Lake Erie

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**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

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

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

Provided by Lake Erie LAMP
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 as *Lyngbya wolleii* 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.

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.
Cyanobacteria Toxins in the Great Lakes

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

*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.*
How Common Are These Blooms?

Occurrence of Microcystins in Lake Erie

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

Toxicity ranges from 0.05–25µg/L

All samples taken below the surface (~ 1 m)

2002 – 2007 Data from MERHAB-LGL
McyA sequences

LE03-WLE1-A07
LE03-WLE1-A12
LE04-882-F02
LE03-WLE1-A05

Microcystis sp. TuM7C
Microcystis aeruginosa K-139
Microcystis aeruginosa UV027
Microcystis aeruginosa PCC7806

LE03-WLE1-C04
Microcystis aeruginosa PCC7941
LE03-WLE1-D01

Microcystis sp. IZANCYA5

LE04-974-C02
LE04-974-D02
LE04-974-C11
LE03-WLE1-A01
LE04-974-C04

Microcystis aeruginosa LE-3
Microcystis aeruginosa NIES-89
LE04-974-C08
LE03-WLE1-D02
LE04-974-B12
LE04-974-B11
LE04-974-B09
LE04-974-E05
LE04-974-C05

Nostoc sp. IO-102-I

Nostoc sp. 152

Anabaena circinalis 90
Anabaena flos-aquae NIVA-CYA83

LE04-1163-H05
LE04-1163-A04
LE03-1163-D04

Planktothrix agardhii CYA126/8
LE04-1163-H07
LE03-1163-E04

Streptomyces verticillus ATCC15003

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

2 different populations producing the same toxin!!
Distribution of the Neurotoxin, Anatoxin-a in Lake Erie

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

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

N = 600

Data from MERHAB-LGL
What Causes Toxic Microcystis Algae to Grow?

- NUTRIENTS
- LIGHT
- WARM TEMPERATURE
- CALM WINDS
- GRAZING

Desire: Algal GROWTH

Ability: Toxins

Warm Temperature

Desire:

No Swimming

Keep Pets Out of Water

Keep out of reach of children

Restrict Activities

Safety Notice
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.
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.

Summary
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