Managing Impacts of HABs on Drinking Water and Public Health

September 3, 2014

NORTHEAST-MIDWEST INSTITUTE

Speakers

- Jeff Reutter, PhD
- Don Scavia, PhD
- Michael Baker
- Karen Sklenar, PhD
- Michael Murray, PhD
- Chad Lord
- Danielle Chesky/Elin Betanzo

OHIO SEA GRANT AND STONE LABORATORY

Harmful Algal Blooms (HABs) in the Great Lakes, US, and World

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Sea Grant
Ohio Sea Grant College Program

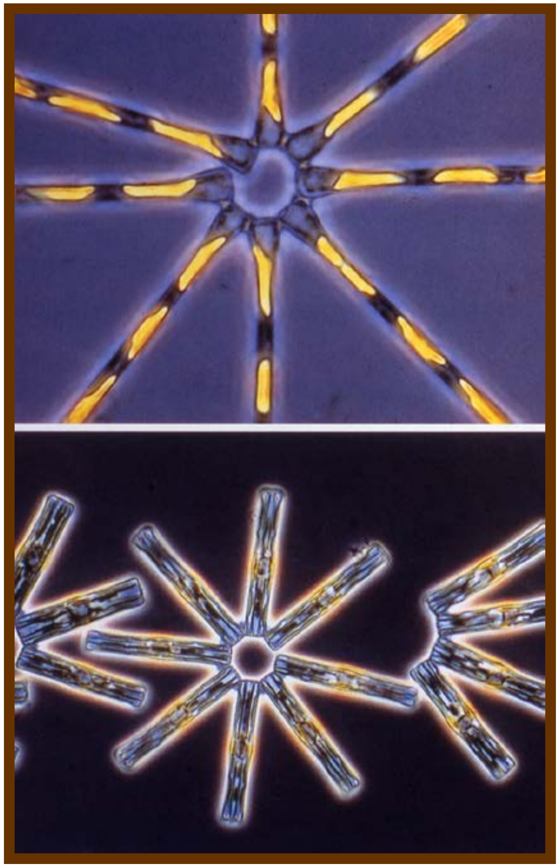
The Ohio State University

NOAA

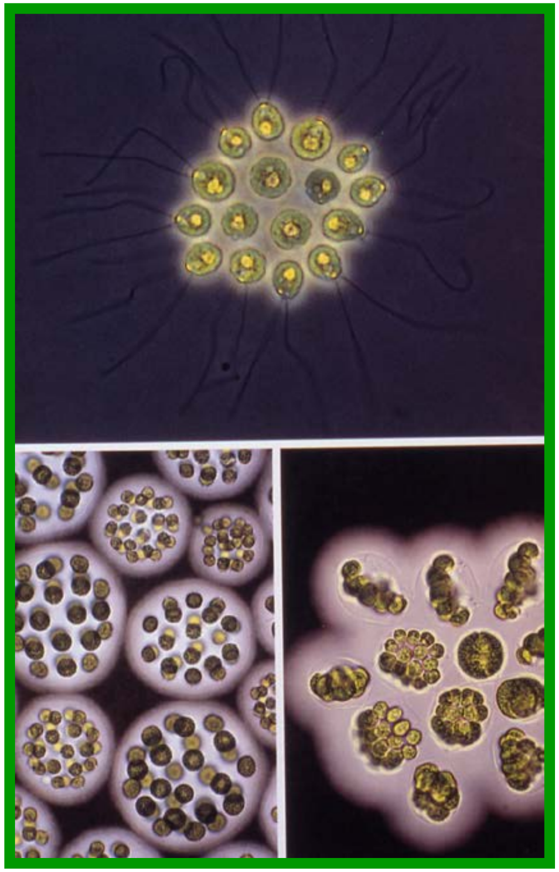
HABs

- What are they?
- Why do we have them?
- Have we had them before?
- Why are we concerned?
- How do we prevent them?

Major groups/kinds of Algae



Diatoms



Greens

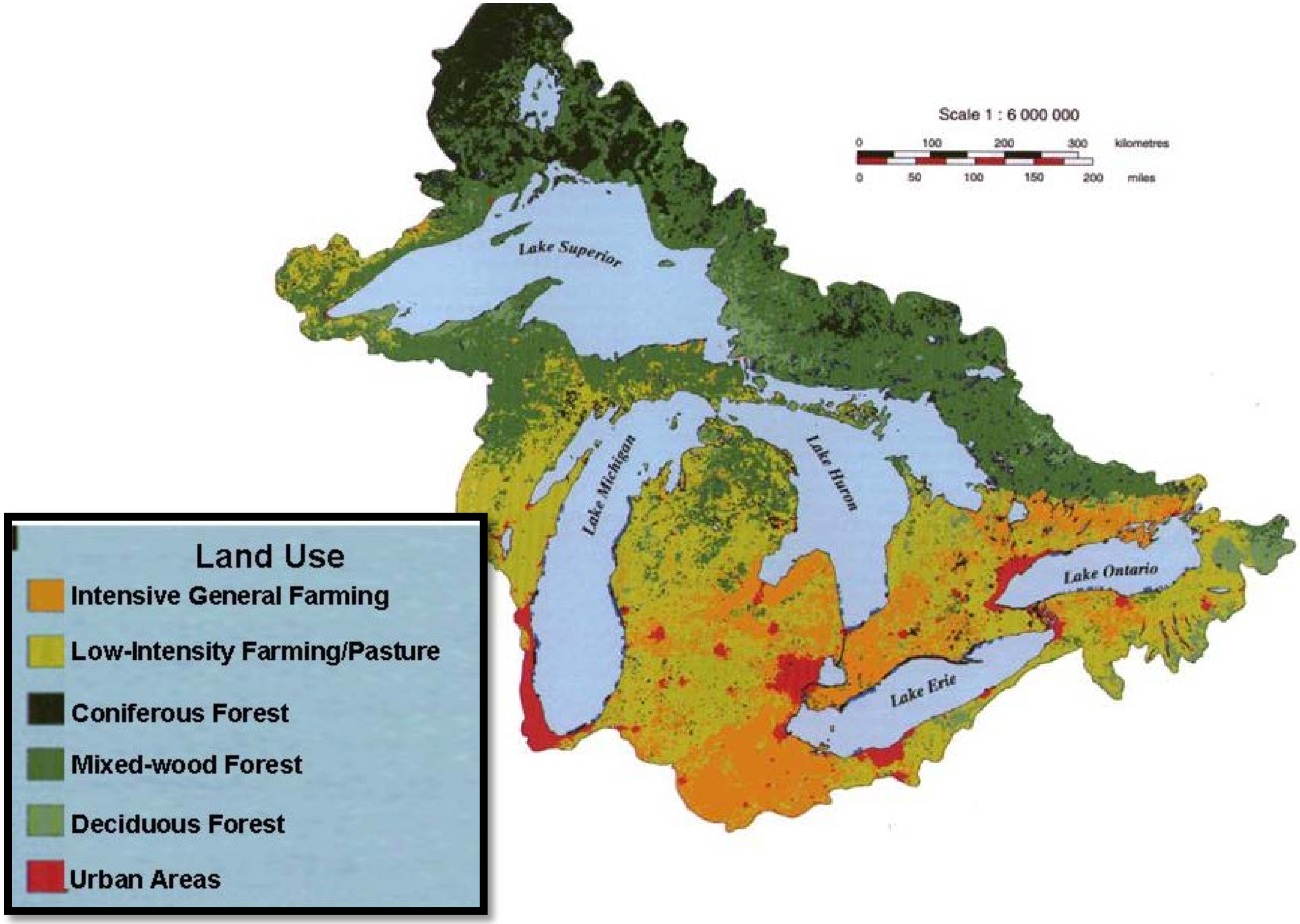
Blue-greens
(Cyanobacteria)

Source: Tom Bridgeman, UT

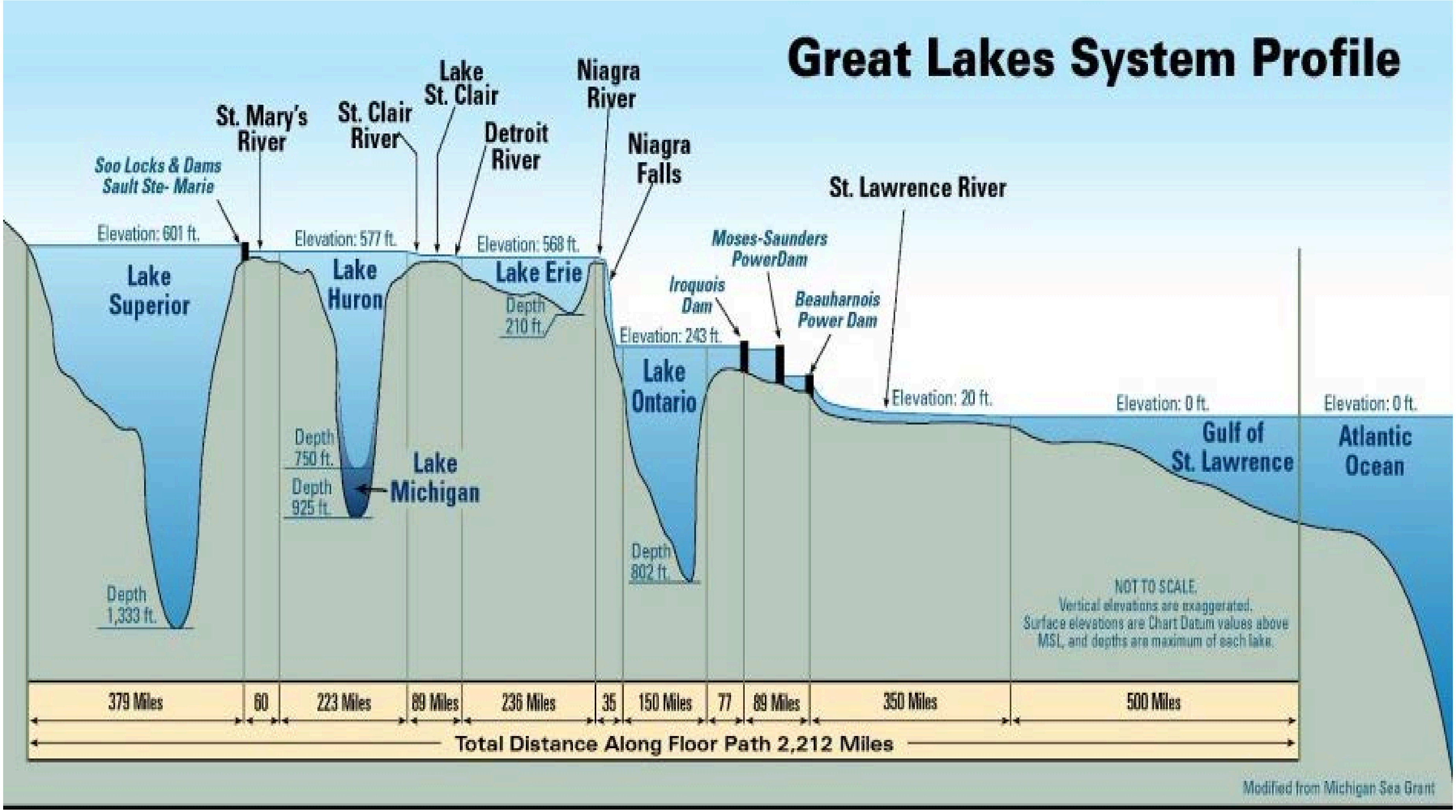
HAB Requirements

- Warm Water
- High concentration of Phosphorus
- High concentration of Nitrogen also helps

Southernmost



Shallowest and Warmest



Discuss 3 Basins & Retention Time

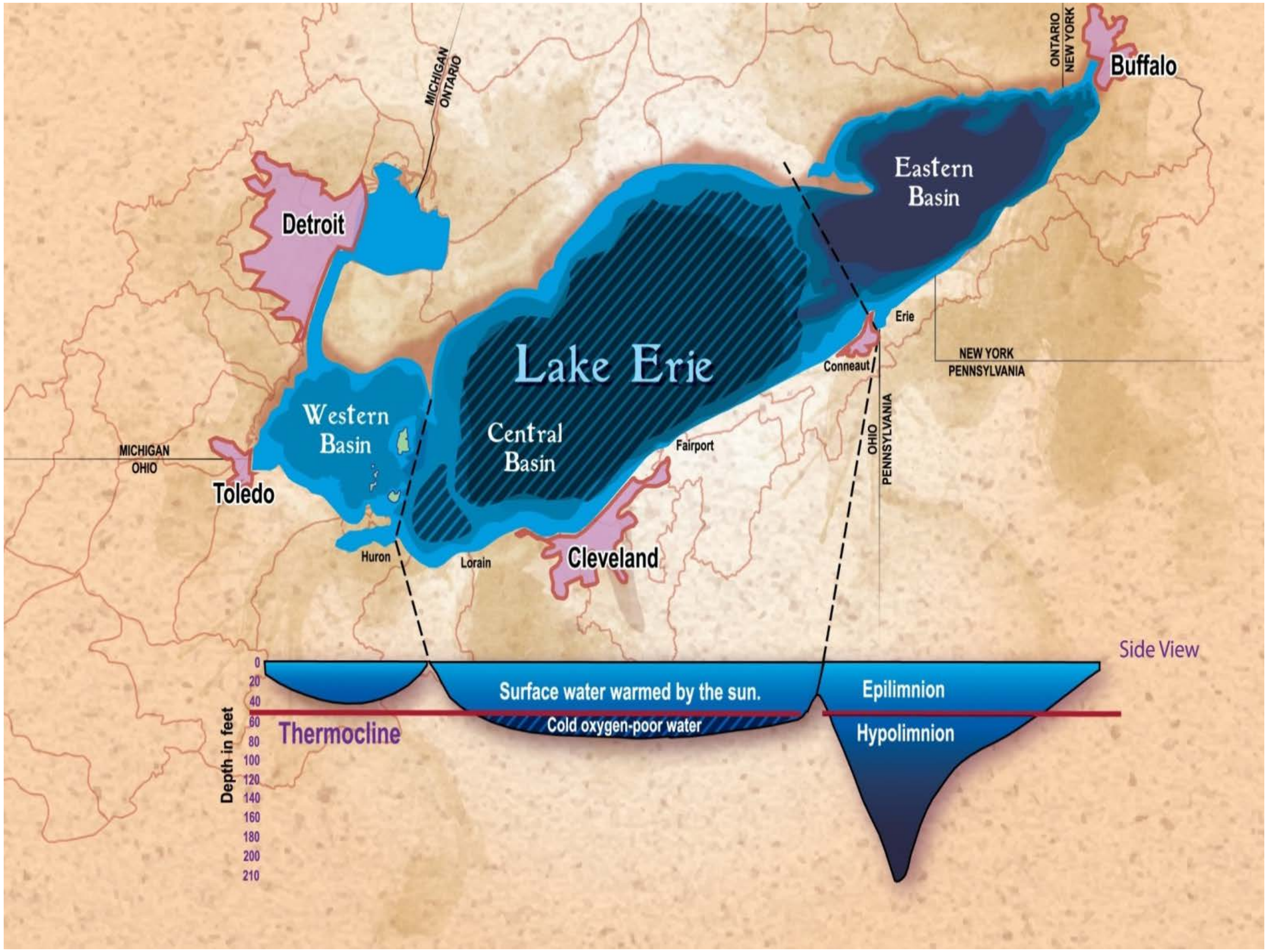
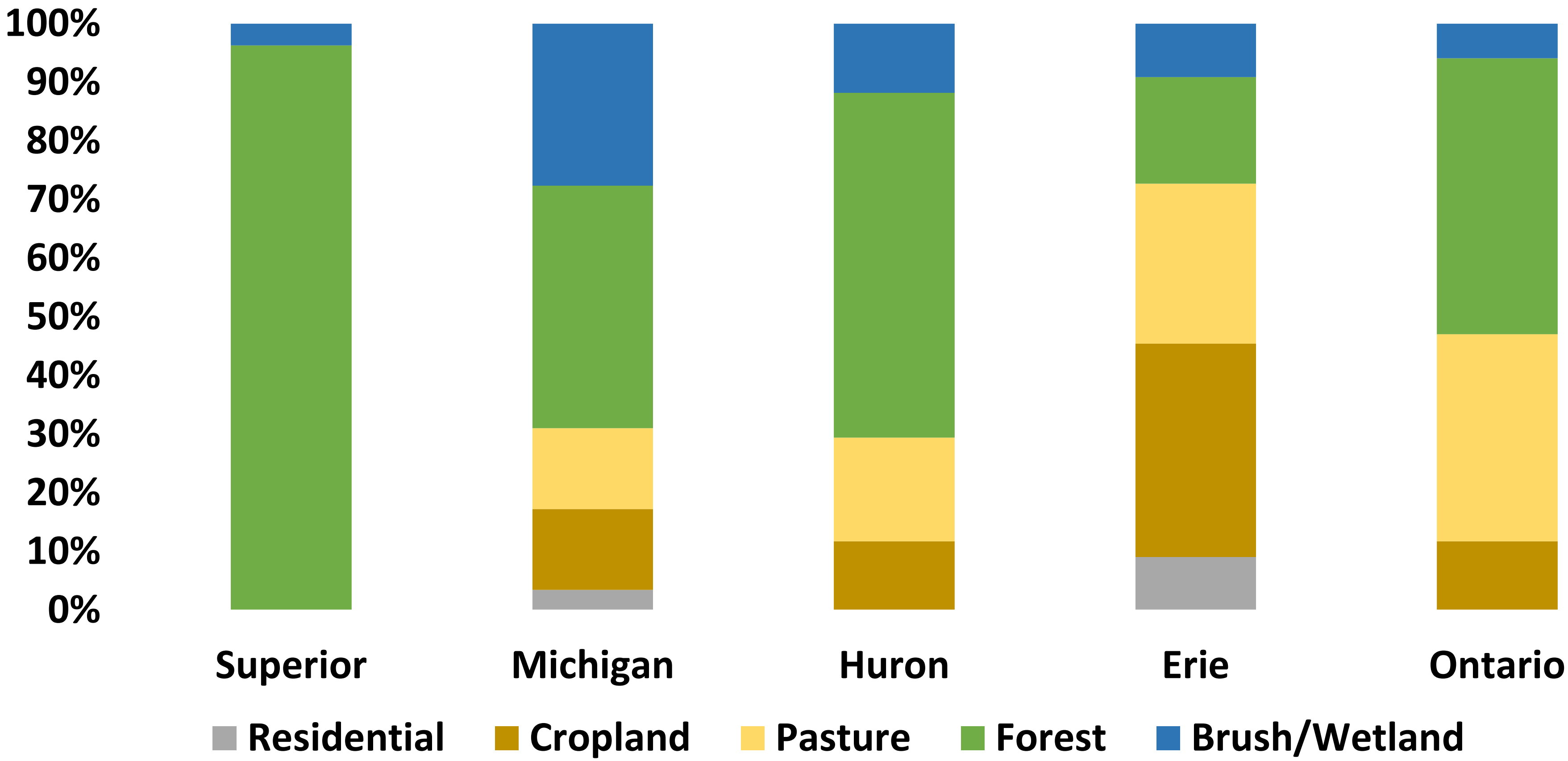


Photo: Ohio Sea Grant

Major Land Uses in The Great Lakes



Blue-green Algae Bloom circa 1971, Stone Lab, Lake Erie

Photo: Forsythe and Reutter

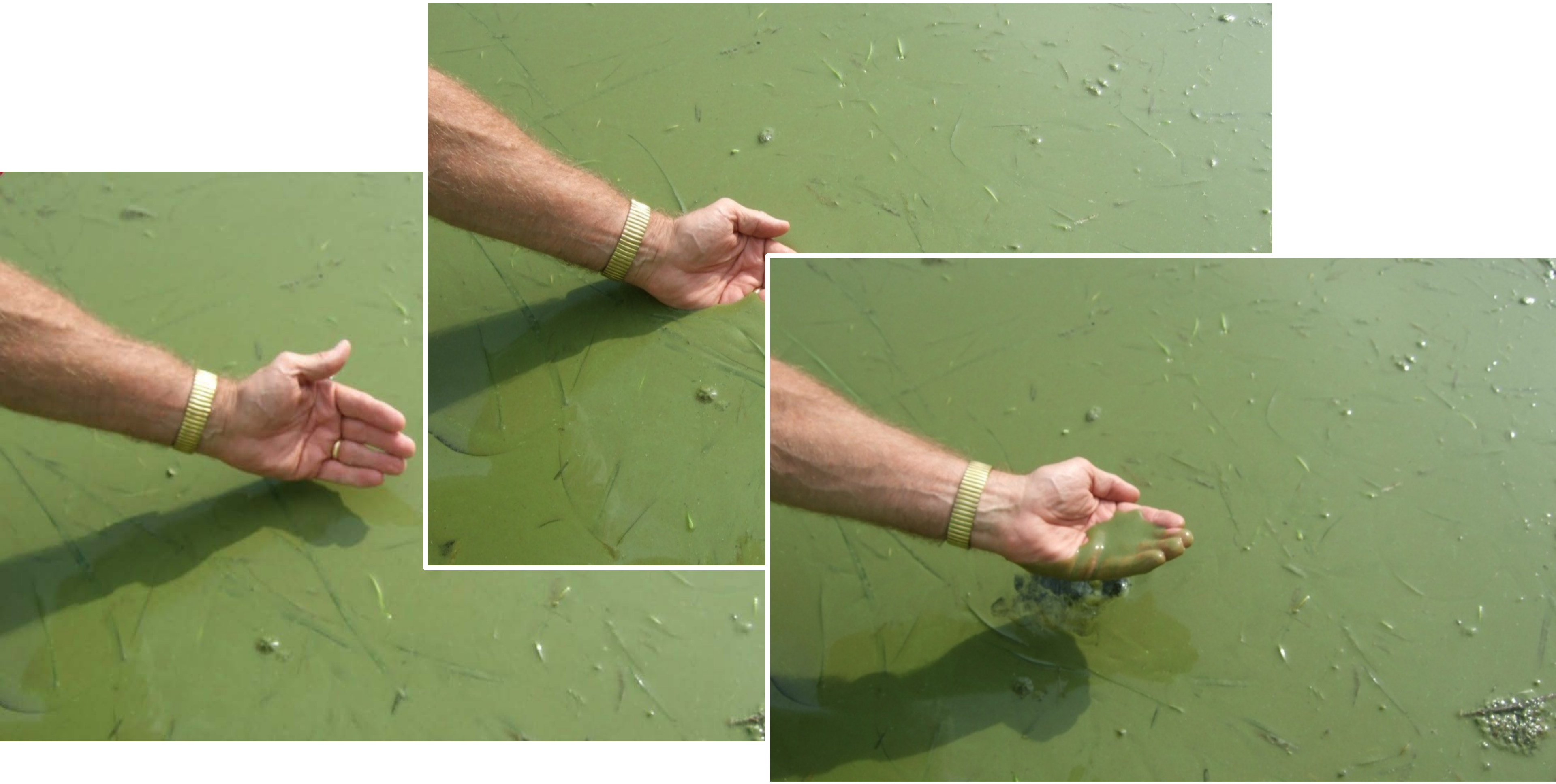
What brought about the rebirth (dead lake to Walleye Capital)?

- Phosphorus load reductions
  - Primarily from point sources
  - 29,000 metric tons to 11,000
  - 62% reduction

Why did we target phosphorus?

- Normally limiting nutrient in freshwater systems
- P reduction is best strategy ecologically and economically
- Reducing both P and N would help
- In saltwater (Gulf of Mexico), N is normally the limiting nutrient

Microcystis, Stone Lab, 8/10/10



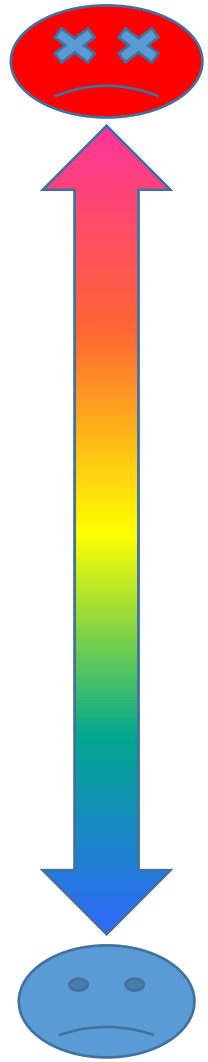
Photos: Jeff Reutter


October 9, 2011
Photo: NOAA Satellite Image

Microcystis, Stone Lab, 9/20/13

Toxicity of Algal Toxins Relative to Other Toxic Compounds found in Water

- **Reference Dose = amount that can be ingested orally by a person, above which a toxic effect may occur, on a milligram per kilogram body weight per day basis.**



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)

City of Toledo Drinking Water Advisory and Ohio EPA Response to Harmful Algal Blooms

Ohio EPA

Harmful Algal Bloom Impacts to Lake Erie Public Water Systems

There are 25 public water systems serving a combined population of over 2.6 million people that use Lake Erie as their source water. 10 in the Western Basin and 13 in the Central Basin

Chronology:
City of Toledo “Do Not Drink” Advisory

<u>August 1, 2014</u>

- **6:30 pm – Ohio EPA was notified by City of water testing results for microcystin above the drinking water advisory threshold.**
  - **Consistent with State response strategy a second set of samples collected to confirm results.**

- **11:00 pm – Additional samples confirm presence of microcystin above drinking water advisory threshold.**

- **We suspect a sudden spike in the bloom, possibly in combination with an unusual amount of extracellular toxin in the Lake, overwhelmed the water treatment plant before they could adjust treatment.**

OhioEPA

Chronology: City of Toledo "Do Not Drink" Advisory

August 2, 2014

- 12: 00 am - Ohio EPA recommends Toledo issue a "Do Not Drink Advisory"
- 2:00 am - City of Toledo issues advisory for all users of City of Toledo Water (nearly 500,000 people)
- 5:00 am - Ohio Emergency Operations Center activated
- 10:00 Governor Kasich Declares state of emergency for Wood and Lucas Counties
  - Fulton County later added

OhioEPA

Chronology:
City of Toledo "Do Not Drink" Advisory

August 3, 2014

- **4:00 pm – Ohio EPA, City of Toledo, U.S. EPA and other water quality experts reach consensus on sample collection, handling, and testing protocols.**

- **Additional samples collected and analyzed using consensus method by Ohio EPA, U.S. EPA and City of Toledo.**
  - **All results below threshold except two sample results that were near the threshold.**
  - **Decision to collect additional targeted samples**

Ohio EPA

Chronology:
City of Toledo "Do Not Drink" Advisory

August, 4, 2014

- **9:00 Ohio EPA and City discuss additional results**
  - **All within acceptable levels**
  - **Ohio EPA recommends lifting the advisory**

- **9:35 Mayor announces decision to lift advisory**

OhioEPA

Ohio Harmful Algal Bloom Strategy

- **Ohio EPA began sampling for algal toxins at public water systems in 2010**

- **Ohio EPA worked with Ohio Department of Health of Dept. of Natural Resources to establish a State of Ohio HAB Response Strategy in early 2011**
  - Standardized definitions, sample collection procedures, algal toxin thresholds, and public notice language

- **Drinking Water HAB Response Strategy updated annually**

Algal Toxin Sampling at Public Water Systems

- **There are No National Standards for Cyanotoxins**
- **Public Water Systems are Not Required to Monitor**
- **Ohio EPA Samples Public Water Systems for Algal Toxins based on Presence of a Bloom**
- **Ohio EPA Encourages Public Water Systems to establish their own monitoring Capability**

Ohio EPA Algal Toxin Thresholds

Threshold (ug/L)	Microcystin*	Anatoxin-a	Cylindrospermopsin	Saxitoxin
Do Not Drink- All consumers	**1 - 20**	**20 - 300**	**1 – 20**	**0.2 - 3**

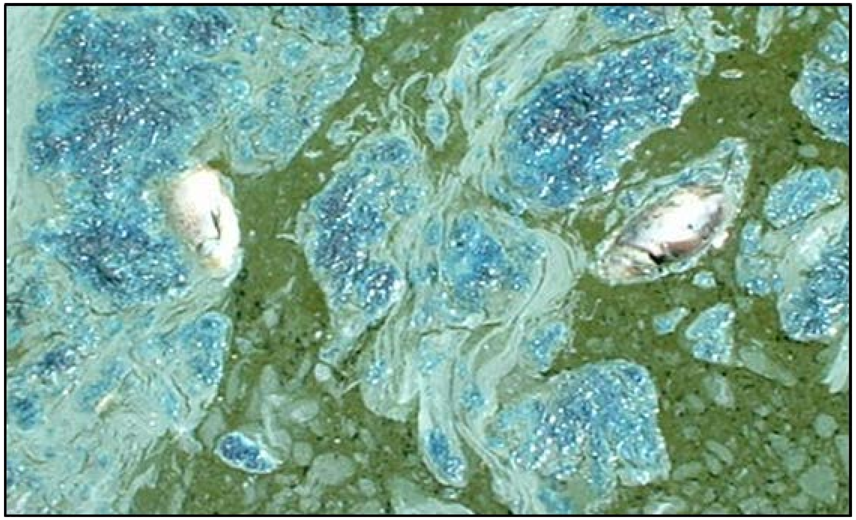
Microcystin threshold based on World Health Organization Guideline

- **Additional considerations**
    - **Newer Studies**
    - **Sensitive sub-populations**
        - **Infants, children, & individuals with liver damage**

Ohio EPA

Drinking Water Adverse Impacts

- Toxin production
- Taste and odor problems
- Increased organic carbon load
- Dissolved oxygen dips
- Nuisance
- Costs to Communities



Examples of Economic Impacts of Algae to Public Water Systems

- **Toledo: historically <u>$200,000/month</u> on carbon treatment.**
- **Carroll Township: <u>$250,000</u> new ozone treatment**
- **Celina: <u>$7.2 million</u> new treatment and ~<u>$500,000/year</u> on carbon & ozone**
- **Columbus: $820,000 responding to 2013 bloom**

OhioEPA

On-Going Efforts

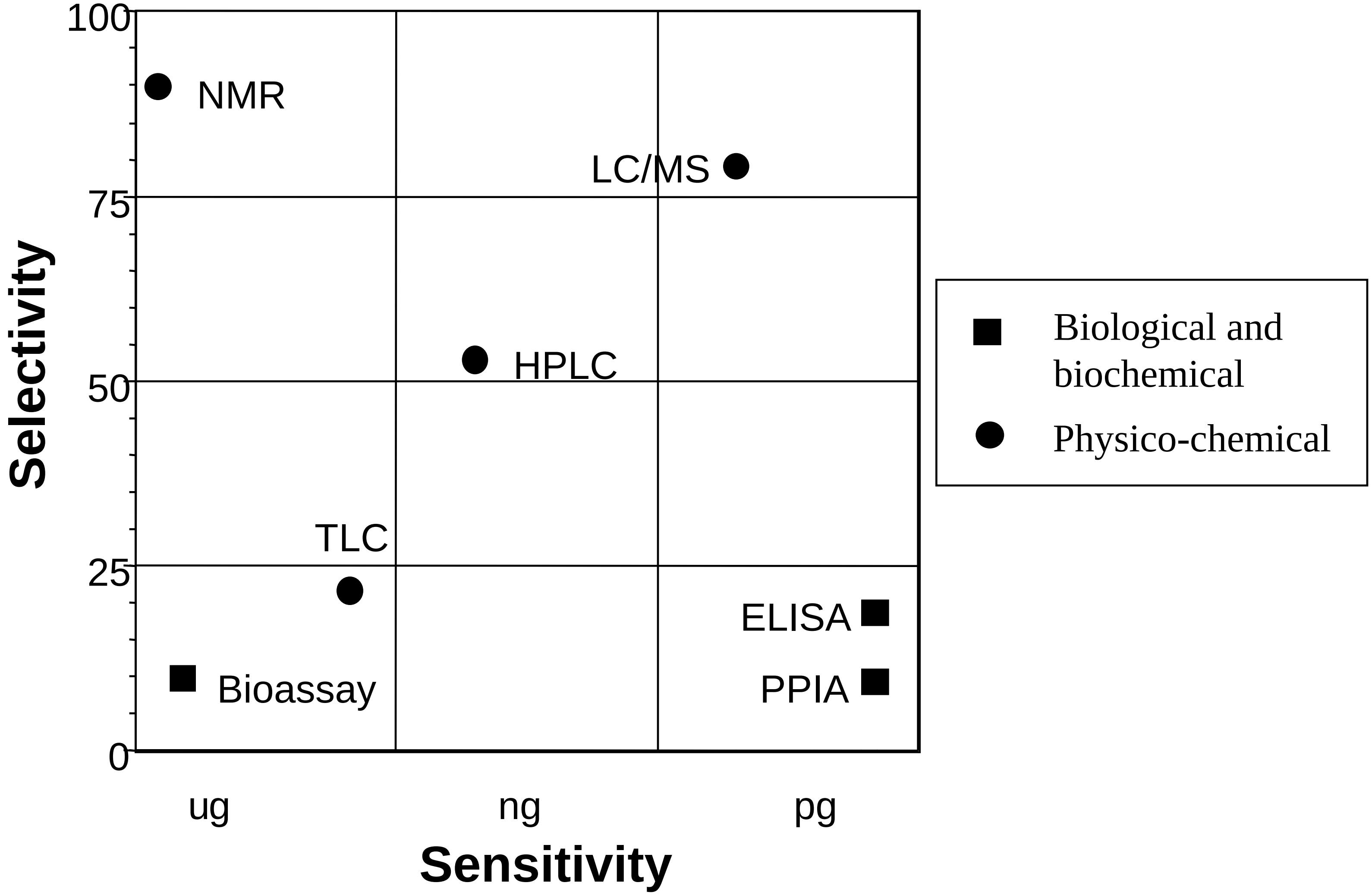
- Routine Outreach and Technical Assistance to Public Water Systems (including sampling)
- Continue working with U.S.EPA and public water systems on analytical methods and cyanotoxin treatment (focus on Lake Erie PWSs).
- Funding
  - One Million Dollars for Laboratory Equipment and Training
  - $50 Million in 0% Interest Loans for Infrastructure Improvements to Address HABs
  - $100 Million in 0% Interest Loans for Waste Water Treatment Plant improvements to Remove Phosphorous

OhioEPA

Karen Sklenar, PhD

The Cadmus Group

Selectivity and Sensitivity Relationships between Analytical Methods for Microcystins



Treatment Process	Relative Effectiveness
Intracellular Cyanotoxins Removal (Intact Cells)	
Pretreatment oxidation	Avoid pre-oxidation that lyses cells; removing intact cells is: 1) more cost effective than chemical inactivation/degradation; 2) removes a higher fraction of DBP precursors; 3) removes a higher fraction of intracellular taste and odor compounds; and 4) it is easier to monitor removal.
Coagulation, Sedimentation and Filtration	Effective for the removal of intracellular/particulate toxins.
Membranes	Microfiltration and ultrafiltration are effective at removing intracellular/particulate toxins. Typically, pretreatment is used.
Flotation	Flotation processes, such as Dissolved Air Flotation (DAF), are effective for removal of intracellular cyanotoxins since many of the toxin-forming cyanobacteria are buoyant.

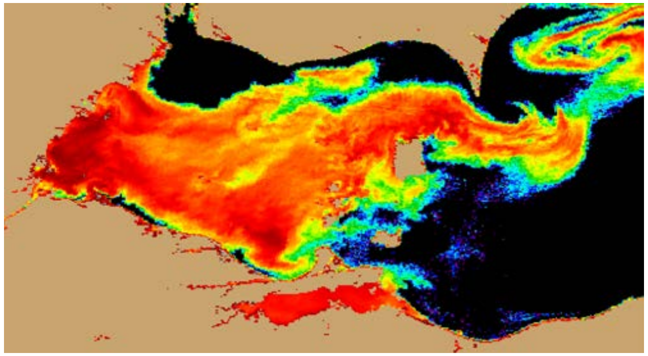
Treatment Process	Relative Effectiveness
Extracellular Cyanotoxins Removal	
Membranes	Typically, nanofiltration has a molecular weight cut off of 200 to 2000 Daltons; individual membranes must be piloted to verify toxin removal. Anatoxin-a has a molecular weight of 165 Daltons. Reverse osmosis is effective.
Potassium Permanganate	Effective for oxidizing microcystins and anatoxins. Not effective for cylindrospermopsin and saxitoxins.
Ozone	Very effective for oxidizing extracellular microcystin, anatoxin-a and cylindrospermopsin.
Chloramines	Not effective
Chlorine dioxide	Not effective with doses typically used for drinking water treatment.
Chlorination	Effective for oxidizing extracellular cyanotoxins as long as the pH is below 8, ineffective for anatoxin-a
UV Radiation	Effective at degrading toxins but at impractically high doses
Activated Carbon	PAC/GAC: Most types are generally effective for removal of microcystin, anatoxin-a, saxitoxins and cylindrospermopsin. Because adsorption varies by carbon type and source *water* chemistry, each application is unique; activated carbons must be tested to determine effectiveness. Mesoporous carbon for microcystin and cylindrospermopsin. Microporous carbon for anatoxin-a.

Don Scavia, PhD

GRAHAM INSTITUTE

Federal Activity on HABs, Hypoxia: Harmful Algal Bloom and Hypoxia Research and Control Amendments Act of 2014

- Reauthorized in June 2014; NOAA lead (main)
- Authorizes Interagency Task Force on Harmful Algal Blooms and Hypoxia
- Great Lakes Hypoxia and HABs
  - Integrated assessment to be prepared by end of 2015
  - Plan for reducing, mitigating, controlling



Microcystis bloom, Lake Erie, Sept. 3, 2011
GLERL, MERIS data

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Other Federal Activities Relevant to HABs, Hypoxia

- **Great Lakes Restoration Initiative**: includes funding of nonpoint source reduction projects, wetland restoration
- **Farm Bill**: includes Regional Conservation Partnership Program

NRCS

- Need to utilize science to increased targeting of projects, maximize effectiveness

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Other Federal Activities Relevant to HABs, Hypoxia

- **<u>Safe Drinking Water Act</u>**: Cyanotoxins considered for addition list of contaminants regulated in CCL3
- **<u>Clean Water Act: Waters of the U.S. rule</u>**: Clarification of scope of CWA, implications for wetlands
- **<u>Clean Water Act, Total Maximum Daily Loads:</u>** Potential lessons from Chesapeake Bay

NRCS

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Binational Approach, Climate Considerations

- **Great Lakes Water Quality Agreement**: Annex 4 process underway
- **IJC Lake Erie Ecosystem Priority:** 2014 synthesis report, included recommendations on load reductions
- **State/provincial commitment**

NRCS

- **Climate change HABs, hypoxia:** increased risks of more intense spring storms, increased nutrient loads, longer HABs, hypoxia

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Phosphorus Task Force II Recommendations (IJC similar)

- **~40% reduction in P loading (Ohio Phosphorus Task Force II, 3/14/13)**
- **This amount would be different in other locations around the country.**

How Long Will Recovery Take?

- Due to short retention time for water in Lake Erie (~2.7 years) and shorter time in the Western Basin (20-50 days), recovery will be almost immediate if P loading is reduced.
- Important to transfer what we learn in solving Lake Erie problem to other locations where recovery would take much longer.

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