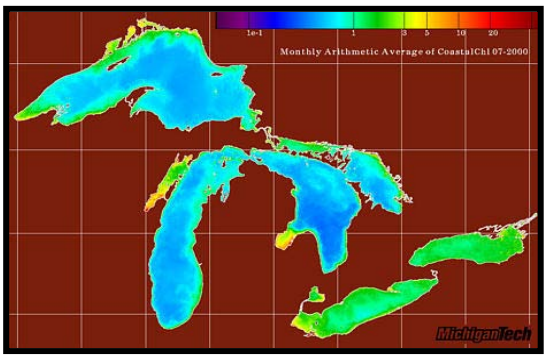
Harmful Algal Blooms and Hypoxia in the Great Lakes Region

Introduction



The Laurentian Great Lakes are a major resource to North America, containing 18% of the world's surface freshwater and 90% of the surface freshwater of the U.S. They serve as the focus for a multi-billion dollar tourist and recreation industry, supply 40 million people with drinking water, provide habitat for wildlife and fish, and support transportation and diverse agricultural production. The basin is home to 15% of the U.S. and 60% of the Canadian population.

Issues Being Addressed

In the Great Lakes, the complex issue of synergistic and unexpected effects of multiple stressors is a growing concern. The 1980s and early 1990s experienced a period of improving water quality, likely due to phosphorus abatement programs that limited nutrients and reduced cyanobacterial (blue-green algae) blooms. Unfortunately, harmful algal blooms (HABs) and low bottom water oxygen (hypoxia) have once again become important issues in the lower Great Lakes.

Hypoxia occurs frequently in the summer in western Lake Erie. HABs have been responsible for the closure of beaches, death of wildlife, and contamination of drinking water sources. HABs in the Great Lakes are primarily caused by cyanobacteria, especially *Microcystis*, which produce potent toxins that are a health threat to humans, wildlife, and pets. Macroalgae (or seaweeds), such as *Cladophora*, also have experienced a resurgence in the Great Lakes. *Cladophora* forms foul-smelling blooms that accumulate in masses along beaches, can clog water intakes, and potentially harbor pathogens, such as *E.coli*.

Algal mats in Lake Ontario. Photo: Greg Boyer, SUNY ESF

Although HABs and hypoxia are both naturally occurring, human activities can promote or worsen these events. For example, an increase in nutrient loads from nonpoint sources is hypothesized as one potential cause for the recent resurgence of HAB and hypoxia events in the region. Further, the establishment of the invasive zebra mussel, which has fundamentally altered the ecosystem, is thought to have a role in HAB occurrence. The impacts of climate change add to an already complex situation, highlighting the need for a comprehensive adaptive management approach.

Program Description

NOAA's Center for Sponsored Coastal Ocean Research (CSCOR) in the National Ocean Service's National Centers for Coastal Ocean Science (NCCOS) supports multidisciplinary and integrated research to investigate HABs and hypoxia in the Great Lakes in order to identify the causes and develop effective management strategies. This research is targeted to support regional ecosystem management approaches by providing predictive capabilities to evaluate management scenarios. Examples of recent efforts and advances include:

Hypoxia Forecasting: An important regional research project is addressing the Lake Erie hypoxic or "dead" zone, which has grown worse in recent years. CSCOR is funding a project to create, test, and apply models to forecast how man-made (land use, invasive species) and natural (climatic variability) stressors influence Lake Erie ecology and hypoxia formation. The researchers are mapping the extent of hypoxia across Lake Erie, investigating the causes and consequences of hypoxia (with an emphasis on hypoxia effects on fish production), and forecasting alternatives for the management of nutrient loading to minimize hypoxia-induced problems.

Harmful Algal Bloom Response and Prediction CSCOR funded research and modeling to develop protocols for a monitoring and alert system for toxic cyanobacterial blooms in Lake Erie, Lake Ontario and Lake Champlain. The researchers on this project developed an integrated HAB alert system, which combines the application of satellite detection, conventional HAB detection methods, and novel quantitative molecular tools to detect, assess, predict, control, and mitigate HAB events. They also developed transport modeling capability for Lake Erie and Ontario, ruled out certain environmental parameters as predictors for cyanobacteria density, and identified other important harmful cyanobacteria and toxins in the system. Their practical, tiered alert approach and knowledge gained provides the building blocks for developing forecast capabilities. Researchers also coordinated with public health and water quality managers to raise awareness about toxic HAB impacts and the need for sustained HAB monitoring in the Great Lakes.

Harmful Algal Bloom Impacts: A current project funded by CSCOR through the ECOHAB program aims to improve understanding of microcystin toxicity in fish, with a focus on chronic exposure, which has been less well studied. The results will improve efforts to predict impacts on ecosystem health.

Looking to the Future

NOAA and EPA recently led the effort by the Interagency Working Group on Harmful Algal Blooms, Hypoxia, and Human Health to complete the *Scientific Assessment of Freshwater Harmful Algal Blooms*, required by the Harmful Algal Bloom and Hypoxia Research and Control Act. This assessment provides the framework for future HAB work in freshwater systems around the U.S. and in the Great Lakes.

The Great Lakes ecosystem is the most clearly bounded regional ecosystem under NOAA's purview and mission responsibilities. It contains a suite of environmental stresses common to all coastal systems, and it has a long history of bi-national and interagency partnerships and collaborations. For these reasons, the Great Lakes have a high potential for success in developing integrated ecosystem forecasting tools and having them applied to manage HABs and hypoxia in a regional ecosystem framework.

Resources: *Dr. Robert Magnien, Director, NOAA Center for Sponsored Coastal Ocean Research. 301-713-3338 x159; rob.magnien@noaa.gov, website: http://www.cop.noaa.gov/*

CSCOR HABs and Hypoxia Research in the Great Lakes

Current and Recent HAB and Hypoxia Projects Supported by CSCOR

Ecological Forecasting (ECOFORE)

Forecasting the Causes, Consequences, and Potential Solutions for Hypoxia in Lake Erie (FY 2006-continuing).

University of Michigan, NOAA Great Lakes Environmental Research Lab (GLERL), E2, Inc., LimnoTech, Inc., U. Wisconsin, Western Michigan U., Heidelberg College. Creating, testing and applying models to forecast how anthropogenic (land use, invasive species) and natural stresses (climatic variability) influence hypoxia formation and ecology in Lake Erie with and emphasis on fish production.

Ecology and Oceanography of Harmful Algal Blooms (ECOHAB)

Investigating Chronic Toxicity and Bioaccumulation of Microcystins in Freshwater Fish Using Toxicogenomics and Histopathology (FY 2006-continuing).

University of Tennessee. Investigating toxin concentrations that cause negative effects in fish during chronic low-level exposure and bioaccumulation. Determining, via biomarker gene expression, toxicogenetic and histopathological approaches that can be used in ecological forecasting of ecosystem health.

Complex Interactions Between Harmful Phytoplankton and Grazers: Variation in Zebra Mussel Effects Across Nutrient Gradients (FY 2004-2008).

Michigan State University, NOAA GLERL. Developing management protocols/practices to reduce effects of increasing cyanobacterial growth in zebra mussel-invaded lakes and to predict how future invaders (including exotic predators of zebra mussels) and changes in nutrient loading are going to impact harmful phytoplankton in the Great Lakes.

Monitoring and Event Response for Harmful Algal Blooms (MERHAB)

Tier-Based Monitoring for Toxic Cyanobacteria in the Lower Great Lakes (FY 2002-FY2008)

SUNY College of Environmental Science and Forestry (ESF), SUNY at Brockport, SUNY at Buffalo, University of Tennessee, University of Vermont, Western Michigan University, New York Sea Grant. Developing an integrated alert system to monitor and detect toxic cyanobacteria blooms in the lower Great Lakes (Lake Erie, Lake Ontario) and Lake Champlain.

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