--- 2015 Great Lakes Conference ---

The Great Lakes: Advancing Knowledge and Improvement

OHIO SEA GRANT AND STONE LABORATORY

Ecological and Economic Importance of Lake Erie and the Impacts of Harmful Algal Blooms

Dr. Christopher J. Winslow

Interim Director, Ohio Sea Grant College Program

March 10th, 2015

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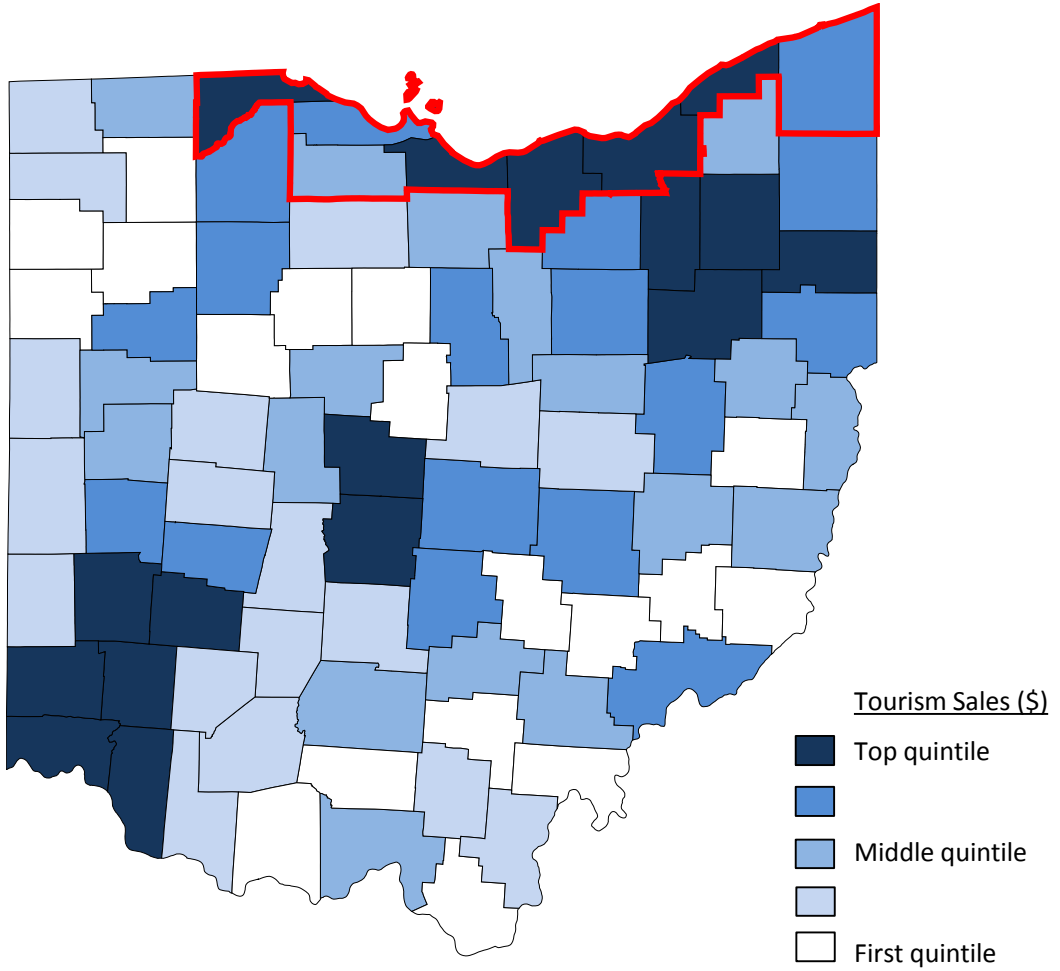
The Economic Impact of Tourism in the Lake Erie Region of Ohio

Total Tourism Impact	
Lake Region	
Sales	$12.9 billion
Wages	$3.3 billion
Taxes	$1.7 billion
Employment	119,491

Funded by the Ohio Sea Grant College Program and the Office of Tourism Ohio

TOURISM ECONOMICS
AN OXFORD ECONOMICS COMPANY



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Tourism Sales (Output) (US$)	Direct*	Indirect	Induced	Total
Agriculture, Fishing, Mining	-	72,165,627	26,803,587	98,969,215
Construction and Utilities	-	134,753,378	54,342,751	189,096,130
Manufacturing	-	535,737,046	242,910,102	778,647,147
Wholesale Trade	-	21,365,207	15,141,607	36,506,814
Air Transport	230,116,638	3,010,766	2,712,000	235,839,403
Other Transport	933,974,895	124,503,351	66,350,562	1,124,828,809
Retail Trade	2,622,707,546	64,497,534	259,333,429	2,946,538,509
Communications	-	135,022,292	58,439,840	193,462,131
Finance, Insurance and Real Estate	281,887,179	442,974,715	302,817,722	1,027,679,616
Business Services	-	559,455,722	161,300,916	720,756,638
Education and Health Care	-	1,854,609	399,471,064	401,325,673
Recreation and Entertainment	1,576,733,846	38,346,274	32,511,351	1,647,591,471
Lodging	886,644,456	13,573,138	11,297,344	911,514,938
Food & Beverage	2,000,436,660	34,403,890	97,934,101	2,132,774,651
Personal Services	-	55,136,254	93,667,070	148,803,324
Government	-	51,250,674	289,560,603	340,811,277
TOTAL	8,532,501,220	2,288,050,478	2,114,594,048	12,935,145,746

Direct = spending by visitors on goods and services during their visits.

Indirect = spending by businesses on goods and services in order to accommodate the guest

Induced = spending by employees whose wages are earned because of tourism spending

- The tourism industry generated $1.7 billion in taxes in 2013.
- Tourism generated $847 million in state and local taxes
  - $510 million in state taxes
  - $337 million in local taxes

Tourism-Generated Taxes (US$)	
	Total
Federal Taxes	811,222,211
State Taxes	509,942,467
Local Taxes	337,335,475
TOTAL	1,658,500,152

Tourism Employment

	Direct	Indirect	Induced	Total
Agriculture, Fishing, Mining	-	785	271	1,056
Construction and Utilities	-	450	93	543
Manufacturing	-	1,073	444	1,517
Wholesale Trade	-	81	59	140
Air Transport	1,207	12	11	1,230
Other Transport	10,335	1,183	598	12,116
Retail Trade	9,898	820	3,283	14,001
Communications	-	506	175	681
Finance, Insurance and Real Estate	1,841	2,282	1,360	5,483
Business Services	-	4,632	1,429	6,061
Education and Health Care	-	24	4,081	4,106
Recreation and Entertainment	20,737	876	535	22,148
Lodging	11,743	169	132	12,045
Food & Beverage	33,498	646	1,809	35,952
Personal Services	-	605	1,442	2,047
Government	-	236	130	366
TOTAL	89,258	14,380	15,853	119,491

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– Tourism supports 1 in every 12 jobs in Lake Region

Lake Erie Stats

Photo courtesy of Grave Yard Rabbit of Sandusky Bay

- Shared by 4 states and 2 countries
- Drinking water for 11 million people
- Houses over 20 power plants (greatest water use)
- Houses 300 marinas in Ohio alone
- Walleye Capital of the World


http://collectivetravelradio.com/travel/ohio/lake-erie-shores-islands

- 40% of all Great Lakes charter boats
  - *Also*, Ohio's charter boat industry is largest in North America
  - $1.5 billion sport fishery
  - Most valuable freshwater commercial fishery in world (GLFC)


Photos courtesy of http://enformable.com


https://www.cedarpoint.com/things-to-do/roller-coasters

- Again, tourism value is $12.9 billion

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50:2 Rule

(Not exact, but instructive)

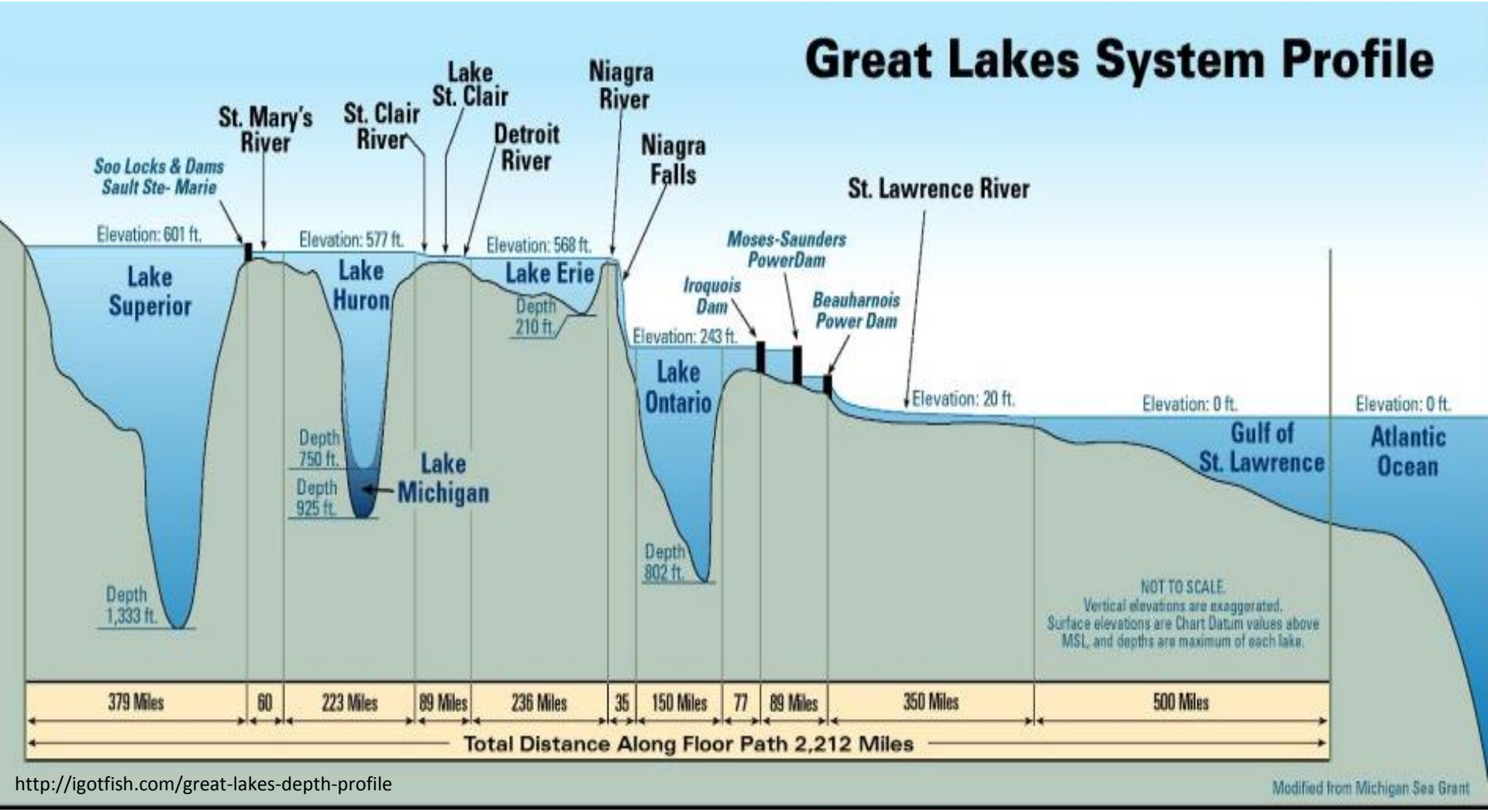
Lake Superior: 50% of the water and 2% of the fish

50:2 Rule

(Not exact, but instructive)

Lake Erie: 2% of the water and 50% of the fish

Setting the Stage for HABs



http://igotfish.com/great-lakes-depth-profile

Great Lakes Land Use

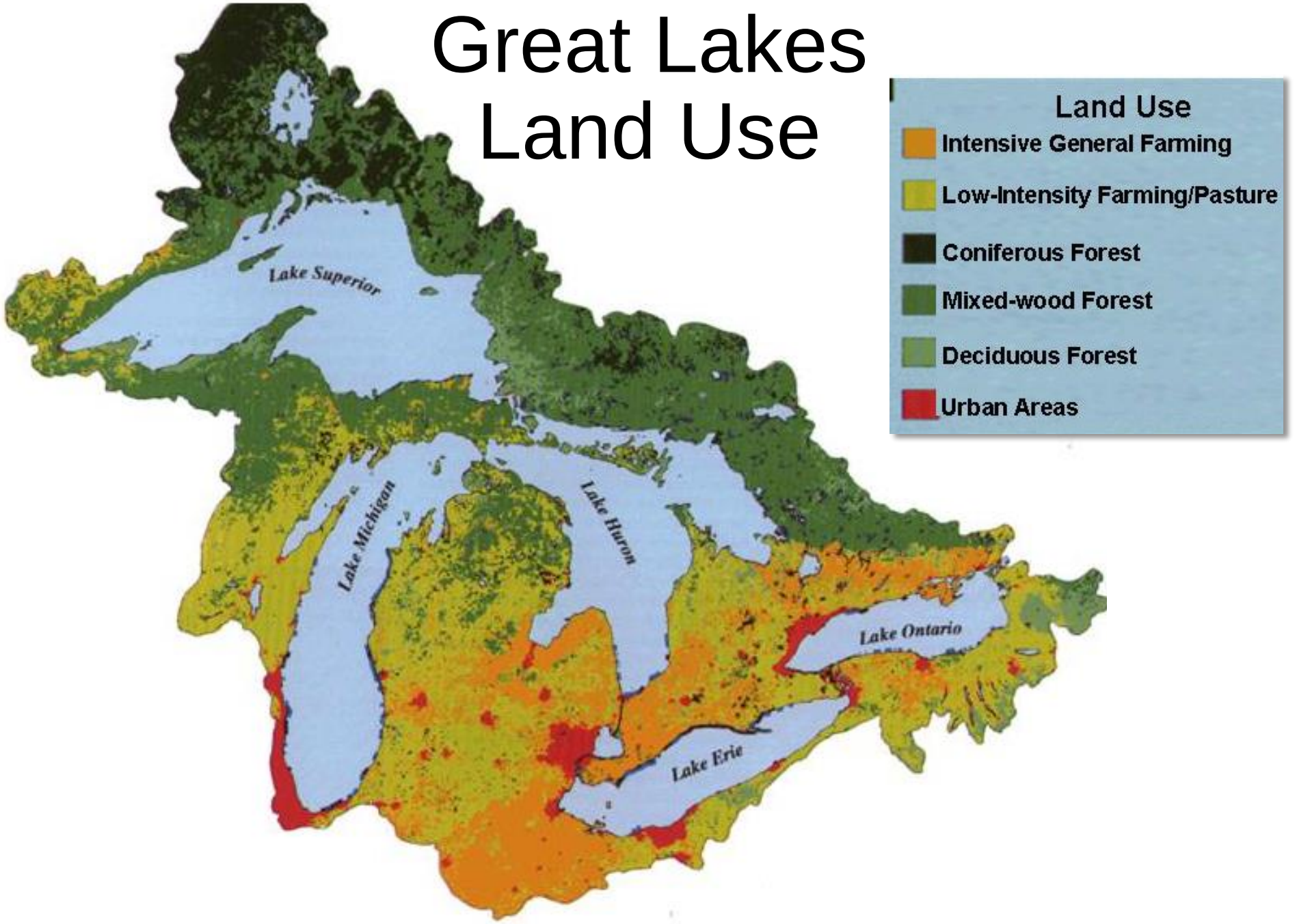


Image: Ohio Sea Grant

Great Lakes Land Use Continued

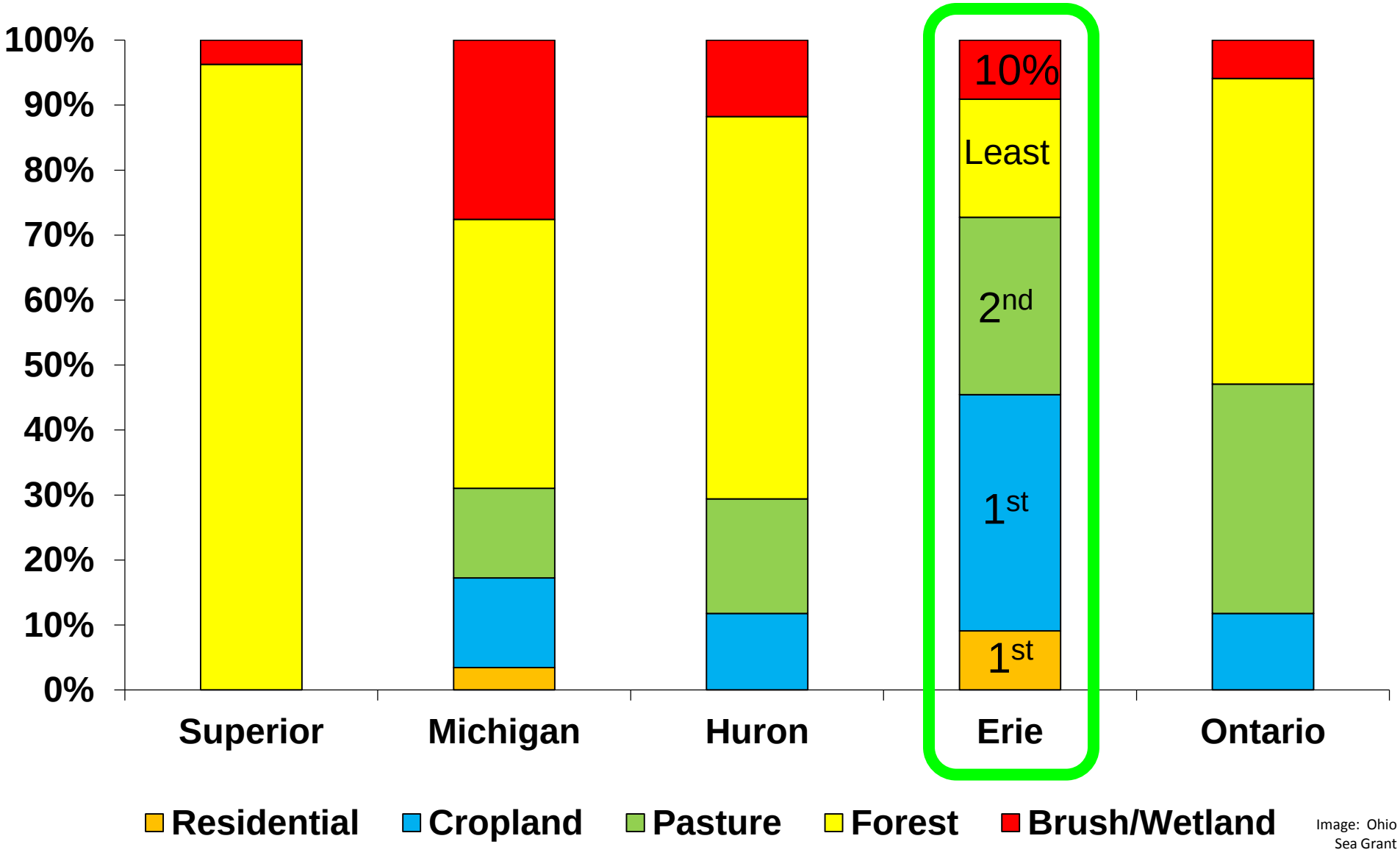


Image: Ohio Sea Grant

Because of Land Use Lake Erie Gets…..

- More sediment and nutrients (i.e., fertilizers and sewage) 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!!


http://www.dispatch.com/content/stories/local/2011/08/26/algae-warning-tarnishes-kelleys-island.html

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

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

Source: Dr. Peter Richards, Heidelberg University

Great Lakes Land Use

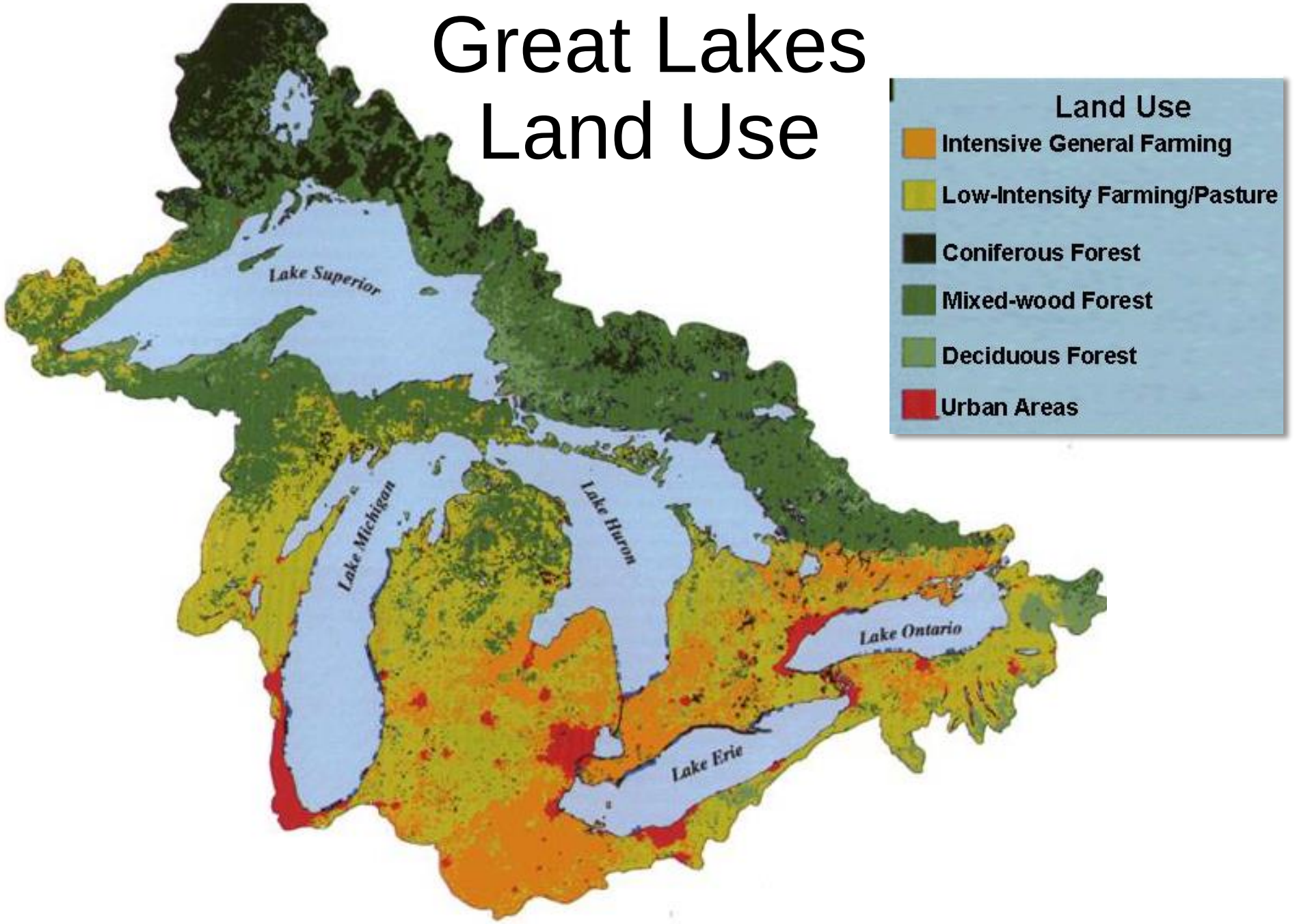
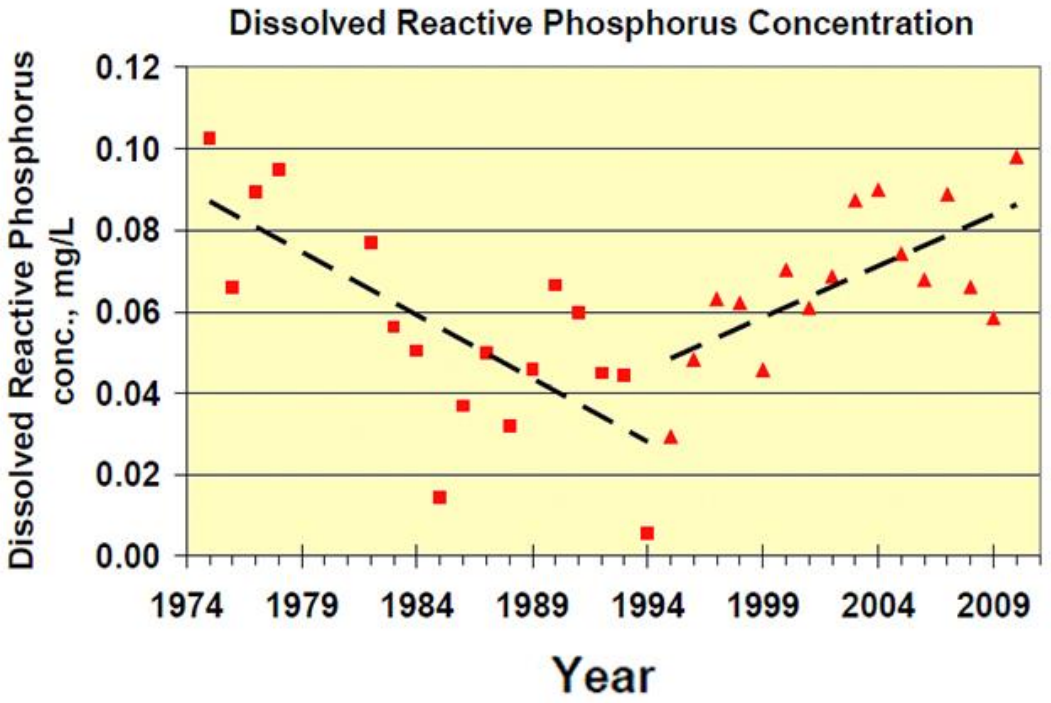


Image: Ohio Sea Grant

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



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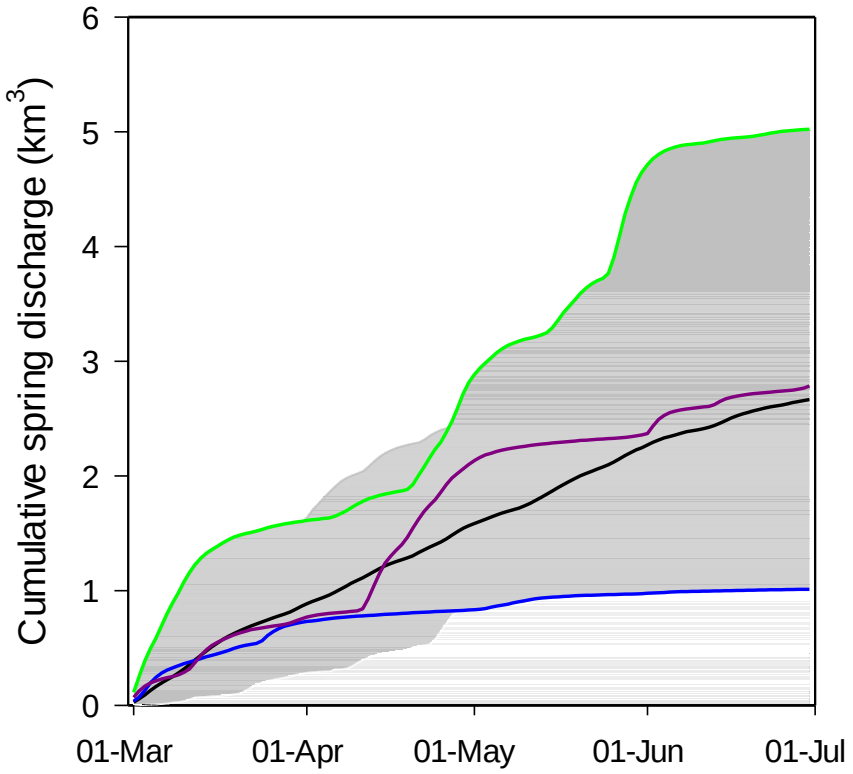
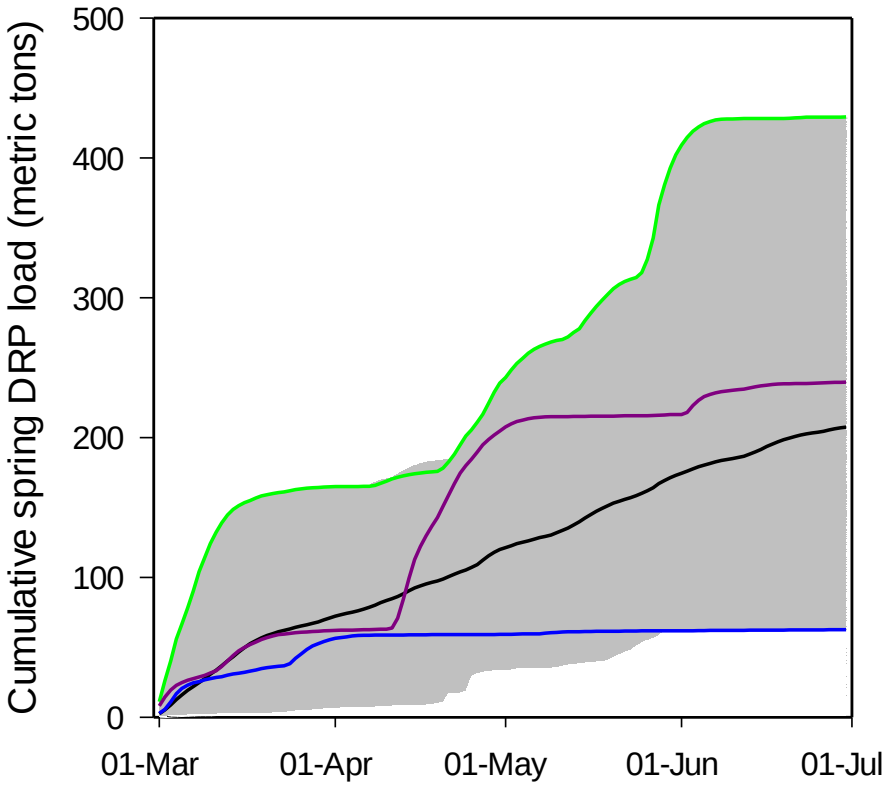
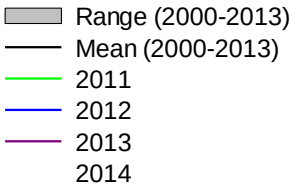
Discharge and Phosphorous Data

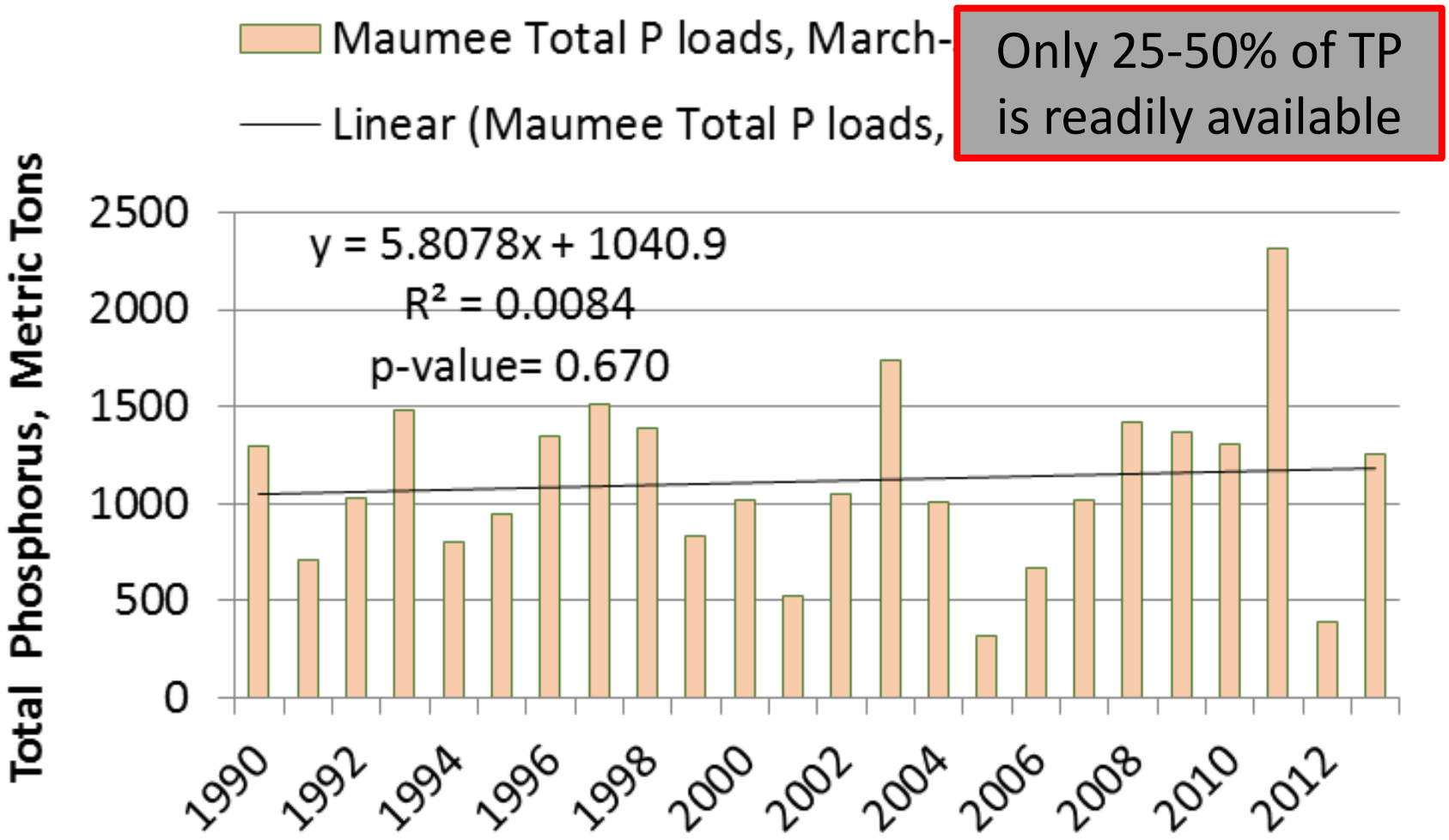






Source: Dr. Peter Richards, Heidelberg University

13% Increase in TP



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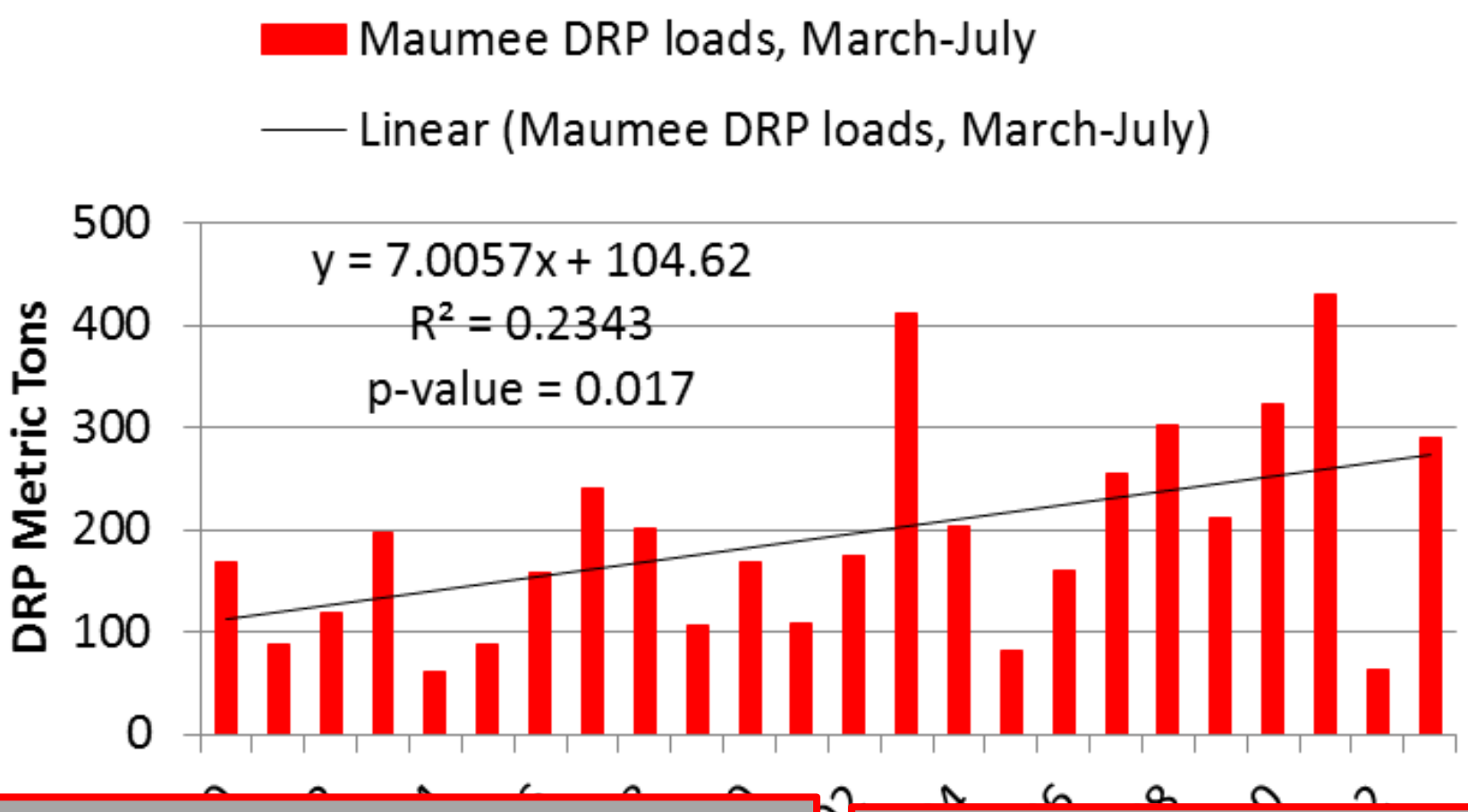
144% Increase in DRP



- ~3% of all LE tributary water
- YET 50% of LE phosphorous !!

Detroit concentration NOT high enough to cause bloom

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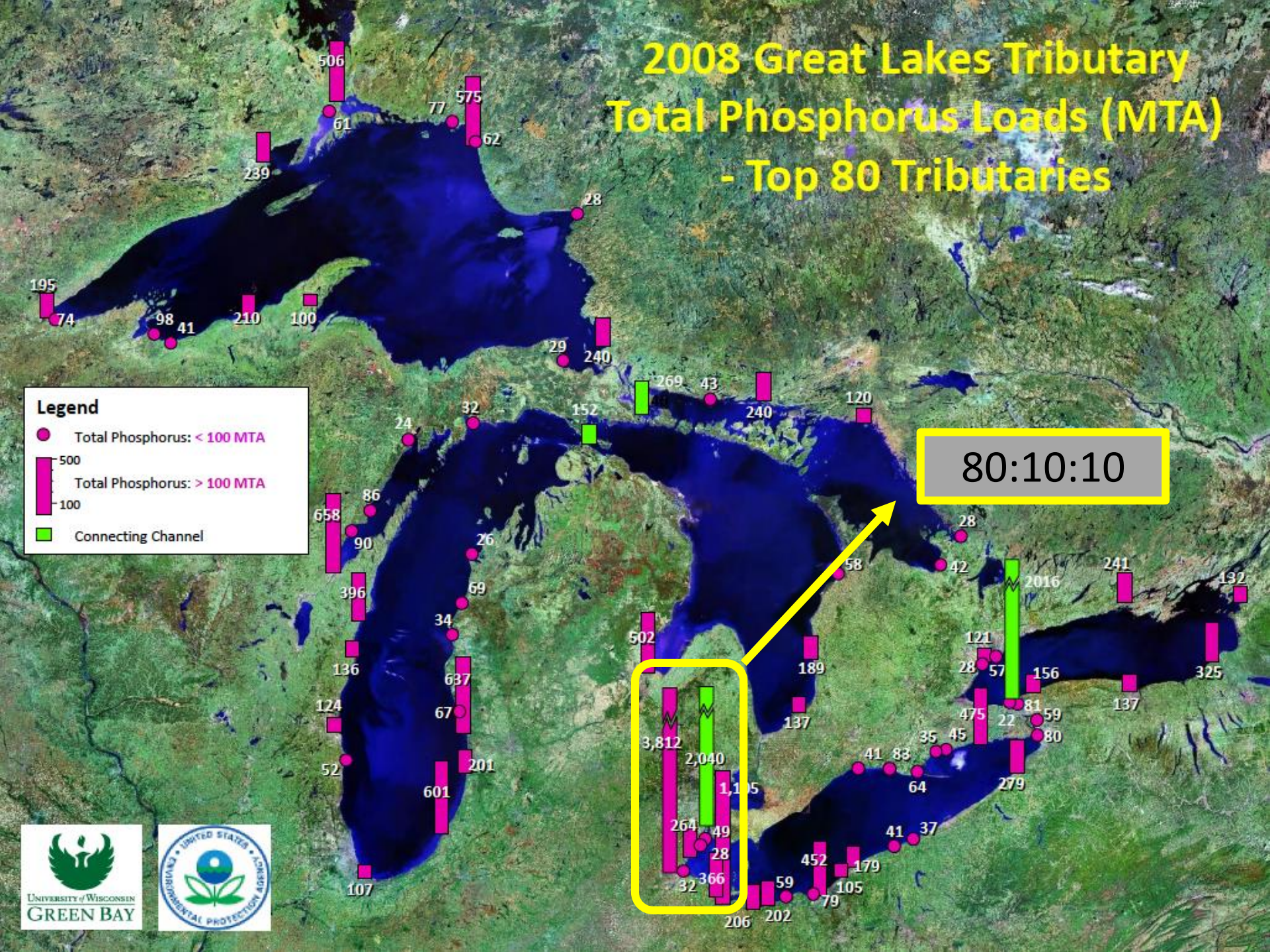
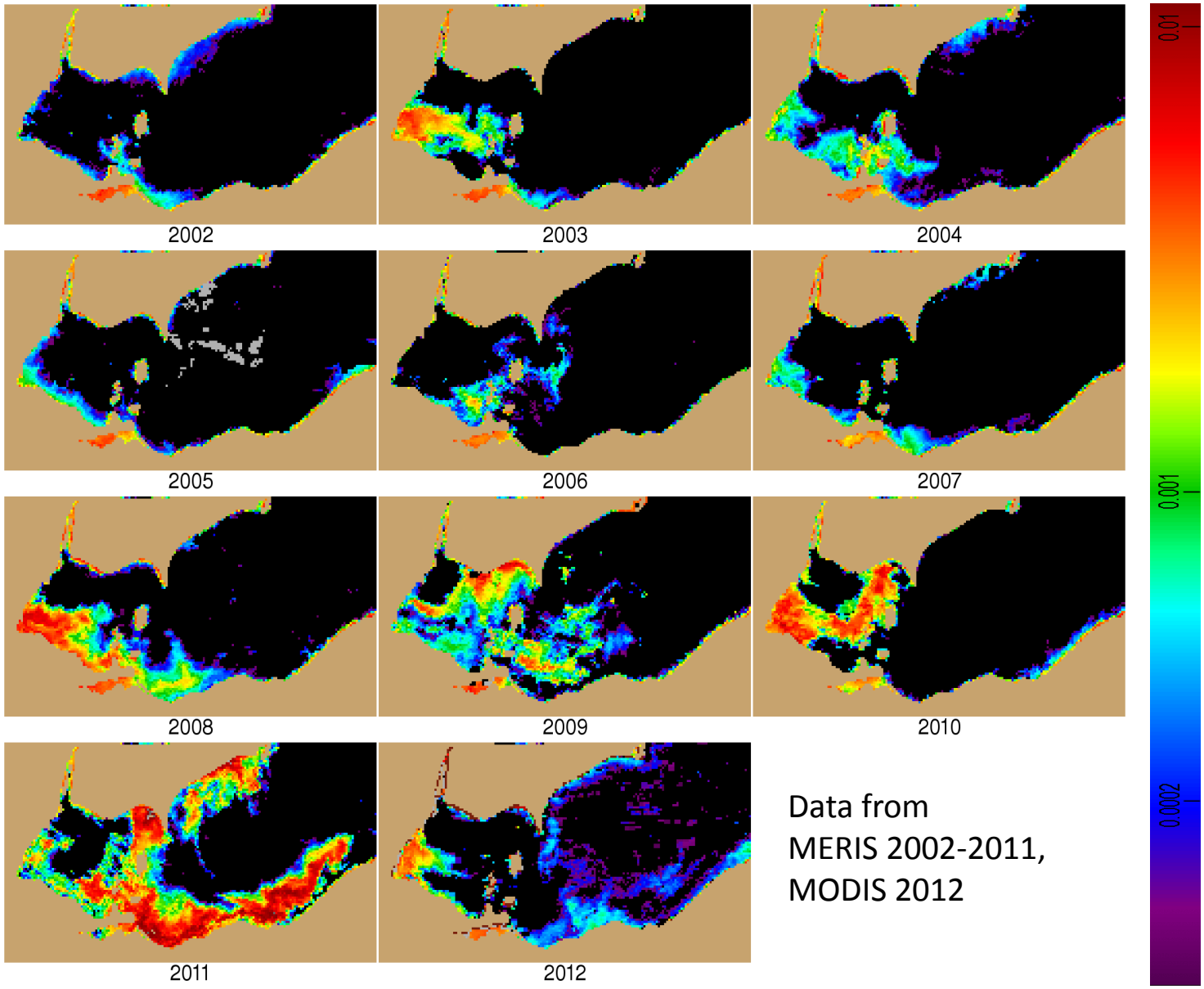
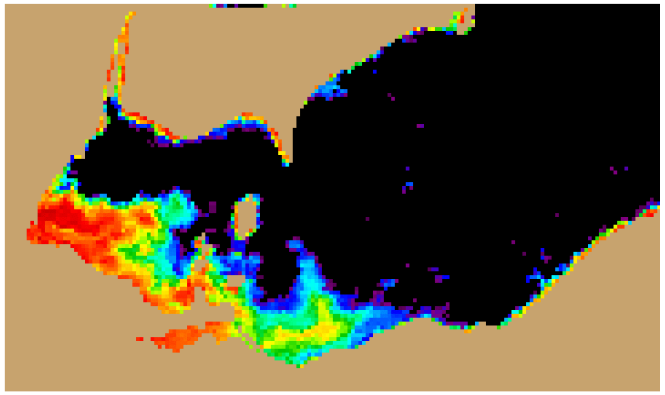

2008 Great Lakes Tributary
Total Phosphorus Loads (MTA)
- Top 80 Tributaries
Legend
Total Phosphorus: < 100 MTA
500
Total Phosphorus: > 100 MTA
100
Connecting Channel
80:10:10
506
61
77
575
62
239
28
195
74
98
41
210
100
29
240
269
43
240
120
32
24
152
86
658
90
26
396
69
34
136
637
67
124
52
201
601
107
502
189
137
3,812
2,040
1,195
264
49
28
32
366
59
206
202
452
179
105
79
41
37
64
41
83
35
45
475
22
59
80
279
28
57
2016
121
156
81
241
132
325
137
42
58
28
University of Wisconsin
Green Bay
United States Environmental Protection Agency

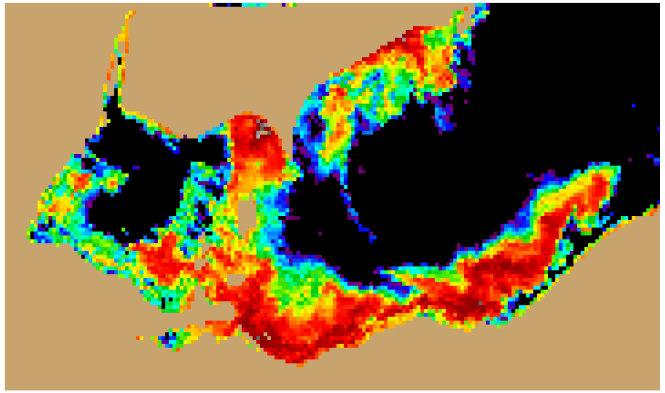


Data from
MERIS 2002-2011,
MODIS 2012



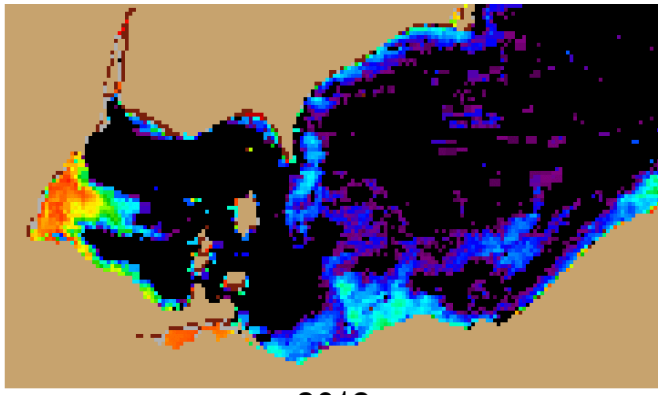
2008

- 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



2011

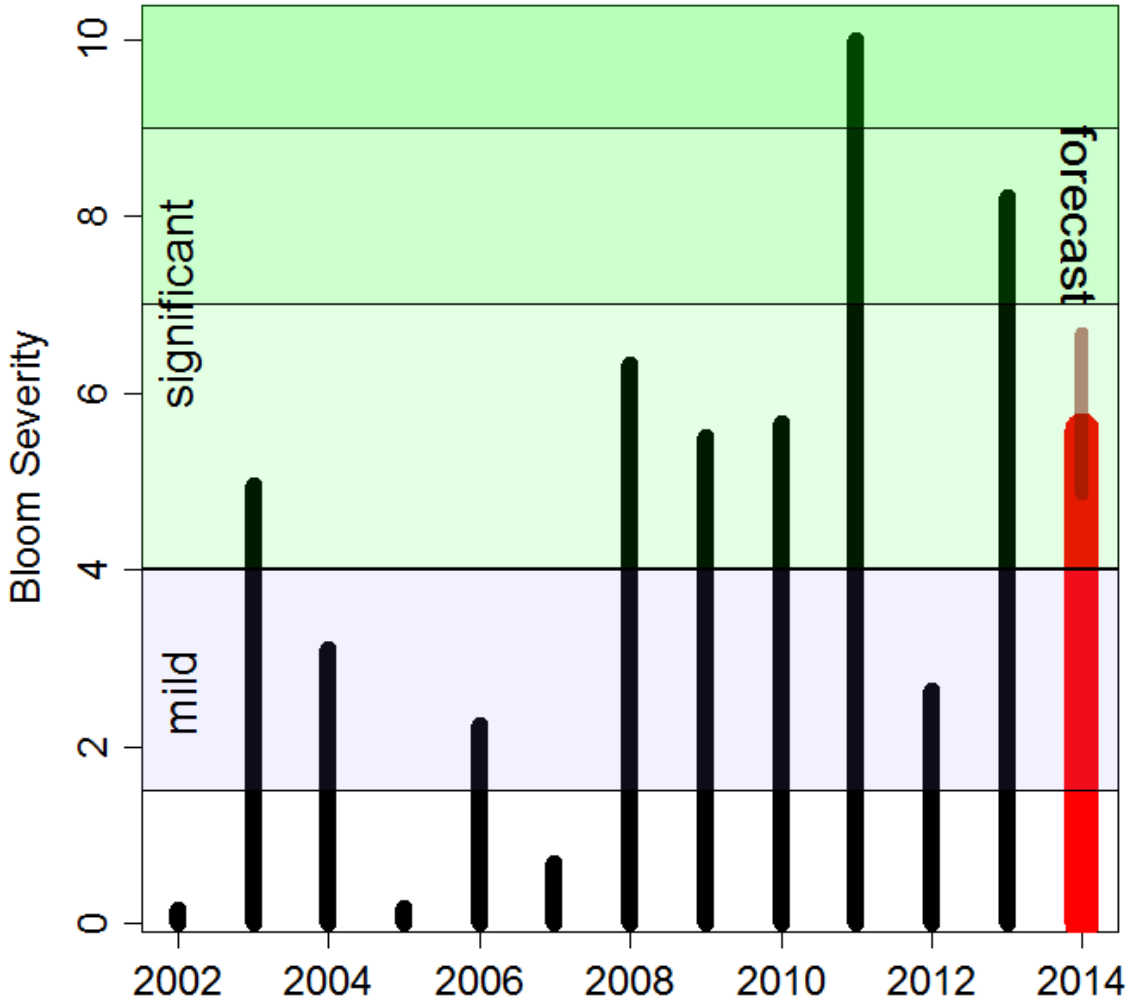
- Ann. discharge = 6.2 billion m^3
- Spring discharge = 5.0 billion m^3
- Ann. P load = 3,100 tonnes
- Spring P load = 2,300 tonnes



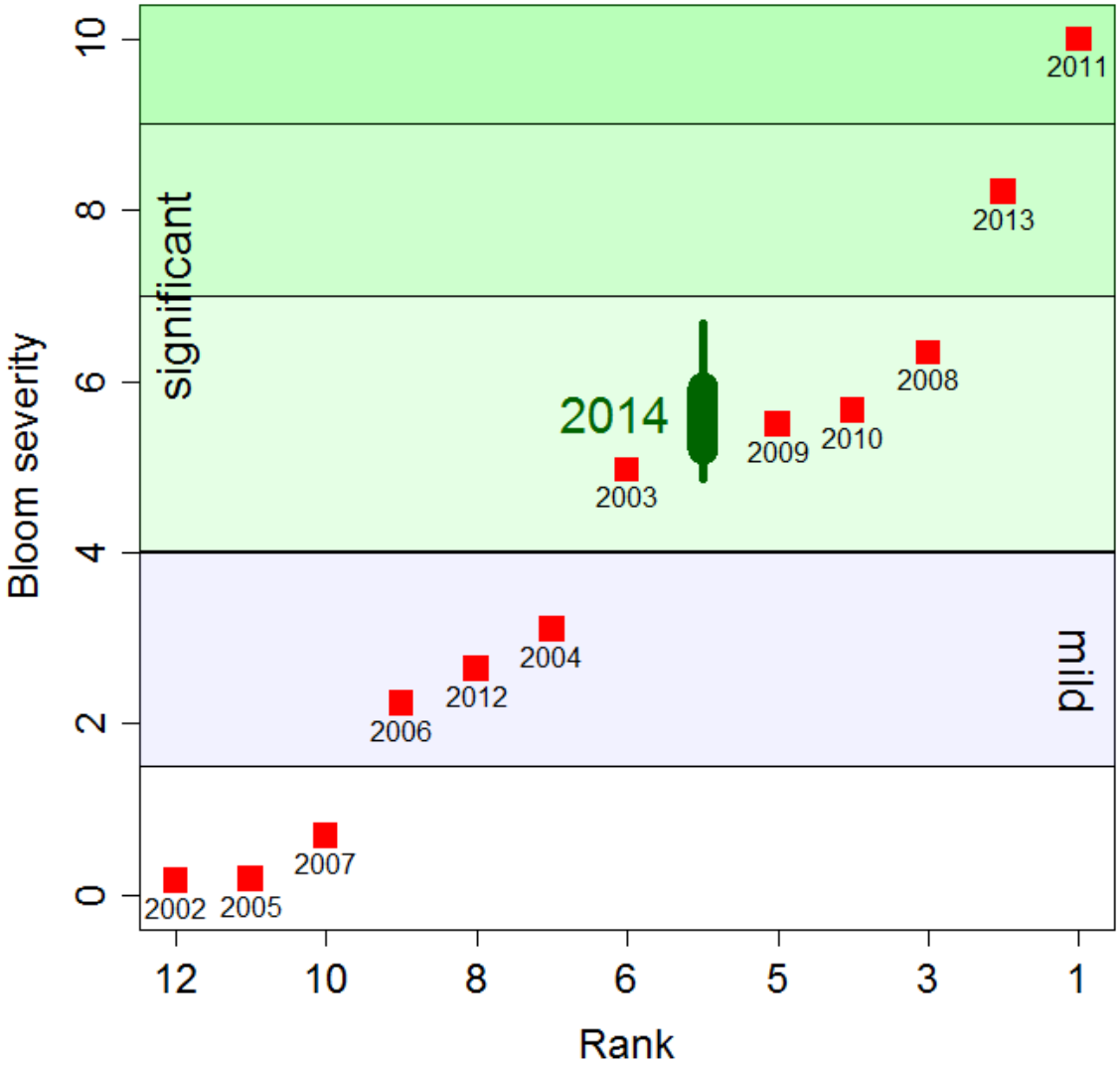
2012

- 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

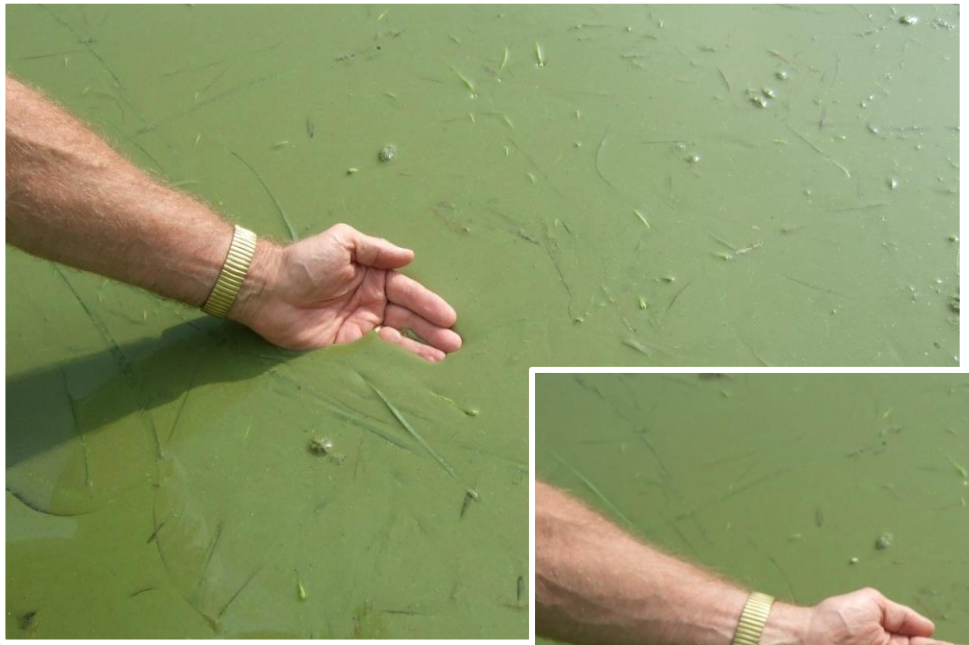
We Can Predict with Some Accuracy



We Can Predict with Some Accuracy



Microcystis at Stone Lab (8/10/10)



Microcystis, Stone Lab, 9/20/13


September 11th, 2011

Photo: NOAA Satellite Image

Microcystis near Marblehead

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http://coastwatch.glerl.noaa.gov/gallery/jpg/a1.13267.1852.LakeErie.143.250m.jpg

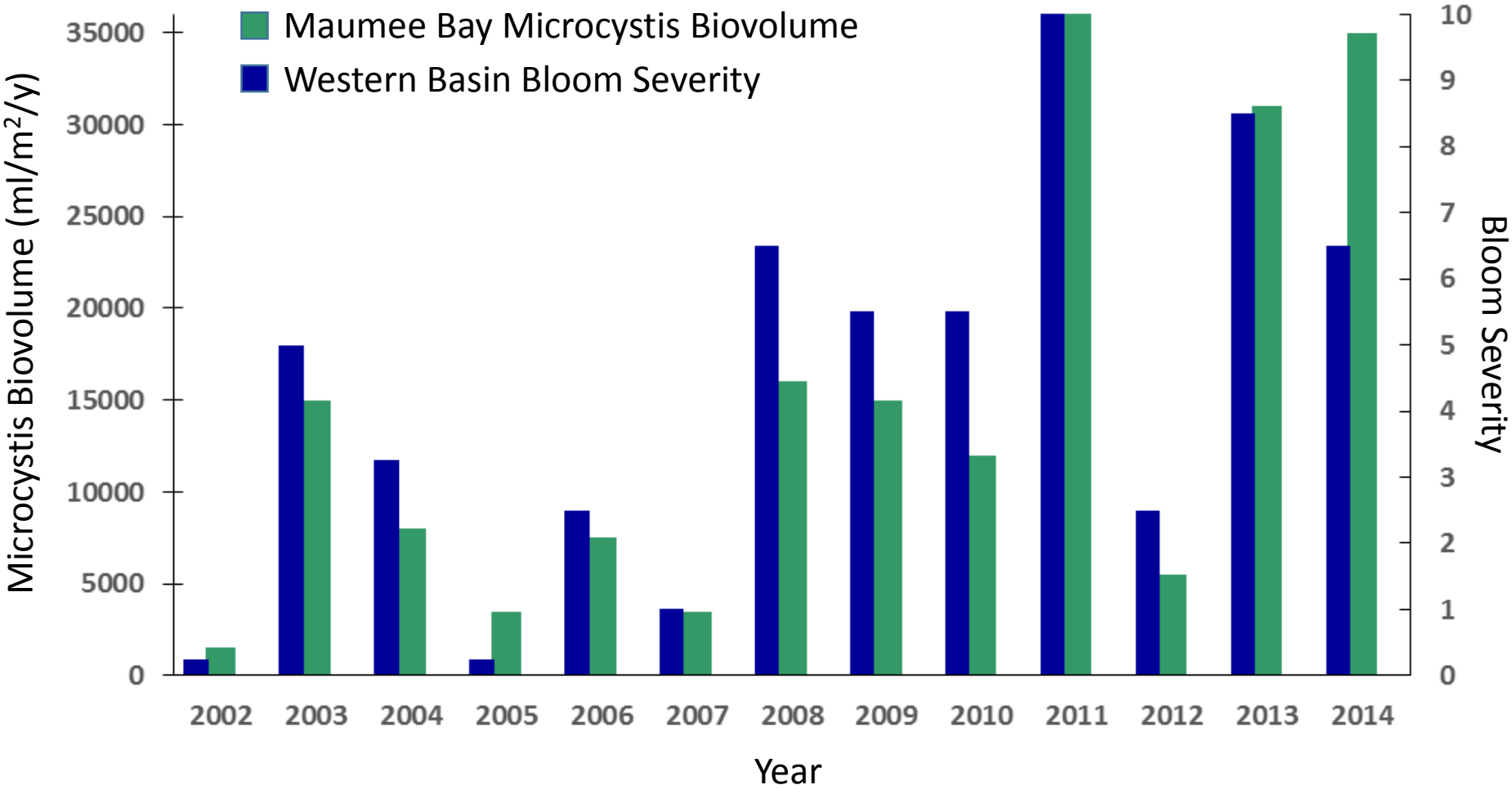
Not Just Western Basin Problem?

October 9, 2011

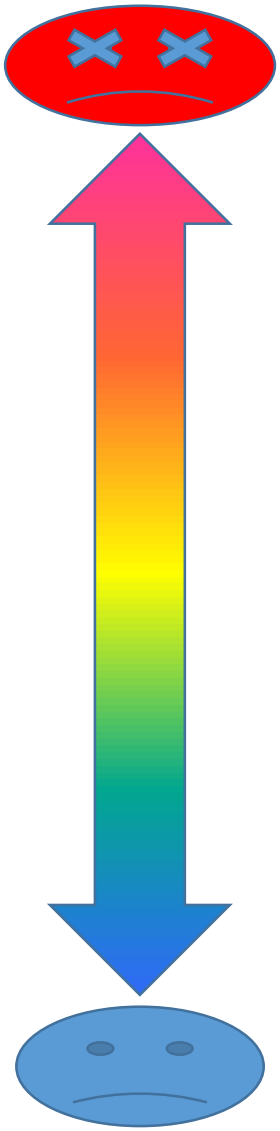
Photo: NOAA Satellite Image

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?


Maumee Bay Microcystis Biovolume
Western Basin Bloom Severity
Microcystis Biovolume (ml/m²/y)
Bloom Severity
Year
35000
30000
25000
20000
15000
10000
5000
0
10
9
8
7
6
5
4
3
2
1
0
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014

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)

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Legislative/Regulatory Movement

Board of Regents Lake Erie R&D Initiative

2+ M[illion] [illegible] "[illegible]"

OSU CFAES's "Field to Faucet" adding additional support

- "Arm" water treatment plants with tools, technology, and training to remove toxins

3. Land Use Pra[illegible]nt, Water Quality and Engineered S[illegible]onitoring and BMPs)
4. Human Healt[illegible]e and liver impact)
5. Economics and Policy

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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)
- Plac
  -
  -
- Con tions
  - 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)

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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%
- ly

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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)

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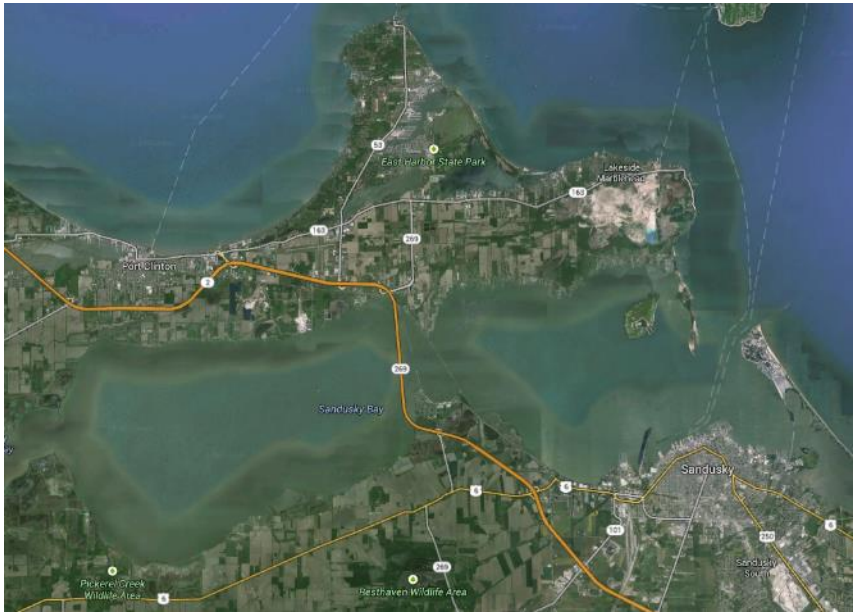
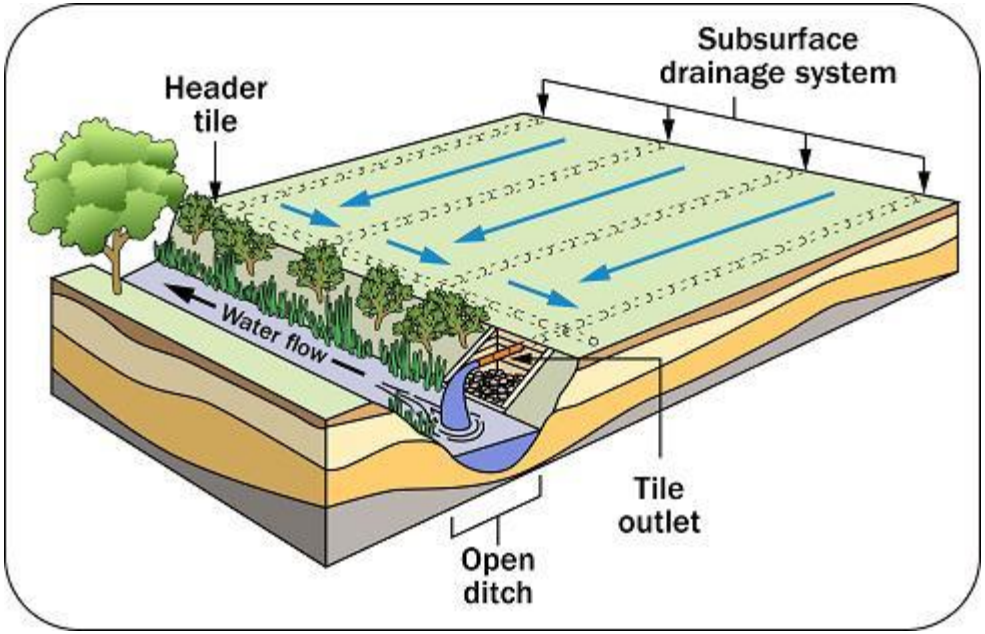
- **Source tracking and toxigenicity of *Planktothrix* in Sandusky Bay.** George Bullerjahn and Michael McKay (Bowling Green State University)
- **Mapping drain tile and modeling agricultural contribution to nonpoint source pollution in the western Lake Erie basin.** Kevin Czajkowski and April Ames (University of Toledo)





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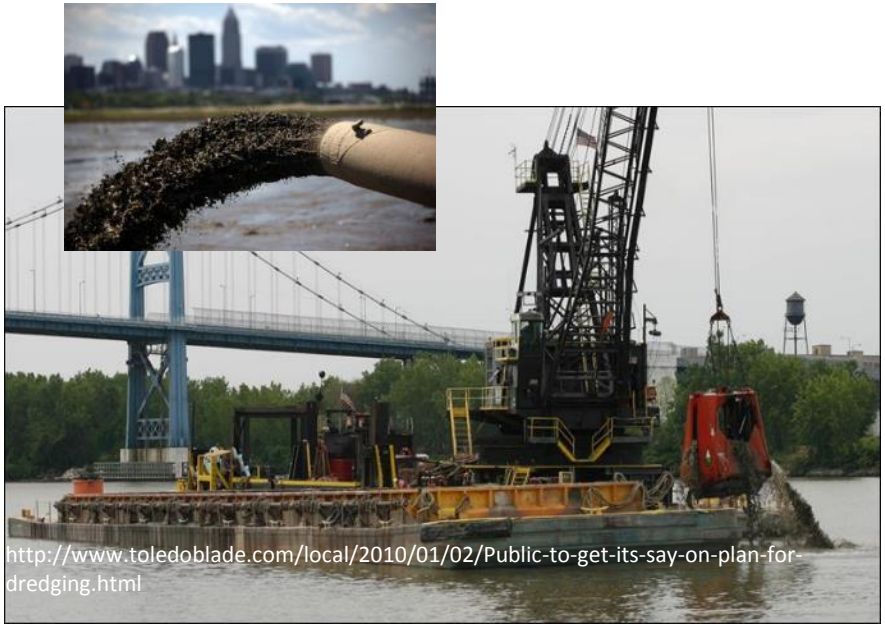
- **Beneficial reuse of dredged material in manufactured soil blending: economic, logistical and performance considerations.** Elizabeth Dayton (OSU) --- 3rd yr
- **Impacts of climate change on public health in the Great Lakes due to harmful algae blooms.** Jay Martin, Tim Buckley, Stuart Ludsin (OSU), and Carlo DiMarchi (Case Western) --- 2nd yr



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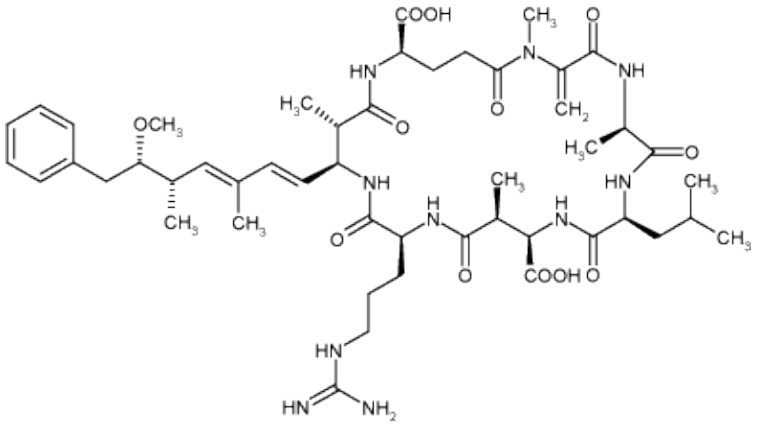
- **The role of nitrogen concentration in regulating cyanobacterial bloom toxicity in a eutrophic lake.** Justin Chaffin (OSU)
- **OSU Stone Lab's Water Quality Lab (**Justin Chaffin; OSU**):**
  - Charter captain survey work
  - Sample method comparison



14% N by weight (vs. ~7%)

Equipment used	Sample depth	Institutions
Intergraded tube sampler	Surface to lake bottom[1,2]	Lake Erie Center U. Toledo, Stone Lab Ohio St. U., USGS Ann Arbor
Intergraded tube sampler	Surface to 2 meter depth	Charter boat captains
Intergraded tube sampler	Surface to twice Secchi disk depth[1,2]	USGS Sandusky, Ohio DNR
Van Dorn sampler	Pooled together [1] meter, mid depth, [1] meter above bottom[2]. Or mid depth in less than 4 meters of water	Ohio EPA

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Questions?

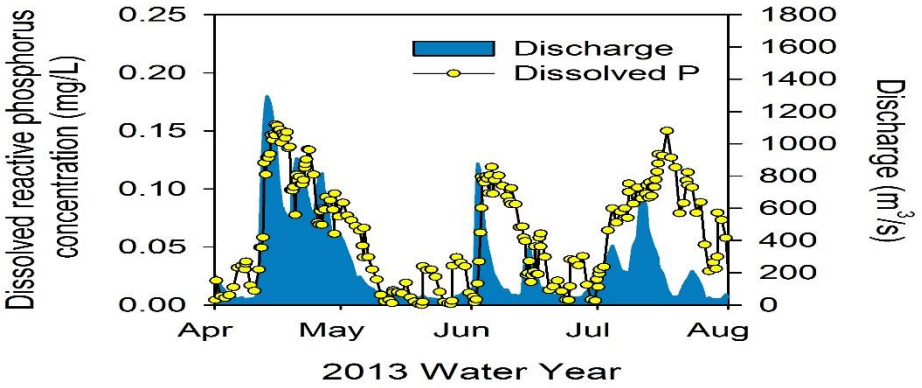
- For more information:
  - Dr. Christopher Winslow
  - ***Phone***: 614-292-8949
  - ***E-mail***: winslow.33@osu.edu

Where did the dissolved phosphorus come from?

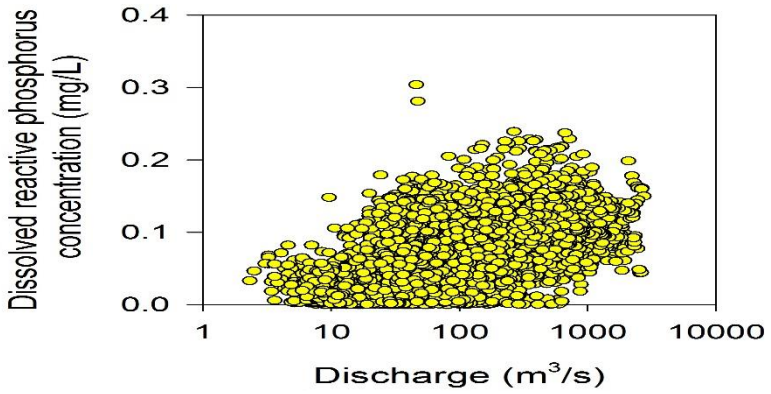
Dissolved phosphorus is highly bioavailable to algae

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

1) Concentration increases during storms

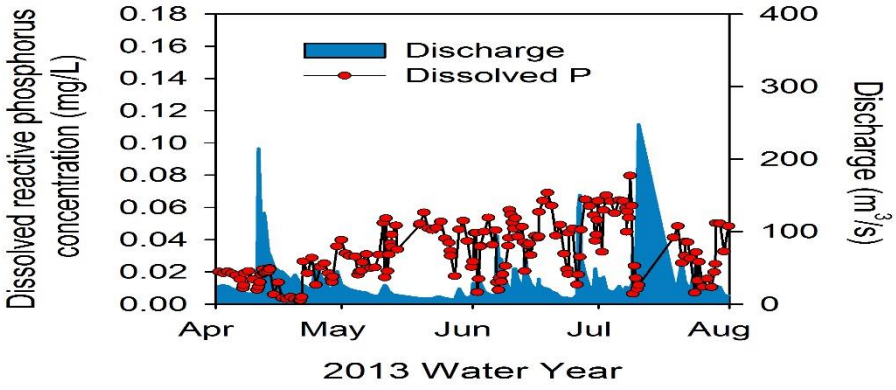


2) Concentration increases with flow



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

1) Concentration increases during low flow



2) Concentration decreases with flow