
Lake Erie
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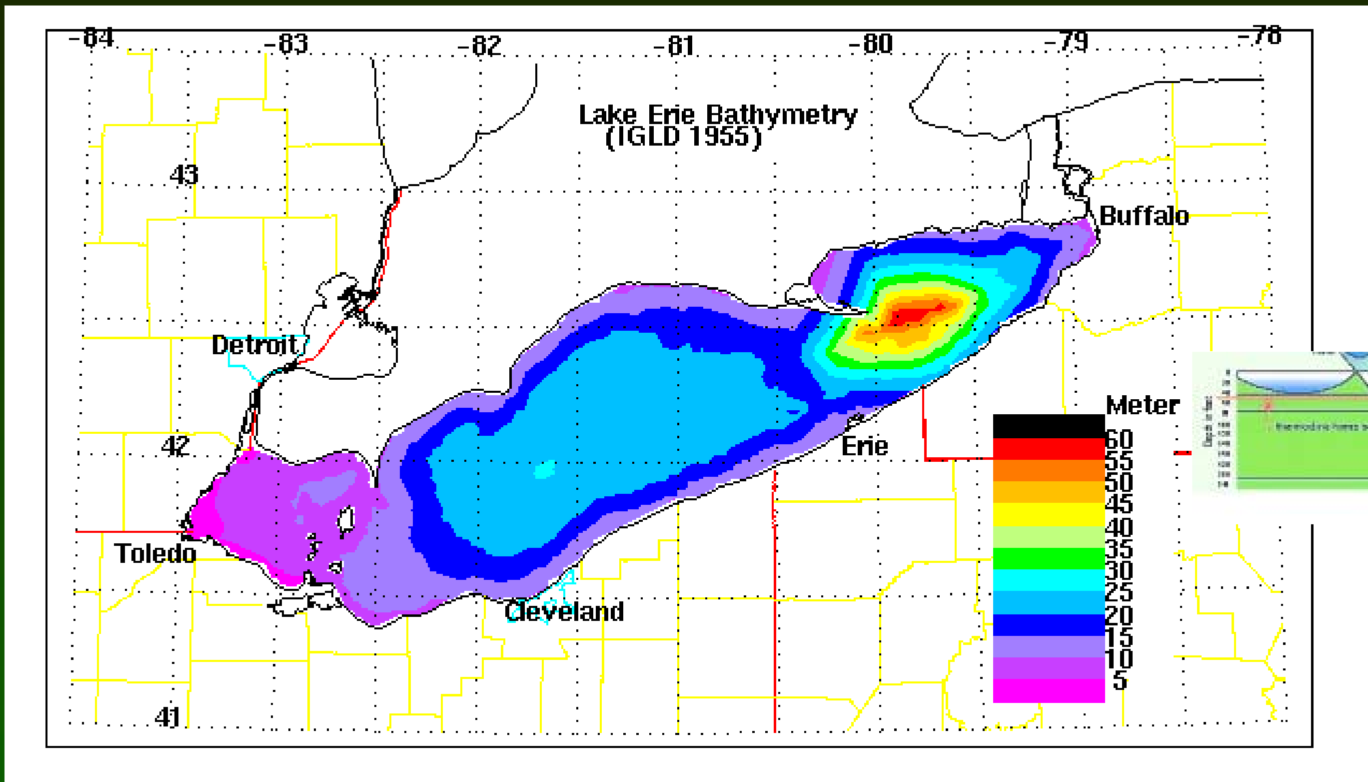
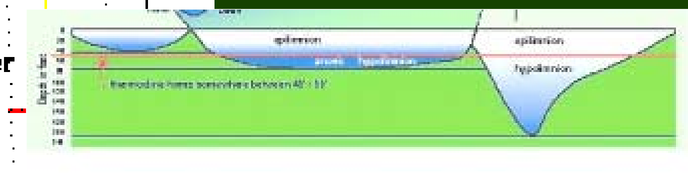
Environment Canada

Nearshore Regions of Lake Erie





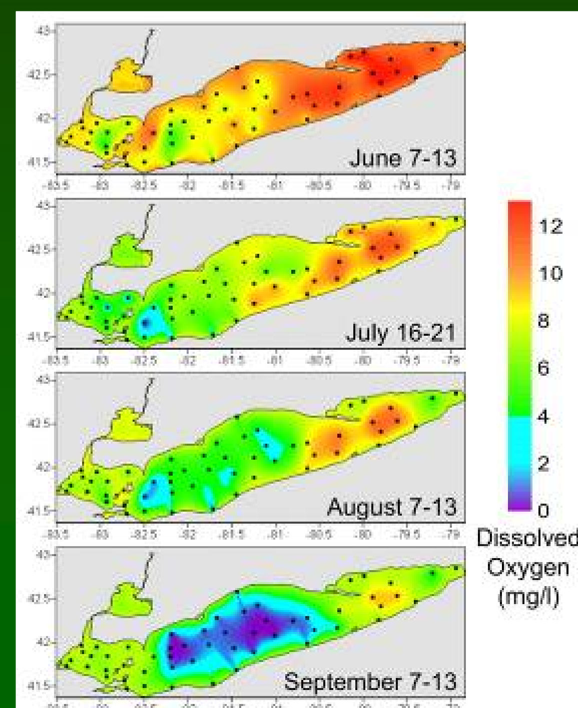
def. Nearshore: thermocline reaches bottom

Affects: Nutrient cycling from sediments
Light transmission to the bottom
Mixing of the benthic layer

Nutrient Inputs into Lake Erie

- Target goals of Section 1 Annex 3
  - Reduce algal biomass below nuisance levels
  - Restore aerobic hypolimnetic conditions

Lake Erie Cladophora ca 1970's



NOAA
2000 data

Phosphorus Loads Have Decreased

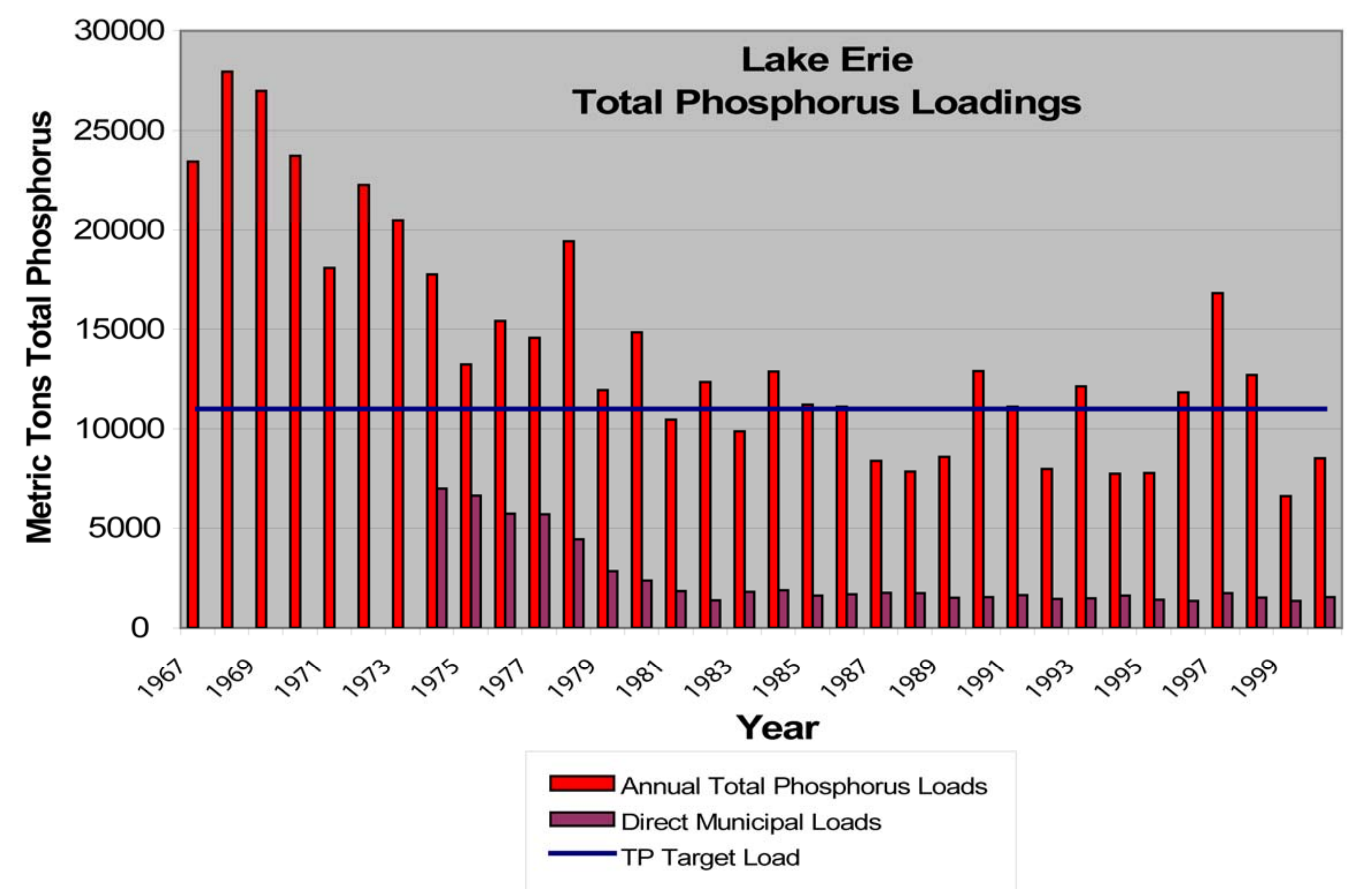
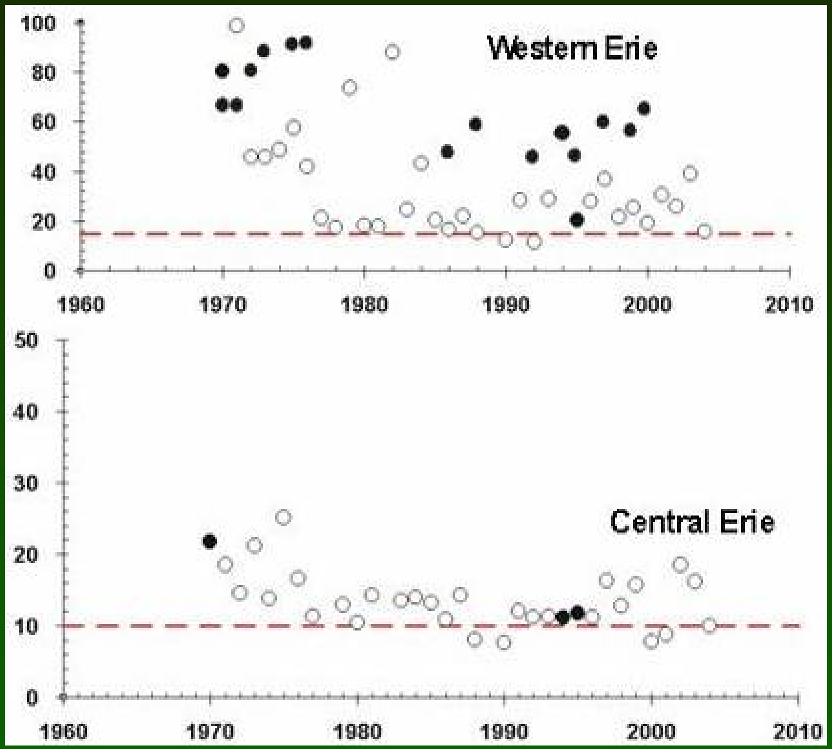
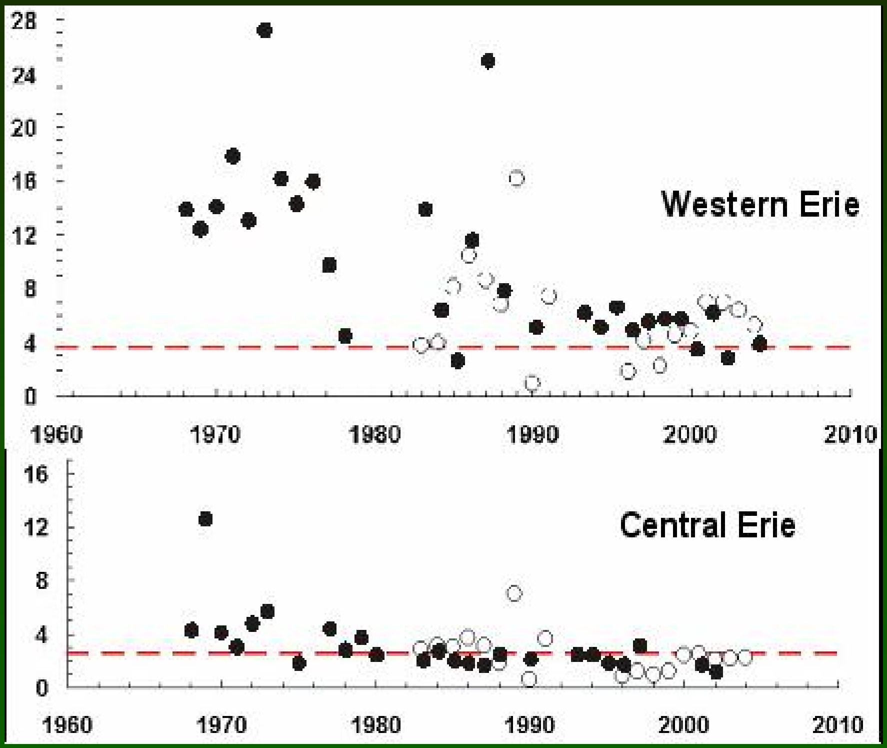


Figure 1. Total Phosphorus loads to Lake Erie from 1967 – 2001. Estimated direct municipal loads are also presented for the period of record (1974 – 2001).

Figure prepared by Annex 3 Technical sub-group

This Has Translated to Improved Water Quality in Lake Erie





Decrease in spring [TP] → Decrease in summer Chl-a

Figure prepared by Annex 3 Technical sub-group
Open circles = Canadian data, Closed circles = US data

State of Lake Erie

- Nutrient management remains the top priority for improving the lake.
- The focus of the Lake Erie LaMP is to assess the state of knowledge on the science of nutrients in the lake, and to develop a binational nutrient management strategy.
- In 2009, binational collaborative monitoring will help to fill information gaps to better understand how nutrient concentrations and loads harm Lake Erie.

State of Lake Erie Continued

- Yellow perch stocks are recovering.

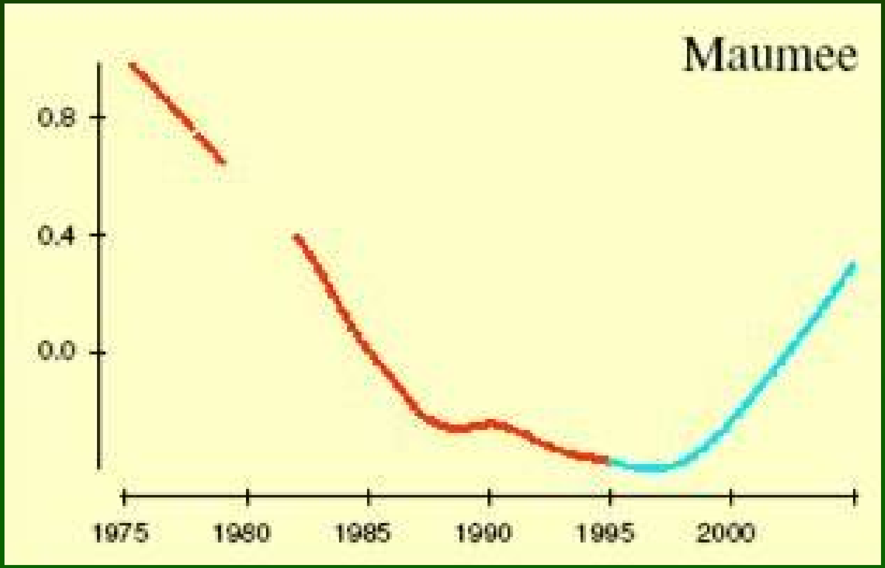
  Walleye, lake trout, and lake whitefish are struggling.

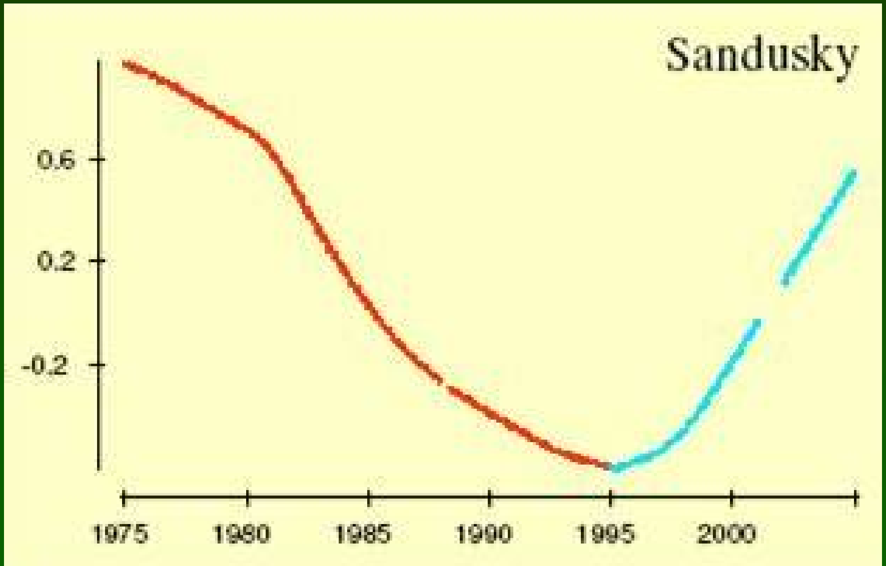
  Contaminants levels, specifically PCBs and mercury, continue to affect fish consumption.
- Aquatic Invasive Species are changing the food web, potentially affecting nearshore algae and the frequency of botulism outbreaks.
- Remedial Action Plans and watershed implementation projects have contributed to localized improvements in the Lake Erie ecosystem.

Provided by Lake Erie LAMP

State of Lake Erie Continued

- Disturbing trend that over the past few years, the in-lake soluble phosphorus concentrations and tributary loadings of dissolved phosphorus are increasing.





Dissolved reactive phosphorus levels entering Lake Erie

Provided by P. Richards Heidelberg College, courtesy of J. Reutter

This Has Led to an Increase in Harmful Algal Blooms (HABs)

- Hypoxia and anoxia in the central basin are more extensive and occur over a longer period of time.
- Blooms of nuisance algae such as Cladophora in the last few years rival those of the 1970s.
- Benthic cyanobacteria such *Lyngbya wollei* forms dense floating mats in Maumee Bay.
- Potentially harmful algal blooms such as *Microcystis* are becoming more and more common.

Provided by Lake Erie LAMP

What Does This Look Like in Pictures?

October 2007 –
Microcystis bloom

Hand courtesy of
Tom Bridgeman

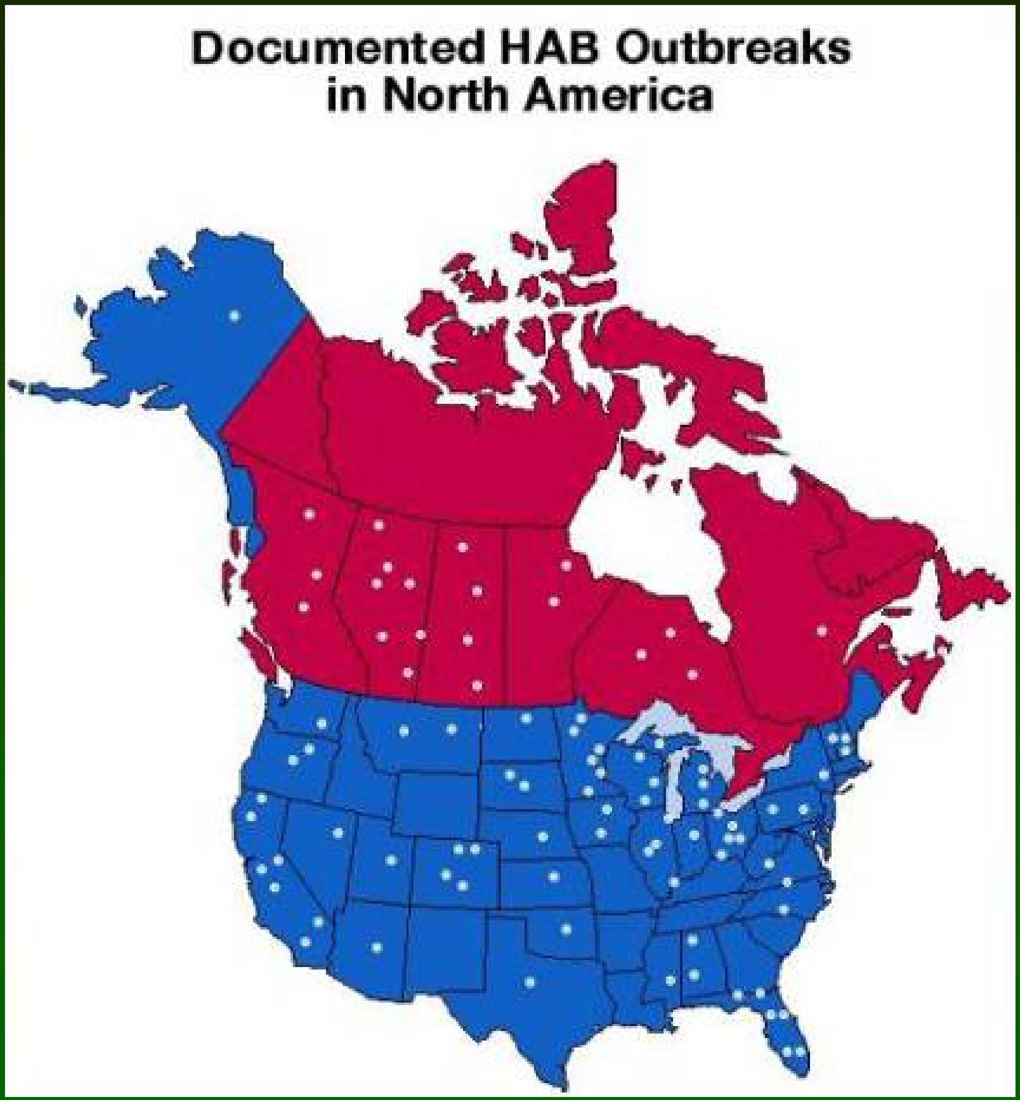
2007 Lyngbya bloom near Toledo
Picture courtesy of the Toledo Blade

Impacts of Harmful Algal Blooms:

- Fouling of beaches and shoreline
  - Loss of recreation dollars,
  - Aesthetics
- Taste and odor impairments of drinking water
  - Fish and food tainting
- Damage to ecosystem (hypoxia or toxins)
- Direct risks to human and animal health

Increasing severity

So How Common Are Toxic Blooms?



- Toxic blooms are very common and have been reported in every state and almost all provinces of North America.
- Many reports end up in the “grey” literature and do not get counted.

From USEPA, Adv. Exp. Med. Biol. 2008

Outbreaks in the US

- 1925: Farmer lost 125 hogs and 4 cows at Big Stone Lake in South Dakota. (first report in the US)
- 1930: *Microcystis* bloom on Ohio and Potomac Rivers caused intestinal illness in 5,000-8,000 people.
- 1975: Cyanobacterial bloom led to endotoxic shock in Washington DC.
- 1980: Several cases of illness in Pennsylvania following a bloom.
- 1996-1998: 24 Public water supply companies were surveyed for microcystins. 80% of the samples tested positive.

  Several examples where treatment of algae with copper sulfate in a drinking water reservoir led to gastroenteritis within 5 days.
- 2004: Approximately 50 people reported illness following exposure to toxic cyanobacterial blooms in Nebraska lakes and reservoirs.
- 2000 →: Numerous document wildlife and domestic animal fatalities.

Cyanobacteria Toxins in the Great Lakes

J. Great Lakes Res. 26(3):241–249
Internat. Assoc. Great Lakes Res., 2000

Isolation and Characterization of Microcystins, Cyclic Heptapeptide Hepatotoxins from a Lake Erie Strain of *Microcystis aeruginosa*

Scott M. Brittain[1], Jim Wang[3], Lisa Babcock-Jackson[2], Wayne W. Carmichael[1*], Kenneth L. Rinehart[3], and David A. Culver[2]

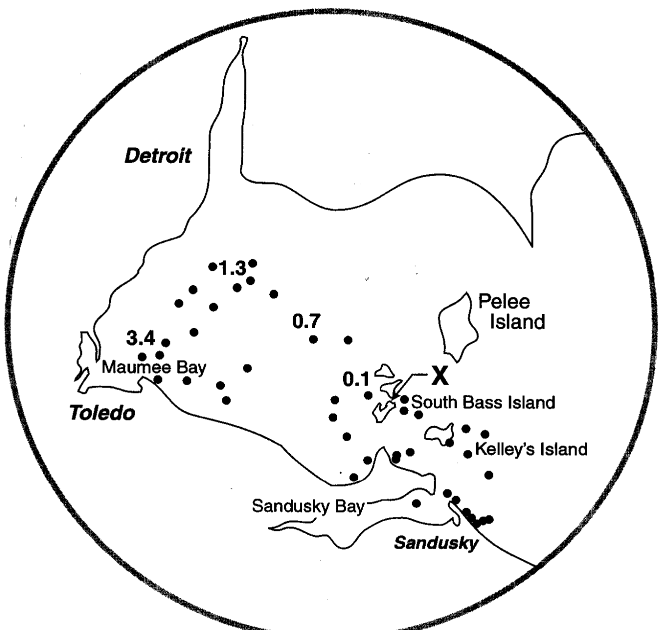
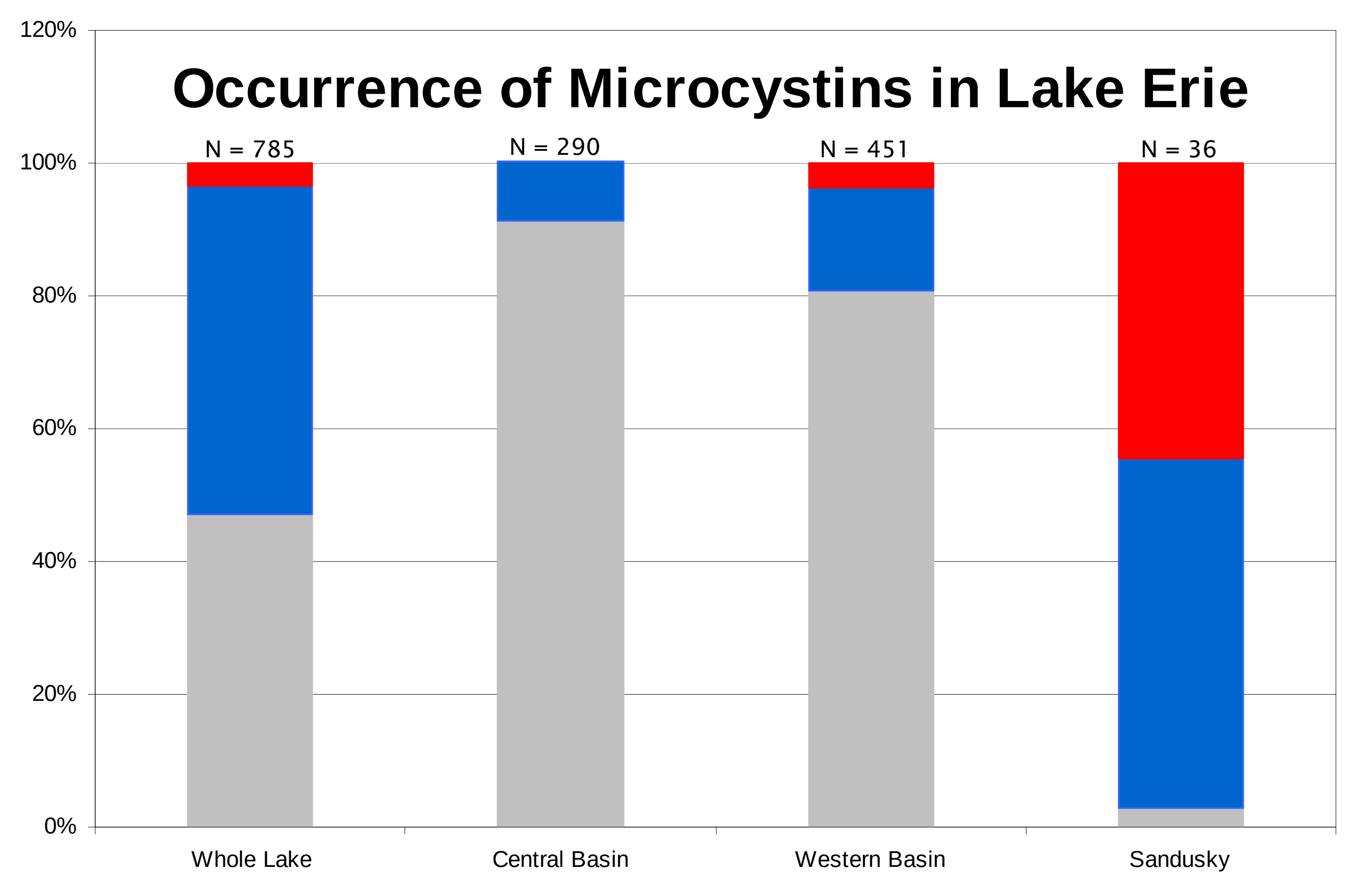


FIG. 2. Microcystis aeruginosa *field collection sites: Put-In-Bay, Lake Erie, Ohio. "X" marks Hatchery Bay where > 1 µg/L microcystin was detected in October 1995.*

- Cyanobacterial toxins first reported in Lake Erie in the mid-1990s
- Identified the toxin as microcystin, a peptide hepatotoxin produced by *Microcystis aeruginosa*

How Common Are These Blooms?

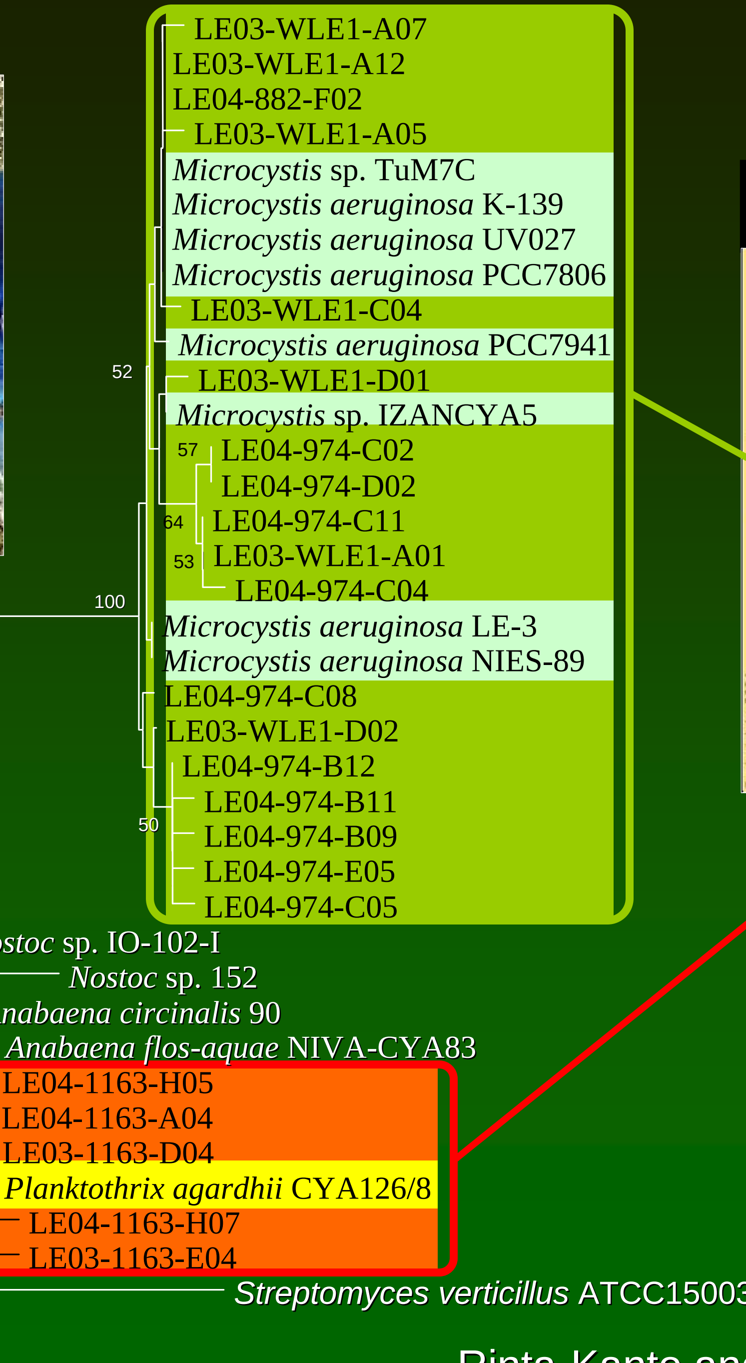


Toxicity ranges from 0.05-25ug/L

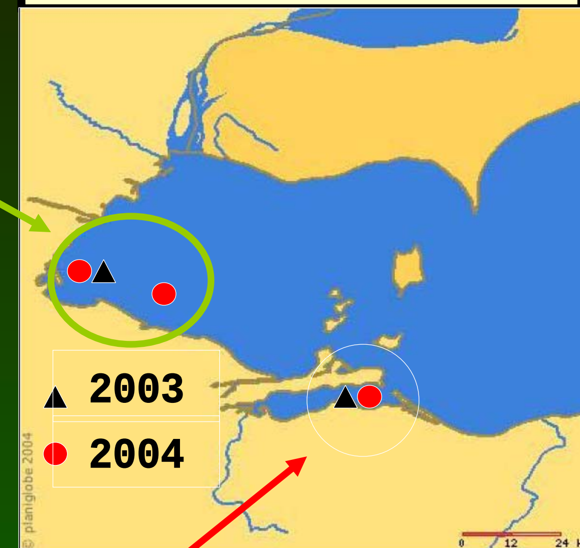
All samples taken below the surface (~ 1 m)

Percent occurrence of no, low and high toxicity samples by basin

2002 – 2007 Data from MERHAB-LGL



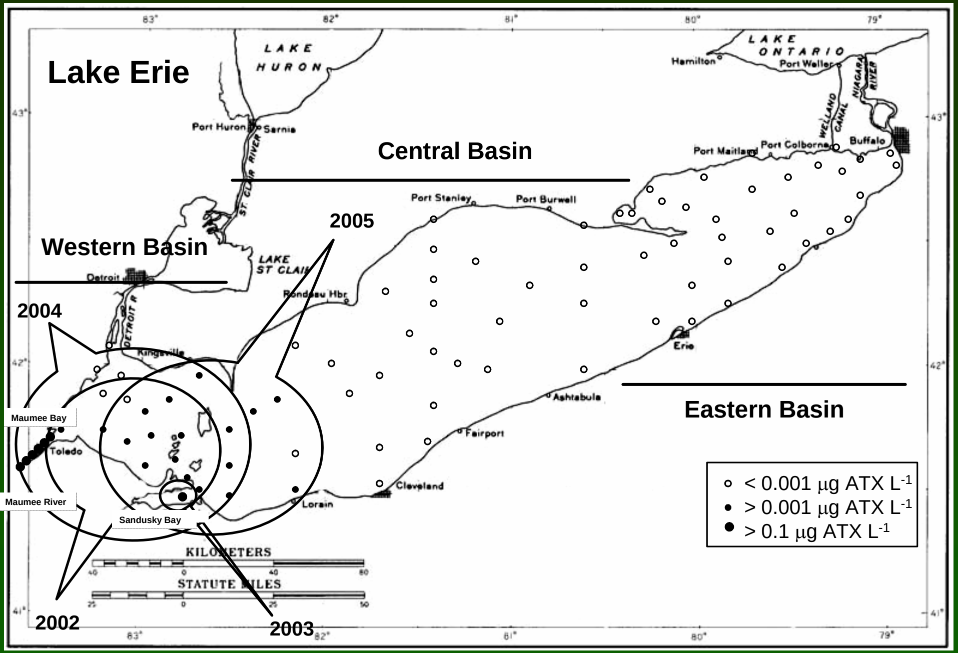
McyA sequences



2 different populations producing the same toxin!!

Rinta-Kanto and Wilhelm, 2006, AEM 72:5083

Distribution of the Neurotoxin, Anatoxin-a in Lake Erie



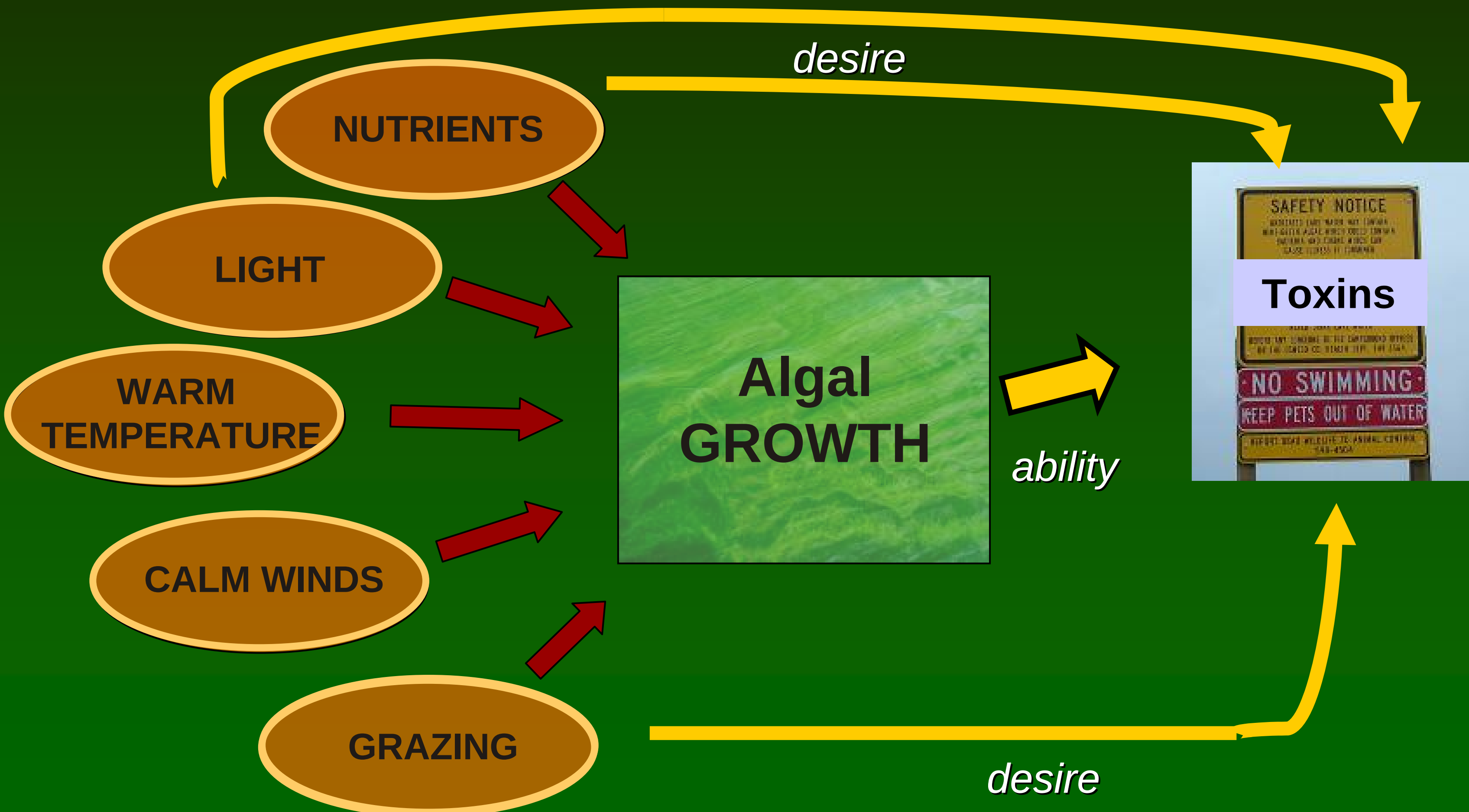
Distribution of anatoxin-a in Lake Erie 2002-2006 (Yang, 2007)

- Different organisms (Anabaena sp.)
- Different Ecology (nitrogen fixer)
- Poses a very different problem

N = 600

Data from MERHAB-LGL

What Causes Toxic *Microcystis* Algae to Grow?



Desire (Why Algae Make Toxins?)

- In general, toxic strains have a large N, P requirement than non-toxic (Zurawell et al 2005) Healthy cells make more toxin.
- Effect of trace metals has been inconsistent. No direct effect, but low Fe can impact nitrogen utilization.
- High Light intensity seems to promote toxin production. (cell health effect?). UV light effects also appear inconsistent.

Summary

- Cyanobacteria produce a number of toxins but not all species are toxic.
- Hepatotoxic microcystins are probably the toxin of most concern for human health.
- These toxins can be produced by a number of different species making visual monitoring difficult. Both toxic and non-toxic populations exist.
- Healthy cells tend to make more toxin, thus higher nutrient conditions in the nearshore region tend to promote higher biomass events and additional toxic blooms.

Acknowledgments

- Susan Watson, Environment Canada
- Steven Wilhelm, University Tennessee
- Nancy Stadler-Salt, Environment Canada
- Murray Charlton, Environment Canada
- Jeff Reutter, Ohio Sea Grant
- Tom Bridgeman, University of Toledo
- A host of others……..