Indicator: Algal Blooms in Western Lake Erie

Background

Since the 1960s scientists have recognized that Lake Erie has been undergoing accelerated or cultural eutrophication (Beeton 1961). Eutrophication is a natural aging process of lakes, but it can be accelerated by human activities. Cultural eutrophication refers to the accelerated aging of a lake caused by elevated nutrient loadings (primarily phosphorus in freshwater systems) from human activities.

Concurrently during the 1960s, the public at large recognized that Lake Erie was highly eutrophic, as evidenced by:

- algal blooms covering large areas of the lake during summer months (Figure 1);
- attached green algae, called *Cladophora*, covering most rocky and human-made structures;
- decomposing algae washing up on bathing beaches which had to be removed by bulldozers;
- blue-green algae causing taste and odor problems in some municipal water supplies; and
- dissolved oxygen being depleted (used up by decomposing algae) from many of the deeper areas of the lake.

Figure 1. Microcystis aeruginosa *bloom in western Lake Erie (Photo credit: NASA Landsat Program).*

Status and Trends

In response to algal blooms in Lake Erie during the 1960s (Table 1), the U.S. and Canada signed the 1972 Great Lakes Water Quality Agreement that led to a coordinated effort to reduce phosphorus inputs to the Great Lakes, including Lake Erie. Between the late 1960s and early 1980s there was an approximate 60% reduction in phosphorus loading to Lake Erie. Lake Erie responded with reduced phosphorus concentrations (Panek et al. 2003). Lower phosphorus concentrations reduced algal biomass (Nicholls et al. 1977), including an 89% decline of the blue-green alga *Aphanizomenon flos-aquae* between 1970 and 1983-1985 (Makarawicz and Bertram 1991).

Table 1. A summary of the history of algal blooms in western Lake Erie.

Decade	Algal Blooms	Reference
1960s	By the mid- to late 1960s, seasonal algal blooms were reported over the entire portion of the western basin of Lake Erie. Mats of algae washed ashore, fouling beaches. Newspaper headlines announced, "Lake Erie Is Dead," when actually the lake was more alive than ever. It was undergoing cultural eutrophication, aging caused by a high influx of nutrients (primarily phosphorus) due to human activities. The blue-green algal blooms were composed of *Anabaena*, *Aphanizomenon*, and *Microcystis*. In addition, massive growths of the attached green algae *Cladophora* were reported as prevalent in the western basin.	Bentley 2000
1970s	Algal blooms occurred annually, predominated by *Aphanizomenon flos-aquae*, but were reported as decreasing in intensity and number during the 1970s.	Herdendorf 1986; Ohio Sea Grant 1995
1980s	No massive algal blooms were reported during the early 1980s. Algal blooms, when present, were predominated by *Aphanizomenon flos-aquae*. Zebra and quagga mussels arrived in the mid- to late 1980s.	Herdendorf 1986; Ohio Sea Grant 1995
1990s	Large algal blooms of *Microcystis* were reported in western Lake Erie in 1995 and 1998. During September of 1995 an algal bloom resembling a thick slick of grass-green paint extended over the entire surface of the western basin.	Great Lakes Environmental Research Laboratory 2006; Vanderploeg 2002
2000s	During the 2000s blooms of toxic *Microcystis* were reported as common in the western basin. In August 2003, a massive bloom of the cyanobacteria *Microcystis aeruginosa* formed in western Lake Erie and persisted for nearly a month. Surface scums of *Microcystis* containing high concentrations of the toxin microcystin washed ashore in Michigan and Ohio, resulting in foul-smelling, rotting, algal mats. Beaches and recreational boating areas were rendered unusable and sport fishing was adversely affected. The *Microcystis* bloom of 2003 was perhaps the most severe in Lake Erie's recent history, but it was only the latest in a trend towards increasing frequency of *Microcystis* blooms in the last decade. The 2003 bloom was followed by smaller blooms in 2004 and 2005. *Microcystis* has reappeared in 2006, but the extent of the bloom remains to be determined.	Bridgeman 2005; Ouellette et al. 2006

Zebra mussels arrived in the Great Lakes in the mid- to late 1980s. The mussels are filter feeders capable of removing much of the planktonic algae (phytoplankton) from the water. Colonization of Lake Erie by zebra mussels resulted in several years of improved water clarity and dramatic food web changes, especially a shift in algal production from phytoplankton to bottom-dwelling algae and plants.

In the 1990s, however, large late-summer algal blooms began to reappear in western Lake Erie. Blooms occurred sporadically in the late 1990s, but seem to be increasing in frequency since at least 1992 (Table 1). The summers of 2003-2006 have all had blooms of varying magnitude. These recent blooms have been dominated by the blue-green alga (cyanobacteria) *Microcystis aeruginosa. Microcystis* had been a common species in Lake Erie for at least a century, but rarely grew to nuisance bloom proportions. Blooms of *Microcystis* become most evident during calm periods when the cells float to the surface and form a scum. Continually windy weather may prevent the formation of surface scums, but the overall biomass of algae in the water may still be high (as in 2005).

Blooms of *Microcystis* are of concern because *Microcystis* is poor food for the tiny grazing crustaceans (zooplankton) that are, in turn, important food for larval fish. In addition, *Microcystis* often contains a potent toxin called microcystin that when ingested by animals may damage the liver. Since most municipalities along the lakeshore obtain drinking water from Lake Erie, this is of special concern. It is believed that water treatment procedures are effective in removing the toxin and, to date, there have been no reports of the toxin in drinking water supplies.

It appears from several research studies that recent algal blooms in western Lake Erie are linked to nutrient loading, nutrient releases by zebra mussels, and selective feeding by zebra mussels, but much more work needs to be done. Research performed by the Great Lakes Environmental Research Laboratory (GLERL) and partners has provided hypotheses and some answers to explain the zebra mussel-*Microcystis* connection.

Experiments at GLERL with water from Saginaw Bay and Lake Erie have shown that zebra mussels selectively filter and reject phytoplankton so as to promote and maintain *Microcystis* blooms (Vanderploeg 2002). Using special video equipment, GLERL showed that mussels filter the water whether or not *Microcystis* is present, but they spit *Microcystis* back into the water, while at the same time they eat other algae. Thus, the competitors of *Microcystis* are removed. This probably explains why *Microcystis* has been a dominant alga in many summers. At the same time this selective feeding process is occurring, the mussels are excreting nutrients (phosphate and ammonia) derived from the phytoplankton they eat as part of digestion and metabolic processes. These nutrients, in turn, serve to fertilize further growth of *Microcystis*.

Management Next Steps

Canadian and United States governments have supported a "hold the line on phosphorus levels" position to help prevent further deterioration of Lake Erie. In addition, much more effort must be expended on preventing exotic species, like zebra and quagga mussels, from entering the Great Lakes.

Currently, there is much uncertainty as a result of insufficient knowledge of how the Lake Erie ecosystem is functioning and the factors and processes driving the ecosystem. The major, poorly understood changes in Lake Erie have taught us that management programs, research, and monitoring must be sustained and closely coupled in order to achieve our goals for Lake Erie. In addition, some managers have recommended that we explore development of management strategies to adapt to these invaders, like zebra mussels, which are now a permanent part of the Great Lakes ecosystem.

Research/Monitoring Needs

Much greater emphasis needs to be placed on detection, characterization, and prediction of harmful algal blooms. In addition, research is warranted on evaluating the role of habitat alteration on increasing nutrient loadings resulting from changes in land use practices, altered hydrology, and further food web changes.

Research, in support of modeling for adaptive management, is warranted on the following:

- upper food web predator-prey interactions, population dynamics and coupling with the lower food web;
- determination of organic carbon flow pathways through the microbial food chain, benthic primary and secondary production, and coupling with pelagic food web;
- zebra and quagga mussel population dynamics and processing of nutrients; and
- the impact of fine-scale physical processes on ecosystem-level biological interactions in Lake Erie.

Further, monitoring of key stressors like nutrient loads, zebra mussel density distribution, and food web dynamics is necessary for site-specific calibration of a Lake Erie ecosystem model.

Microcystis is known to produce toxins called microcystins that have been responsible for some bird and fish kills. Further research is warranted into what triggers *Microcystis* to produce the toxins because they are not always in production.

References

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Links for More Information

Great Lakes Environmental Research Laboratory. The zebra mussel connection: Nuisance algal blooms, Lake Erie anoxia, and other water quality problems of the Great Lakes: http://www.glerl.noaa.gov/pubs/brochures/mcystisflyer/mcystis.html

Ohio Sea Grant College Program. Lake Erie water quality, 1970s to mid-1980s PDF: http://ohioseagrant.osu.edu/_documents/publications/FS/FS-040%20Lake%20Erie%20water%20quality%201970s%20to%20mid-1980s.pdf

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