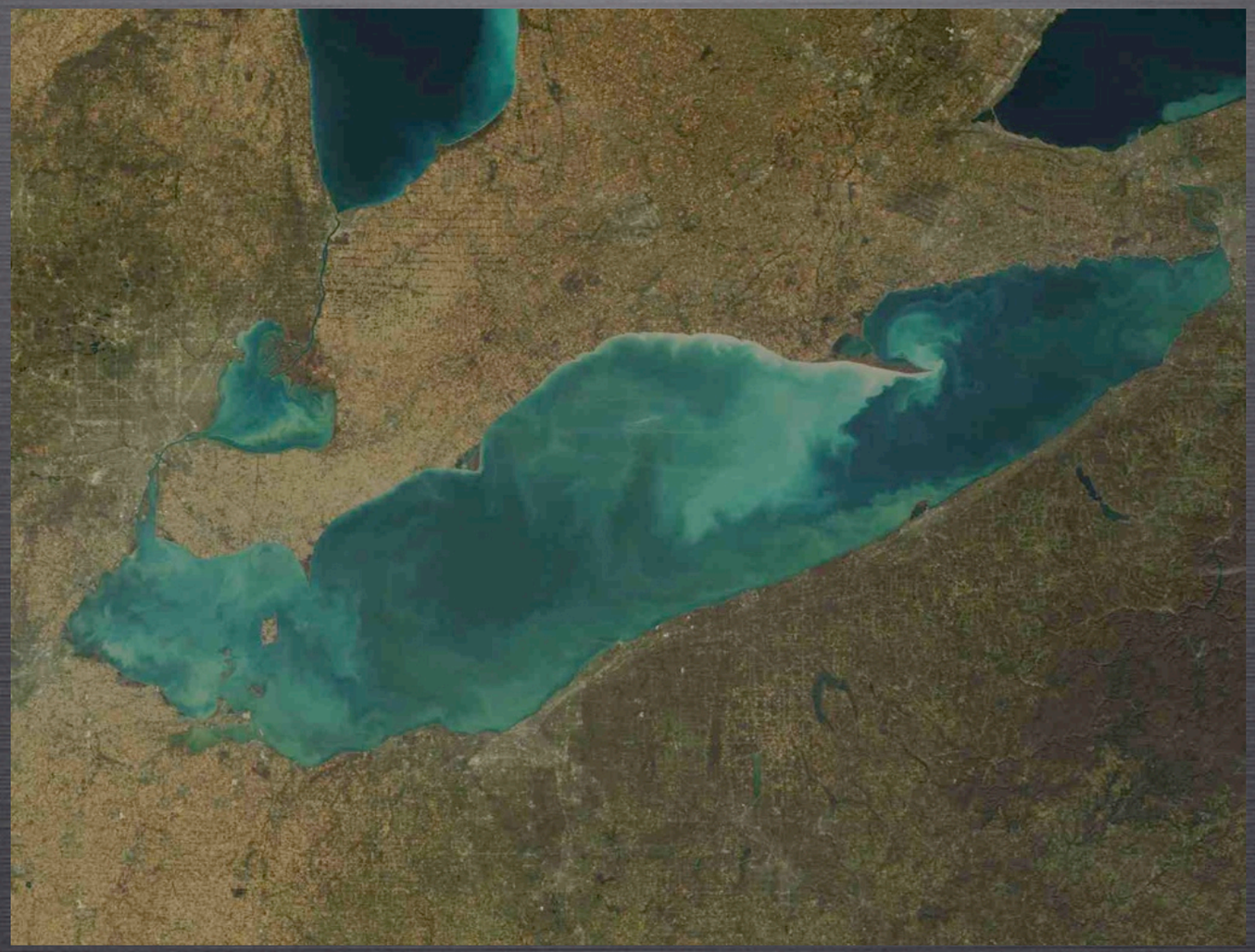
Phosphorus and Blue-Green Algal Blooms

Western Lake Erie Basin

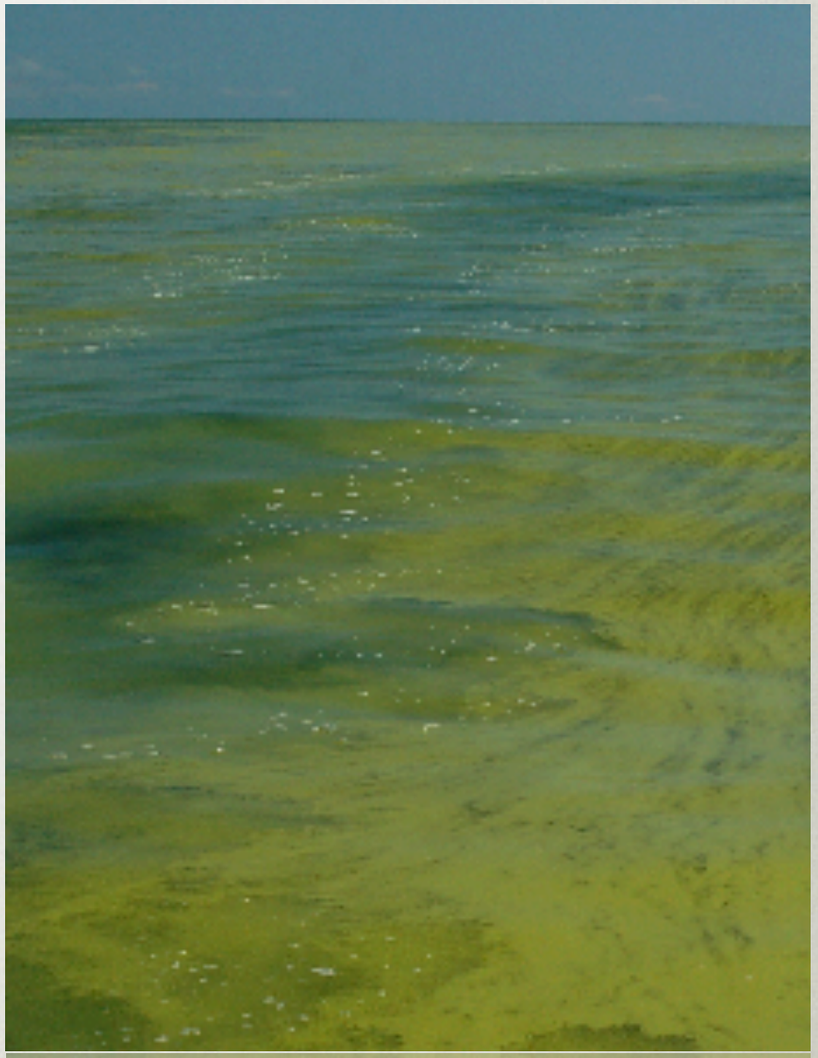


Algal Issues Workshop: November 10, 2009

Lake Erie HABs
Recent History

- 1960s-1980s *Anabaena* and *Aphanizomenon*
- 1985 - 1995 reduction in algal blooms (total phosphorus (TP) reductions, *dreissenid* invasion, higher lake levels, lower tributary flows)
- Resurgence in toxic *cyanobacterial* blooms, especially *Microcystis*, have been observed in the **lower Great Lakes** over the last decade in areas where total phosphorus (TP) levels are below historically high levels and meeting set goals (Mederious, 2006)
- 1995 - *Microcystis aeruginosa* blooms began to occur in the western basin and recurred with varying intensity through... 2001.

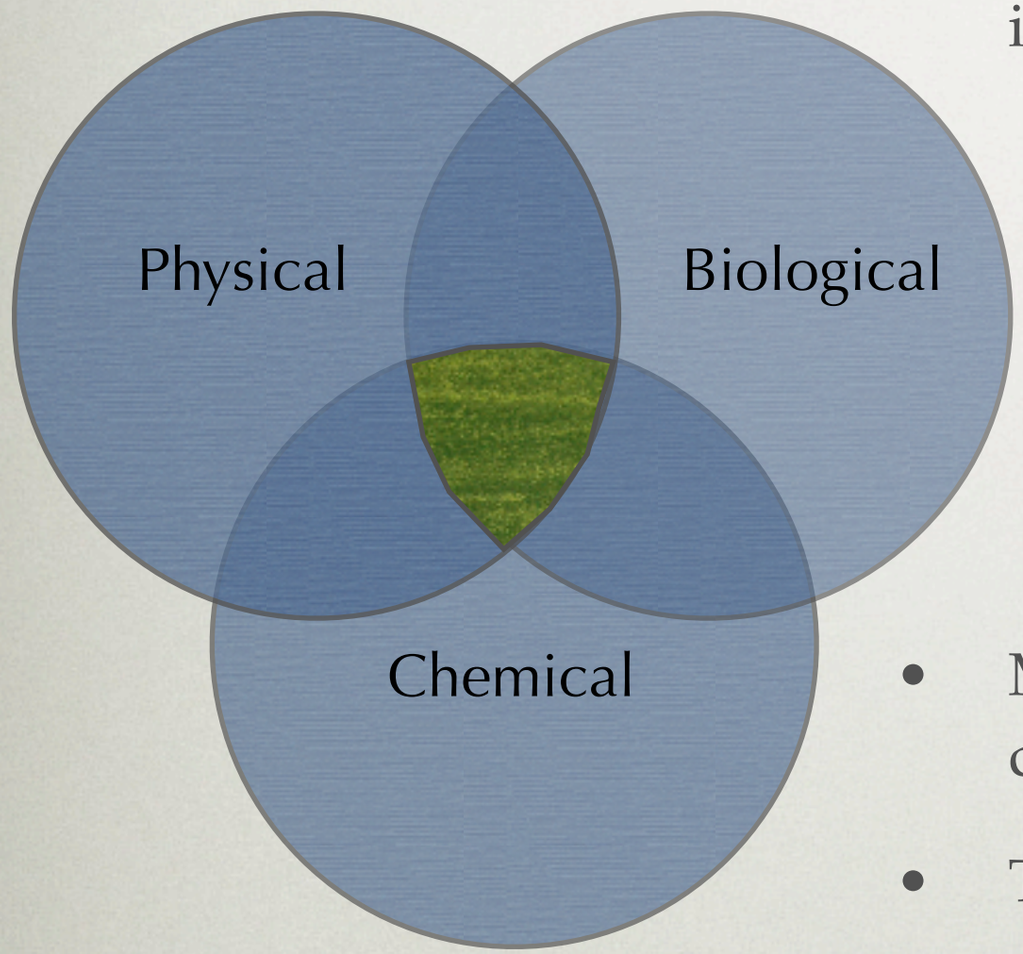
2009, Randy Sanders



Lake Erie HABs
Recent History

- 2002 - No major algal blooms, lower tributary flows
- August 2003 - A massive bloom of *Microcystis* formed in the western basin and persisted for nearly a month.
- Blooms also occurred in 2004, 2005, 2006, with particularly extensive blooms in 2007 and 2008 (Bridgeman, 2008).
- 2006 - a benthic mat-forming blue-green algae tentatively identified as *Plectonema wollei* emerged in Maumee Bay and began fouling the shoreline in thick foul-smelling mats.
- Long-term trend of increasing discharge from major tributaries.

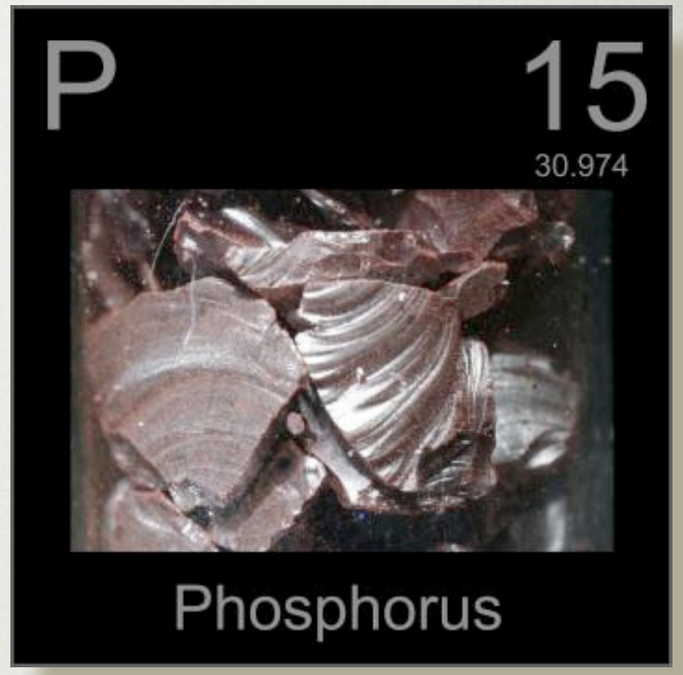
Lake Erie HABs
No Smoking Gun



- Causes for the increased abundance and apparent severity of HABs in the Western Basin of Lake Erie are influenced by...
  - Physical (light, temperature, lake levels, turbidity, anoxia, tributary discharge)
  - Biological (preferential adaptability, *dreissenids, phytoplankton competitiveness*)
  - Chemical (CO_2, phosphorus, nitrates, iron)
- Most likely a combination of all three, but what is controllable?
- Turbidity and dissolved reactive phosphorus.

Phosphorus

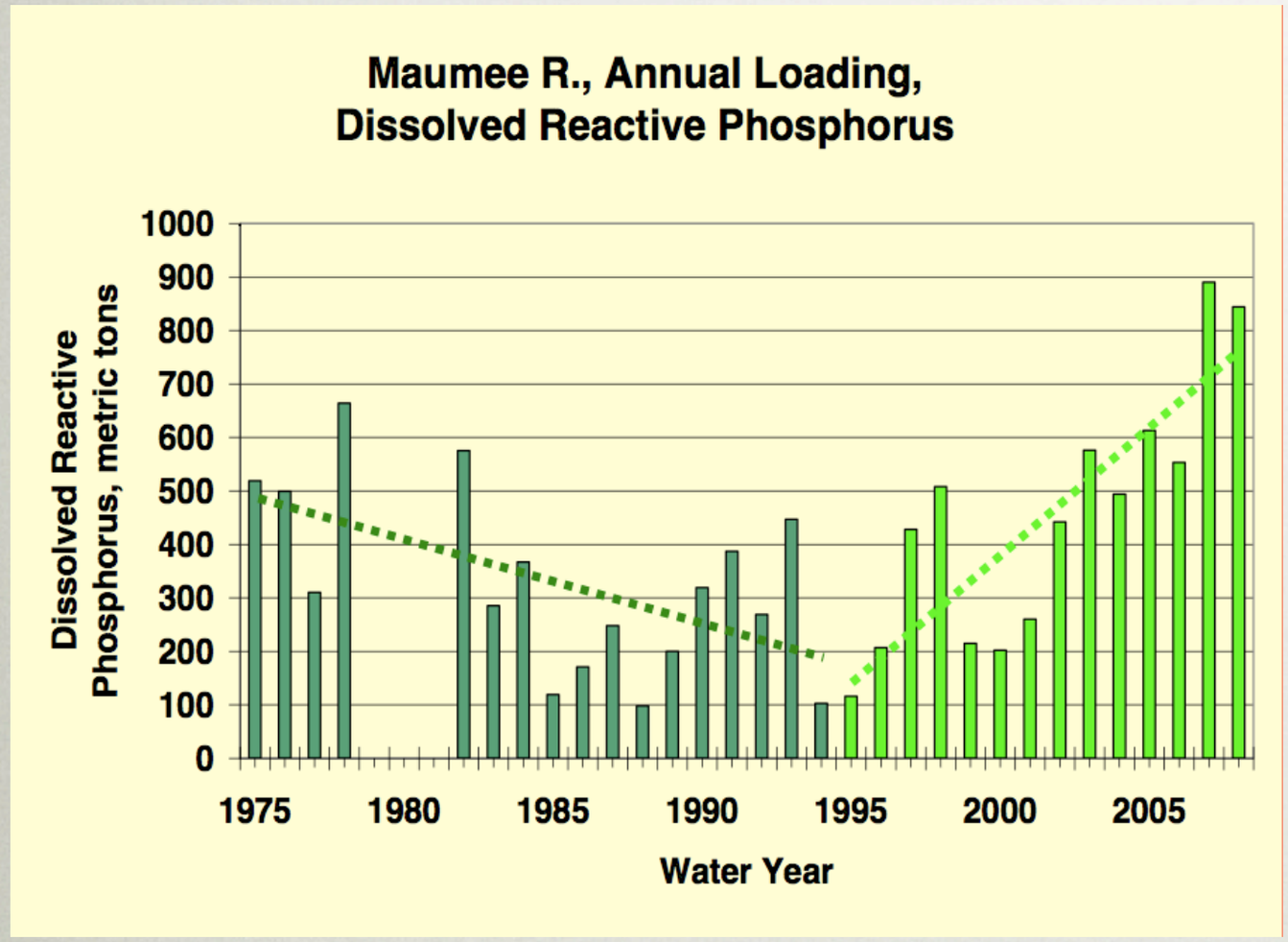
- Great Lakes WQA 1972 and Annex 3 (1978)
- Limiting nutrient for algal growth in freshwater systems
- Implicated phosphorus as primary cause of nuisance algal growth phosphorus concentrations "…should be limited to the extent necessary to prevent nuisance growths of algae, weeds and slimes that are or may become injurious to any beneficial water use."



- "year-round anaerobic conditions in bottom waters of the central basin of Lake Erie"
- Initiated efforts to reduce phosphorus loads
- Established targets phosphorus loads (11,000 metric tons) to control eutrophic conditions.

Phosphorus

Dissolved Reactive - Heidelberg University

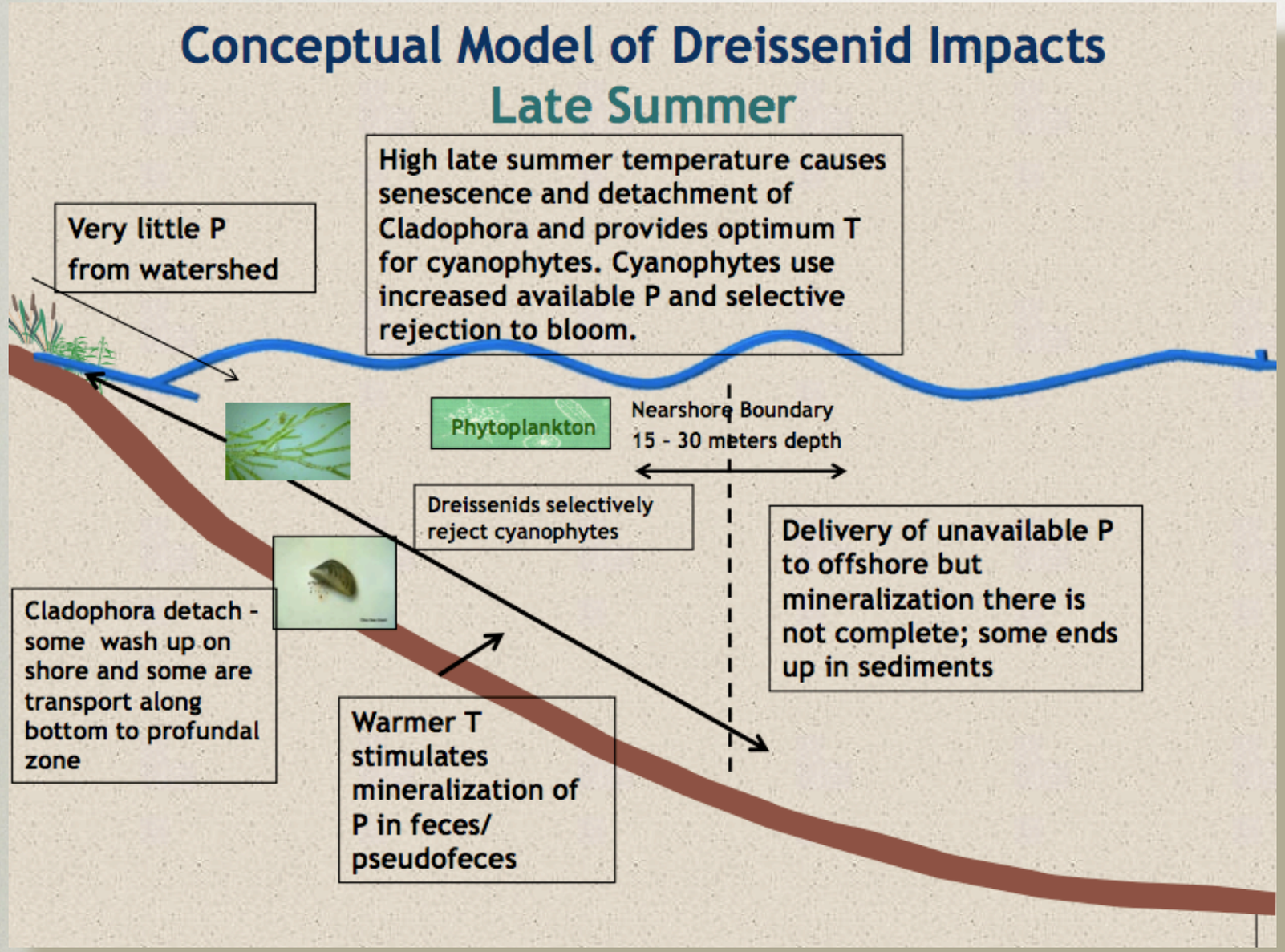


- Total Phosphorus (TP) has seen a steady decline over the past 30 years. Sediment loads, Agricultural BMPs.
- DRP has seen a stark increase over the past 15 years.
- Highest DRP loads from the Maumee to Lake Erie occur during early spring melt and runoff. (Rain on snow on exposed soil/enriched soil)
- However, Microcystis algal blooms generally occur in mid to late summer (Bridgeman, 2007)

Disconnect

Phosphorus

internal lake cycling

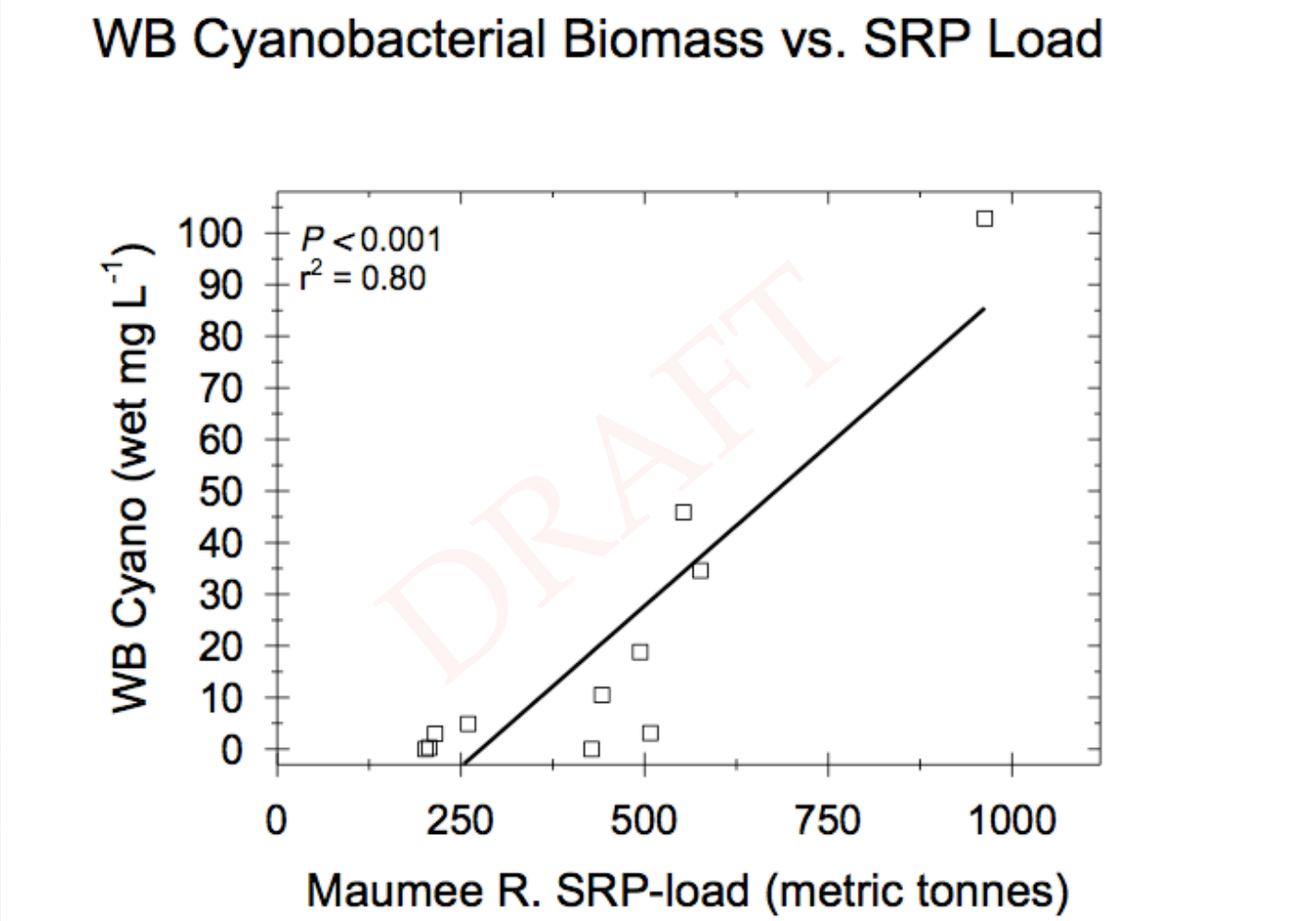


Joe DePinto, LimnoTech

- Anoxia releases P into water column.
- Re-suspension of TP sediment during wind/wave/lake storms. Causing physical and microbial release of DRP.
- Biological facilitated release of DRP and *microcystis*

Phosphorus

Ohio Phosphorus Task Force



Data are from ODNR's Lake Erie monitoring program. (Analysis by D. Kane, Alliance College).

- Initiated by OhioEPA (University, State Agencies, Federal)
- Causes of increased DRP loads?
  - Management of commercial fertilizers.
  - Management of animal waste.
  - Soil compaction in no-till soybeans.
  - Soil P build-up.
- Management recommendations and research needs.

Lake Erie Monitoring

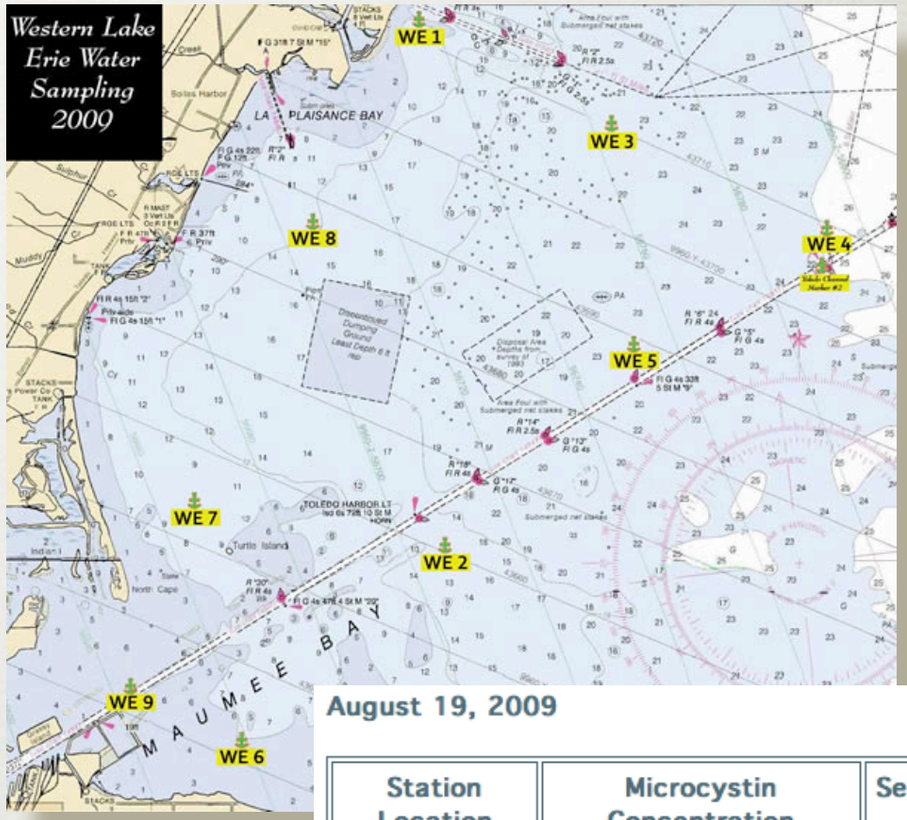
University of Toledo

- Frequent sampling May through October every 10 days to two weeks.
- Relationship to total and dissolved nutrients, DO, pH, turbidity.
- Timing with Maumee Runoff events. Nutrient loads and sedimentation.
- *Microcystis* Buoyancy and competition.
- Seasonal decline in available nitrogen leads to a transition from *Microcystis* to *Aphanizomenon*.
- Interaction with sediment turbidity, Maumee vs. re-suspension. Anecdotal, no “cause and effect” yet.

Lake Erie Monitoring

NOAA

- Event response research program.
- 5 GL sites plus western Lake Erie.
- Determine the factors controlling microcystin production and to develop methods for determining the location and extent of blooms from satellite imagery.
- Identification of a 'probable bloom' on the satellite image triggers sampling.
- Initial screening based on an ELISA technique for microcystin quantification.



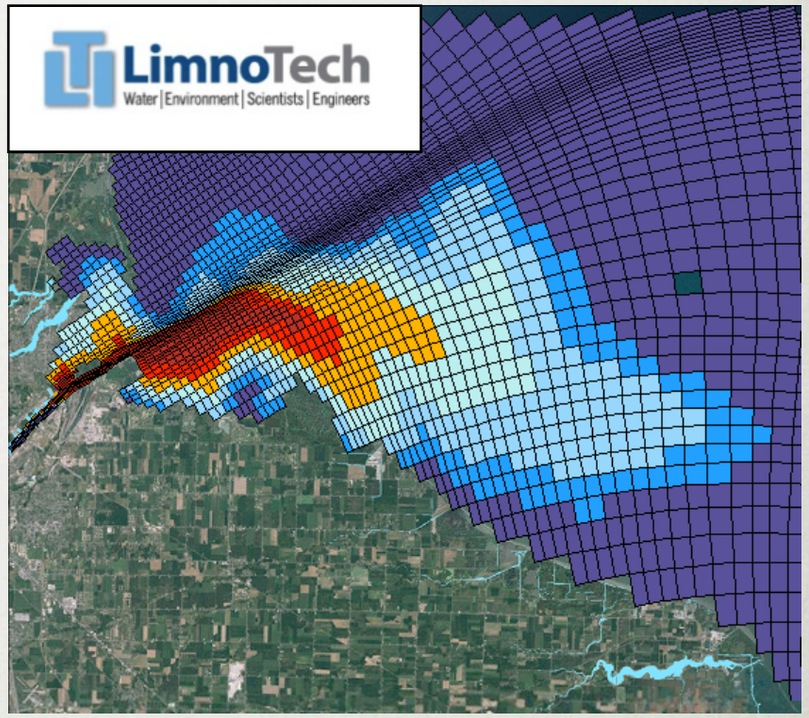
August 19, 2009

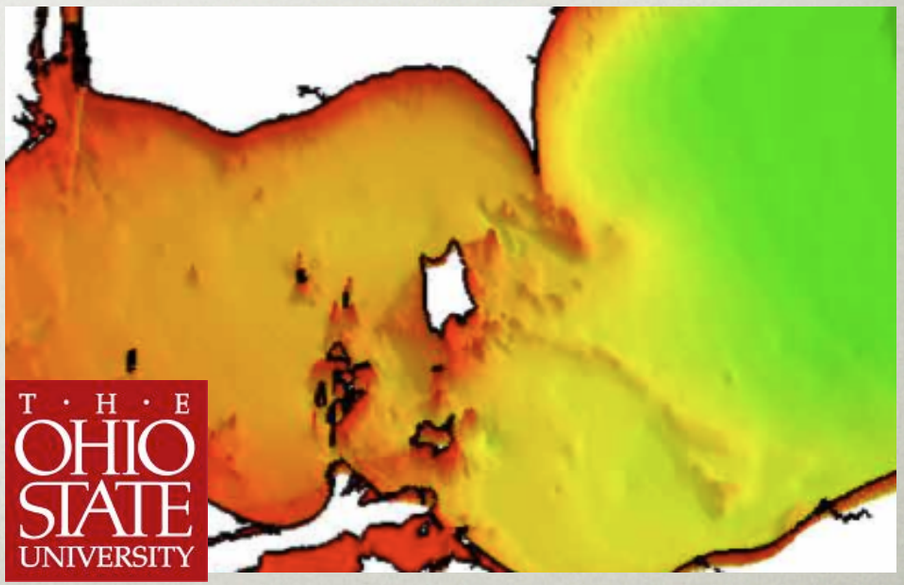
Station Location	Microcystin Concentration	Secchi	Temp
WE6	3.582861	0.5	16.6 C
WE7	1.266501	1.25	26 C
WE8	1.091985	2	25.6 C
WE9	2.731609	0.5	26.3 C
WE2	1.187344	1	25.9 c

Other Lake Erie Monitoring...

Lake Erie Models

- DiToro Eutrophication model
  - 1976 - Lake Erie process-based
  - Dynamic mass-balance of P, N, Si, DO, diatom and non-diatom chlorophyll, zooplankton
- LimnoTech Hydrodynamic
  - Quantify relationship between sources of sediment and nutrients to the system and aquatic ecosystem endpoints of concern:
    - Sedimentation in navigational channel
    - Microcystis blooms
    - Nearshore benthic algal blooms
- Dr. Ethan Kubatko, OSU
  - Finite-element grid to model the hydrodynamic lake characteristics wind, wave, water levels, water velocities, and water quality.





GLRI Proposal

USGS / Heidelberg / LimnoTech

- Link the land to the Lake.
- Relationship between tributary loads during storm events and open Lake algal blooms.
- Sampling based on hydrograph, lag-times.
- Late winter/early spring storm event (High DRP), mid-to-late summer storm event.
- Geochemical tracers... Maumee River, Detroit River and re-suspended sediments (Se and Cl)
- 23 miles of river downstream from Waterville, Maumee Bay, Open Lake. Field measurements, nutrients, major ions, chlorophyll a, *microcystis*, other blue-greens.