important to keep in mind **this overall research program must result in products** (e.g., a forecasting tool, spatial maps that could benefit future research, a means to control exotic species, or unique scientific understanding that could benefit future ecosystem forecasting efforts).

A list of research questions/hypotheses that ultimately would be of interest to this program follows. This list is not exhaustive, but gives a general sense of the kinds of research that this program would support. Also see the 2004 Lake Erie Science Planning Workshop Report for additional research needs/priorities.

Certainly, as proposals are solicited and the field program develops, the scope of the overall research will narrow. A narrowing of focus will especially be likely to occur during (hopeful) upcoming years of sampling (2006-2007), as we learn from the data and this year's sampling effort.

Central basin hypoxia/anoxia: The primary goal of this research will be to determine whether recurrent low-oxygen events influence population, community, and food web dynamics in Lake Erie, with particular emphasis on understanding the effects of central basin "dead zone" formation on fisheries production and exotic species persistence. A second thrust of this research effort will focus on improving our ability to model oxygen availability in three dimensions across the lake such that reliable hindcasts and short-term forecasts of hypoxic conditions can be made.

Ecological Consequences

a. How does hypoxia influence the normal diel-migration behavior of benthic macroinvertebrates, zooplankton, and fish through indirect effects on other habitat (e.g., temperature, food, predation risk)?

b. How does hypoxia influence trophic (food web) interactions?

c. How does hypoxia influence species composition, abundance, diversity, and production of microbes, phytoplankton, zooplankton, benthic macroinvertebrates, and fish?

d. Can formation of hypoxia help explain the persistence of *Bythotrephes* in such high numbers in central Lake Erie (e.g., by providing a refuge from planktivorous fish predation)?

e. Development of models that help understand the influence of oxygen availability on population, community, or ecosystem dynamics are of interest.

Modeling and forecasting hypoxia

a. What is the extent of hypoxia/anoxia, and biological oxygen demand, in central Lake Erie? Has it been stable, growing, or shrinking?

b. Are there particular physical conditions (e.g., nutrients, temperature, wind, circulation) that influence the timing, magnitude, and duration of hypoxia? Any physical data collections that could enhance 3-D modeling capabilities are of interest.

c. Are there particular biological attributes (e.g., phytoplankton production, dreissenids, round gobies) that influence the timing, magnitude, and duration of hypoxia?

d. What are the linkages between west basin inputs and hypoxia/anoxia formation in central Lake Erie?

e. How does hypoxia influence nutrient fluxes, including the distribution of biological production?

f. What are settling and accumulation rates of organic matter across the lake, and how do they influence hypoxia/anoxia formation?

g. Are current estimates of phosphorus and organic carbon loads from tributaries (e.g., Detroit River) accurate? To what degree does nutrient loading influence oxygen availability?

Fish Production: Although an ultimate goal of this research program is to improve the ability of Lake Erie agencies to forecast recruitment variability of important fisheries, fish recruitment investigations should either add to our understanding of food-web dynamics across basins, help better understand if and how fisheries are influenced by hypoxia/anoxia, or perhaps help improve our understanding of HABs or hypoxia/anoxia formation.

a. How does habitat availability (e.g., oxygen, temperature, light, turbidity, food, predators) influence the distribution, behavior, community composition, or production of fish(es) in Lake Erie? How does habitat availability for fishes vary across basins? Data collections that support development of a coupled physical-biological model, which will initially predict water mass characteristics (i.e., fish habitat), and eventually could be used to forecast fish distributions and growth are encouraged.

b. How persistent are habitat conditions for fish spatially and temporally?

c. What role do fish play a role in HABs or hypoxia/anoxia formation?

d. What role do fish play in influencing the abundance and distribution of zooplankton, including exotic cercopagids, across basins?

e. What role do inputs from rivers play in influencing the distribution and abundance of fish in Lake Erie?

f. What are major pathways of energy flow through the food web, and how do they vary across basins?

Harmful Algal Blooms (HABs): Again, HABs research is of **secondary importance** in the context of this program, owing to other large research programs exploring this issue. However, research involving HABs that also involves one or more other of these research ideas would be of interest, if there were an obvious, important tie-in.

a. How do HABs directly and indirectly influence production and species composition of other components of the food web (e.g. , zooplankton, fish), including their trophic interactions?

b. Do HABs in western Lake Erie influence oxygen availability in central Lake Erie?

c. Do food web interactions (e.g., zooplanktivory by fish) influence the timing, duration, and magnitude of HABs in western Lake Erie?