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Harmful Algal Blooms:

Causes and consequences for the western basin of Lake Eire

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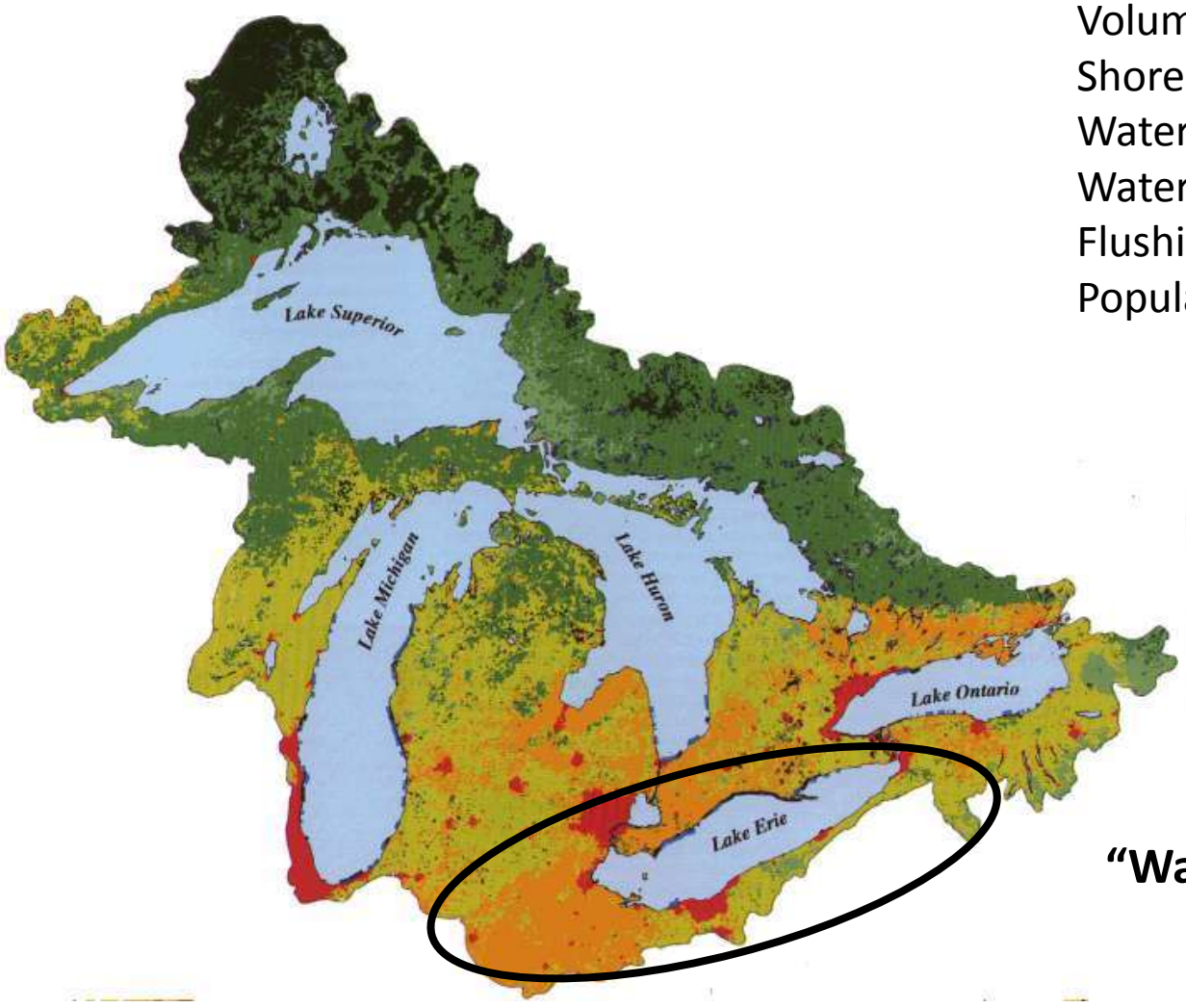
Lake Erie:

Southern most, warmest, and most productive Great Lake

Length: 241 miles
Breadth: 57 miles
Average Depth: 19 m
Maximum Depth: 64 m
Volume: 116 cubic miles
Shoreline Length: 871 miles
Water Surface Area: 9,910 square miles
Watershed: 30,140 square miles
Flushing Time: 2.6 years
Population: 10.5 million U.S.
1.9 million Canada



"Walleye Capital of the World"

Phytoplankton

- a.k.a: algae, pond scum, microscopic plants
- Transform sunlight into food
- Base of aquatic food webs
- Harmful and toxic algal blooms

All after Entwisle et al. (1997)

Microcystis scum on *Lyngbya* mats, Lake Erie Center, August 2011. credit: T. Crail

Wikimedia Commons

Microcystis sp.

- Colony forming phytoplankton
- Can produce the toxin microcystin

- Microcystin toxin is harmful to both humans and pets
  - Both chronic and acute toxicity, liver and skin
  - Drinking water recommendation, < 1 μg/L

World Health Organization

  - Recreational contact recommendation, < 20 μg/L

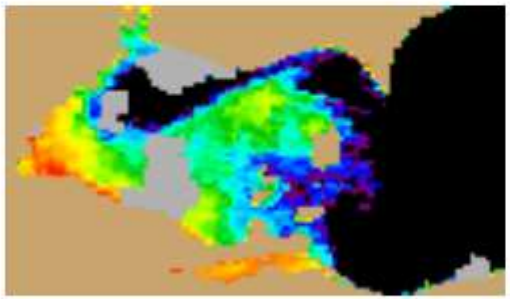
Ohio EPA

USGS

Background

- Recent large HABs
- HAB management information needs:
  - improved monitoring
  - short-term prediction
  - strategies for bloom prevention

Experimental
Lake Erie Harmful Algal Bloom Bulletin
2011-011
18 August 2011
National Ocean Service
Great Lakes Environmental Research Laboratory
Last bulletin: 11 August 2011



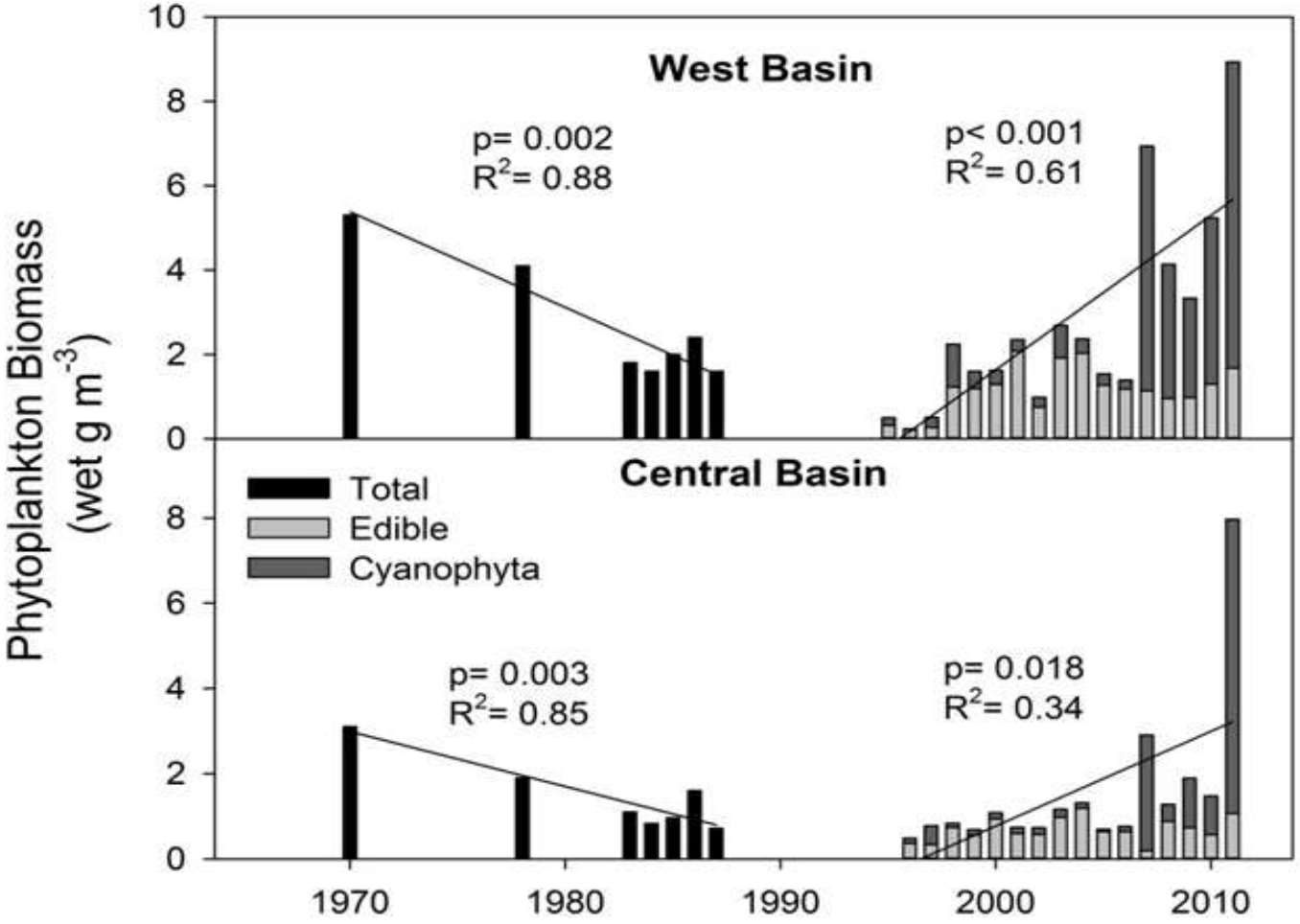
Conditions: A confirmed Microcystis bloom persists in Western Lake Erie.

Analysis: A large Microcystis bloom remains in Western Lake Erie. Model trajectory indicates an easterly transport over the weekend, potentially to Pelee Point by August 21. Recent wind conditions have been relatively low, allowing the biomass to be concentrated in the surface. Low wind stress is predicted over the weekend, so this trend should continue. Water temperatures remain high (nearly 25 C) which should allow the bloom to persist at its present intensities through next week.

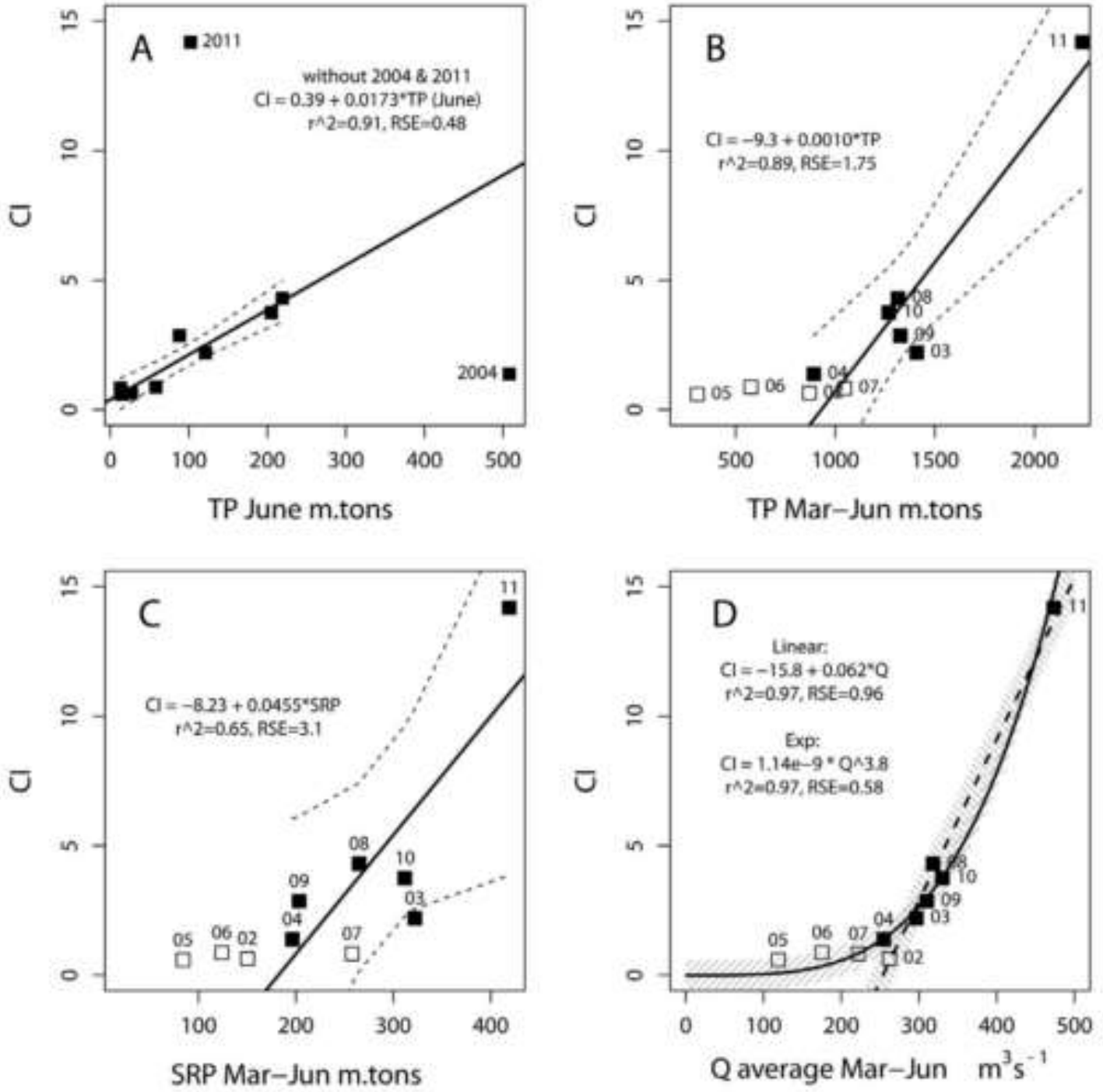
-Wynne, Tomlinson

Western Basin Algal Booms

Similar trend through the mid-1990s
Then a resurgence



Scavia et al. 2014



Stumpf et al. 2012

Most significant sources:

Detroit and Maumee Rivers > River Raisin > others

Scavia et al. 2014

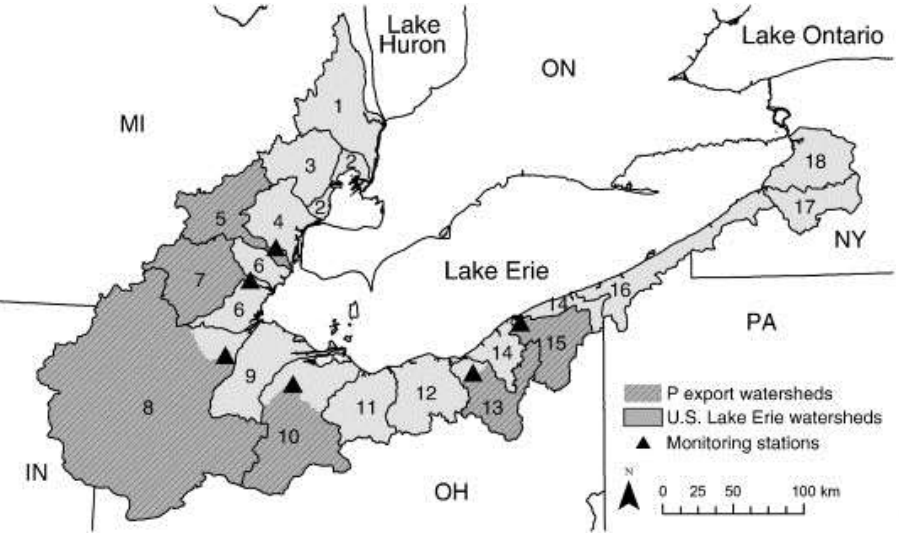
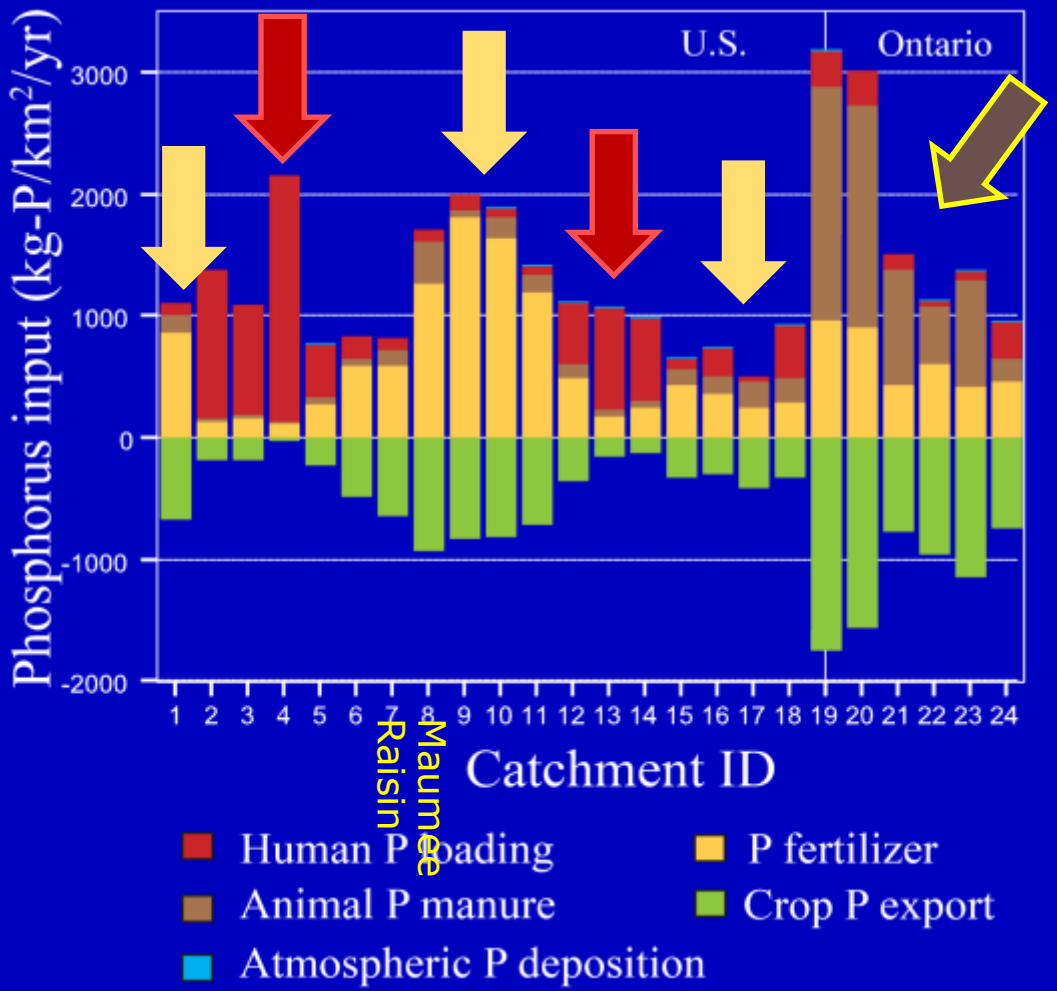


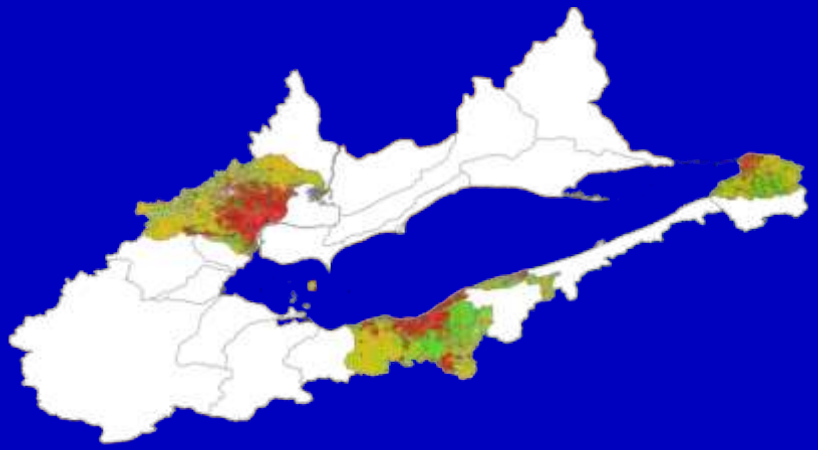
Table 1
Watershed characteristics, land use, precipitation and human population for 18 watersheds of the U.S. Lake Erie basin. Land use is from 1992, precipitation is average of 1974–2007, and population density is from 2002.

ID	Watershed	State	Area km	Land uses (percent)				Avr. PPT[a] (mm/yr)	Pop[b] #/km²
				Agr.	Urb.	For.	Wetl.		
Upper western region			9707	48.1	21.3	21.1	6.7	816	469
1	St. Clair	MI	3078	72.8	2.5	17.1	7.0	762	60
2	Lake St. Clair	MI	662	30.1	37.8	20.0	7.4	830	764
3	Clinton	MI	1914	39.5	27.3	22.4	7.0	829	563
4	Detroit	MI	1694	18.7	59.1	17.9	2.4	853	1267
5	Huron	MI	2359	49.0	9.0	27.7	8.9	845	270
Lower western region			30,834	84.3	3.3	9.5	1.6	945	63
6	Ottawa-Stony	MI, OH	1779	70.9	10.2	14.8	2.3	886	111
7	Raisin	MI, OH	2813	79.2	2.2	13.9	3.1	907	61
8	Maumee	IN,MI, OH	17,052	86.8	3.1	7.8	1.3	948	62
9	Cedar-Portage	OH	2512	85.9	3.7	4.9	2.5	913	76
10	Sandusky	OH	4718	86.2	2.3	8.7	1.2	973	48
11	Huron-Vermilion	OH	1960	76.0	1.9	20.2	1.1	1005	45
Central and eastern region			13,573	38.4	12.6	42.1	4.9	1040	259
12	Black-Rocky	OH	2326	50.7	15.1	30.2	2.9	1001	319
13	Cuyahoga	OH	2074	27.9	25.2	37.9	6.1	1017	519
14	Ashtabula-Chagrin	OH,PA	1655	24.4	22.4	41.0	9.1	1021	420
15	Grand	OH	1841	38.4	2.7	43.9	13.7	1021	60
16	Chautauqua-Conneaut	OH,PA,NY	2330	37.9	7.3	48.9	2.7	1063	142
17	Cattaraugus	NY	1421	42.2	1.1	55.7	0.3	1097	25
18	Buffalo-Eighteenmile	NY	1926	44.7	12.1	42.3	0.2	1073	273
U.S. Lake Erie Basin			54,114	66.3	8.8	19.7	3.3	946	185

[a] PPT: precipitation.
[b] Pop: population.

Relative importance of individual P sources





Animal manure is the largest P input to the agricultural watersheds of Ontario

Fertilizer is the largest P input to both U.S. and Canada agricultural watersheds

Human loading is the largest P input for urbanized watersheds

Han et al. 2012

Causes of *Microcystis* HAB initiation

- **Critical water temperature**

  >18 °C

- **Sufficient light**

  Stratification can be a cue

- **Sufficient nutrients**
- **Microcystis cells**

  Mixing can be a cue

- **Others?**

  Nutrient ratios, competition, grazing pressure, micro nutrients

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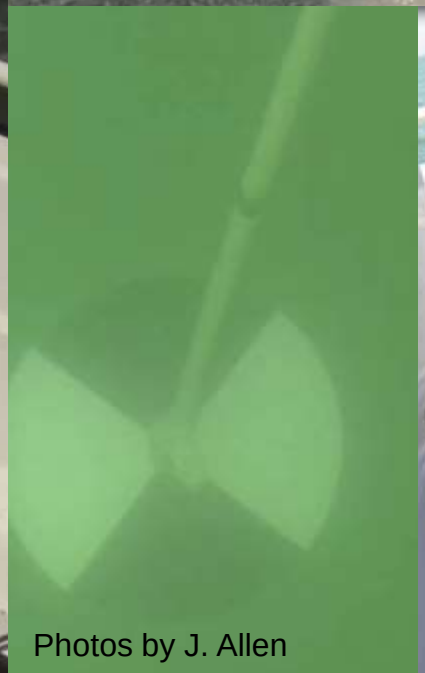
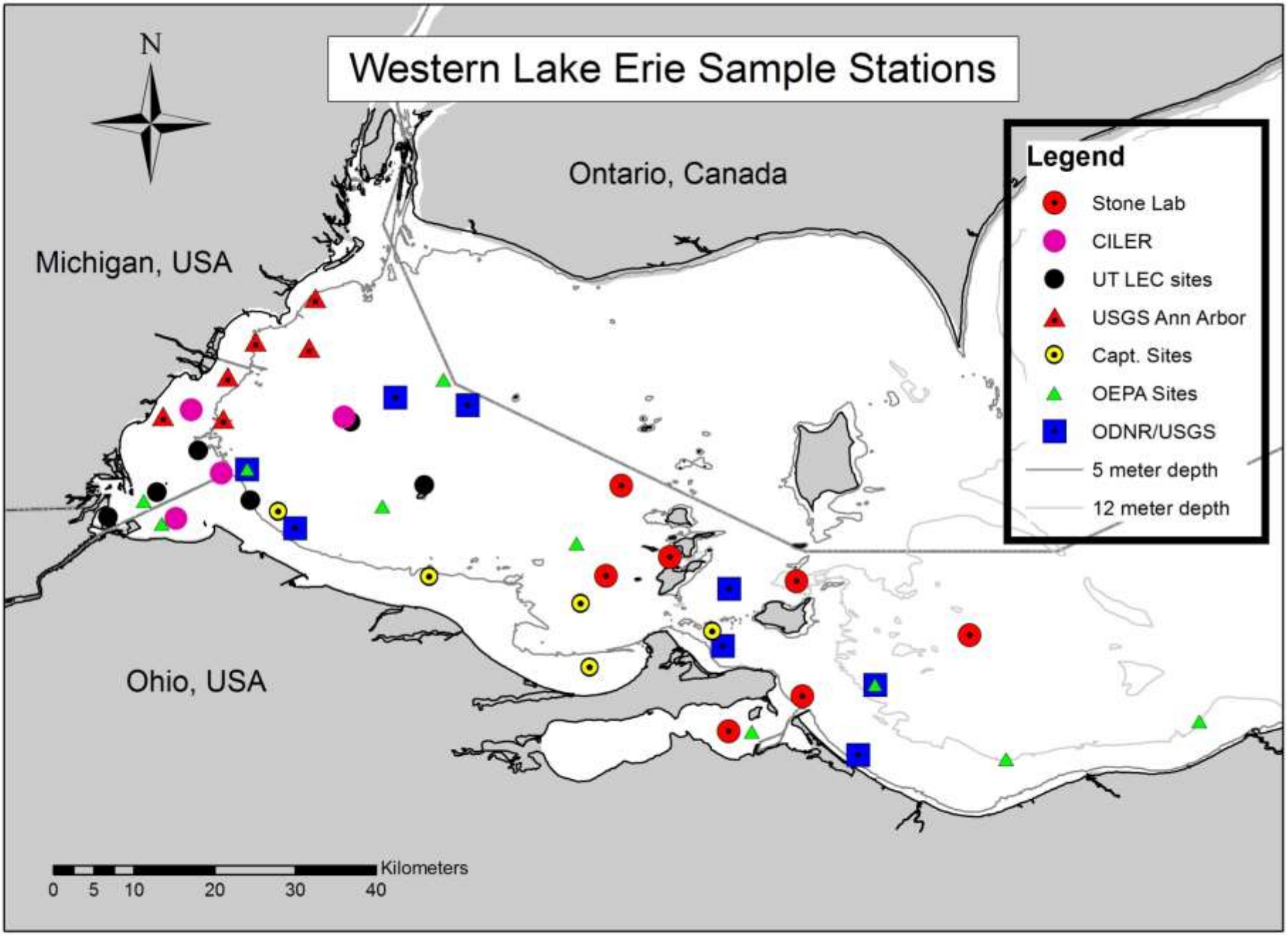
Sample collection



Photos by J. Allen


Western Lake Erie Sample Stations
N
Ontario, Canada
Michigan, USA
Ohio, USA
Legend
Stone Lab
CILER
UT LEC sites
USGS Ann Arbor
Capt. Sites
OEPA Sites
ODNR/USGS
5 meter depth
12 meter depth
Kilometers
0 5 10 20 30 40

Take home points

- Microcystin toxin is harmful to both humans and pets
  - Both chronic and acute toxicity, liver and skin
  - Drinking water recommendation, < 1 μg/L

    World Health Organization
  - Recreational contact recommendation, < 20 μg/L

    Ohio EPA
- Blooms result from combination of river influence and within basin processing
- Nutrient loading is a primary driver of bloom size, all sources matter
- Causes of HAB initiation poorly understood, inhibiting bloom prediction - topic of current work

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