Harmful Algal Blooms: Lessons Learned From Lake Erie and Elsewhere

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Ohio Sea Grant?

- Modeled after Land Grant Program; one of 33 in US
  - Research, education and outreach
- Guided by NOAA National Strategic Plan
  1. Resilient Communities/Economies
  2. Sustainable Fisheries
  3. Healthy Coastal Ecosystems
  4. Environmental Literacy

OSU’s Stone Lab?

- Ohio State University’s Island campus
  - Typical year on the island --- Classes, students (K-Gray), researchers
HABs...Not Just a Lake Erie Problem

Grand Lake St. Marys
Photo: Ohio EPA
HABs...Not Just a Lake Erie Problem

Muddy Creek
Photo: Ohio EPA

Lake Hope
Photo: Ohio EPA

Buckeye Lake
Photo: Columbus Dispatch

Burr Oak
Photo: Ohio EPA

Caesar Creek Lake
Photo: Ohio EPA

Ohio River
Photo: Ohio EPA
Lake Erie HABs Case Study:教训吸取是可转移的
Setting the Stage for Lake Erie HABs
Great Lakes Land Use Continued

Image: Ohio Sea Grant
Because of Land Use Lake Erie Gets.....

• More sediment and nutrients (i.e., fertilizers and sewage/manure) than all the other Great Lakes

• Above are exacerbated by storms
  - We are seeing more frequent and severe storms due to climate change
  - Data on next slide

• Don’t forget, it is also the shallowest (sunlight)

• As a result Lake Erie is the most productive of the Great Lakes, and likely will be.

Maumee Storm Runoff Statistics (from 1960-2010)

- Statistically significant increases in:
  - Number of storm runoff events per year (up 67%)
  - Number of spring runoff events (up 40%)
  - Number of winter runoff events (up 47%)
  - Annual storm discharge (up 53%)
  - Summer storm discharge (up 27%)

- Other seasonal comparisons show increases but they are not significant.

80-90% of loading occurs 10-20% of time

Source: Dr. Peter Richards, Heidelberg University
Discharge and Phosphorous Data

Cumulative spring discharge (km$^3$)

Cumulative spring DRP load (metric tons)

Range (2000-2013)

Mean (2000-2013)

2011
2012
2013
2014

Source: Dr. Peter Richards, Heidelberg University
13% Increase in TP

Only 25-50% of TP is readily available

\[ y = 5.8078x + 1040.9 \]

\[ R^2 = 0.0084 \]

p-value = 0.670
144% Increase in DRP

- ~3% of all LE tributary water
- YET 50% of LE phosphorous!!
- Detroit concentration NOT high enough to cause bloom
Maumee River at Waterville, Ohio

Annual Dissolved Reactive Phosphorus Load

Dissolved Reactive Phosphorus
Annual Flow-Weighted Mean Concentration

Graphic © Laura Johnson, NCWQR
2008 Great Lakes Tributary Total Phosphorus Loads (MTA) - Top 80 Tributaries

Legend
- Total Phosphorus: < 100 MTA
- Total Phosphorus: > 100 MTA
- Connecting Channel

80:10:10
Data from
MERIS 2002-2011,
MODIS 2012
- **Ann. discharge** = 8.0 billion m$^3$
- **Spring discharge** = 3.4 billion m$^3$
- **Ann. P load** = 3,800 tonnes
- **Spring P load** = 1,300 tonnes

- **Ann. discharge** = 6.2 billion m$^3$
- **Spring discharge** = 5.0 billion m$^3$
- **Ann. P load** = 3,100 tonnes
- **Spring P load** = 2,300 tonnes

- **Ann. discharge** = 6.1 billion m$^3$
- **Spring discharge** = 1.0 billion m$^3$
- **Ann. P load** = 2,500 tonnes
- **Spring P load** = 400 tonnes
We Can Predict with Some Accuracy
Microcystis at Stone Lab (8/10/10)
Microcystis, Stone Lab, 9/20/13
Microcystis near Marblehead

Photo: Richard Kraus, United States Geological Survey

October 9th, 2011
Not Just Western Basin Problem?

October 9, 2011

Photo: NOAA Satellite Image
Microcystin Concentrations

- 1 ppb WHO drinking water limit
- 20 ppb WHO swimming limit
- 60 ppb highest level for Lake Erie until 2011
  - 1200 Lake Erie Maumee Bay area 2011
- 84 ppb highest level for Grand Lake St. Marys until 2010
  - 2000+ Grand Lake St. Marys 2010
- Currently no national standards
  - How do we test?
  - How do we treat?
Toxin Reference Doses

- Dioxin (0.000001 mg/kg-d)
- Microcystin LR (0.000003 mg/kg-d)
- Saxitoxin (0.000005 mg/kg-d)
- PCBs (0.00002 mg/kg-d)
- Cylindrospermopsin (0.00003 mg/kg-d)
- Methylmercury (0.0001 mg/kg-d)
- Anatoxin-A (0.0005 mg/kg-d)
- DDT (0.0005 mg/kg-d)
- Selenium (0.005 mg/kg-d)
- Botulinum toxin A (0.001 mg/kg-d)
- Alachlor (0.01 mg/kg-d)
- Cyanide (0.02 mg/kg-d)
- Atrazine (0.04 mg/kg-d)
- Fluoride (0.06 mg/kg-d)
- Chlorine (0.1 mg/kg-d)
- Aluminum (1 mg/kg-d)
- Ethylene Glycol (2 mg/kg-d)
Legislative/Regulatory Movement

Board of Regents Lake Erie R&D Initiative

2+ Million allocated across five “Focus Areas”:

1. Lake Erie HABs and Lake Water Quality:
   • Detection, mapping, and warning network
2. Producing Safe Drinking Water:
   • “Arm” water treatment plants with tools/technology and training to remove toxins
3. Land Use Practices and Sources of Enrichment (e.g., edge of field monitoring and BMPs)
4. Human Health and Toxicity (e.g., fish tissue and liver impact)
5. Economics and Policy
Possible Agriculture Action Areas

- Eliminate fall and winter **application** of fertilizer and manure
- Eliminate **broadcast application** and **incorporate** fertilizer
- **Soil testing** of all fields to prevent application of too much P
  - Do not apply P above agronomic need (OSU Ag research)
  - 30% of Ohio fields have too much P already
- No fertilizer when rain is in **forecast** (within 48 hours)
- Place a moratorium on addition of more **tiles**
  - 40-50% of dissolved P leaving fields is going through tiles
- **Treat as leaves?**
- Consider reducing the size of farms falling under CAFO regulations
  - Treat manure and commercial fertilizer the same
  - The algae don’t care about P source

The 4R Nutrient Program:
- Right fertilizer **source** (i.e., manure and P free)
- Right **rate** (i.e., amount; Ag need)
- Right **time** (i.e., rain and frozen ground)
- Right **place** (i.e., only where needed)
What Other Levers Can We Turn?

- **Lawn Care** Recommendations:
  - Follow Scott’s lead….all lawn care fertilizer sellers and lawn care applicators meet the zero P goal
- Reduce **property runoff** (e.g., rain barrels, terraces, porous surfaces, etc.)
- **Sewage Treatment Plant** Recommendations:
  - Reduce **volume** to treatment plants (“low-flow”)
  - Expedite actions to **eliminate CSOs**
- **Immediate Needs:**
  - Arm water treatment plants with tools, technology, and training to remove toxins
  - Reduce load of P into Lake Erie by 40%
Questions?

• For more information:
  - Dr. Christopher Winslow
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• Should nitrogen be managed in Lake Erie? The potential role of nitrogen fixation by cyanobacteria. Darren Bade, Xiaozhen Mou, and Laura Leff, (Kent State University); 2nd yr.

• Linking agricultural production and Great Lakes ecosystem services --- modeling and valuing the impacts of harmful algal blooms in Lake Erie: Elena Irwin, Mike Fraker, Seyoum Gebremariam, Jay Martin, and Wendong Zhang (OSU)
• **Source tracking and toxigenicity of *Planktothrix* in Sandusky Bay.** George Bullerjahn and Michael McKay (Bowling Green State University)

• **Mapping drain tile and modeling agricultural contribution to nonpoint source pollution in the western Lake Erie basin.** Kevin Czajkowski and April Ames (University of Toledo)
• Beneficial reuse of dredged material in manufactured soil blending: economic, logistical and performance considerations. Elizabeth Dayton (OSU) --- 3rd yr

• Impacts of climate change on public health in the Great Lakes due to harmful algae blooms. Jay Martin, Tim Buckley, Stuart Ludsin (OSU), and Carlo DiMarchi (Case Western) --- 2nd yr
• The role of nitrogen concentration in regulating cyanobacterial bloom toxicity in a eutrophic lake. Justin Chaffin (OSU)

• OSU Stone Lab’s Water Quality Lab (Justin Chaffin; OSU):
  – Charter captain survey work
  – Sample method comparison

14% N by weight (vs. ~7%)
Where did the dissolved phosphorus come from?

Dissolved phosphorus is highly bioavailable to algae

Indicators of non-point sources
  e.g., land runoff
  Example: Maumee River

Indicators of point sources
  e.g., effluent
  Example: Cuyahoga River

1) Concentration increases during storms

2) Concentration increases with flow

1) Concentration increases during low flow

2) Concentration decreases with flow
1960-70 vs. 1980-90’s vs. Post 1994

• Dead lake image
• Phosphorus reductions from POINT sources (29,000 metric tons to 11,000)
  - Somewhat aided by agriculture practices