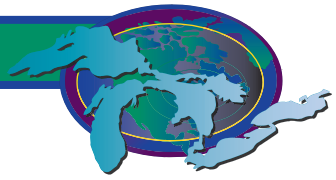

## Phosphorus Concentrations and Loadings

Indicator #111

### Overall Assessment

| | |
|---|---|
| Status: | **Open Lake - Mixed; Nearshore - Poor** |
| Trend: | **Open Lake - Undetermined; Nearshore - Undetermined** |
| Rationale: | **Strong efforts that began in the 1970s to reduce phosphorus loadings have been successful in maintaining or reducing nutrient concentrations in the Great Lakes, although high concentrations still occur locally in some embayments, harbors and nearshore areas.** |

### Lake-by-Lake Assessment

**Lake Superior**

Status: Open Lake - Good; Nearshore - Not Assessed
Trend: Open Lake - Undetermined; Nearshore - Undetermined
Rationale: Average phosphorus concentrations in the open waters are at or below expected levels.

**Lake Michigan**

Status: Open Lake - Good; Nearshore - Poor
Trend: Open Lake - Improving; Nearshore - Undetermined
Rationale: Average phosphorus concentrations in the open waters are at or below expected levels. Concentrations may exceed guidelines in nearshore waters for at least part of the growing season.

**Lake Huron**

Status: Open Lake - Good; Nearshore - Poor
Trend: Open Lake - Undetermined; Nearshore - Undetermined
Rationale: Average phosphorus concentrations in the open waters are at or below expected levels. Most offshore waters meet the desired guideline, but some nearshore areas and embayments experience elevated levels which likely contribute to nuisance algae growths such as the attached green algae, *Cladophora*, and toxic cyanophytes such as *Microcystis*.

**Lake Erie**

Status: Open Lake - Fair-Poor; Nearshore - Poor
Trend: Open Lake - Undetermined; Nearshore - Undetermined
Rationale: Phosphorus concentrations in the three basins of Lake Erie fluctuate from year to year and frequently exceed target concentrations. Extensive lawns of *Cladophora* are common place over the nearshore lakebed in parts of Eastern Lake Erie and are suggestive of phosphorus levels supportive of nuisance levels of algal growth.

**Lake Ontario**

Status: Open Lake - Good; Nearshore - Poor
Trend: Open Lake - Improving; Nearshore - Undetermined
Rationale: Average phosphorus concentrations in the open lake are at or below expected levels. Most offshore waters meet the desired guideline but some nearshore areas and embayments experience elevated levels which likely contribute to nuisance algae growths such as the attached green algae, *Cladophora* and toxic cyanophytes such as *Microcystis*.

### Purpose

- To assesses total phosphorus levels in the Great Lakes
- To support the evaluation of trophic status and food web dynamics in the Great Lakes

### Ecosystem Objective

The goals of phosphorus control are to maintain an oligotrophic state in Lake Superior, Lake Huron and Lake Michigan; to

maintain algal biomass below that of a nuisance condition in Lake Erie and Lake Ontario; and to eliminate algal nuisance growth in bays and in other areas wherever they occur (Great Lakes Water Quality Agreement (GLWQA) Annex 3, United States and Canada 1987). Maximum annual phosphorus loadings to the Great Lakes that would allow achievement of these objectives are listed in the GLWQA. The expected concentrations of total phosphorus in the open waters of the Great Lakes, if the maximum annual loads are maintained, are listed in the following table:

| Lake | Phosphorus Guideline (µg/L) |
|---|---|
| Superior | 5 |
| Huron | 5 |
| Michigan | 7 |
| Erie - Western Basin | 15 |
| Erie - Central Basin | 10 |
| Erie - Eastern Basin | 10 |
| Ontario | 10 |

**Table 1:** Phosphorus guidelines for the Great Lakes.
Source: Phosphorus Management Strategies Task Force, 1980

**State of the Ecosystem**

Phosphorus is an essential element for all organisms and is often the limiting factor for aquatic plant growth in the Great Lakes. Although phosphorus occurs naturally, the historical problems caused by elevated levels have originated from anthropogenic sources. Detergents, sewage treatment plant effluent, agricultural runoff and industrial sources have historically introduced large amounts into the Great Lakes.

Strong efforts that began in the 1970s to reduce phosphorus loadings have been successful in maintaining or reducing nutrient concentrations in the Great Lakes, although high concentrations still occur locally in some embayments, harbors and nearshore areas. Annual phosphorus loadings have decreased in part due to changes in agricultural practices (e.g., conservation tillage and integrated crop management), promotion of phosphorus-free detergents, and improvements made to sewage treatment plants and sewer systems.

Average concentrations in the open waters of Lake Superior, Lake Michigan, Lake Huron, and Lake Ontario are at or below expected levels. Concentrations in the three basins of Lake Erie fluctuate from year to year (Figure 1) and frequently exceed the target levels. In Lake Ontario and Lake Huron, most offshore waters meet the desired guideline, but some nearshore areas and embayments experience elevated levels which likely contribute to nuisance algae growths such as the attached green algae, *Cladophora,* and toxic cyanophytes such as *Microcystis*. For example, in the Bay of Quinte, Lake Ontario, control strategies at municipal sewage plants have reduced loadings by two orders of magnitude since the early 1970s. In spite of these controls, mean concentrations measured between May and October in the productive upper bay have remained between 30 and 35 g/Lin recent years. This level of total phosphorus is indicative of a eutrophic environment. Typical of other zebra mussel-infested and phosphorus-enriched bays in the Great Lakes, toxic cyanophytes such as *Microcystis* have increased in abundance in recent years with blooms occurring in late August and early September.

Similarly, phosphorus concentrations may exceed the guidelines in nearshore waters for at least part of the growing season. Waters near Lake Michigan's eastern shoreline, when sampled in June, 2004, had a median concentration of 9 g/L. Summer sampling at the same locations yielded a median concentration of 6 g/Lbut a number of sampling locations were at or above the 7 g/Lguideline. By comparison, the average open water concentration during the spring of 2004 was 3.7 g/L. *Cladophora* growth is a problem on much of this shoreline.

In parts of eastern Lake Erie and Lake Ontario, extensive lawns of *Cladophora* are commonplace and are suggestive of phosphorus levels supportive of nuisance levels of algal growth (Higgins *et al*. 2005 and Wilson *et al*. 2006). Phosphorus levels in the nearshore (Canadian shores) of eastern Lake Erie and Lake Ontario are periodically elevated above the basin guideline of 10 g/LHowever, efforts to achieve integrated nearshore assessments of phosphorus levels or to relate phosphorus levels to growth of *Cladophora* are difficult because of the highly dynamic nature of water quality in nearshore areas. Phosphorus concentrations in nearshore areas tend to be highly variable over time and from point to point, at times on the scale of meters, due to influences of tributary and other shore-based discharges, weather, biological activity and lake circulation.

**Pressures**

Even if current phosphorus controls are maintained, additional loadings can be expected. Increasing numbers of people living along the Great Lakes will exert increasing demands on existing sewage treatment facilities. Even if current phosphorus concentration discharge limits are maintained, increased populations may result in increased loads. Phosphorus management plans with target loads need to be established for major municipalities. Recent research indicates that even weather and climate changes may be

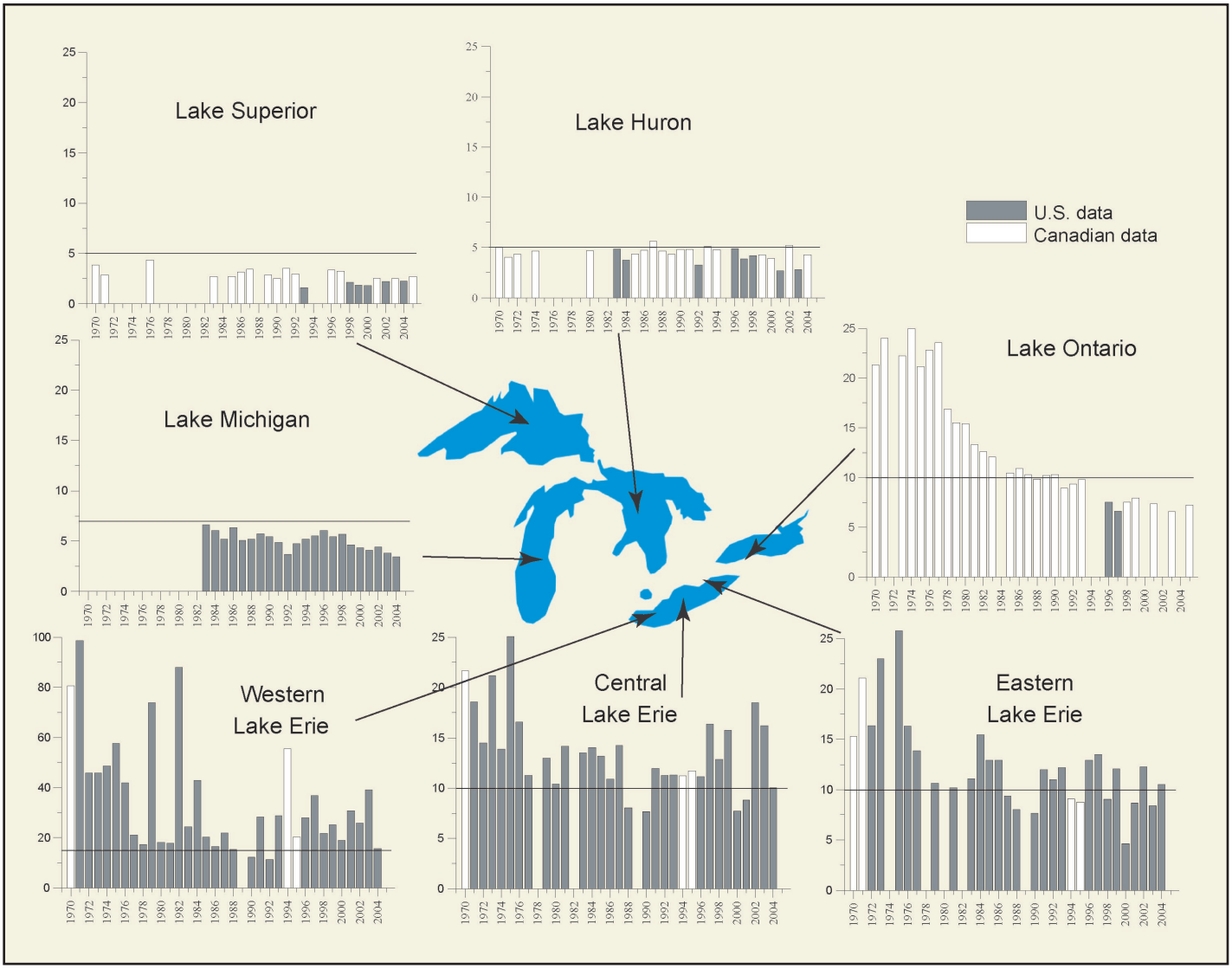


**Figure 1**. Total Phosphorus Trends in the Great Lakes 1970 to 2005.

Blanks indicate no sampling. Horizontal line on each graph represents the expected phosphorus concentration in each lake if the annual phosphorus loading targets, as listed in the Great Lakes Water Quality Agreement, are maintained. Environment Canada data (white bars - average of spring, surface measurements at open lake sites) are used for Lakes Ontario, Huron and Superior, and are supplemented by US data for years in which no monitoring was conducted on that lake. U.S. Environmental Protection Agency data (black bars - average of spring measurements, all depths at open lake sites) are used for the three basins of Lake Erie and for Lake Michigan, and are supplemented by Canadian data for years in which no U.S. monitoring was conducted on that lake.

Source: Science and Technology Branch, Environment Canada and Great Lakes National Program Office, U.S. Environmental Protection Agency

influencing the phosphorus loads to the Great Lakes through changes in snowmelt and storm patterns.

**Management Implications**

Because of the key role phosphorus exerts as the limiting nutrient for productivity and food web dynamics in the Great Lakes, water management agencies must be vigilant to control phosphorus loads to prevent a return to conditions observed in the 1960s. Future activities that are likely to be needed include: 1) Assess the capacity and operation of existing sewage treatment plants in the context of increasing human populations being served. Utilization of state of the art technology to lower effluent concentrations below current targets should be considered for retrofits and upgrades to sewage treatment plants; 2) Conduct studies of the urban and rural nonpoint contributions of phosphorus to better our understanding of their current overall importance, especially with regards to nearshore eutrophication and *Cladophora* abundance, and 3) Conduct sufficient tributary and point source monitoring

to track phosphorus loadings and to better understand the relative importance of various sources.

The surveillance of phosphorus concentrations in the Great Lakes is ongoing and the data are considered to be reliable. Enhanced monitoring of nearshore and embayment sites, as well as tributary monitoring, may be accomplished with better coordination with existing state and provincial environmental programs. Coordinated programs would be most effective if they are tied to a framework such as a Lakewide Management Plan (LaMP) that recognizes the unique phosphorus-related sensitivities of the nearshore areas and also provides the means to interrelate nearshore and offshore nutrient conditions and concerns. The recent reappearance of *Cladophora* in some areas of the Great Lakes strengthens the importance of nearshore measurements.

The data needed to support loadings calculations have not been collected since 1991 in all lakes except Lake Erie, which has loadings information up to 2002, and Lake Michigan with information for 1994 and 1995. Efforts to do so should be reinstated for at least Lake Erie, and work is underway to accomplish this. For the other lakes, the loadings component of this indicator will remain unreported, and changes in the different sources of phosphorus to these lakes may go undetected.

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