Great Lakes HABs Collaborative

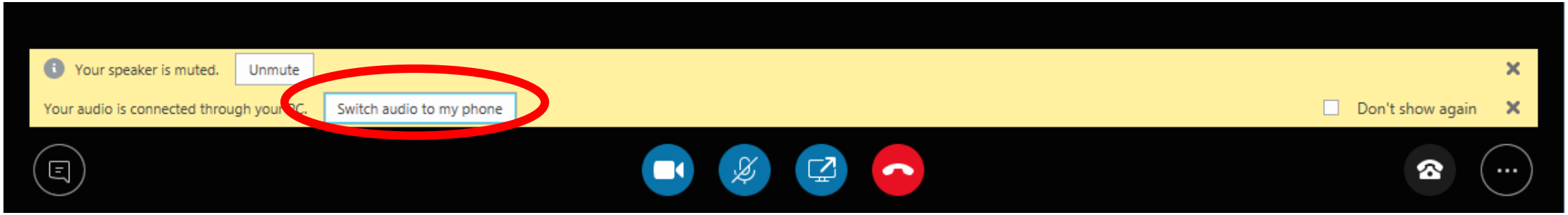
Linking Science and Management
to Reduce Harmful Algal Blooms

Lakewide Management, the Great Lakes Water Quality Agreement, & HABs

March 26, 2020

Webinar presented by the Great Lakes HABs Collaborative

Audio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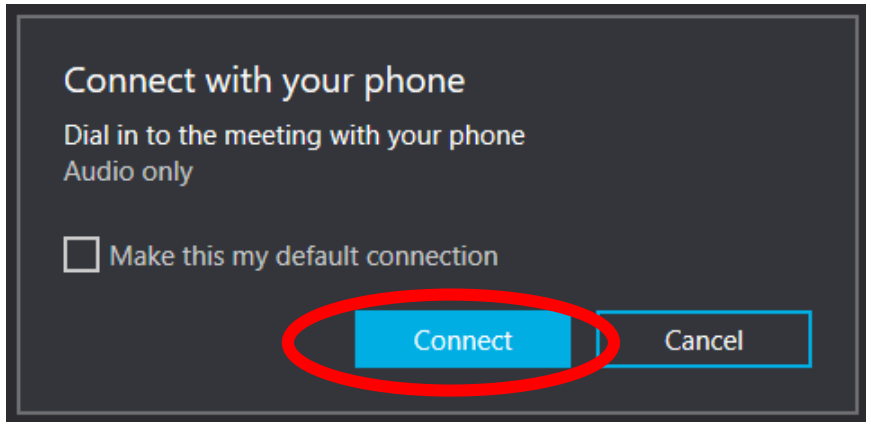
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Questions

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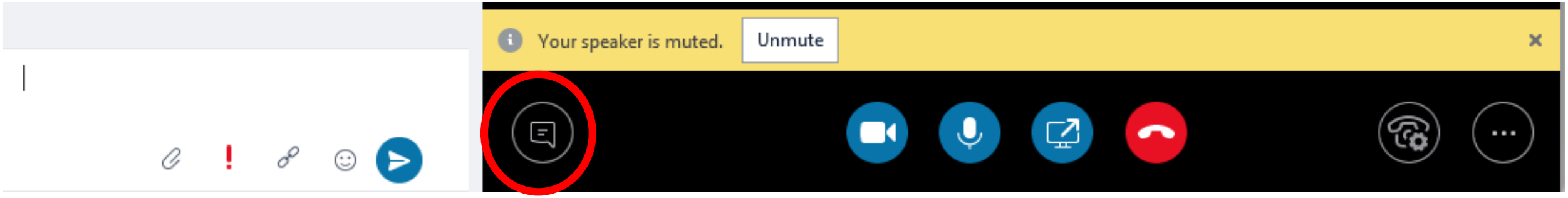
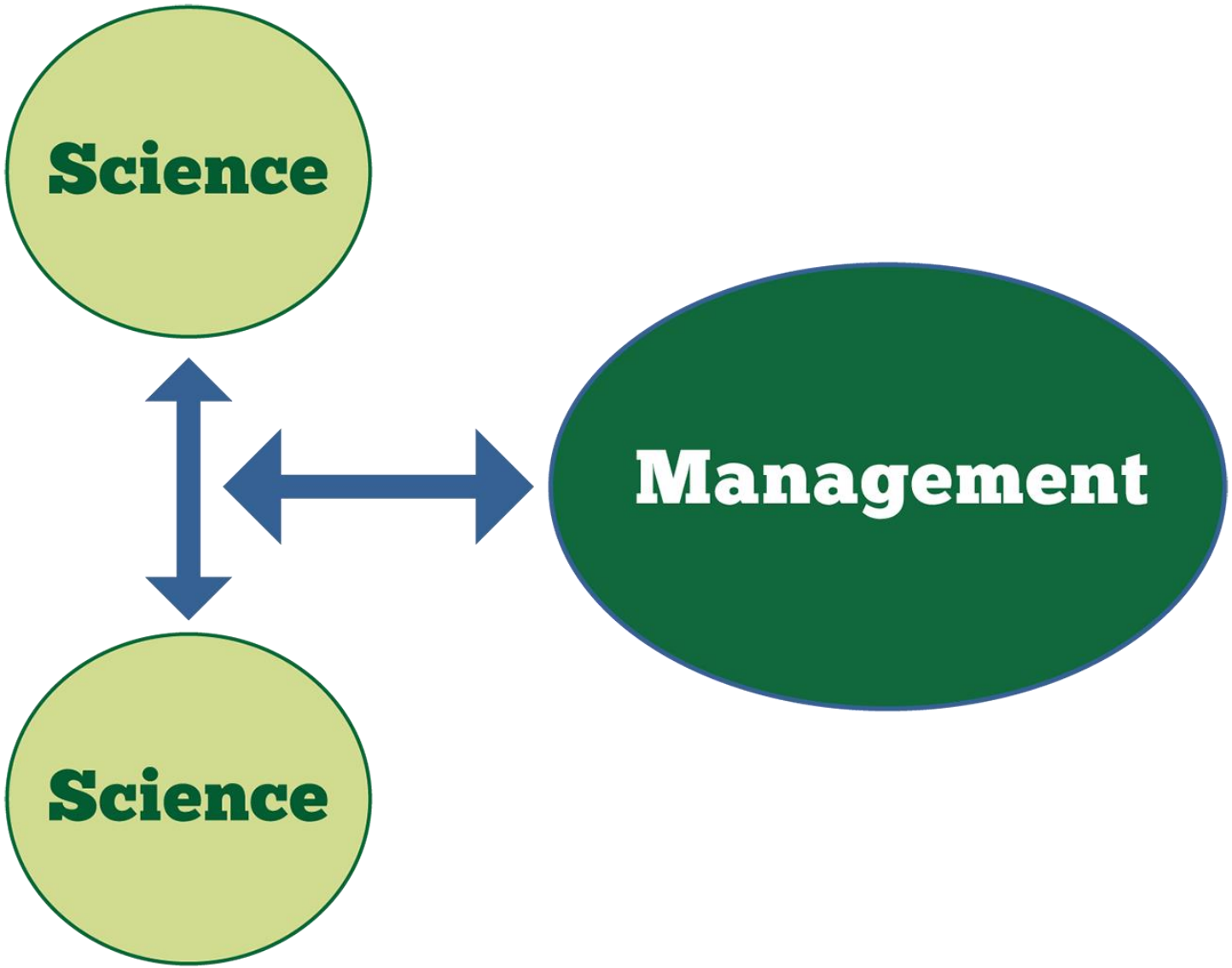
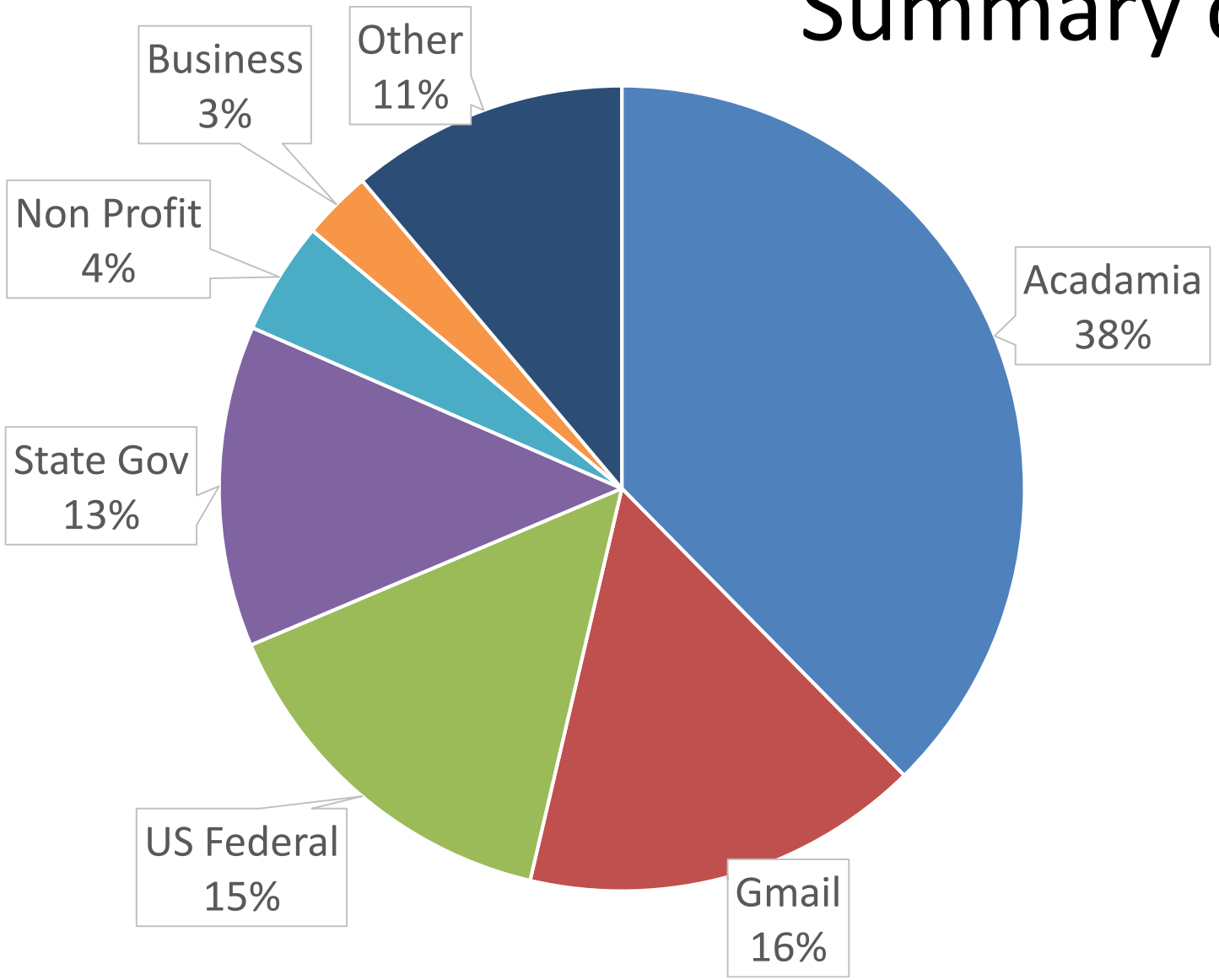



Science
Management
Science


Great Lakes Commission Staff Support
Interested Stakeholders (i.e. Listserv Members)
HABs Collaborative
Steering Committee
The Collaborative, with members identified by the Steering Committee, as needed, based on specific expertise

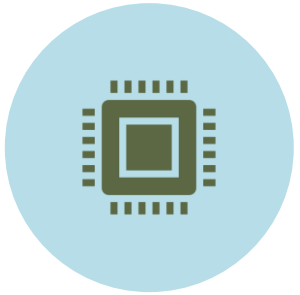
Summary of List Serv members



Other:

- GLC Staff
- Consultants
- Local Government
- Canadian Provincial and Federal
- Education (K-12)
- IJC
- Journalist
- Advocate
- Native Sovereign Nation
- SWCD
- Water Utility

Steering Committee (and Collaborative) Efforts



Webinars: Innovative technologies, LAMPs, & Interstate Technology Regulatory Council… plus one more?

Who Does What? fact sheet on Great Lakes governance structures and HABs

White paper on knowledge gaps (with context and prioritization, where possible)

Building a HABs Collaborative "Research Dashboard"

Stay Connected:

- Join the Listserv
  - Register for future webinars
  - Receive our quarterly newsletter
  - Provide feedback on draft products of the Collaborative (i.e. Fact Sheets and White Papers)

- Tweet with us

Looking ahead to Collaborative products:

1. Draft “Who Does What” Fact Sheet

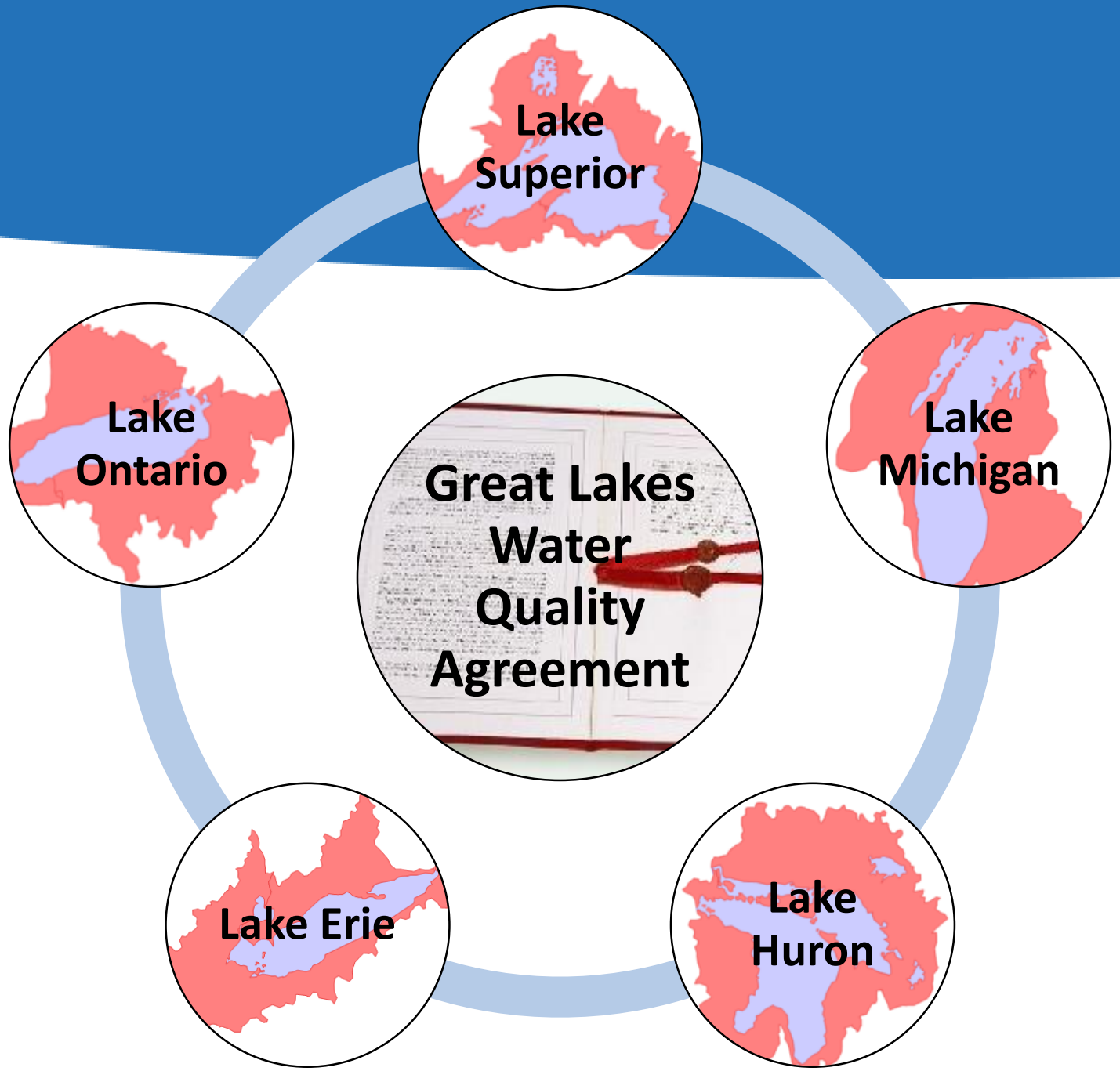
2. Knowledge Gaps White Paper

GLWQA Lakewide Management Annex, LAMPs & Lake Partnerships

Elizabeth Hinchey Malloy – US EPA

Luca Cargnelli – Environment and Climate Change Canada

Great Lakes Water Quality Agreement of 2012


Lake Superior
Lake Ontario
Lake Michigan
Great Lakes Water Quality Agreement
Lake Erie
Lake Huron

Lakewide Management

Mission:

- **Review the cumulative effects of governmental programs on water quality.**
- **Identify additional actions to further restore and protect Great Lakes water quality.**
- **Identify additional research needs.**

Lakewide Action and Management Plans

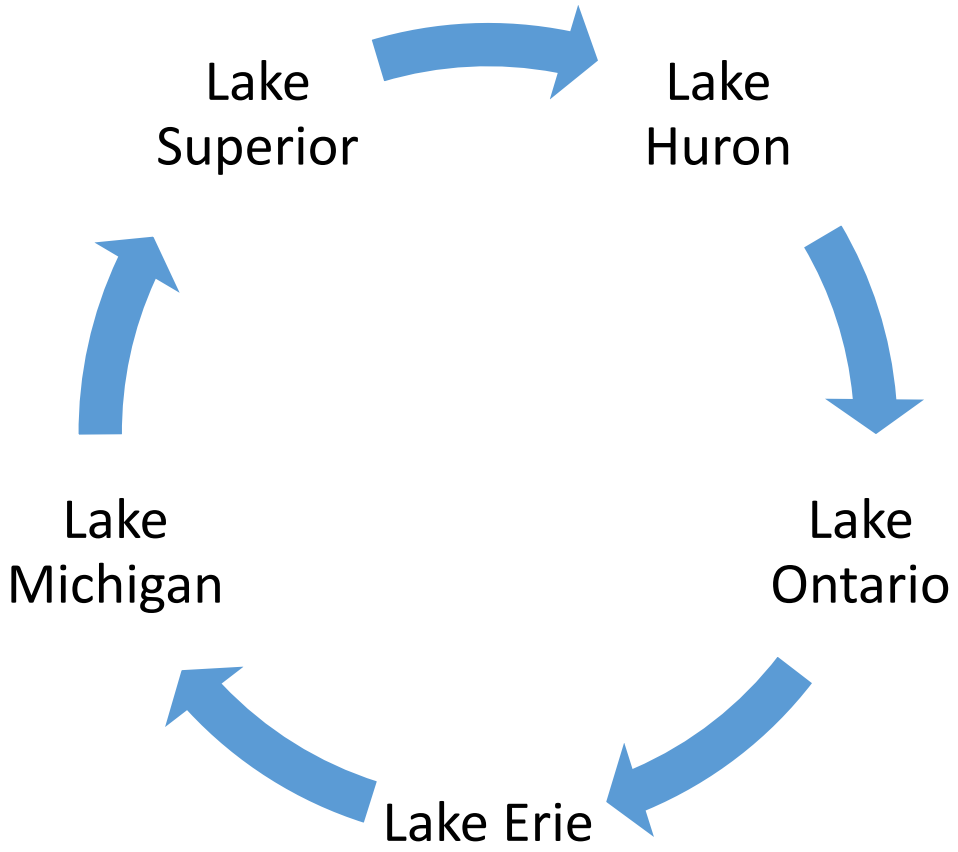
- Acronym: “LAMPs”
- A binational, ecosystem-based management strategy for protecting and restoring the water quality of a lake.
- Five-year strategic plan for:
  - Reducing chemical contamination
  - Managing nutrient levels
  - Preventing and controlling invasive species
  - Restoring native species and habitat

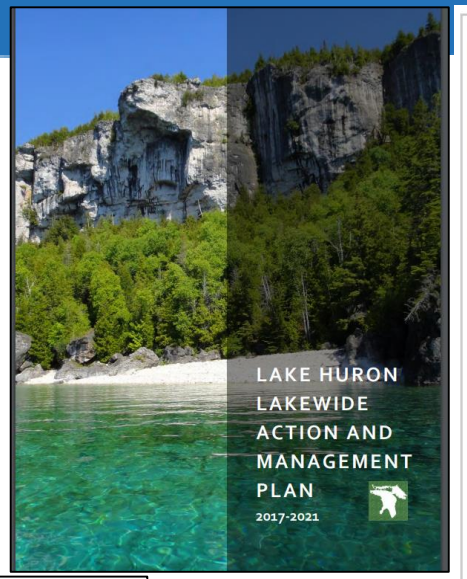

Governmental Partners
Province
States
First Nations
Lake Partnership
Tribes
Metis
Local Govts.
Federal

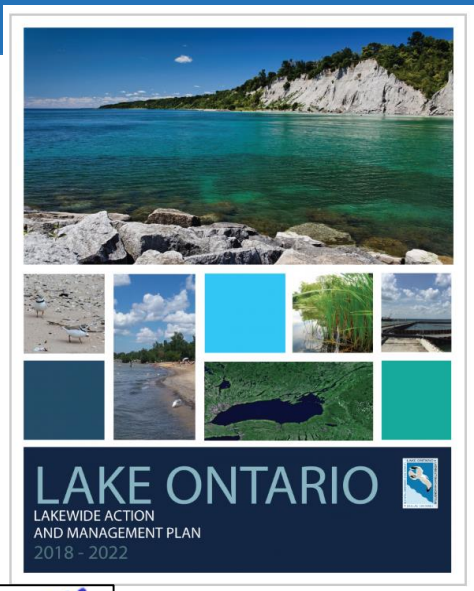
Five Lake Partnerships

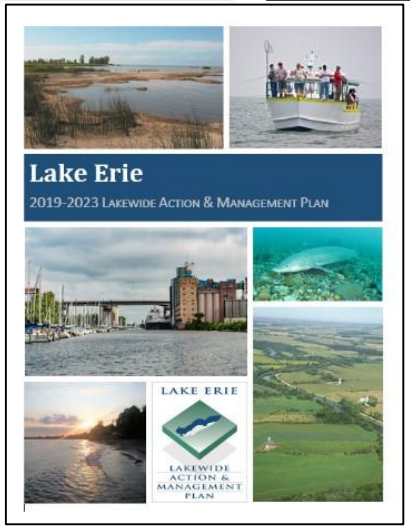
- The “Lake Partnership” for each Great Lake is a collaborative team of environmental protection and natural resource management agencies:
  - *“Federal, states/province, tribal governments, First Nations, Métis, municipal governments, and watershed management agencies.”*
- Public review and input on draft documents is also an important part of developing each LAMP.

5 Lakes on a 5-year Cycle









Cooperative Science and Monitoring Initiative

- Acronym: “CSMI”
- Five-Year Cycle:
  - **Field Year** – science activities, sample collection
  - **Data Analysis** – analysis of collected samples
  - **Report out** – scientific findings, results
  - **Priority Setting** – Lake Partnership identifies needs for next Field Year
  - **Planning** – Agencies and partners develop sampling plans

LAMPs and CSMI Priorities

Action

- Continue implementation of LAMPs!
- Publish LAMPs:
  - Lake Erie in 2020
  - Lake Ontario in 2020
  - Lake Michigan in 2020
  - Lake Superior in 2021
  - Lake Huron in 2022

Science

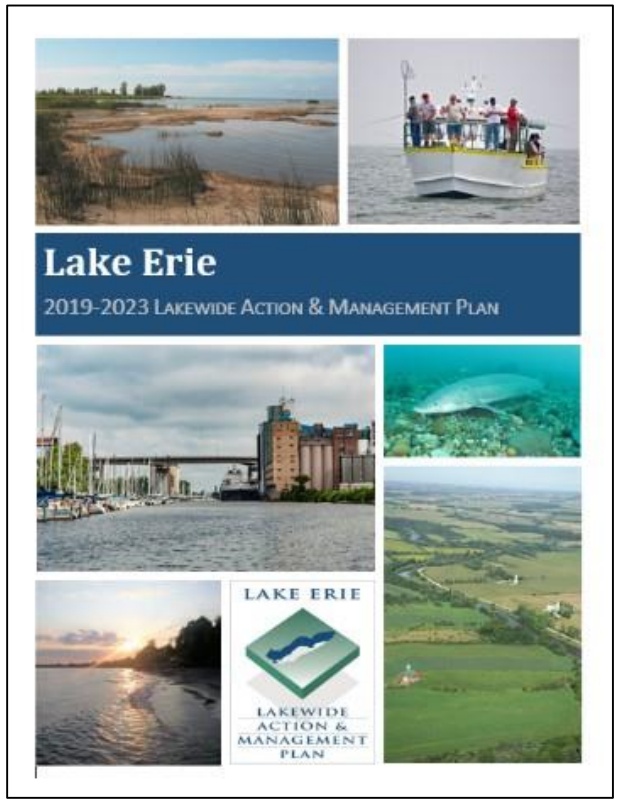
- CSMI Priorities:
  - Lake Huron in 2020
  - Lake Ontario in 2021
  - Lake Erie in 2022

Thank you!

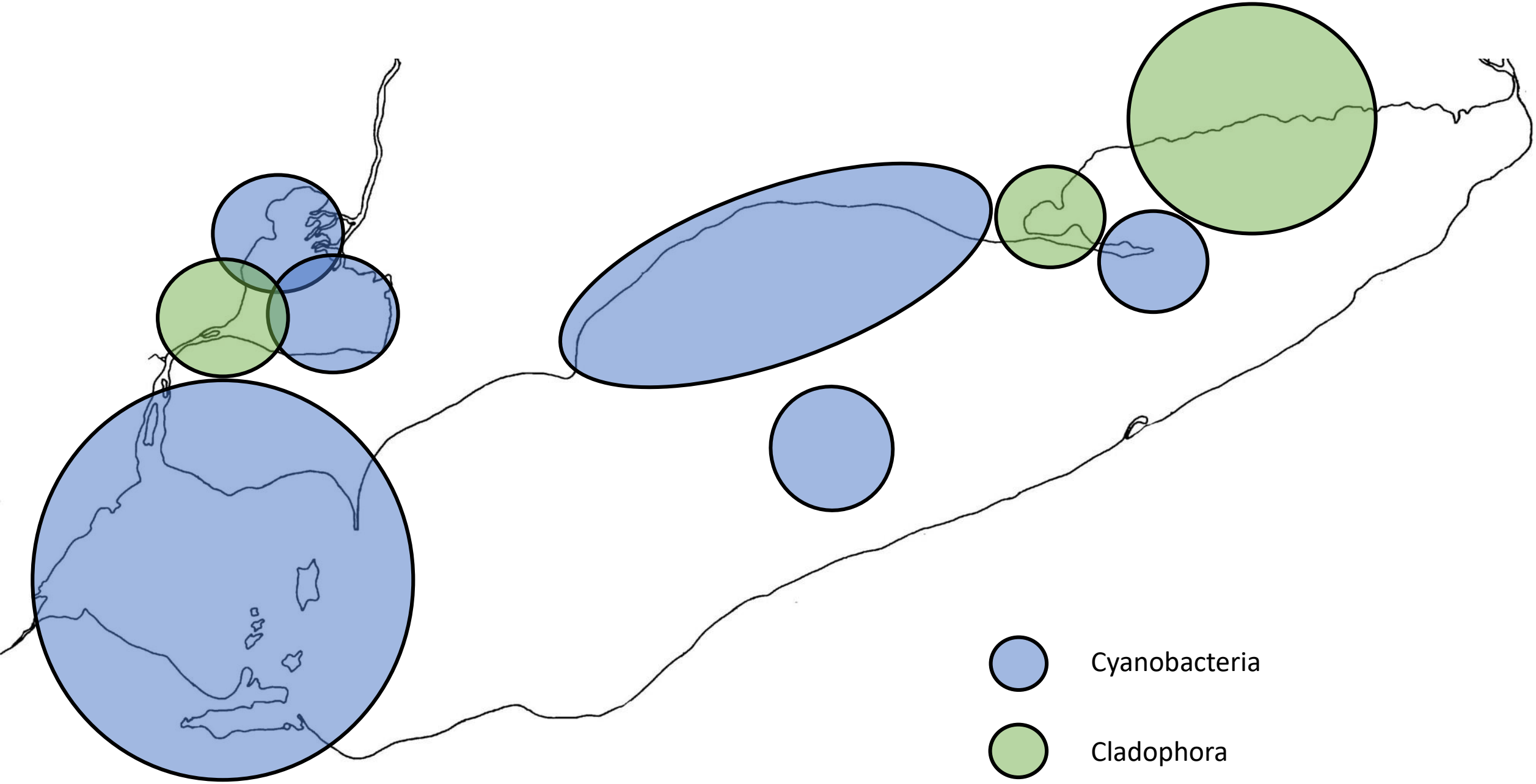
Lake Erie Update

Beth Hinchey-Malloy

Lake Erie Partnership



- 21 agencies representing federal, provincial, state, municipal, conservation authorities, tribes and first nations
- 2019-2023 LAMP was developed over the last two years and is now undergoing final approvals
  - ➢ 41 actions; Actions to reduce nutrient and sediment loading taken directly from US and Canada Domestic Action Plans (DAPs) and Annex 4 Lake Erie Binational Nutrient Reduction Strategy
- 2019 was the CSMI field year on Lake Erie
  - ➢ Science priorities developed in 2017 and 2018, included these eutrophication priorities:
    1) Watershed priorities: Monitoring and modeling of P-reduction effectiveness of agricultural conservation practices at multiple scales
    2) In-lake priorities: Drivers of HABs, toxin production, *Cladophora* production
  - ➢ Reporting out results in 2021 (State of Lake Erie meeting)


Cyanobacteria
Cladophora

Great Lakes HABs Collaborative

Lake St. Clair/Thames River Water Quality and Harmful Algal Bloom Assessment

March 26, 2020

Ngan Diep and Alice Dove

Ontario Ministry of Environment, Conservation and Parks

Environment and Climate Change Canada

Team Leads

MECP-EMRB: Ngan Diep, Xavier Ortiz

ECCC-WQMSD: Alice Dove

ECCC-WHERD: Arthur Zastepa, Sophie Crevecoeur (Tom Edge)

GLIER/University of Windsor: Mike McKay, Thijs Frenken, Ken Drouillard (Jan Cibrowski)

Collaborators

NOAA: Rick Stumpf, Andrea Vanderwoude, Steve Ruberg

ECCC: Luis Leon, Craig McCrimmon

NOSM/MAG Aerospace: Greg Ross, Matt Owen, Mike Ciezadlo

LTVCA: Jason Wintermute

Experimental Lake Erie Harmful Algal Bloom Bulletin

Great Lakes HABs Collaborative

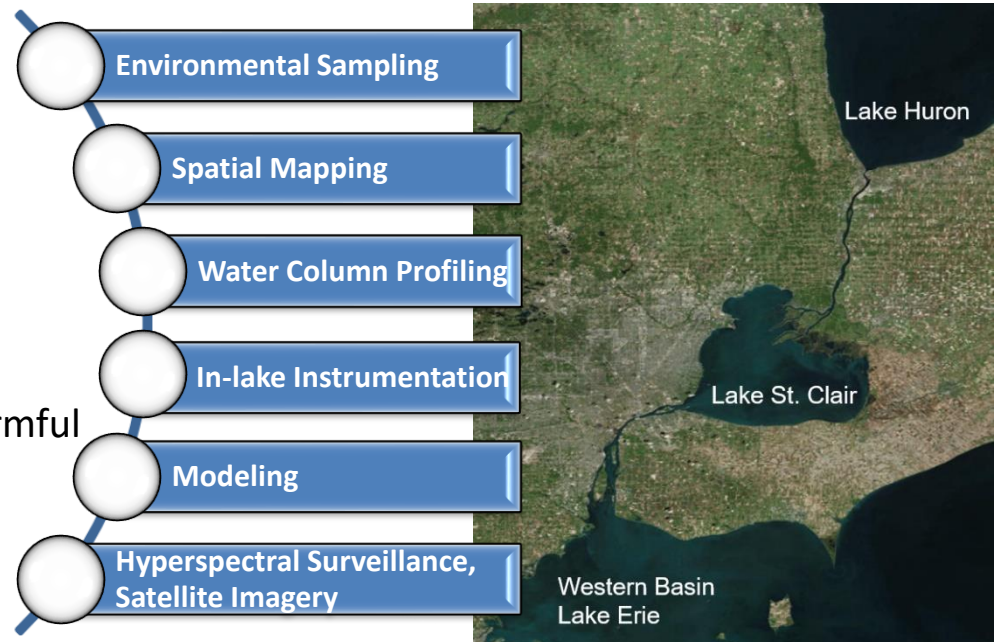
Lake St. Clair/Thames River Water Quality & Harmful Algal Bloom Assessment (MECP/ECCC)

FOUR YEAR PROJECT: 2016 to 2019

- Lake St. Clair is identified as a system that potentially experiences wide-spread harmful algal blooms and receives discharges from a priority tributary, the Thames River (Annex 4 – Nutrients GLWQA)

Project objectives include:

- Assess the range of water quality conditions in Lake St. Clair nearshore with emphasis on the Thames River area
- Assess the extent, occurrence, magnitude and frequency of potential HABs in Lake St. Clair & Thames River
- Assessment of the drivers and causal linkages underlying water quality patterns and cyanobacterial blooms in Lake St. Clair & Thames River
- Quantify the role of Thames River discharges on water quality conditions of Lake St. Clair and relative contributions of nutrients and materials to Detroit River and Lake Erie



Team Leads: Ngan Diep (MECP) and Alice Dove (ECCC)

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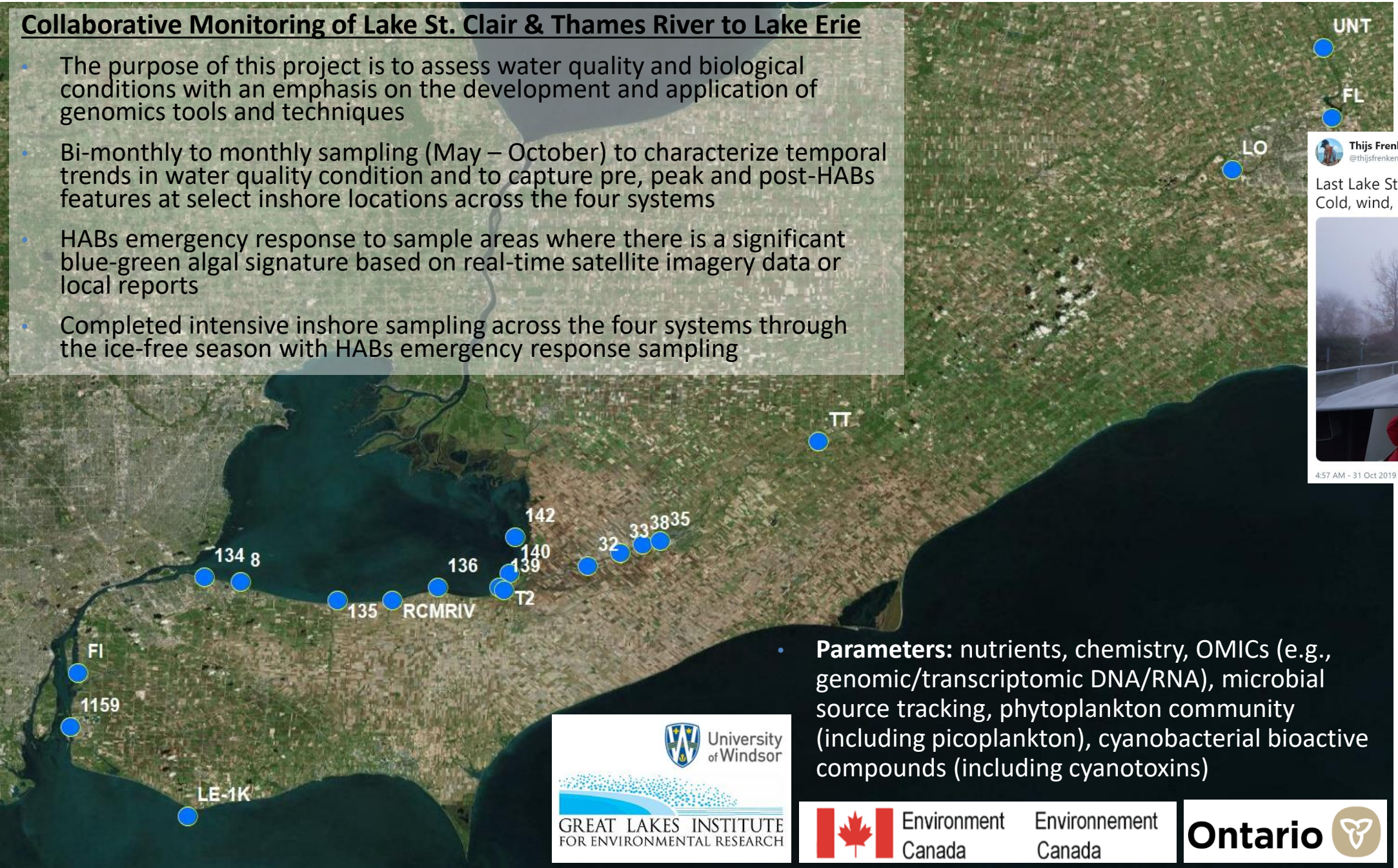
Collaborative Monitoring of Lake St. Clair & Thames River to Lake Erie

- The purpose of this project is to assess water quality and biological conditions with an emphasis on the development and application of genomics tools and techniques
- Bi-monthly to monthly sampling (May – October) to characterize temporal trends in water quality condition and to capture pre, peak and post-HABs features at select inshore locations across the four systems
- HABs emergency response to sample areas where there is a significant blue-green algal signature based on real-time satellite imagery data or local reports
- Completed intensive inshore sampling across the four systems through the ice-free season with HABs emergency response sampling



- **Parameters:** nutrients, chemistry, OMICs (e.g., genomic/transcriptomic DNA/RNA), microbial source tracking, phytoplankton community (including picoplankton), cyanobacterial bioactive compounds (including cyanotoxins)

University of Windsor
GREAT LAKES INSTITUTE FOR ENVIRONMENTAL RESEARCH

Environment Canada | Environnement Canada

Ontario

Collaborative Team Leads

ECCC-WHERD: Arthur Zastepa, Sophie Crevecoeur (Tom Edge)

MECP-EMRB: Ngan Diep, Xavier Ortiz

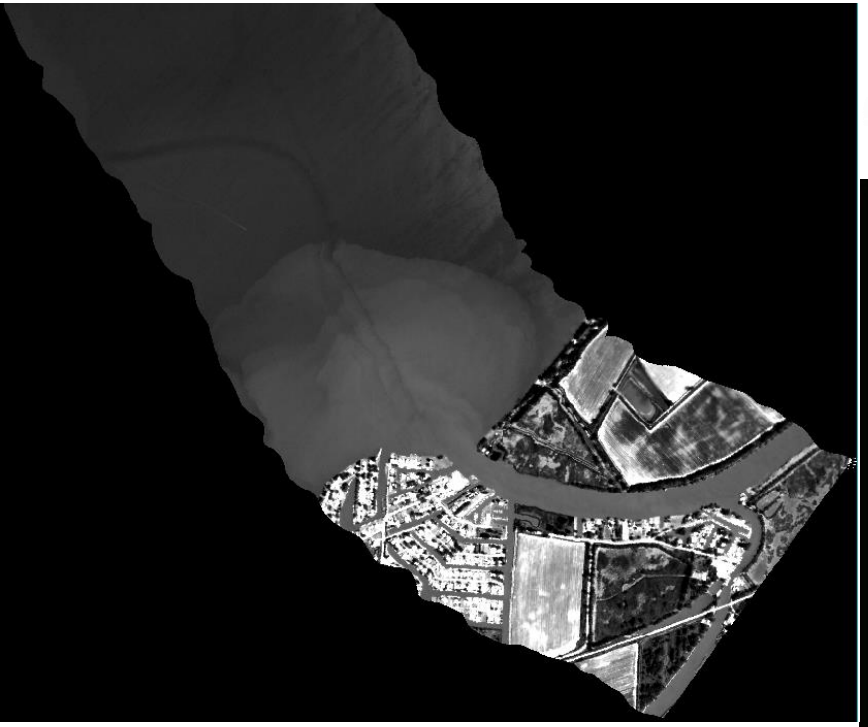
ECCC-WQMSD: Alice Dove, Vi Richardson

GLIER/University of Windsor: Mike McKay, Thijs Frenken, Ken Drouillard (Jan Cibrowski)

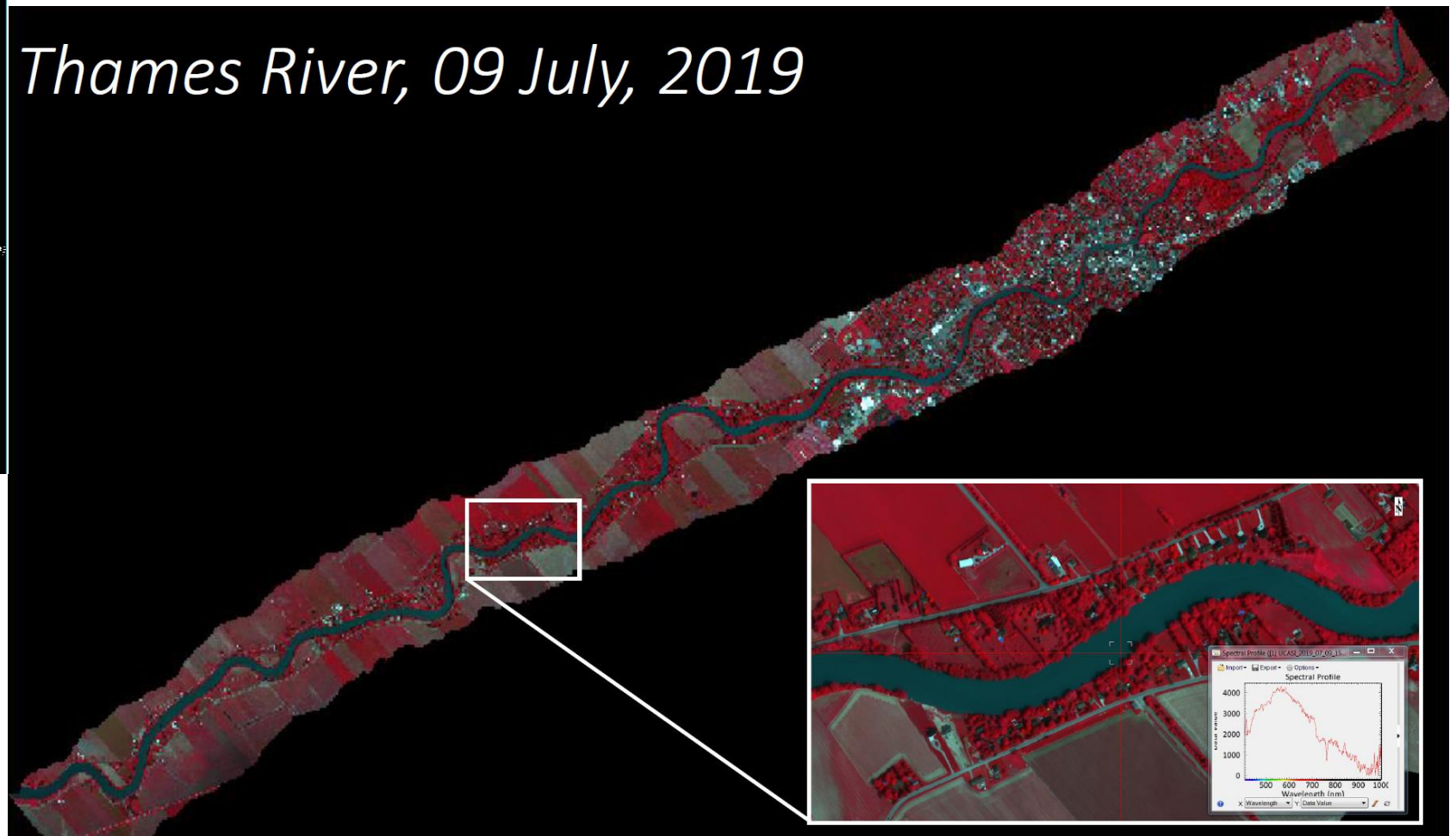
Great Lakes HABs Collaborative

Hyperspectral Remote Sensing of Harmful Algal Blooms in Lake St. Clair/Thames River

NOAA/GLERL – Andrea Vanderwoude, Steve Ruberg
NOSM/MAG Aerospace – Greg Ross, Matt Owen, Mike Ciezadlo
MECP/ECCC – Ngan Diep, Alice Dove

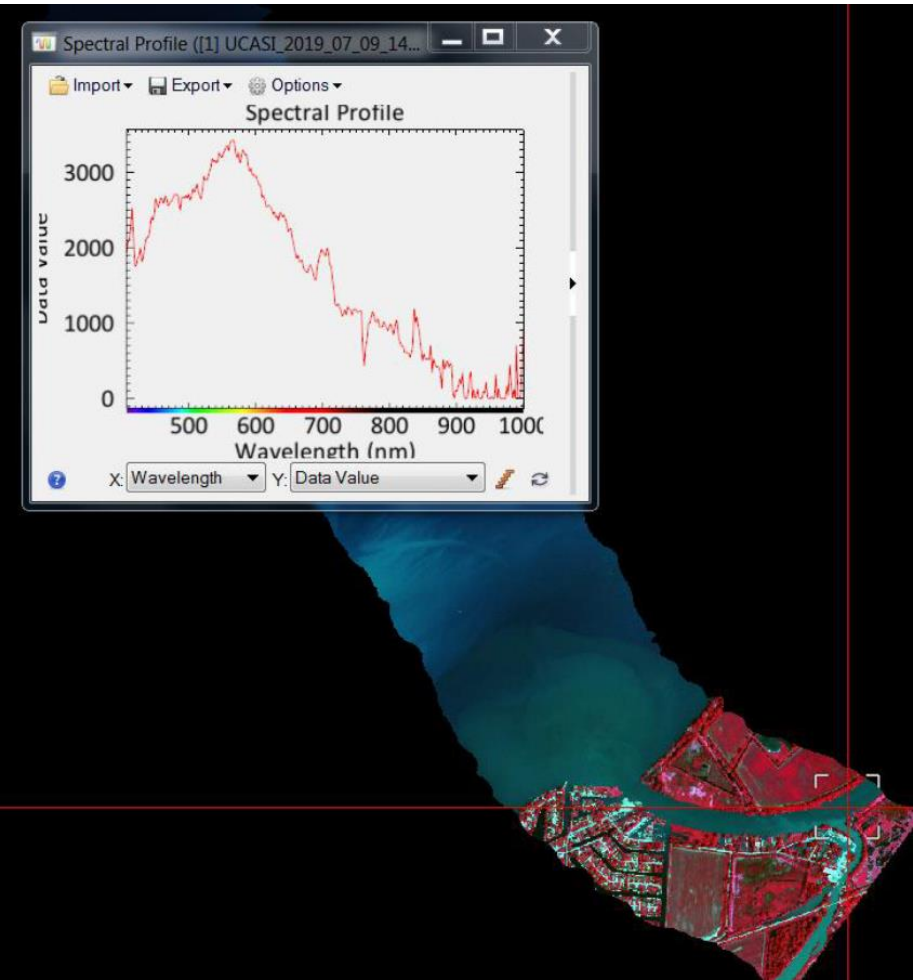


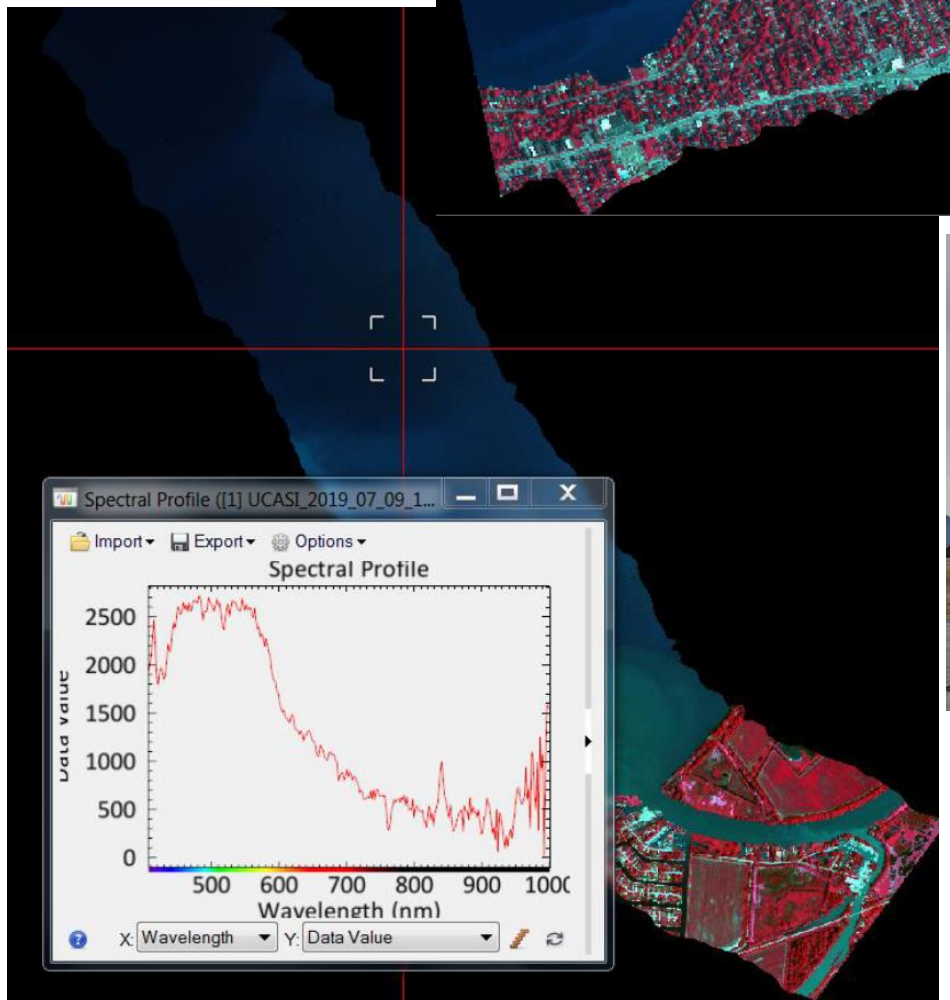
- Hyperspectral detection of cyanobacteria, chlorophyll and temperature
- Flyovers of select areas in Lake St. Clair/Thames River
- Provides hyperspectral data in 400 – 900 nm with ~ 2 m spatial resolution



Great Lakes HABs Collaborative

Hyperspectral Remote Sensing of Harmful Algal Blooms in Lake St. Clair/Thames River





Data collected under the clouds, good coverage of areas that can be difficult for satellites to capture

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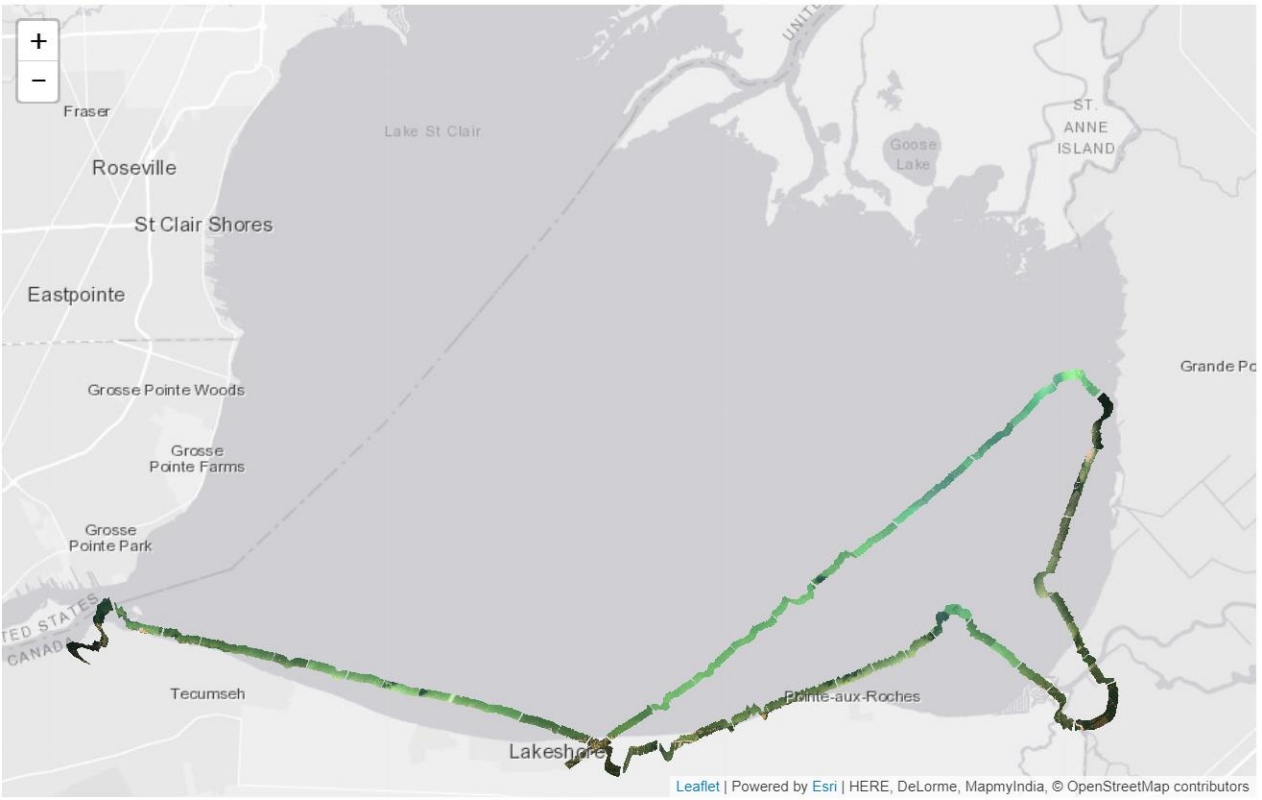
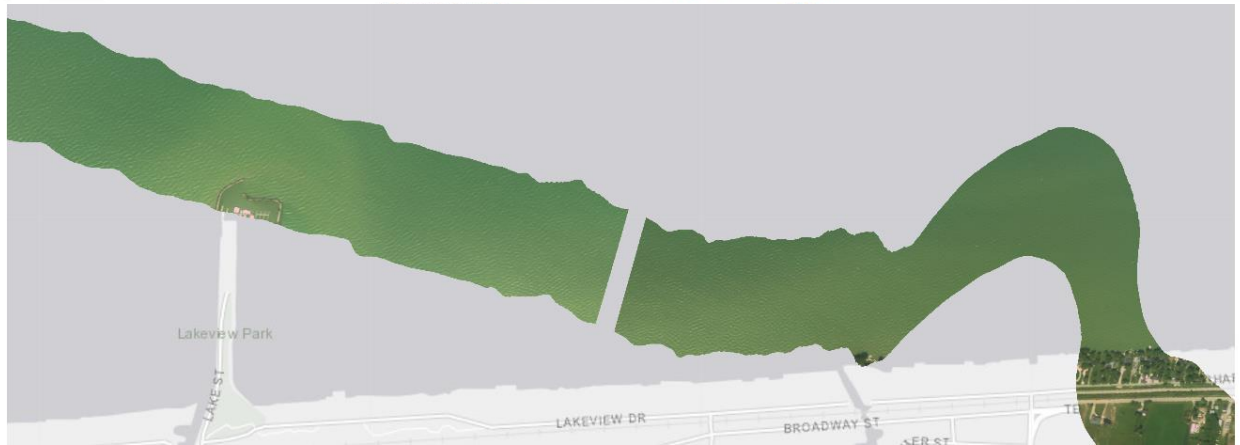
August 2, 2017 flight



September 5, 2017 flight



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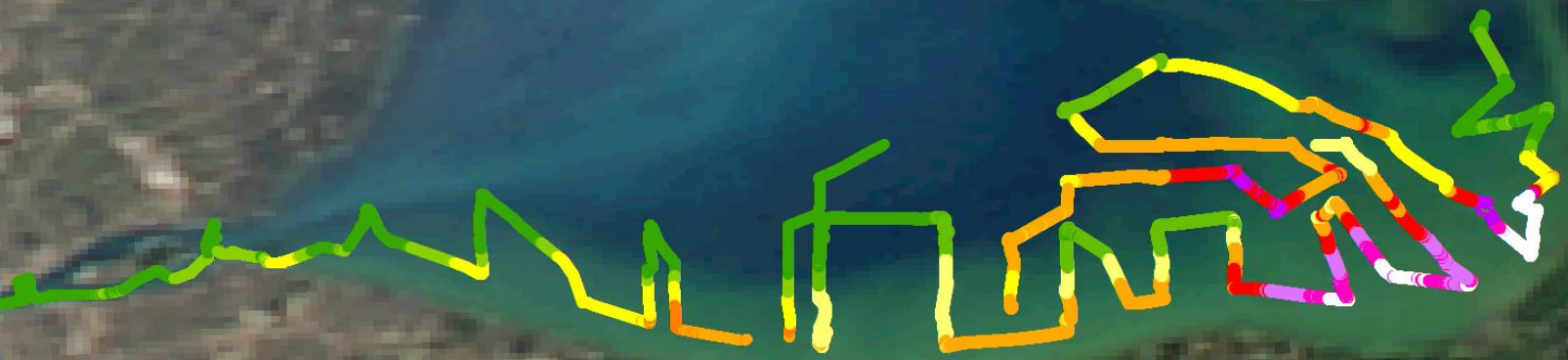
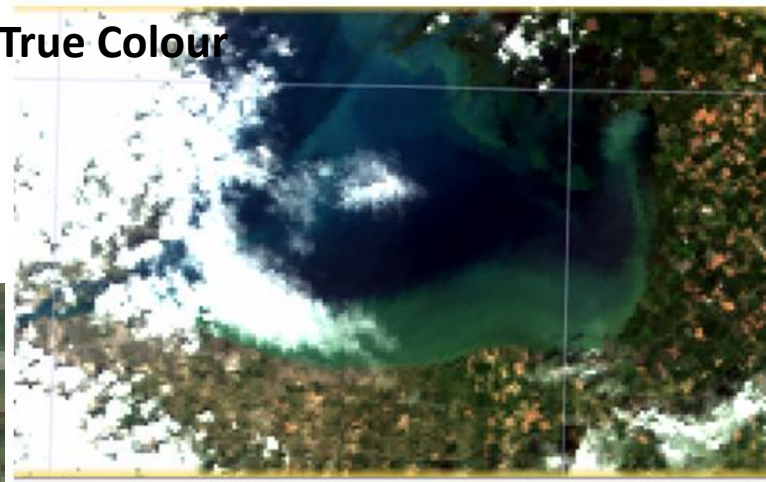
Remote Sensing: Satellite Imagery

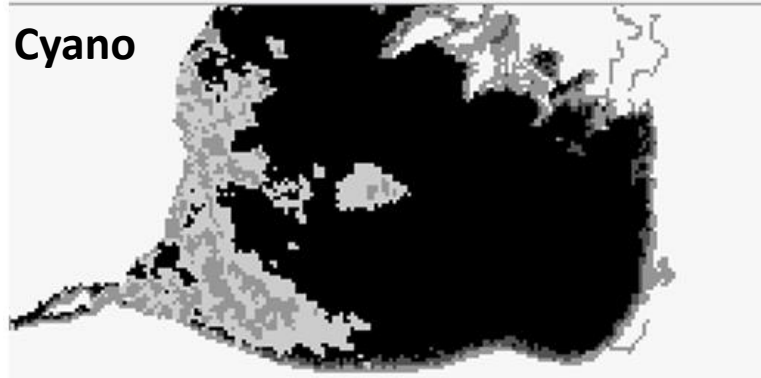
Further work with NOAA

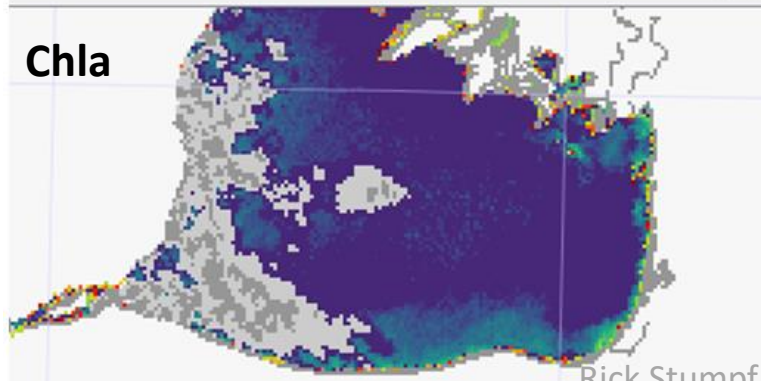
- Ground-truthing satellite imagery data; good correspondence
- Develop site-specific algorithms for Lake St. Clair (chlorophyll, phycocyanin)
- Hyperspectral surveillance – flyovers linking satellite imagery data with surveillance data



August 2018 Chlorophyll





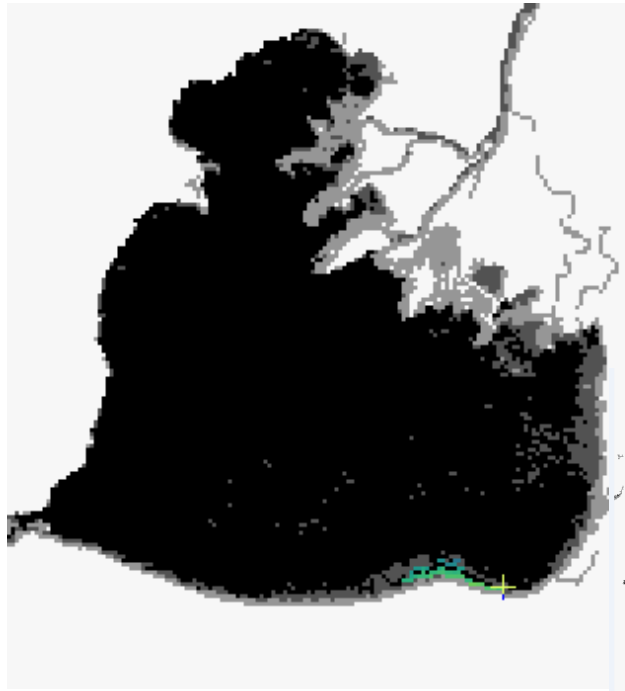


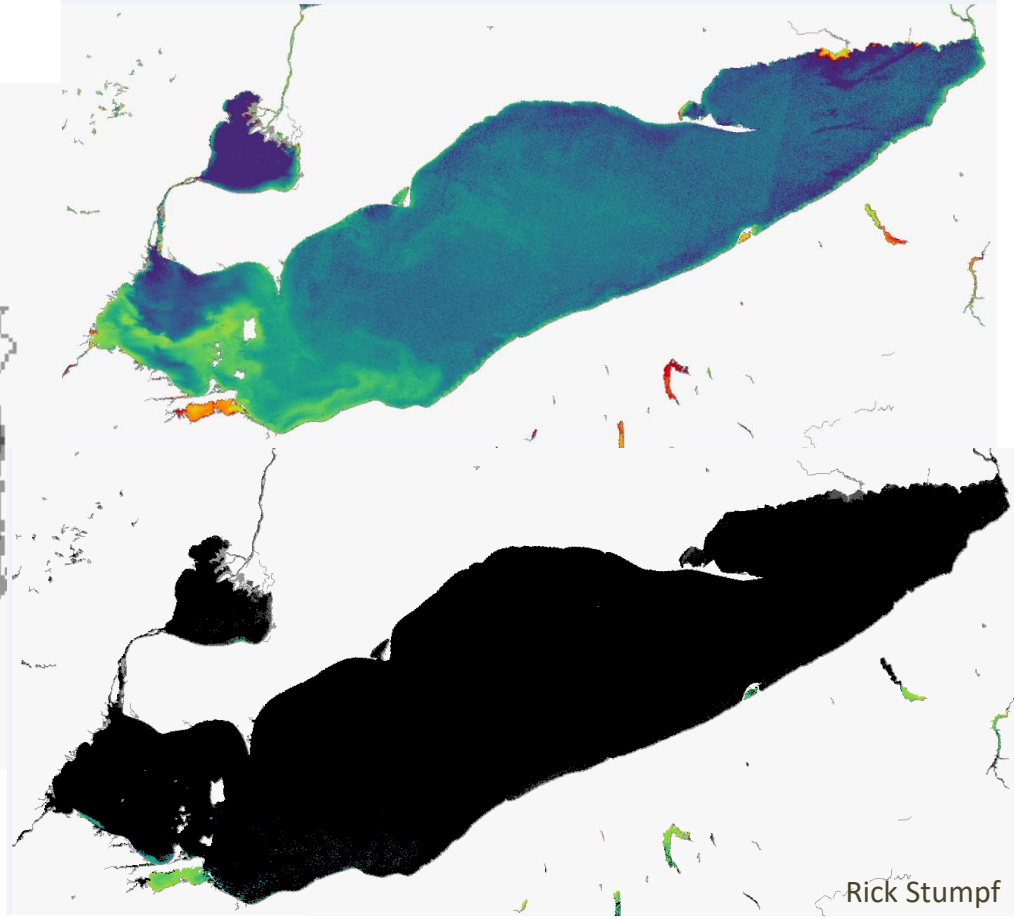
Rick Stumpf

Great Lakes HABs Collaborative

Satellite Imagery & HABs Response Monitoring

- Satellite imagery data indicated a cyano signal in Lake St. Clair, west of the Thames River mouth (Aug & Sep)
- Local reports of HABs in the lower Thames River (Sep/Oct); 2019 river bloom persisted for 3 weeks
- Rapid communication of satellite imagery data (NOAA) and local reports (LTVCA) helped facilitate HABs emergency response monitoring





Collaborative Team & NOAA

NOAA: Rick Stumpf, Shelly Tomlinson, Sachi Mishra

GLIER/University of Windsor: Mike McKay, Thijs Frenken, Ken Drouillard

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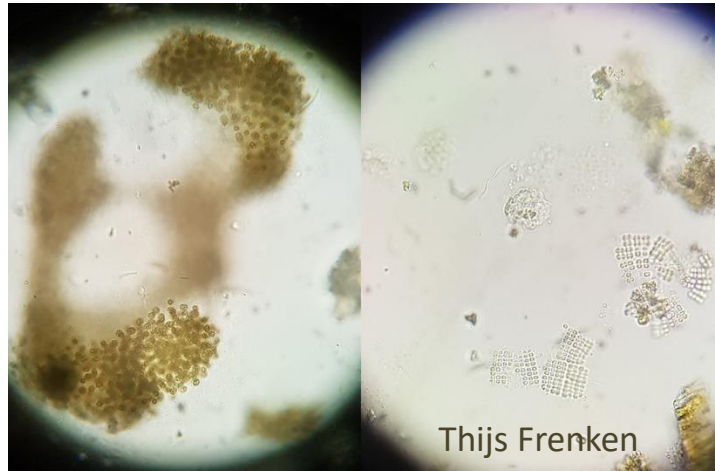
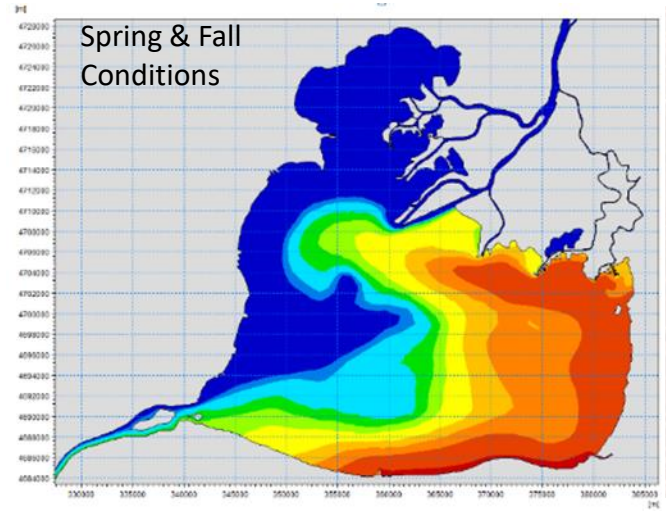
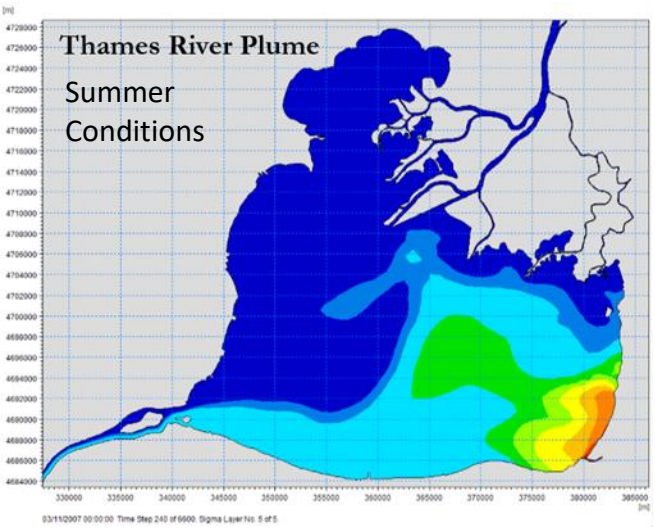


Modeling





ECCC: Luis Leon, Craig McCrimmon, Alice Dove
MECP: Ngan Diep (Peter Nettleton)

- Validation of hydrodynamic models for Lake St. Clair and Thames River (ELCOM, MIKE3, TuFLOW-AED2)
- Assessed impact of tributaries to Lake St. Clair – movement and mixing
- Characterized transport of nutrients and materials from Lake St. Clair & tributaries to Detroit River and Lake Erie
- Nearshore conditions change rapidly on daily time-scales with rapid displacement of water
- Thames R plume is highly dynamic and there are seasonal differences

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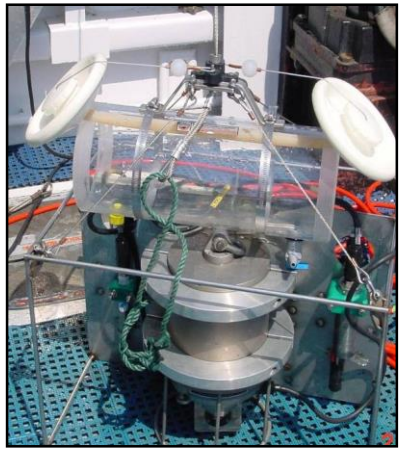
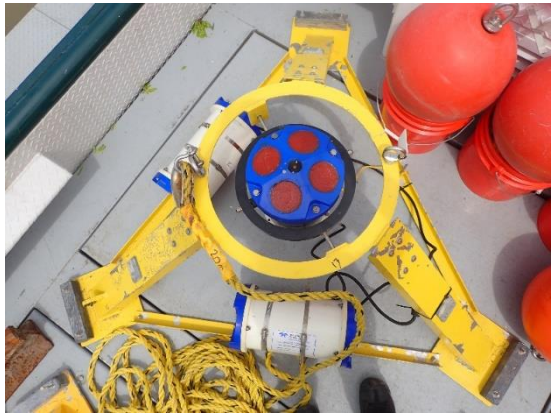
In-lake Instrumentation: Water Quality

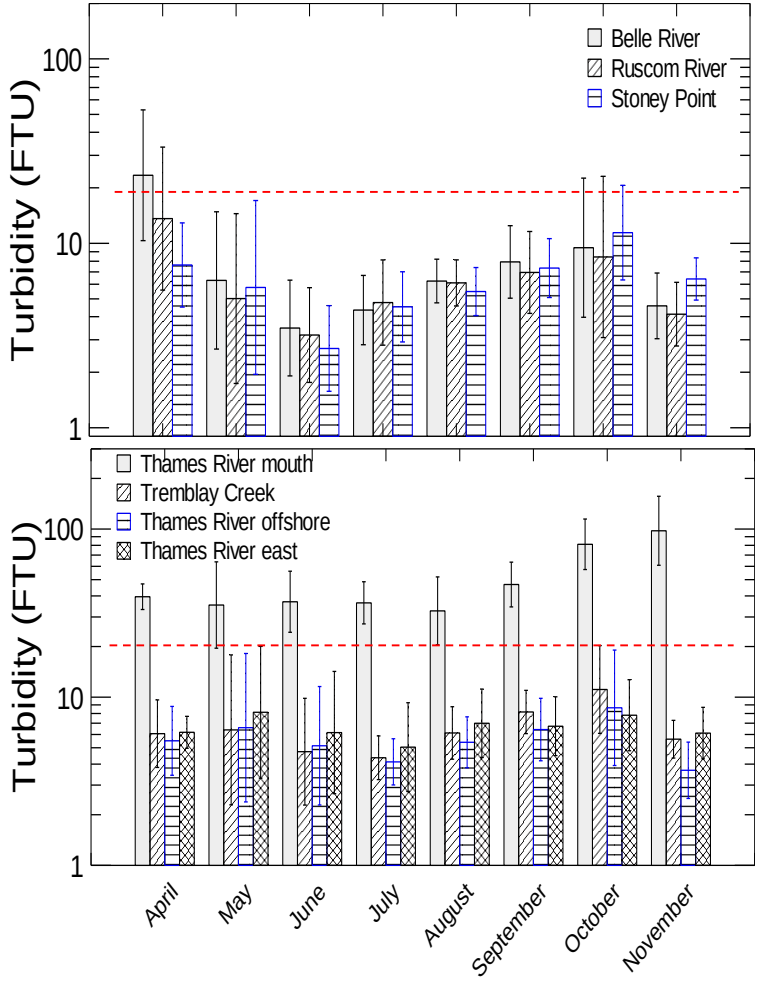
- Large suite of real-time sensors for continuous water quality monitoring
- Key deployment areas: Thames River mouth, inshore/nearshore locations across southern shoreline, upper Detroit River
- Water quality data logged continuously throughout the ice-free season (May – Nov) in 10 to 30 min increments



Parameters: current velocity and direction, turbidity, chlorophyll a, temperature, conductivity, phycocyanin and photosynthetically active radiation (PAR)

Team Leads:
Ngan Diep (MECP) & Alice Dove (ECCC)





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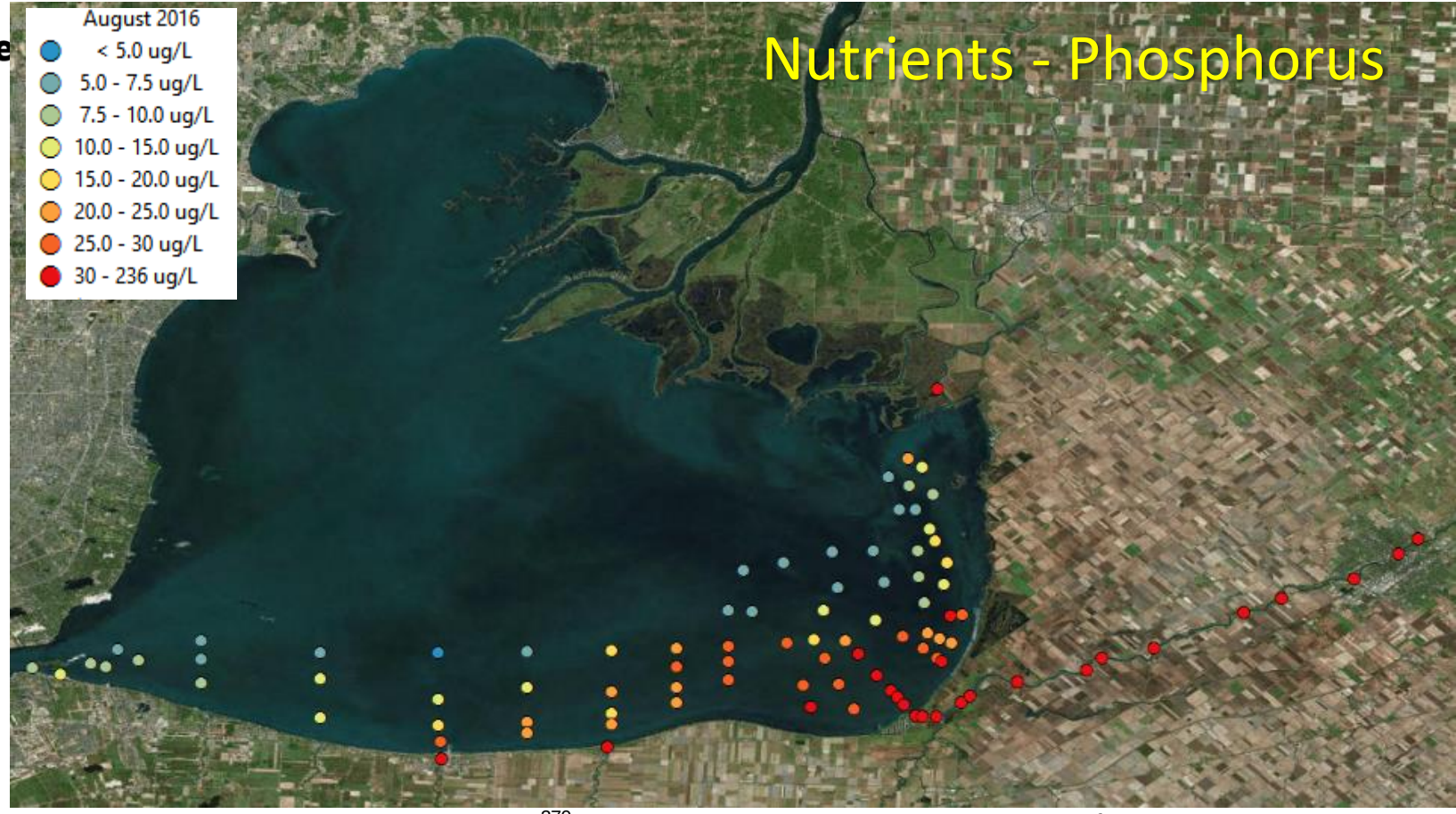
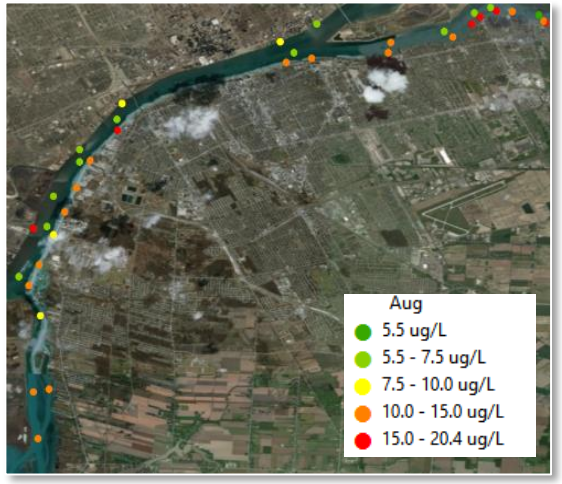
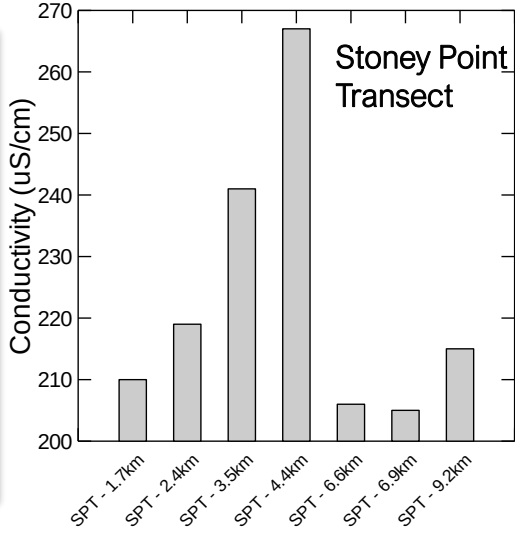
Water Quality Surveillance

- Distinctive water mass characteristics
- Inshore sites: high turbidity/suspended solids, low water clarity and higher conductivity and chloride levels
- Nearshore open water sites: low turbidity/suspended solids, high water clarity and low chloride levels and conductivity
- High variability across sites and surveys

Parameters: total & dissolved phosphorus, soluble reactive phosphorus , chlorophyll, conductivity, chloride, phycocyanin, suspended solids, dissolved organic carbon, sulphate, bacteriodes, nitrogen and secchi, microcystins







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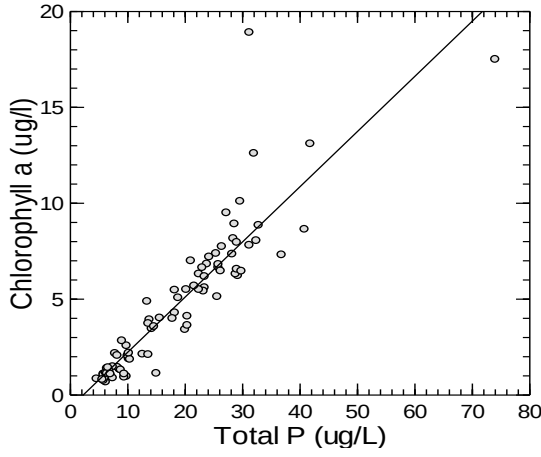

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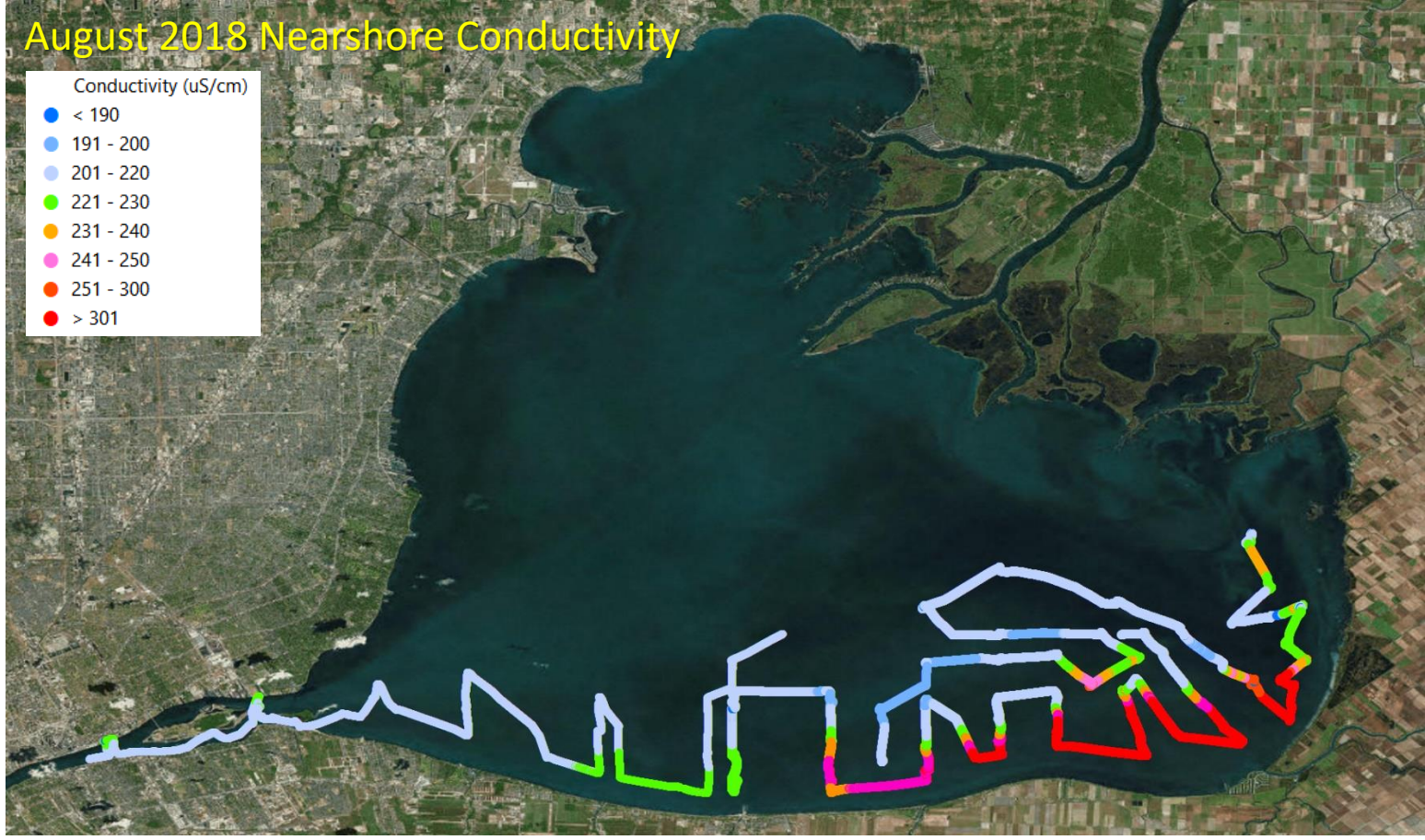
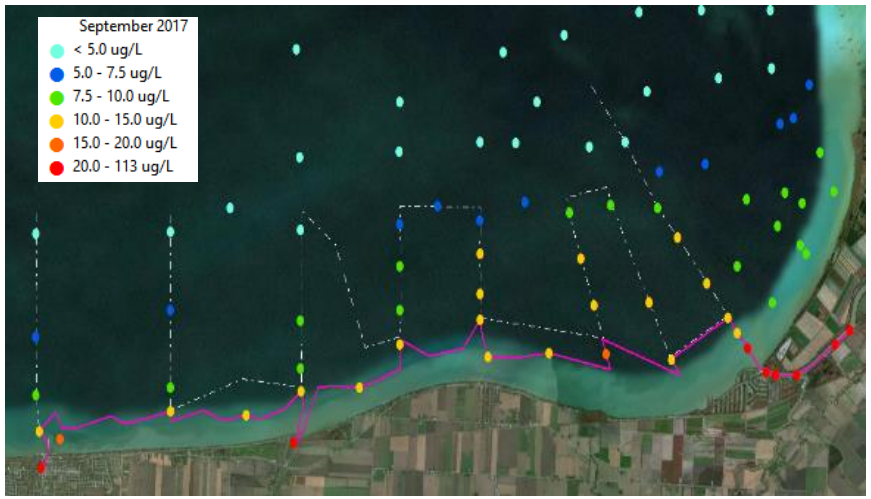
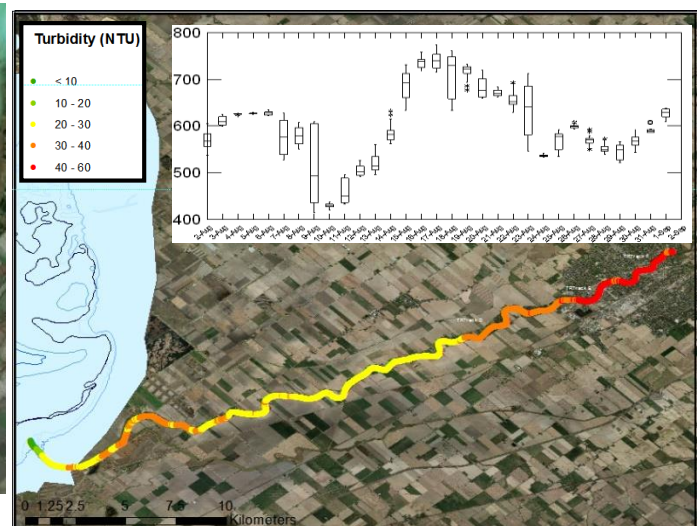
Spatial Mapping

- Extensive spatial mapping along the Canadian shoreline of Lake St. Clair, Thames River and Detroit River
  - 150 – 180 km per week open water
  - 75 km per week inshore
- High variability and strong gradients inshore and near the Thames River mouth area
- Open water and upper Detroit River: moderate chlorophyll a and turbidity levels offshore and near Detroit River
- Distinct water mass characteristics indicative of either lake or tributary plume waters

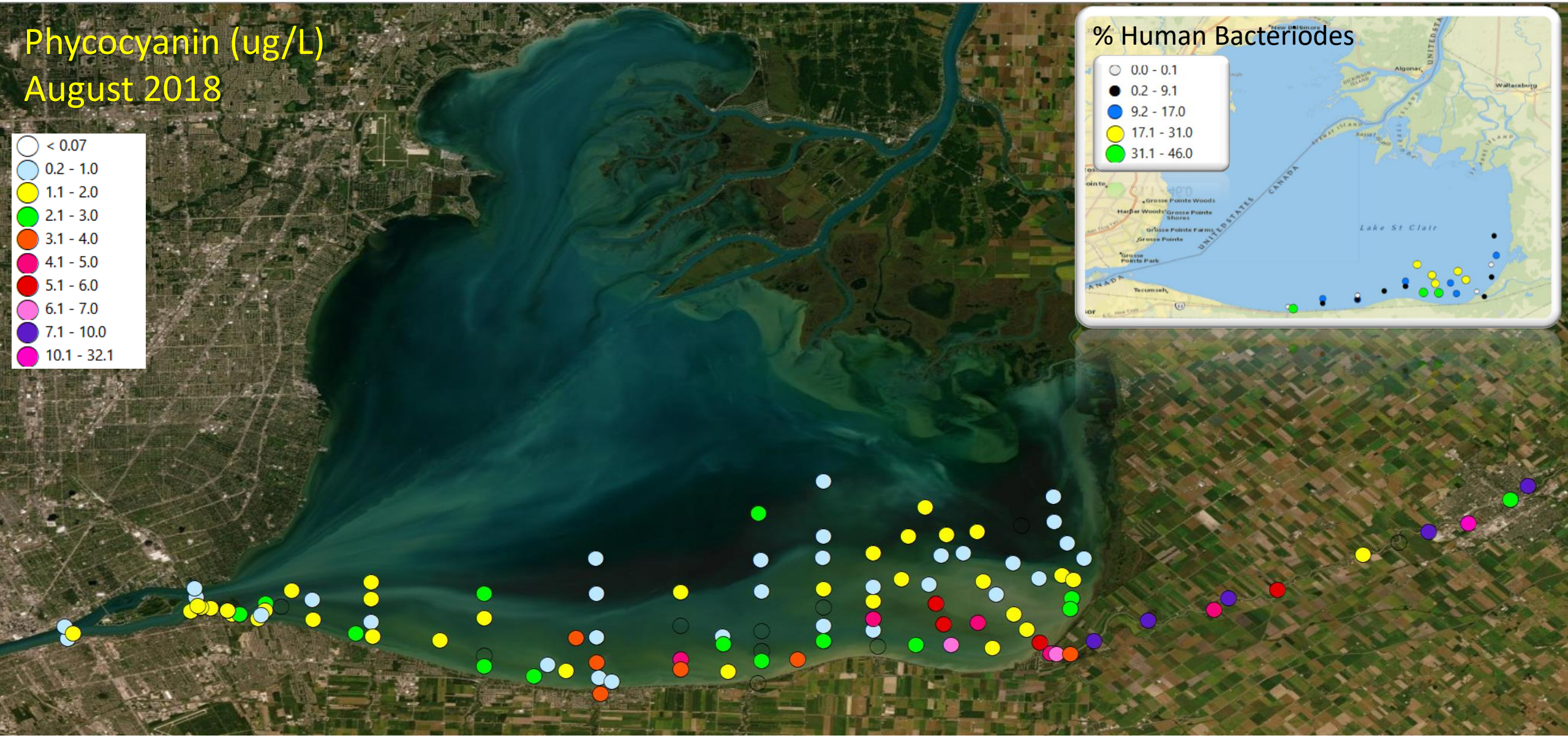






Team Leads:
Ngan Diep (MECP) & Alice Dove (ECCC)

Great Lakes HABs Collaborative



Team Leads:
Ngan Diep (MECP) & Alice Dove (ECCC)

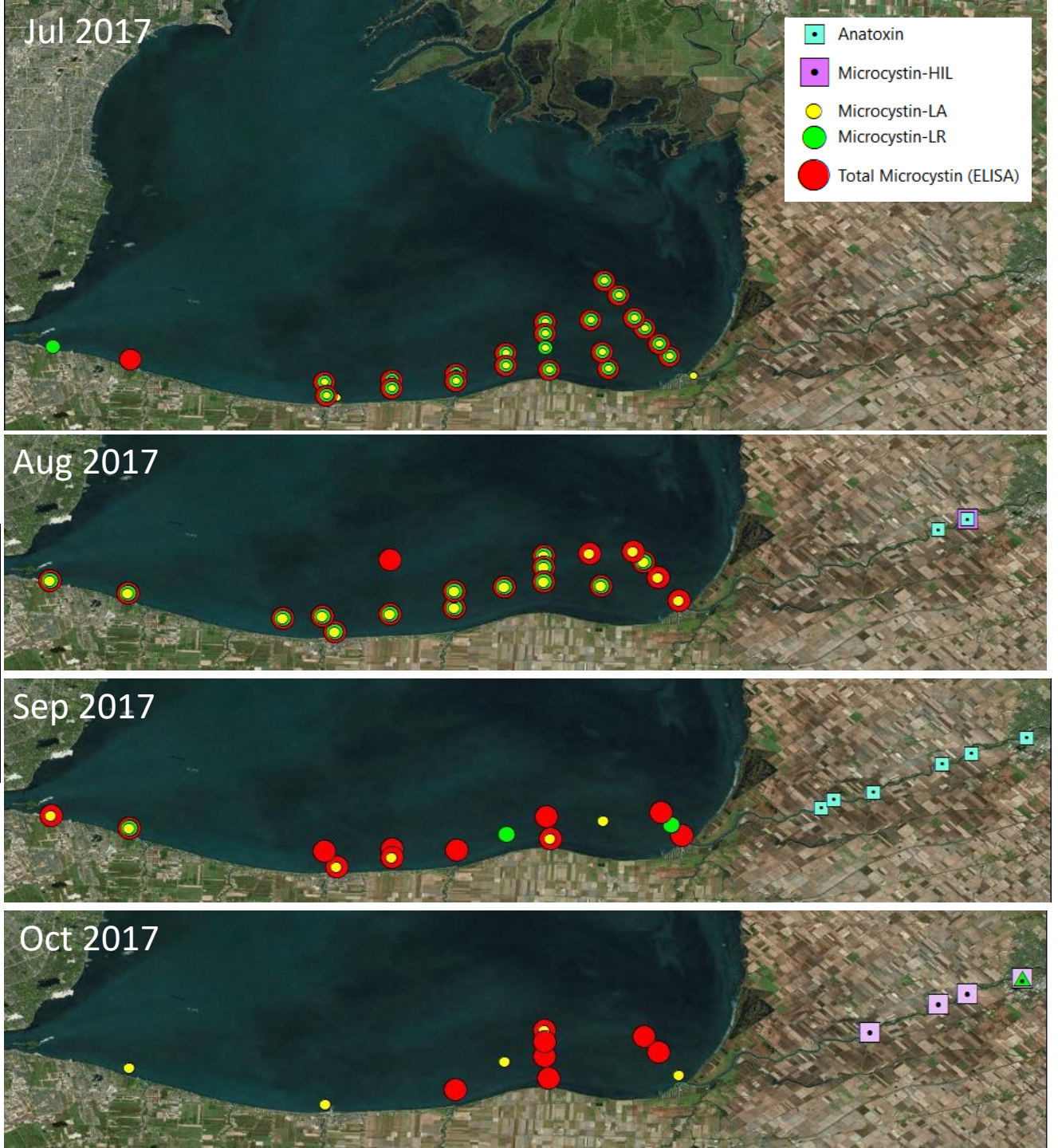
Great Lakes HABs Collaborative

Cyanotoxins

- Microcystin-LR and –LA predominantly along the southern coastline of Lake St. Clair
- Anatoxin-a detected in Thames River
- Mixed cyanotoxin profile for the Thames River
- Generally low levels of cyanotoxins

	Total Microcystin (ELISA)								
	2017			2018			2019		
	N	#Detects	Max (ug/L)	N	# Detects	Max (ug/L)	N	# Detects	Max (ug/L)
Lake St. Clair	150	68	4.9	257	125	4.8	134	88	4.0
Lower Thames	38	0	< mdl	76	11	0.2	79	30	1.4
Ruscom River/Belle River				14	7	2.1	6	3	1.1
Detroit River				56	19	1.0	15	5	1.0
Lake Erie - west basin				14	7	1.0	6	2	2.3
# Upper Thames							23	5	5.8

	2017 (N =217)		2018 (N = 143)		2019 (N = 42)	
	# Detects	Max (ug/L)	# Detects	Max (ug/L)	# Detects	Max (ug/L)
Microcystin-LA	59	0.52	121	0.63	36	0.89
Microcystin-LR	44	0.73	124	0.45	37	1.40
Anatoxin-A	8	0.46	1	0.09	*0*	*< mdl*
desmethylmicrocystin-LR	1	0.07	*0*	*< mdl*	*0*	*< mdl*
Microcystin-HilR	6	0.23	*0*	*< mdl*	*0*	*< mdl*
Microcystin-LW	*0*	*< mdl*	1	0.07	1	0.05
Microcystin-RR	*0*	*< mdl*	5	0.18	13	0.35
Microcystin-YR	*0*	*< mdl*	*0*	*< mdl*	3	0.12
desmethylmicrocystin-RR	*0*	*< mdl*	*0*	*< mdl*	3	0.08



Phytoplankton Overview

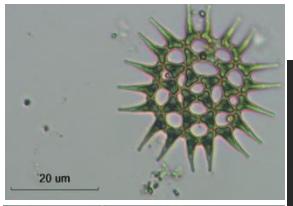
- Data based on select bloom samples
- Additional phytoplankton community assemblage analyses (> 650 samples) based on cyanotoxin and water quality data in 2020/21

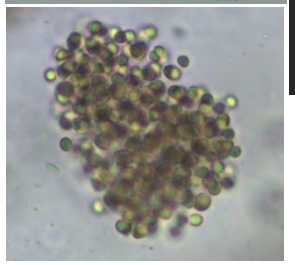
Lake St. Clair

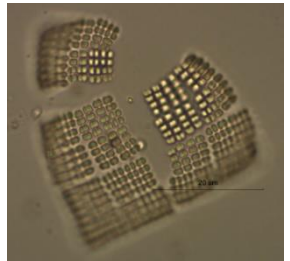
- *Microcystis, Merismopedia, Dolichospermum*
- *Aphanocapsa spp* (2019)
- HABs can occur from July to October
- Microcystin-LA and microcystin-LR
- Total microcystin non-detect to 4.9 ug/L

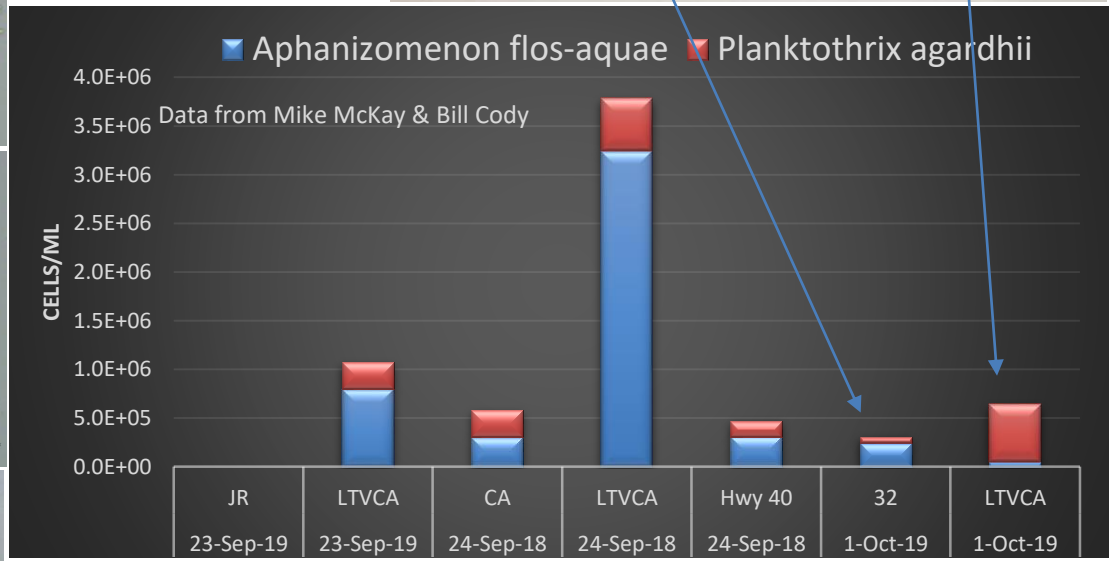
Thames River

- *Aphanizomenon flos-aquae, Planktothrix*
- HABs can occur from August to October
- Total microcystin mainly non-detect (max 1.4 ug/L)
- Varied cyanotoxin profile









Collaborative Team Leads

ECCC-WHERD: Arthur Zastepa, Sophie Crevecoeur (Tom Edge)

GLIER/University of Windsor: Mike McKay, Thijs Frenken, Ken Drouillard (Jan Cibrowski)

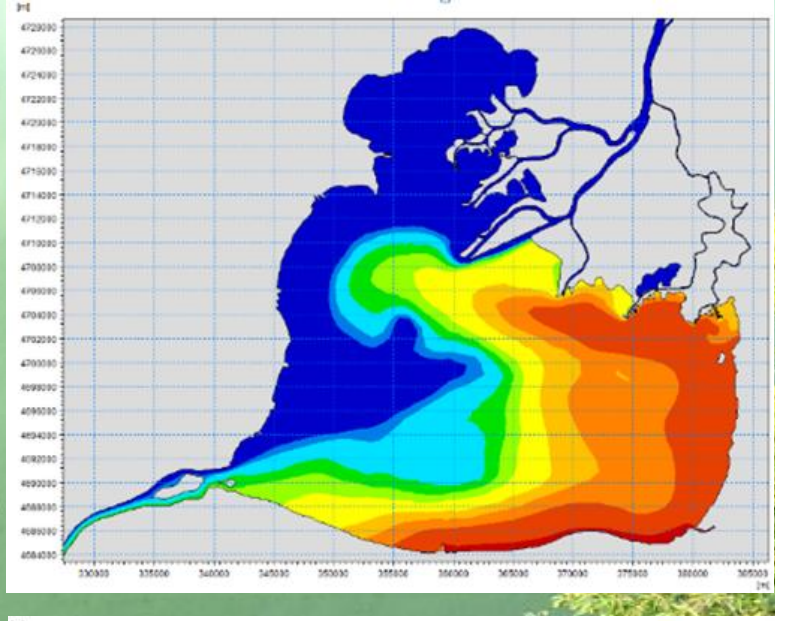
MECP-EMRB: Ngan Diep, Xavier Ortiz

ECCC-WQMSD: Alice Dove, Vi Richardson

LTVCA: Jason Wintermute

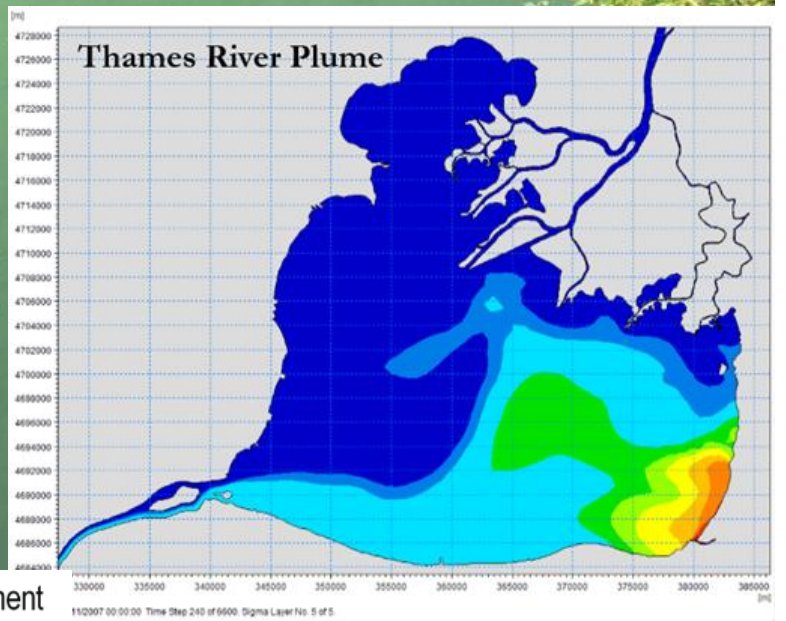
Great Lakes HABs Collaborative

Summary



- Harmful algal blooms do occur in Lake St. Clair and the Thames River, does not co-occur with L Erie blooms

- Microcystin-LA and LR cyanotoxins are present in Lake St. Clair; Thames River exhibited a mixed cyanotoxin profile



- Distinct water mass characteristics
  - Inshore sites (river plume, river plume/lake water mix, algal bloom)
  - Nearshore sites (open water lake sites)
  - Highly dynamic shallow system

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Acknowledgements

MECP Great Lakes Field Operations: Ryan Mototsune, Brian Thorburn & many more
ECCC Water Quality Monitoring Staff: Andrew Mummery, Leah Peacock, Tina Mamone & many more
MECP Laboratory Services Branch and ECCC National Laboratory for Environmental Testing
ECCC TechOps Dive Operations, EPA (Rose Ellison)

University of Windsor
GREAT LAKES INSTITUTE FOR ENVIRONMENTAL RESEARCH
Ontario
Environment Canada
Environnement Canada
NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
Experimental Lake Erie Harmful Algal Bloom Bulletin
Lakehead University Northern Ontario School of Medicine
École de médecine du Nord de l'Ontario
MAG AEROSPACE

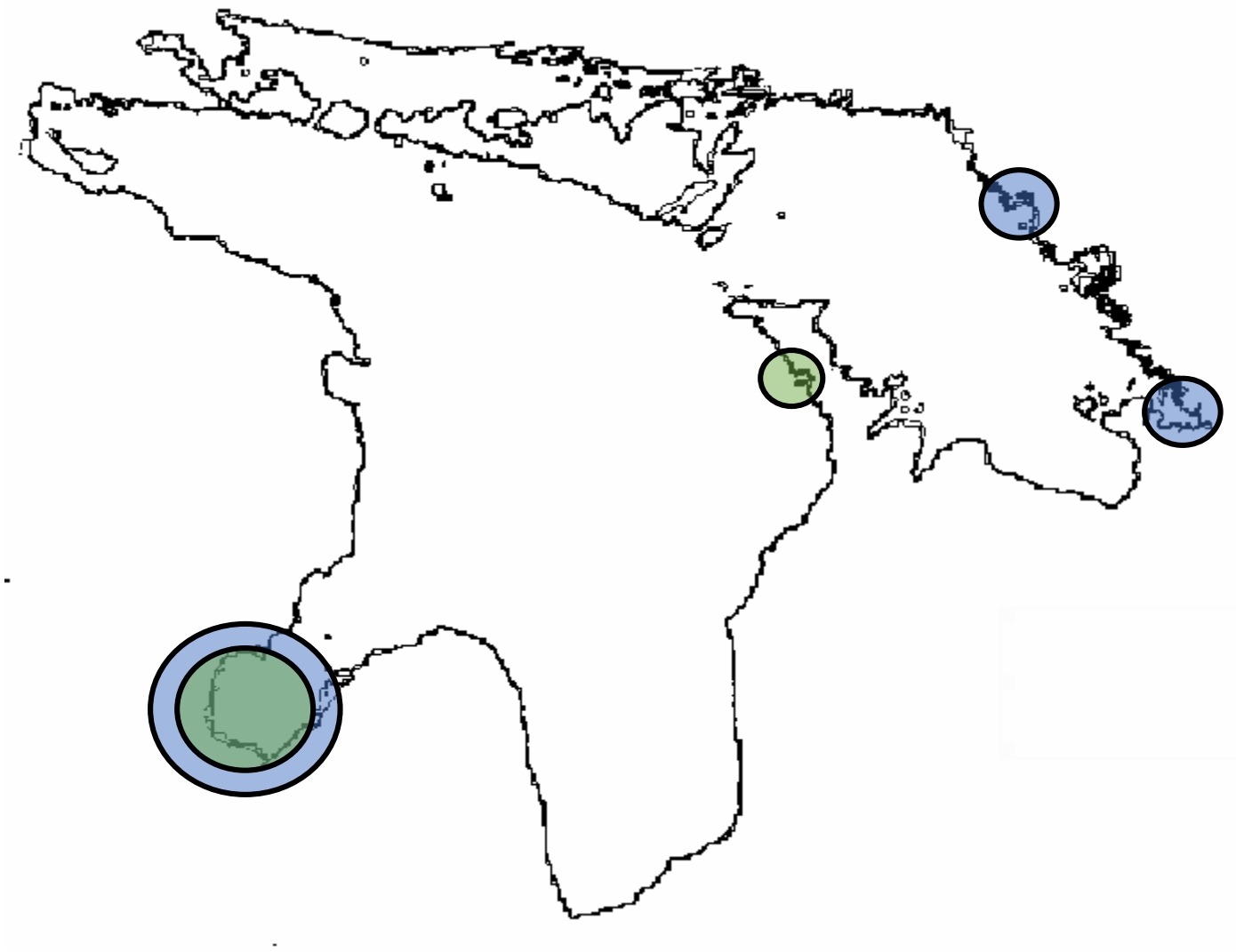
Lake Huron Update

Bretton Joldersma

Michigan Department of Environment, Great Lakes, and Energy

Lake Huron Partnership

- Environment and Climate Change Canada
- Maitland Valley Conservation Authority
- Ontario Ministry of Agriculture, Food and Rural Affairs
- Ontario Ministry of Natural Resources and Forestry
- St. Clair Region Conservation Authority
- Ontario Ministry of Environment, Conservation and Parks
- Department of Fisheries and Oceans Canada
- US Environmental Protection Agency
- Sault Ste. Marie Tribe of Chippewa Indians
- National Oceanic and Atmospheric Administration
- USDA-Natural Resources Conservation Service
- Michigan Department of Natural Resources
- Michigan Department of Environment, Great Lakes, and Energy
- Saginaw Chippewa Indian Tribe of Michigan
- Bay Mills Indian Community
- Little Traverse Bay Bands of Odawa Indians
- United States Geological Survey
- Chippewa Ottawa Resource Authority
- Parks Canada
- Nottawasaga Valley Conservation Authority
- Saugeen Ojibway Nation
- US Forest Service
- US Bureau of Indian Affairs
- US Army Corps of Engineers
- US Fish and Wildlife Service
- Michigan Sea Grant



Addressing the need for coordinated tributary and nearshore monitoring in the Saginaw Bay and Watershed

Angela Brennan, Water Quality Specialist/Hydrologist — USGS

David Karpovich, Professor of Chemistry and Director, Saginaw Bay Environmental Science Institute — SVSU Saginaw Valley State University

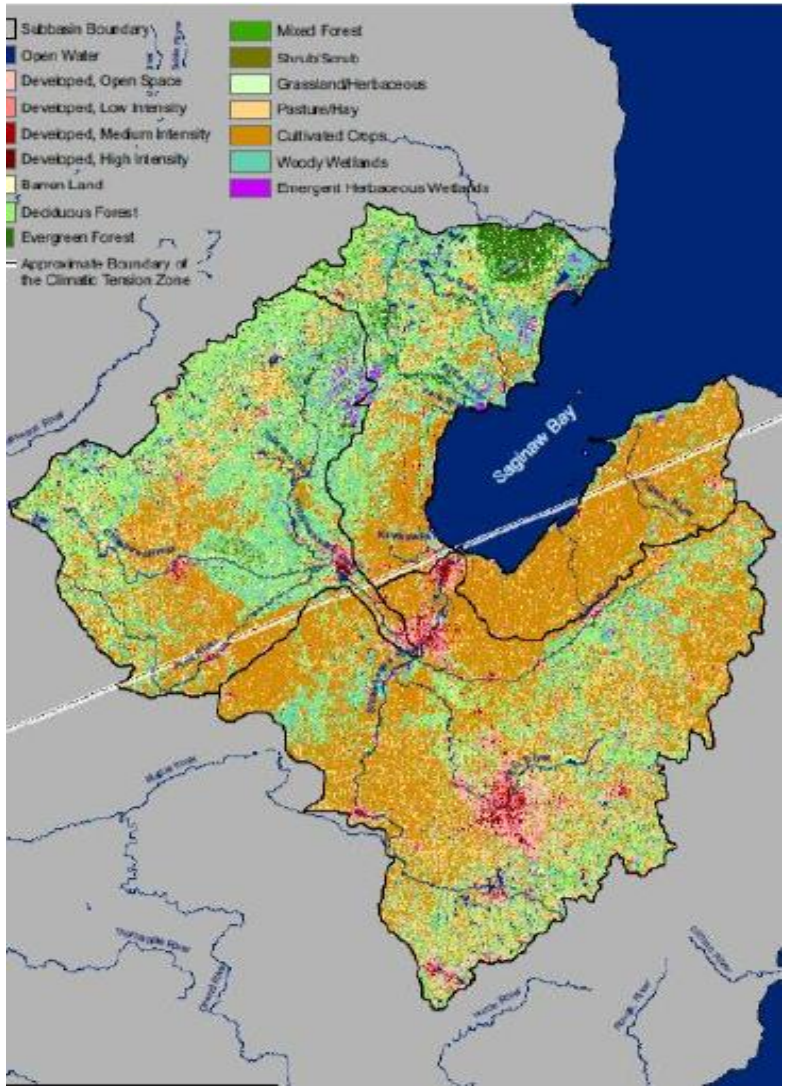
Bretton Joldersma, Lake Huron Coordinator
Kelly Turek, Aquatic Biologist — EGLE

Abby Eaton, Environmental Resources Specialist
Joe Kelpinski, MAEAP Program Manager — Michigan Department of Agriculture & Rural Development

Gust Annis, Conservation Specialist
Mary Fales, Program Director, Saginaw Bay
Doug Pearsall, Senior Conservation Scientist — The Nature Conservancy

Craig Stow, Senior Research Scientist — NOAA GLERL Great Lakes Environmental Research Laboratory

The Saginaw Bay and Watershed



Michigan's largest watershed and a significant resource on the Great Lakes

- 8,700 square miles, all or part of 22 counties
- ~ 7,000 miles of rivers and streams
- Home to:
  - Over 1.4 million people
  - More than 138 endangered or threatened species
  - Migrating birds on the Mississippi Flyway
  - Spawning grounds for many Lake Huron fish species
  - Significant agricultural and industrial resources supporting Michigan's economy

Sediment and Nutrient-related issues in the watershed

- **Altered hydrology**
  - 1,930 miles of ditches (17% of total stream length)
- **Impacts from sediment and nutrients:**
  - Excessive algal growth (Muck) → nearshore
  - Evidence of HABs
  - Degraded stream fish and invertebrate communities
  - Loss of reef spawning habitat
  - Lake Huron offshore → nutrients decreasing
  - Complications from Invasive species → zebra & quagga mussels

Phosphorus Reduction Activities

- 1970s – early 2000s: Total P loads to the Bay fell by 43%
  - Reductions are largely attributed to point source control
  - Over $830 million invested to eliminate CSOs & upgrade WWTP
- 2010: MI limits P in dishwasher detergent (statewide)
- 2012: MI bans P in turf grass fertilizers (statewide)
- 2010 – 2015: 47 GLRI & RCPP grants were awarded for P and nutrient reduction activities with the Watershed (> $30.5 million)

How much is enough?

Goal: Meet the 2012 GLWQA Interim Target: 440 MT Total P per year.

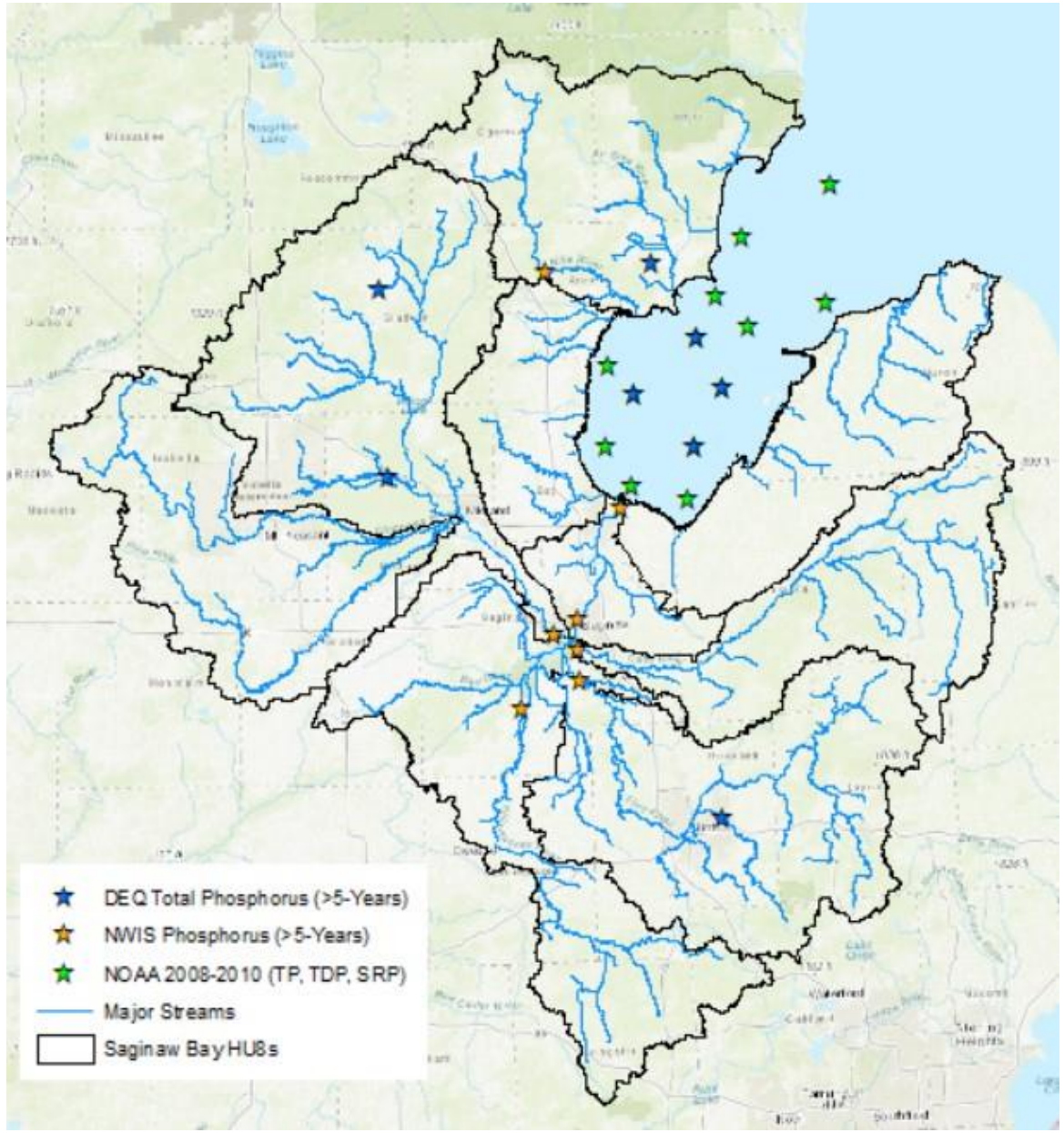
Key questions:

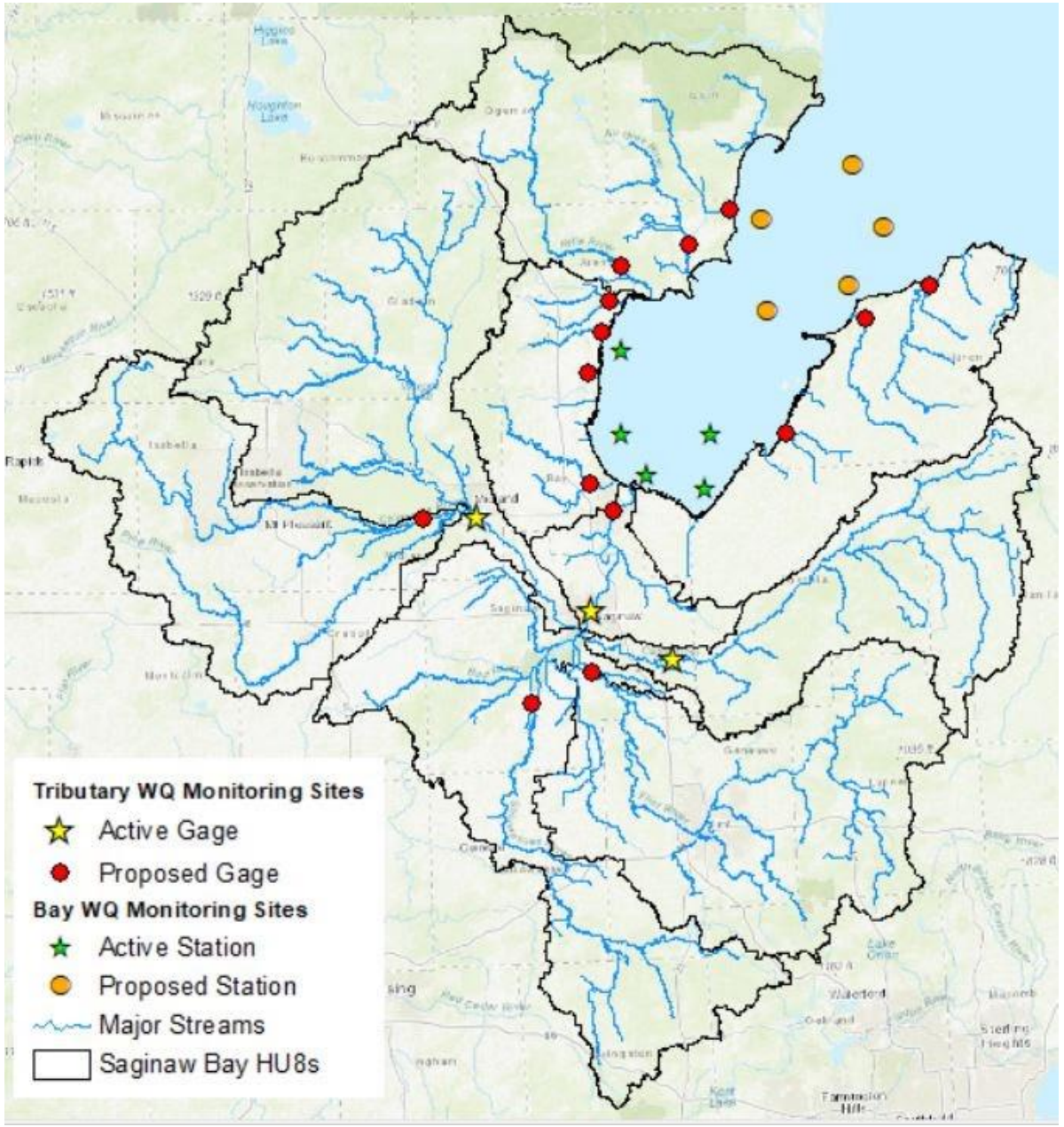
- What is the current condition of the Bay?
- Has progress been made toward the interim target?
- Is the target 440 MT of Total P per year still appropriate?

A surprise to many: We have sparse data →

Water quality data should be…

- Collected over at least 5 years
- In the right locations and frequency
- Co-located with active stream gages
- From sampling & analysis w/same protocols





Proposed monitoring program

- 10 open water sites
- 17 tributary sites
- Duration: 5 years minimum
- Parameters: TP, DRP, Nitrate, Nitrite, Ammonium, TSS, discharge
- Captures major sub-watersheds
- *Selected to inform on where run-off is an issue in the watershed and how it affects the bay.*
- *Results will help determine how much conservation is needed and where (i.e. which sub-watershed).*

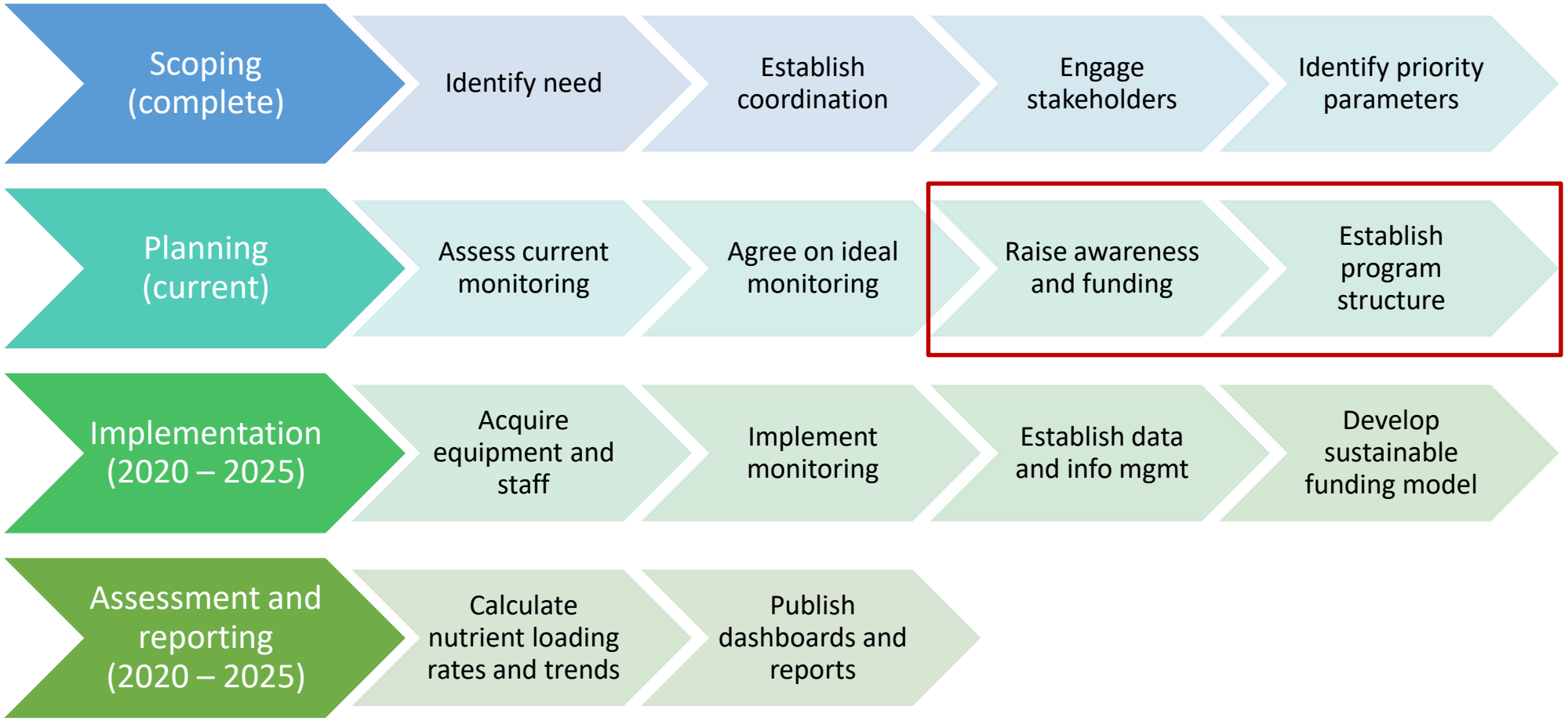
Our objectives align with the Great Lakes management Community

1. Establish and implement a collaborative initiative…
2. Conduct a thorough retrospective analysis...
3. Establish an online data and information management and delivery portal...
4. Calculate nutrient loadings (including TP), determine ecosystem responses, and evaluate trends...
5. Strategically engage partners...
6. Develop a long-term strategy to maintain a water quality monitoring framework...

- 2012 Great Lakes Water Quality Agreement, Annex 4 objectives
- 2017-2021 Lake Huron Lakewide Action and Management Plan
- The Sweetwater Sea: An International Biodiversity Conservation Strategy for Lake Huron
- Sustaining Michigan's Water Heritage (i.e. Michigan Water Strategy)
- Michigan Department of Environmental Quality's Phosphorus Policy Advisory Committee Report, 2007.

Water quality data sets from this program will provide for:

- Evaluating **the effectiveness** of non-point source **management steps**
- Identifying **where management** should be **focused** in the watershed
- Developing response curves to show **stressor-response relationships**
  - Such as **nutrient-HAB relationships**
- Calibrating and validating **ecosystem models** to help:
  - **Forecast** the occurrence of **HABs** and other ecosystem events
  - Understand how **management** of stressors may **affect responses**
  - Predict effects of **climate change** on **ecosystem responses**



Next Steps: Secure funding and move to Implementation

Lake Michigan Update

Beth Hinchey-Malloy

Lake Michigan Partnership

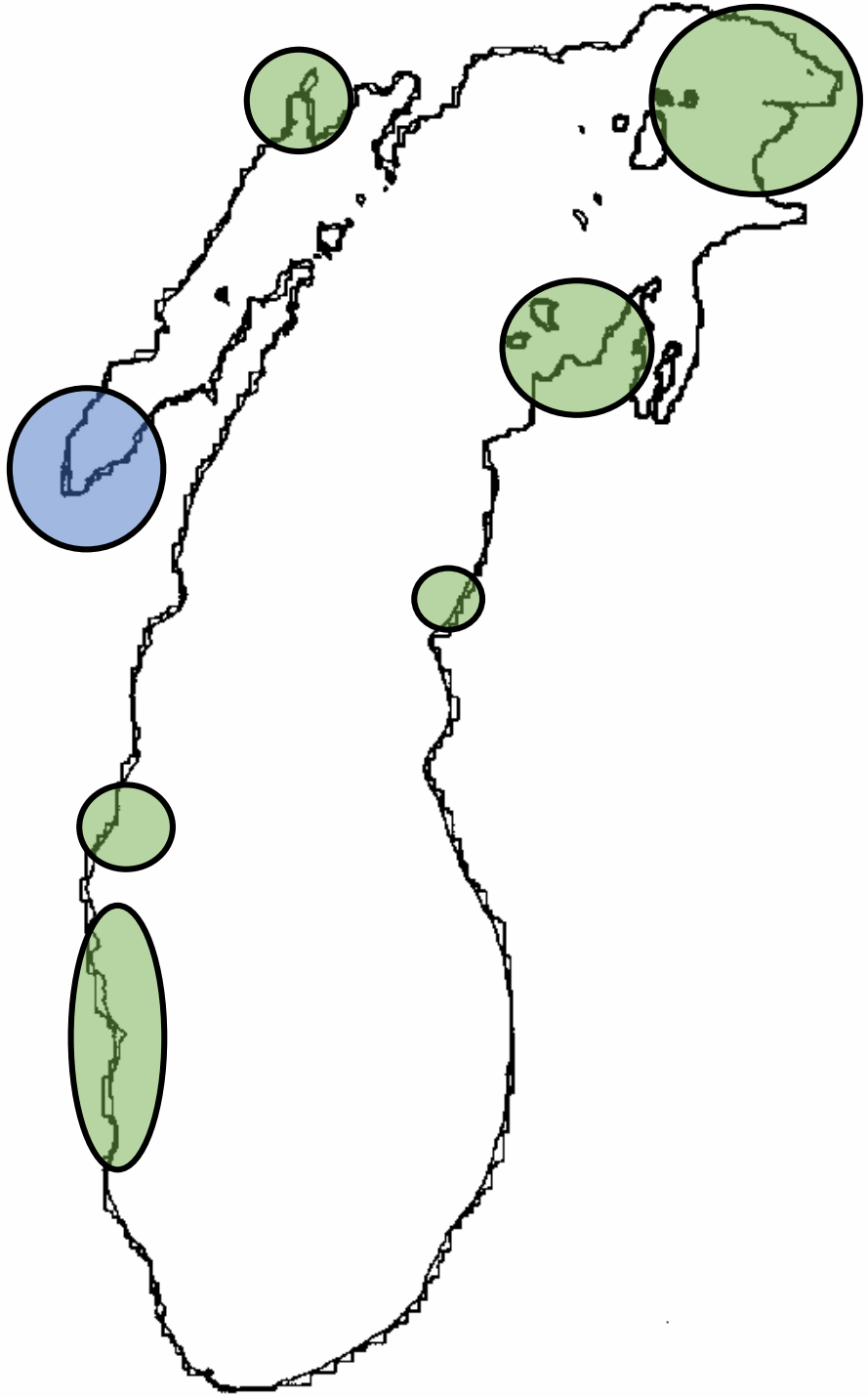
- US Environmental Protection Agency
- National Oceanic and Atmospheric Administration
- US Army Corps of Engineers
- USDA Natural Resources Conservation Service
- US Geological Survey
- US Fish and Wildlife Service
- Bureau of Indian Affairs
- USDA Forest Service
- US National Park Service

20 member federal, state, municipal agencies & tribes

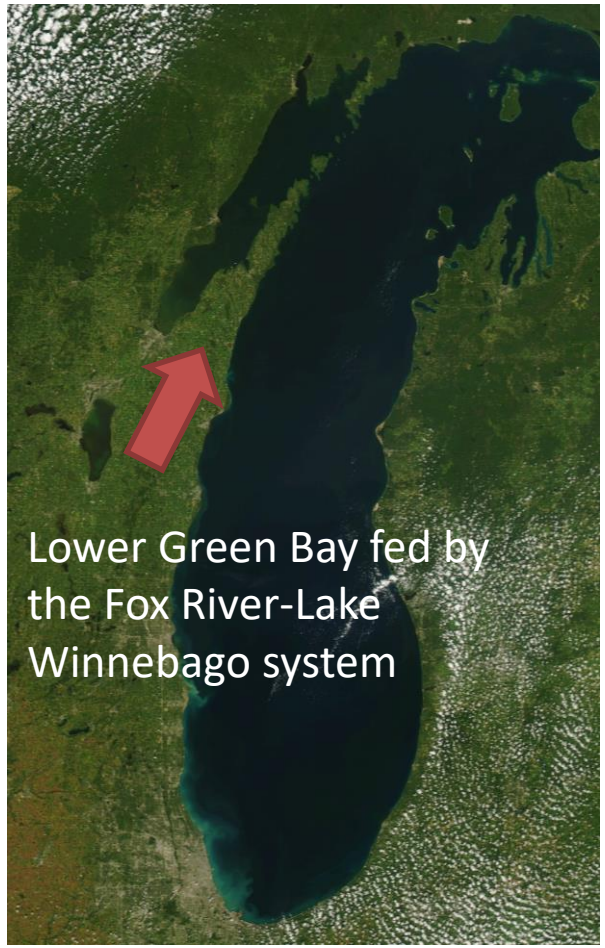
- Illinois Dept of Natural Resources
- Indiana Dept of Natural Resources
- Indiana Dept of Environmental Management
- Michigan EGLE
- Wisconsin Dept of Natural Resources
- City of Milwaukee Office of Environmental Collaboration
- Michigan City Sanitary District
- Chippewa-Ottawa Resource Authority
- Grand Traverse Band of Ottawa and Chippewa Indians
- Little Traverse Bay Bands of Odawa Indians
- Oneida Nation

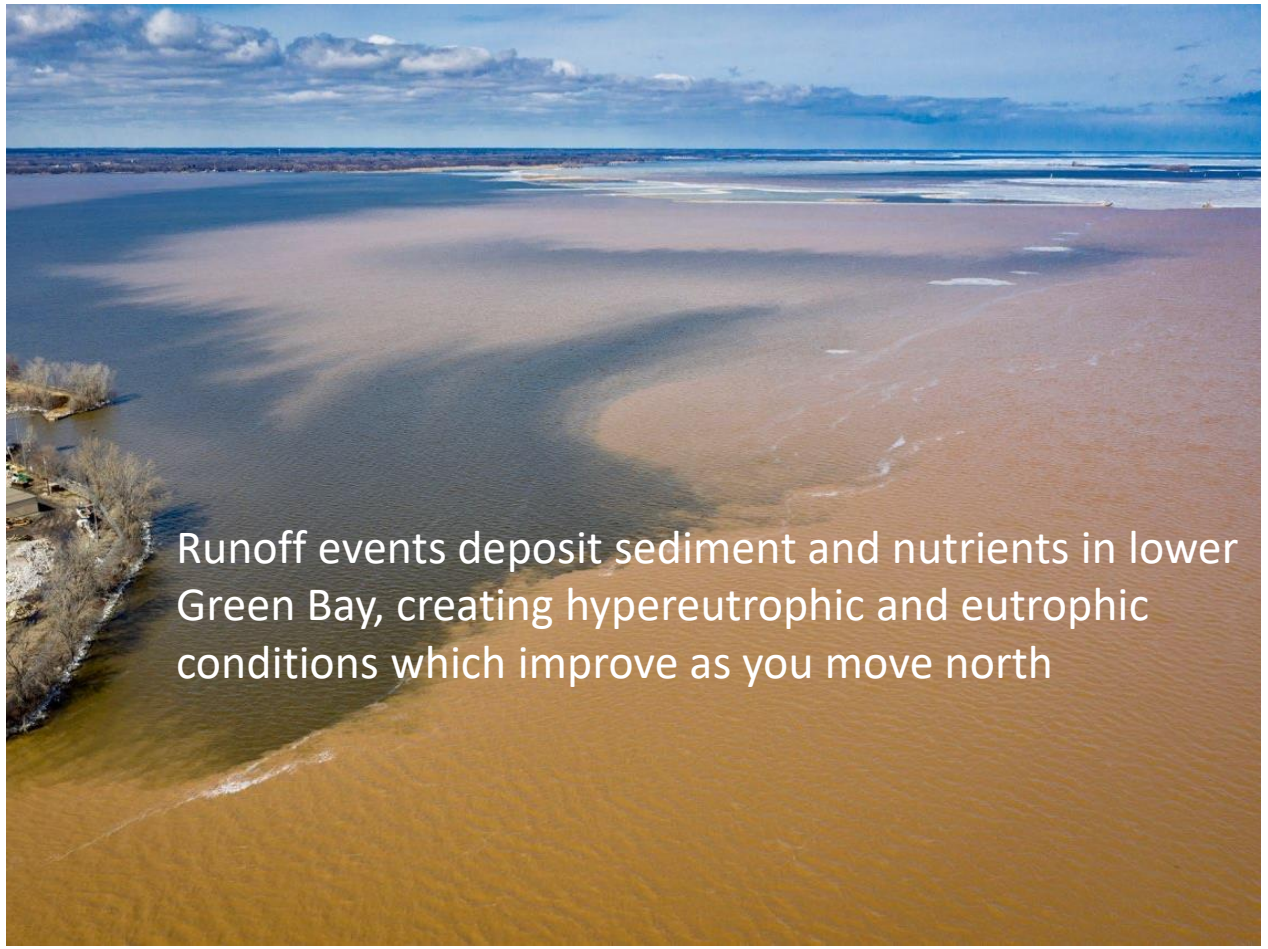
Lake Michigan LAMP

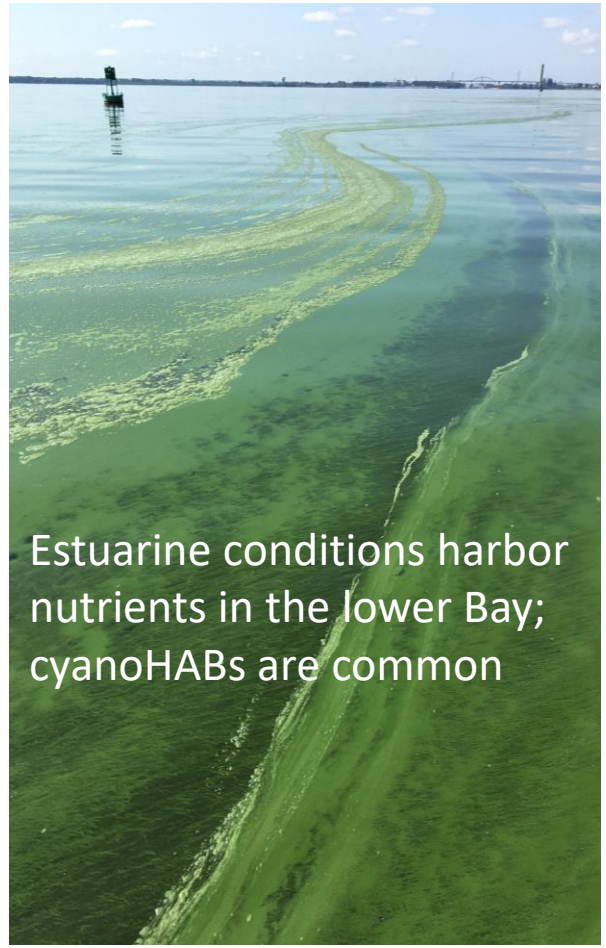
- Lake Michigan Partnership is drafting the 2020-2024 Lake Michigan LAMP.
- LAMP will include *Management Actions* to address nutrient and bacterial-related impacts to the Lake
- Draft LAMP will be available for public comment later this year



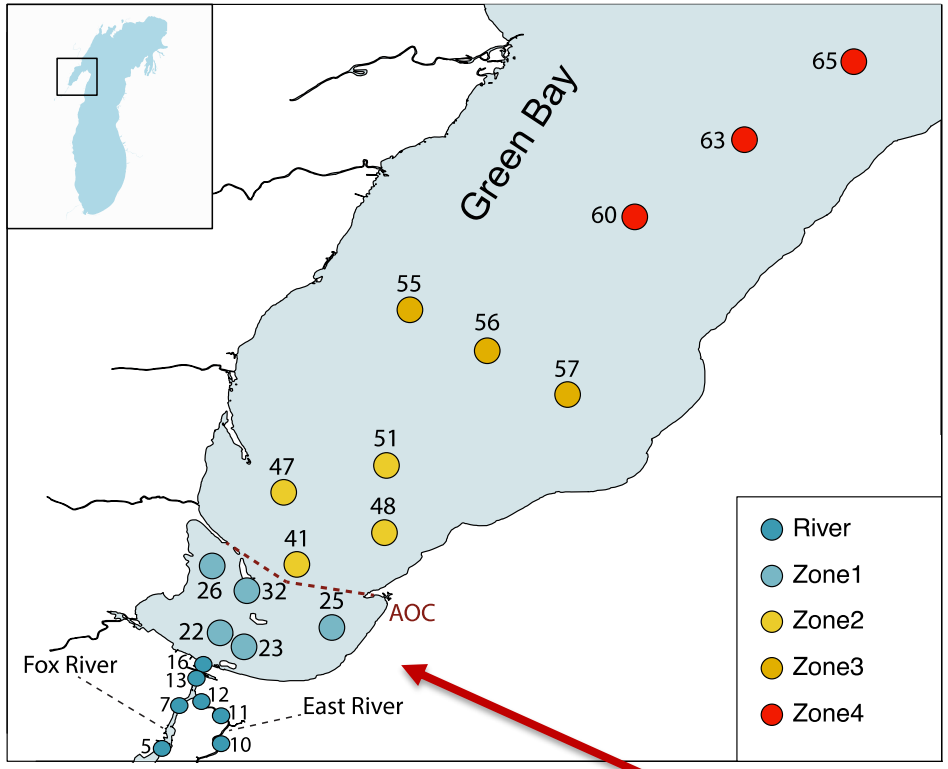
Green Bay Water Quality



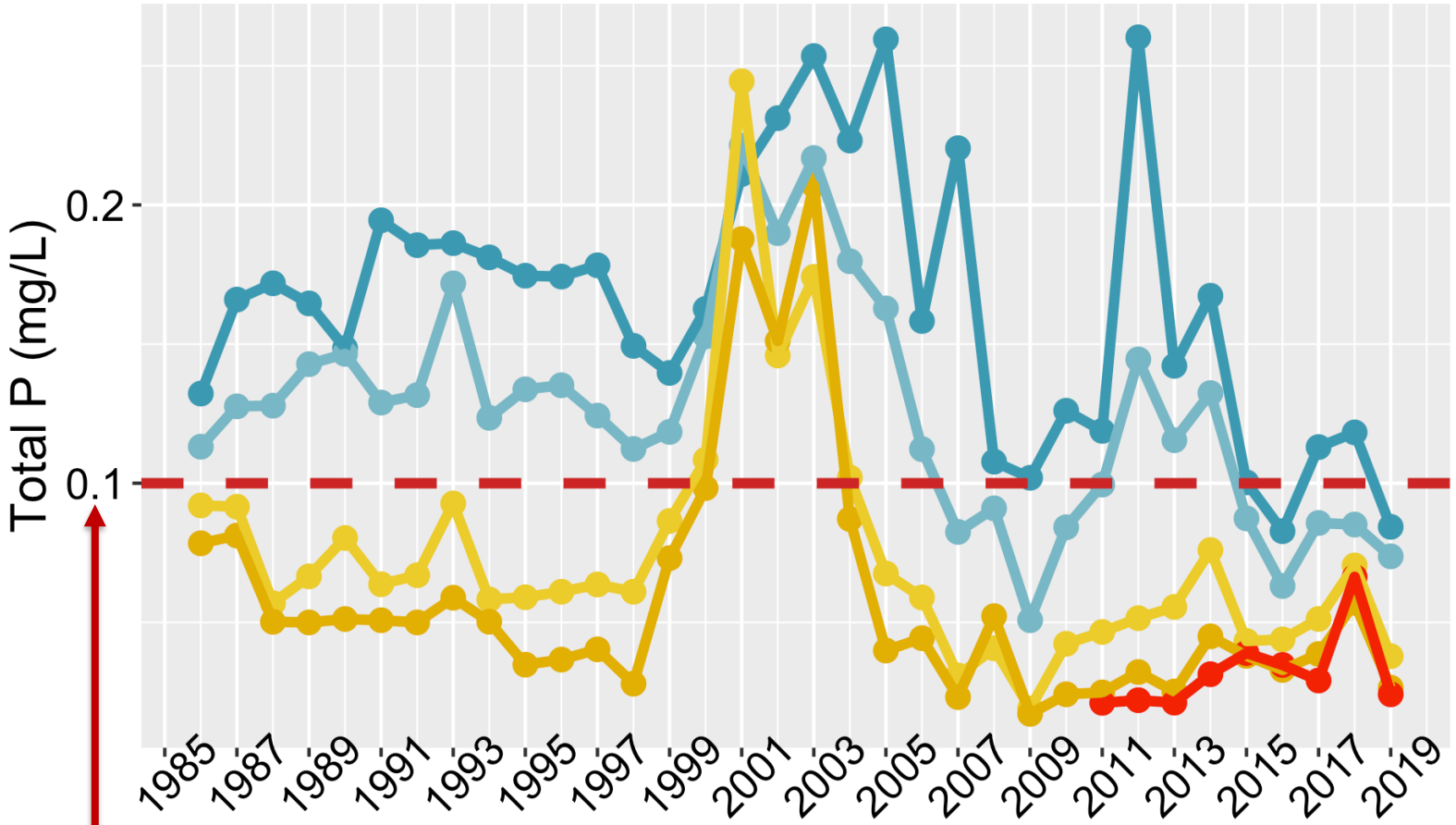




NEW Water Sample Locations

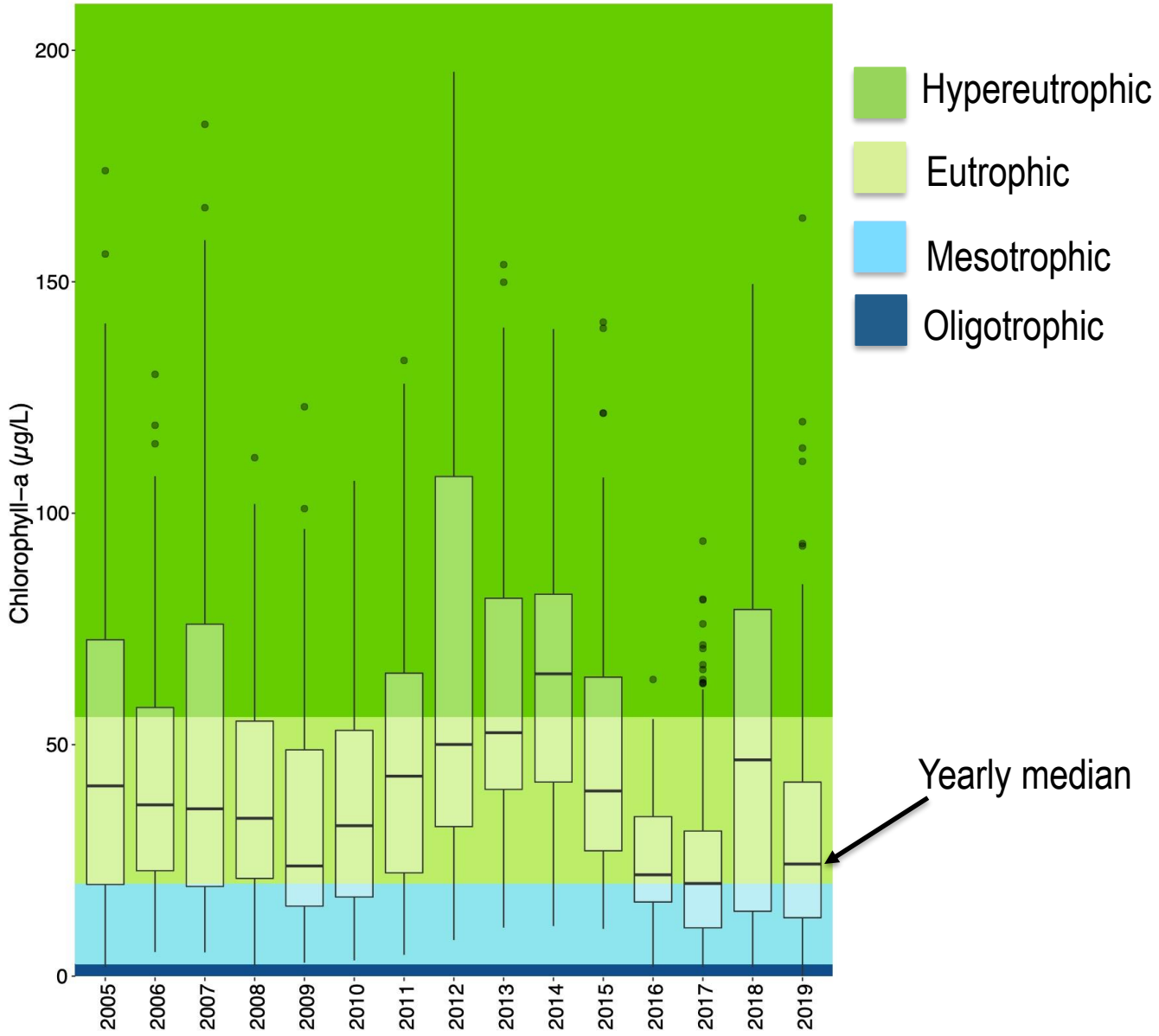


Yearly Average Total Phosphorus 1986-2019

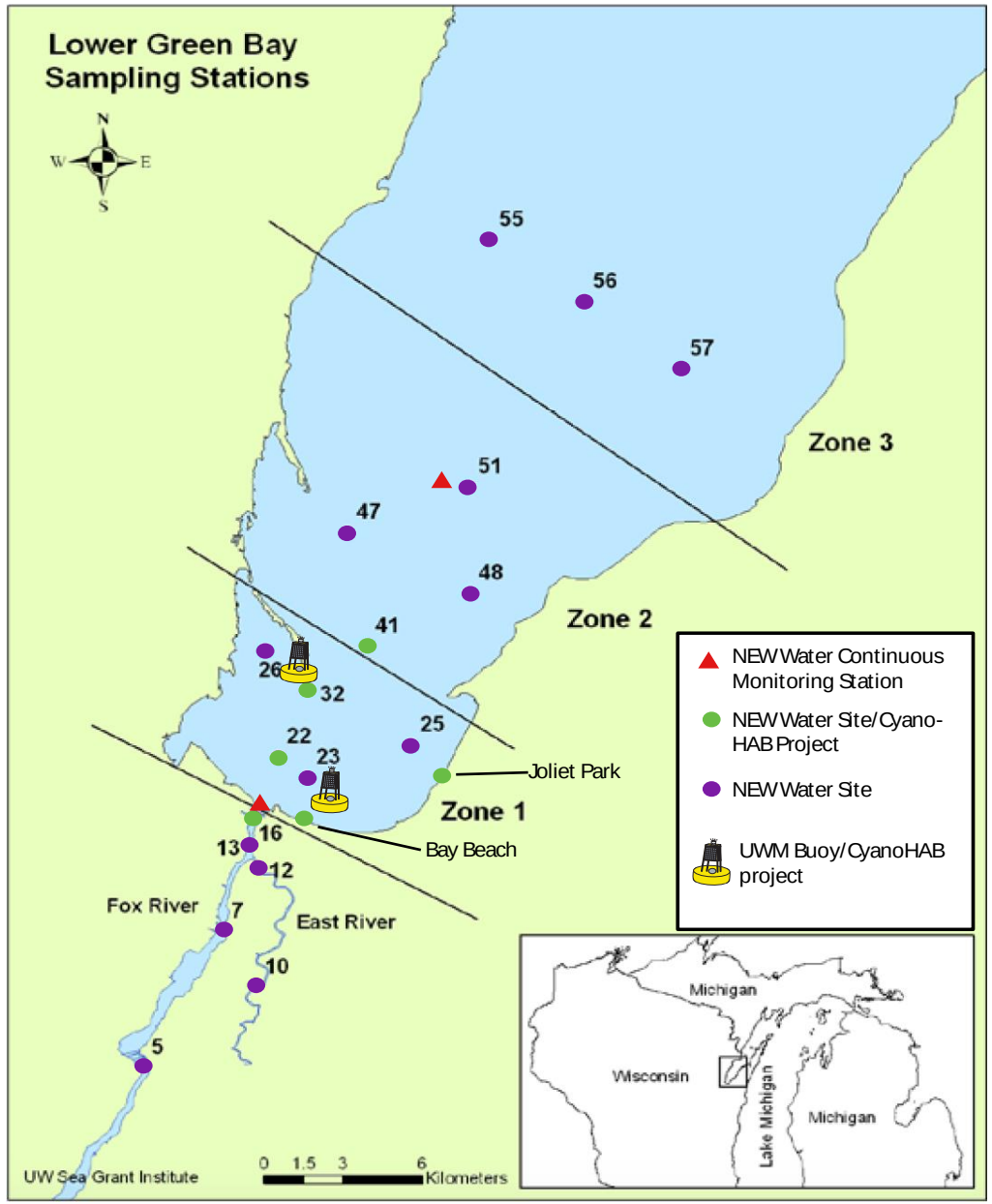


Water quality standard = 0.1 mg/L for Total Phosphorus in the Lower Green Bay Area of Concern (AOC)

Lower Green Bay Chlorophyll and Trophic Status



Great Lakes HABs Collaborative



Spatial Assessment of CyanoHABs and Cyanotoxins

- Diversity and distribution of cyanotoxins in Green Bay, 2016 – 2020
- Cyanotoxin, Nutrient, Pigment analysis
  - Weekly sampling along a transect in lower GB
  - 2-3 samples/ week at Bay Beach and Joliet Park
  - LCMS analysis of cyanotoxins
- Hydrodynamics of lower Green Bay
  - Two water quality monitoring buoys
  - Two continuous monitoring stations
  - Various ADCP deployments
- Temporal modeling of cyanotoxins in Bay Beach area

NEW Water
The brand of the Green Bay Metropolitan Sewerage District

UWM
UNIVERSITY of WISCONSIN MILWAUKEE

UNIVERSITY of WISCONSIN GREEN BAY

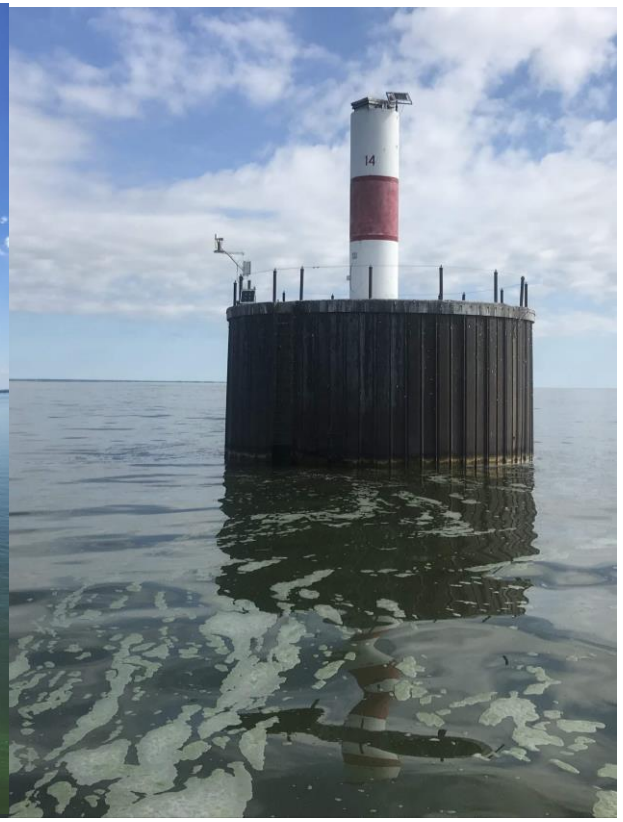
WISCONSIN
UNIVERSITY OF WISCONSIN-MADISON

WISCONSIN DEPT. OF NATURAL RESOURCES

Linking Science and Management to Reduce Harmful Algal Blooms

AERONET-OC program

- Green Bay was one of three U.S. freshwater bodies selected for recent deployments of the SeaPRISM supported by the Landsat project science office
- SeaPRISM records water color in the Bay to enhance water quality products derived from a suite of satellite missions launched and operated by NASA, the United States Geological Survey (USGS), and the European Space Agency (ESA)
- Deployed at a site regularly monitored by NEW Water, Site 41
  - both color measurements and water quality data are available for ground truthing SeaPRISM



Lake Ontario Update

Kristina Heinemann
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Lake Ontario LAMP Manager
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212-637-3857

Lake Ontario Partnership

United States

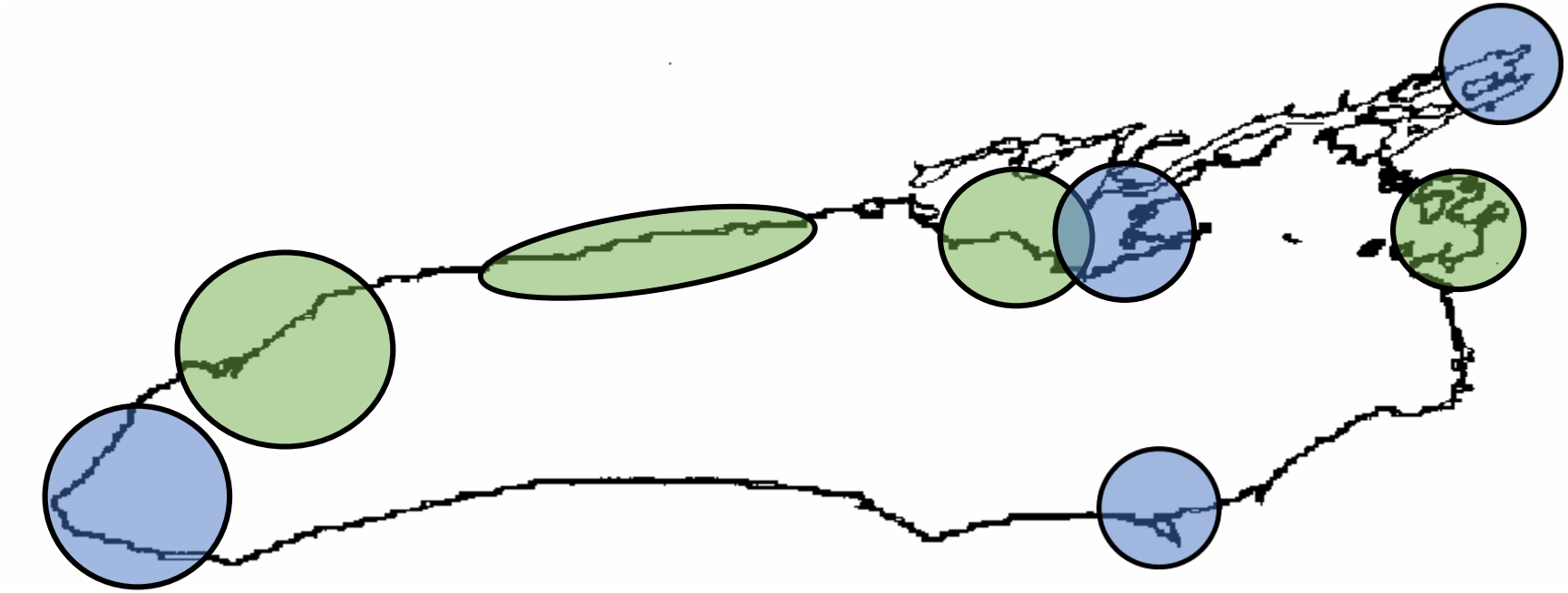
- US Environmental Protection Agency Region 2
- New York State Department of Environmental Conservation
- National Oceanic and Atmospheric Administration
- US Army Corps of Engineers
- USDA Natural Resources Conservation Service
- US Geological Survey
- US Fish and Wildlife Service
- Saint Regis Mohawk Tribe
- Bureau of Indian Affairs
- USDA Forest Service

Canada

- Environment and Climate Change Canada
- Department of Fisheries and Oceans
- Toronto and Region Conservation Authority
- Ontario Ministry of the Environment Conservation and Parks
- Quinte Conservation
- Ontario Ministry of Natural Resources and Forestry
- Credit Valley Conservation
- Parks Canada

Lake Ontario LAMP

- Lake Ontario Partnership works to protect Lake Ontario under the auspices of the 2018-2022 Lake Ontario draft LAMP.
- Draft LAMP includes *Management Actions* to address nutrient and bacterial-related impacts to the Lake:
  - includes priority science and monitoring activities to characterize nutrient concentrations and loadings
  - actions to reduce end-of pipe nutrient discharges and control urban runoff
  - emphasize soil health and other measures to reduce overland runoff of nutrients; and
  - implement RAPs and watershed management plans to reduce nutrients.



Cyanobacterial and Harmful Algal Blooms in Lake Ontario's Areas of Concern (Hamilton Harbour and Bay of Quinte)

Arthur Zastepa and David Depew

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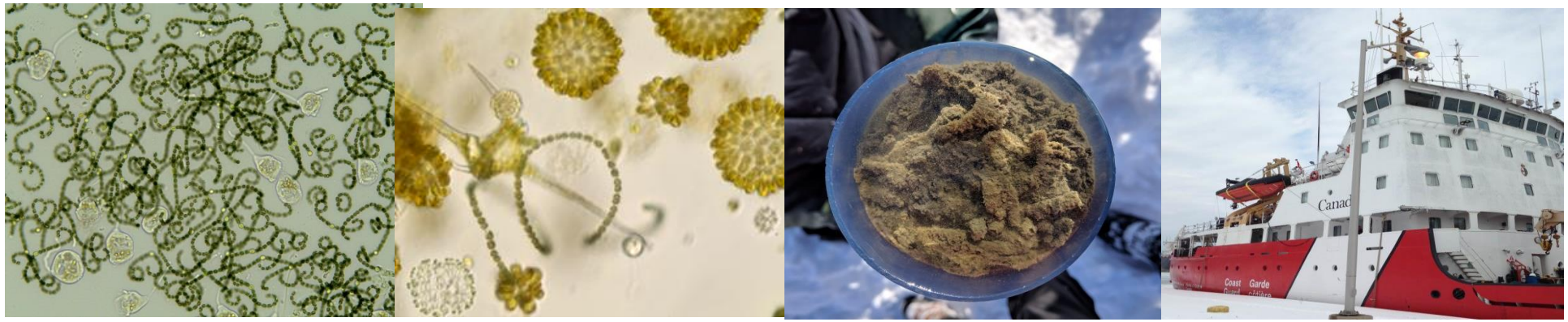
Environment and Climate Change Canada, Canada Centre for Inland Waters, Burlington, Ontario



Areas of Concern, Beneficial Use Impairments

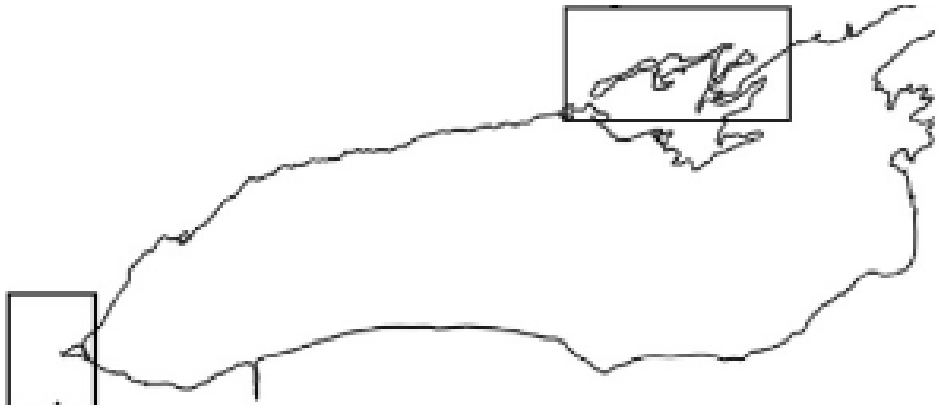
-Hamilton Harbour

-Bay of Quinte

-Toronto and Region

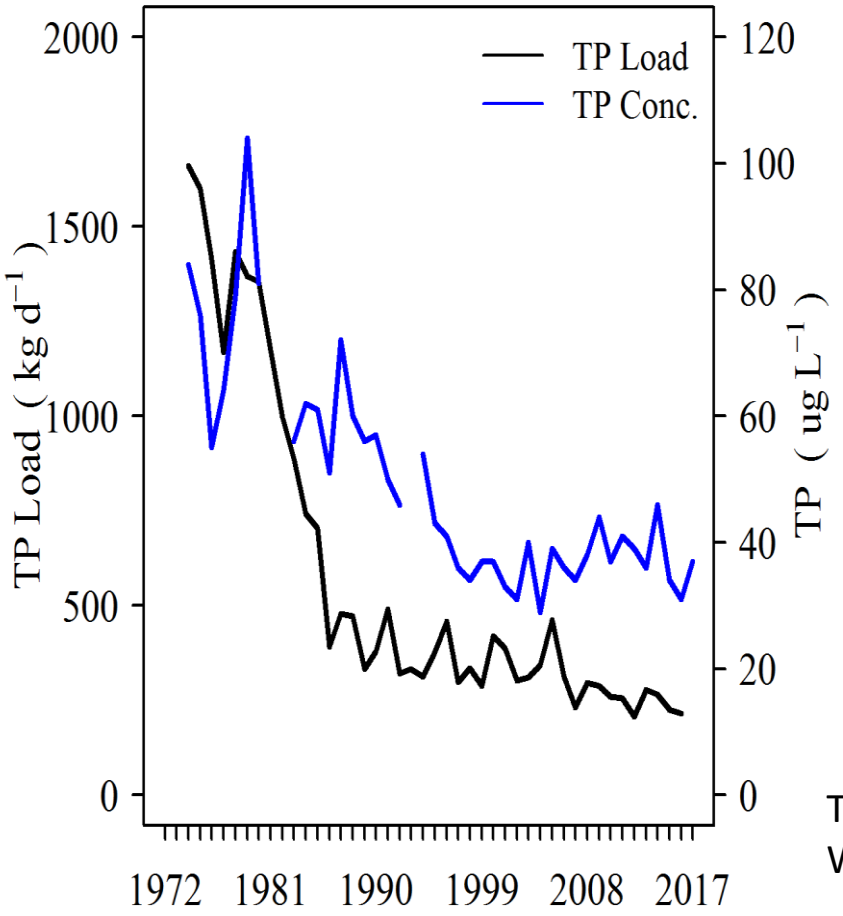
-St. Lawrence River

-Sodus Bay (USA)…



BUI	Description
1	Restrictions on Fish and Wildlife Consumption
3	Degradation of Fish and Wildlife Populations
6	Degradation of Benthos
7	Restrictions on Dredging Activities
8	Eutrophication or Undesirable Algae
9	Restrictions on Drinking Water and Taste and Odour Problems
10	Beach Closures
11	Degradation of Aesthetics
13	Degradation of Phytoplankton and Zooplankton Populations
14	Loss of Fish and Wildlife Habitat

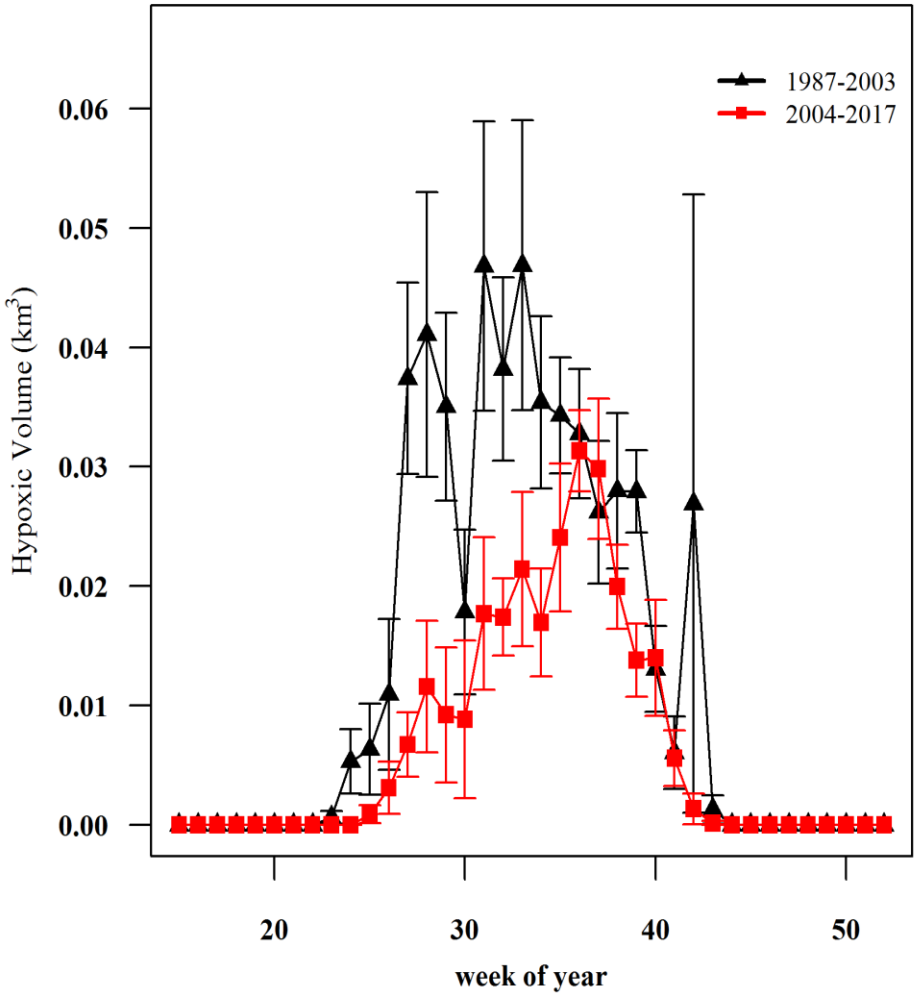
Eutrophication in Hamilton Harbour



- ***Legacy*** of cultural eutrophication
- Dramatic reductions of P inputs associated with point source control
- Downward trend in loadings continues but TP less clear since ~ 2000

TP inputs : See Loadings Report ca. 2016
WQ Data: Stn 1001, May-Sept mean (1m)

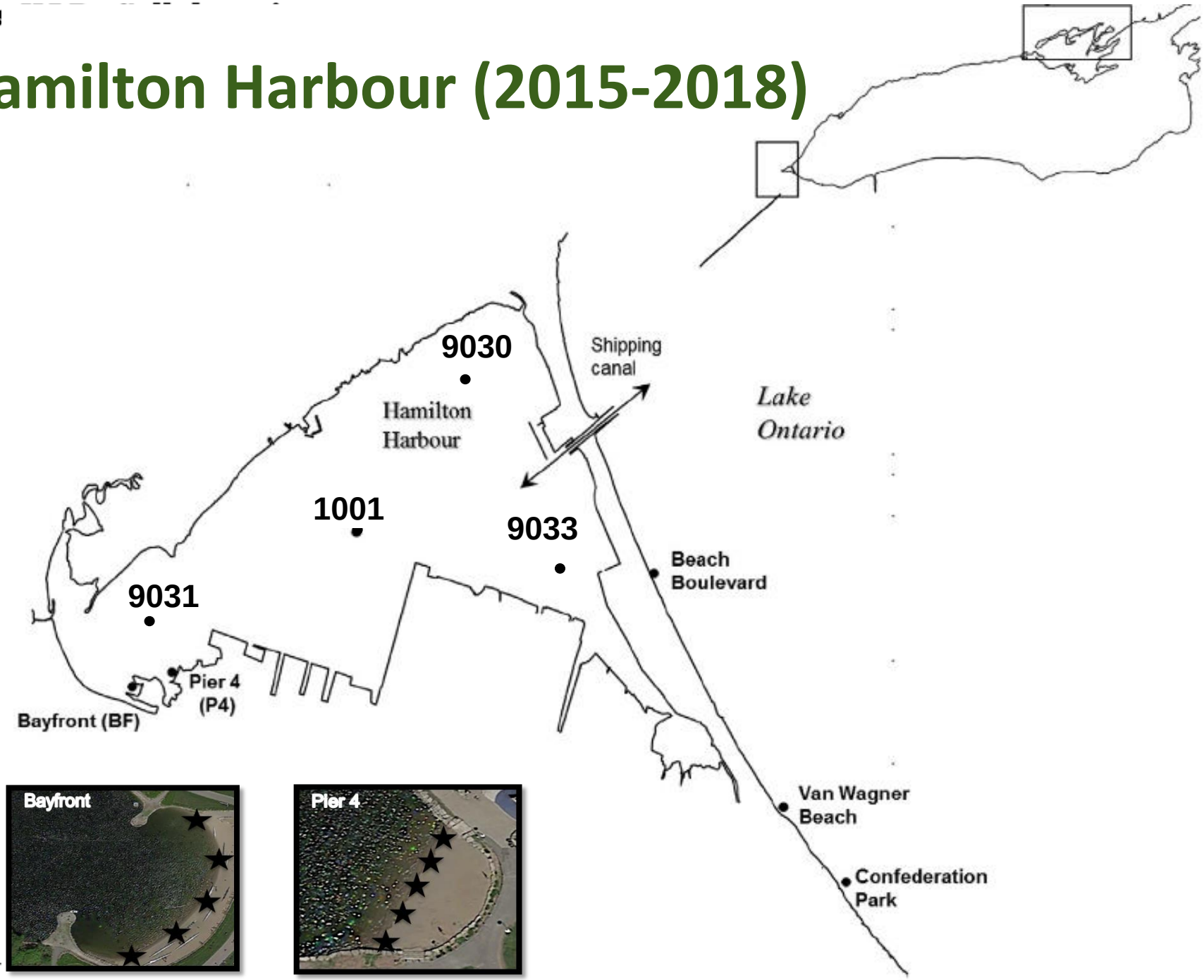
Evidence of recovery…



- Volume of hypoxic water (< 4 mg L^{-1} DO) from May – July has declined ~ 60 %
- Likely due to a reduction of sinking algal biomass
- Hypoxic duration shrinking by ~ 1.5 d yr^{-1}
- Near absence of oxygen persists near sediment-water interface

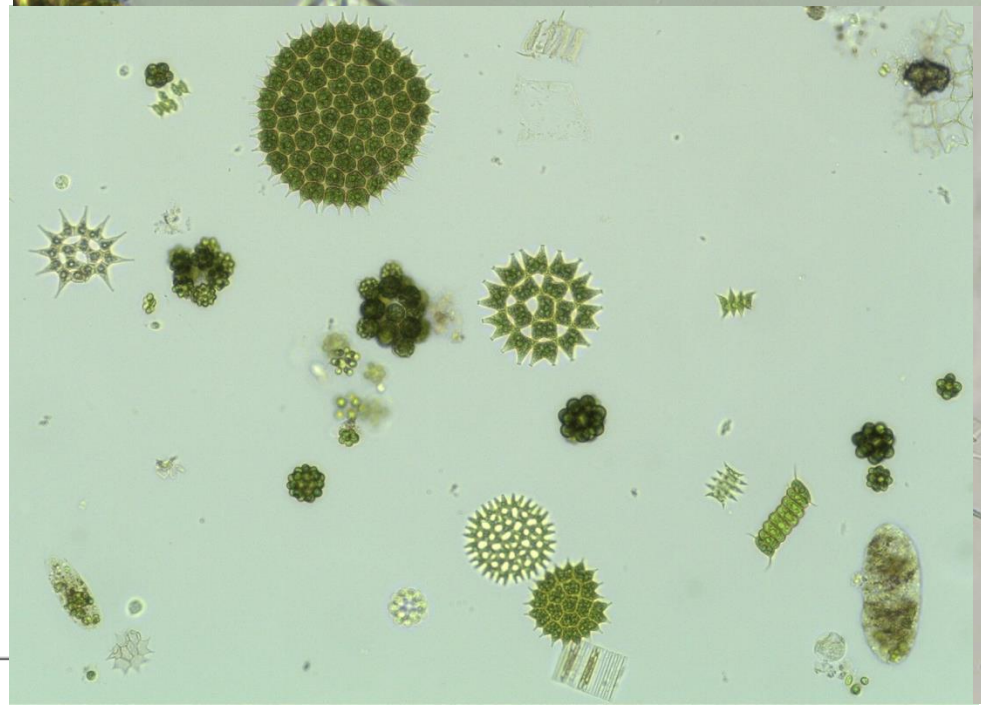
Or Not…

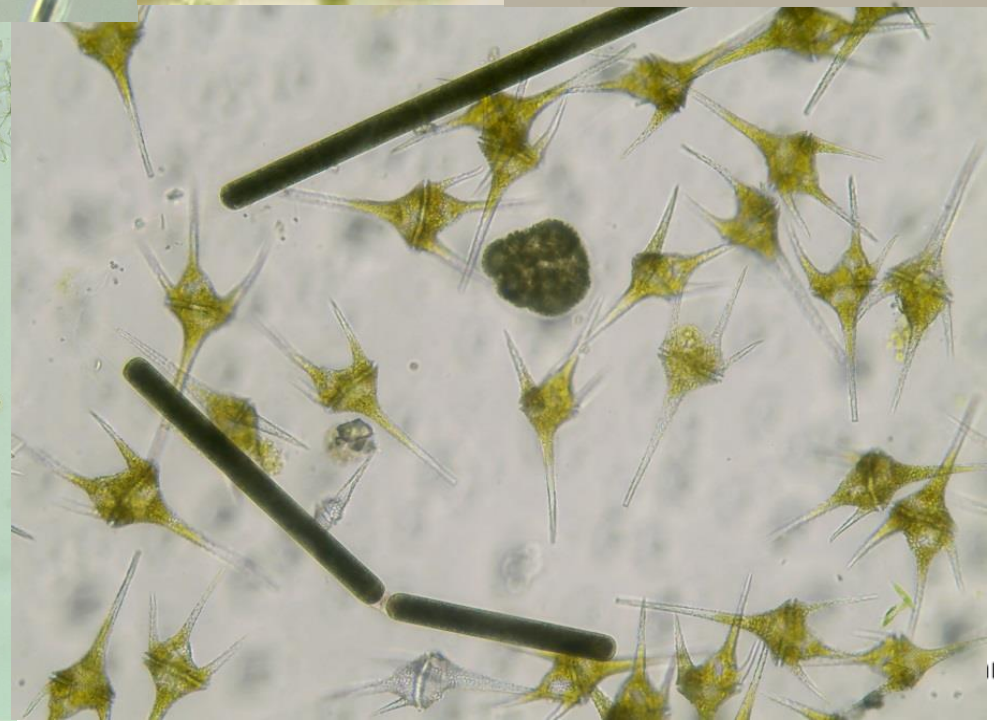
Hamilton Harbour (2015-2018)



Gre

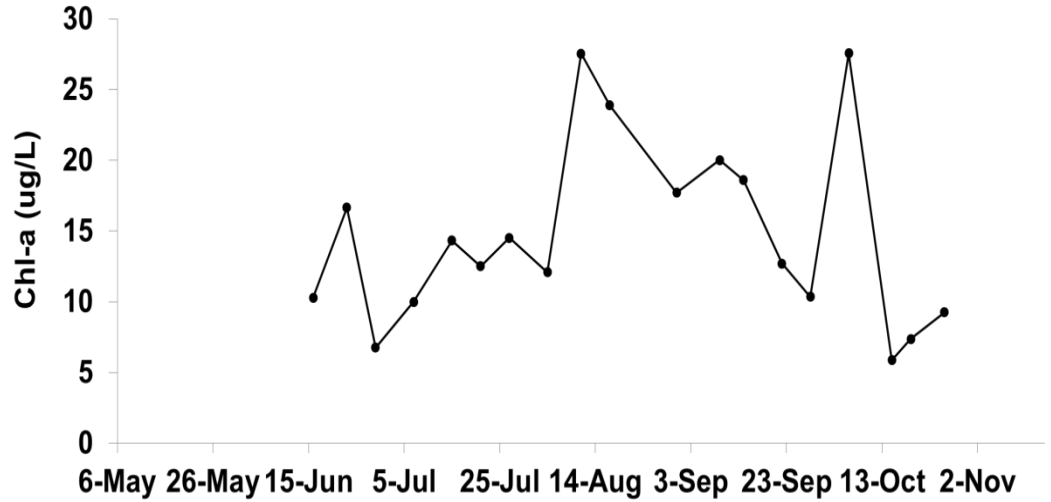
Ph

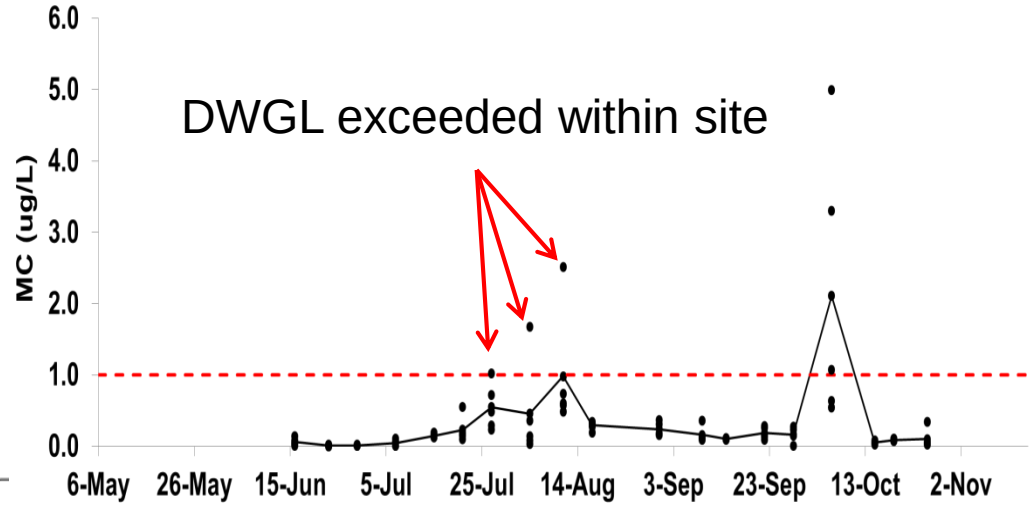




rmful Algal Blooms

Seasonal changes at beaches
→ late summer, early autumn blooms/toxins





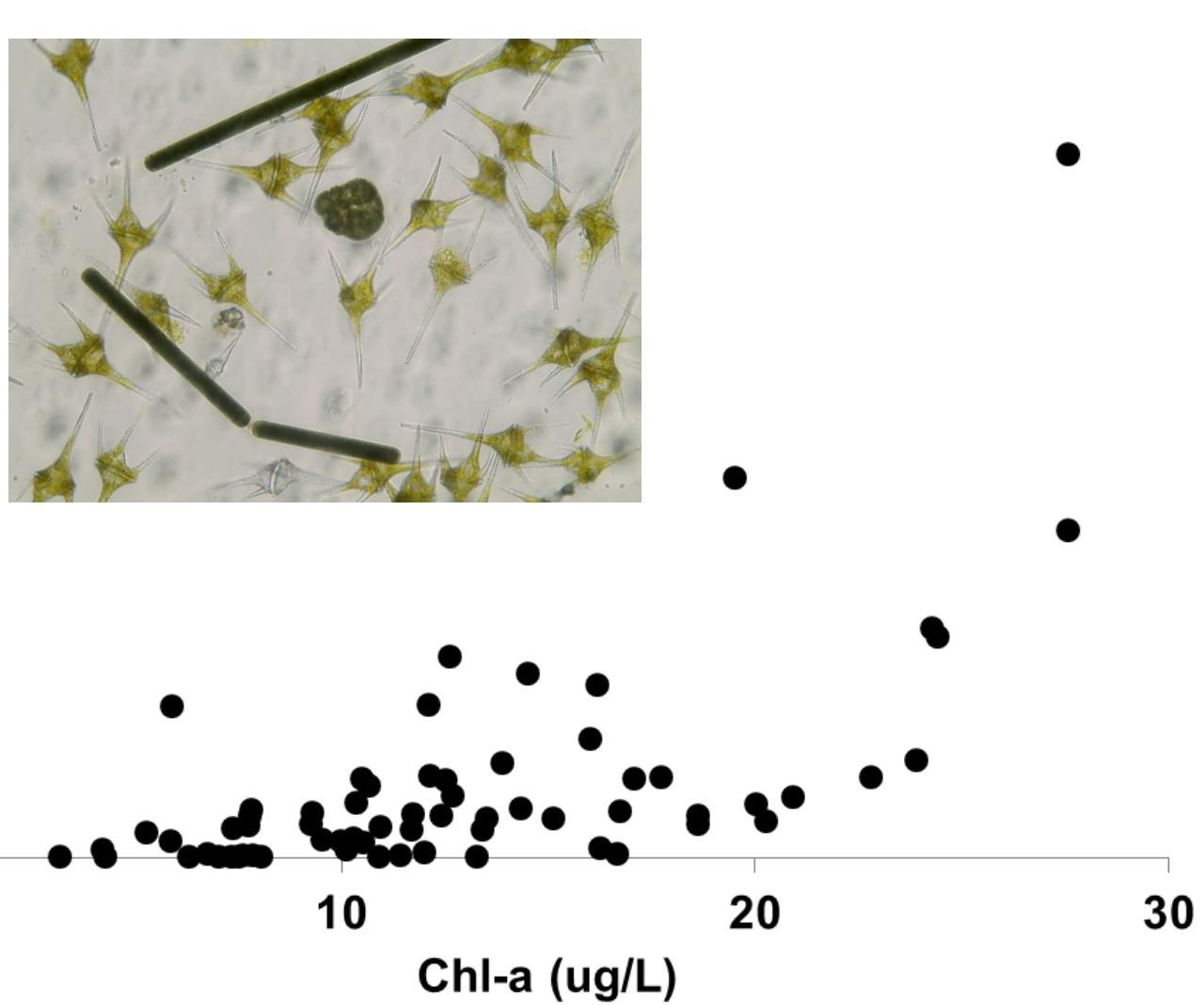
Apparent co-occurrence of chlorophyll and microcystins but...

Recreational guideline: 20 ug/L
- not exceeded
Drinking water guideline: 1 ug/L
- exceeded (July, Aug, and Oct)

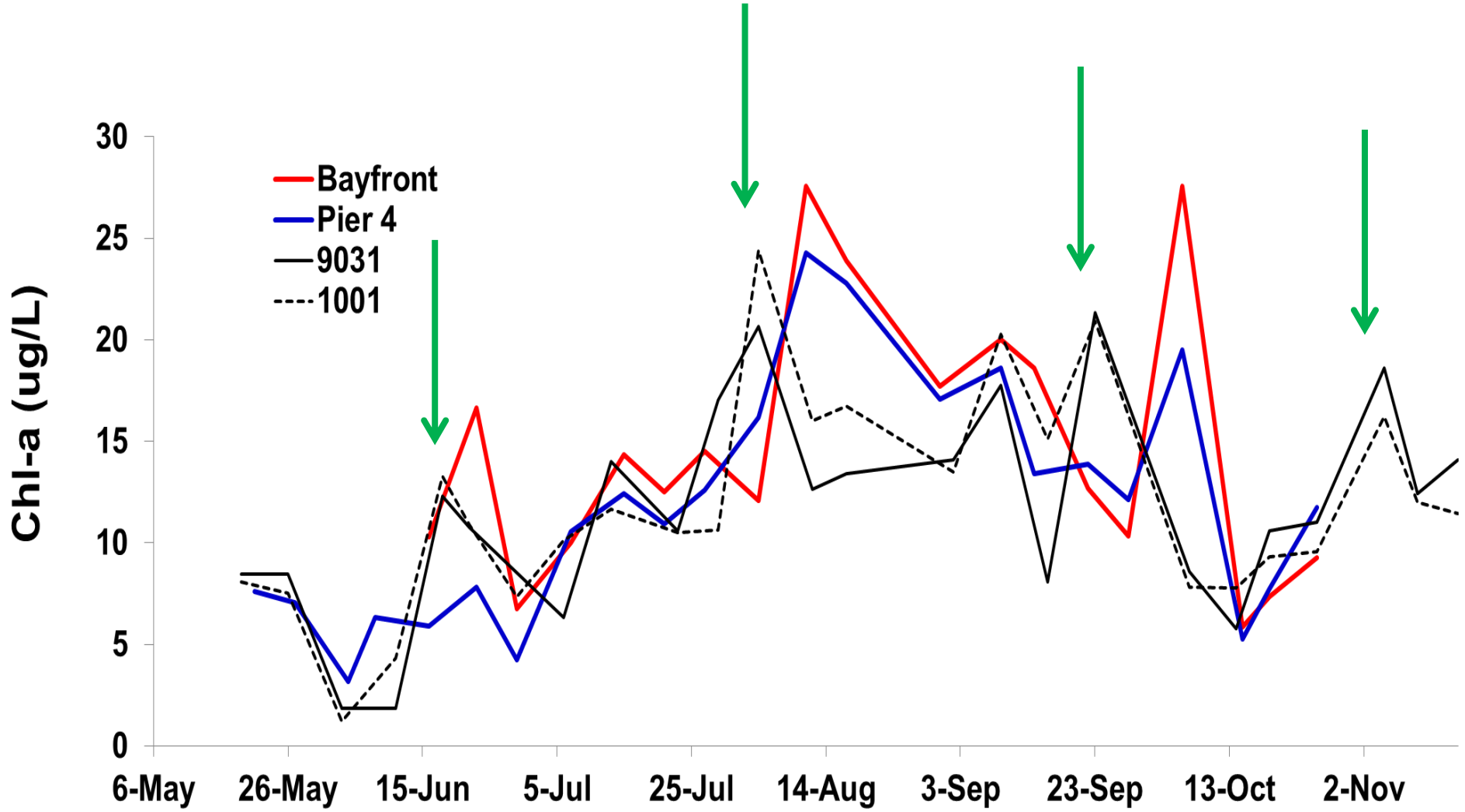
and…

Chlorophyll-*a* ≠ cyanobacteria ≠ microcystins

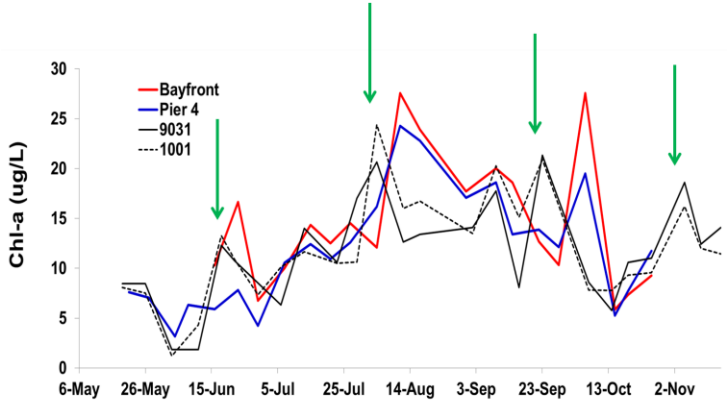
Ceratium (dinoflagellate) bloom August 31st

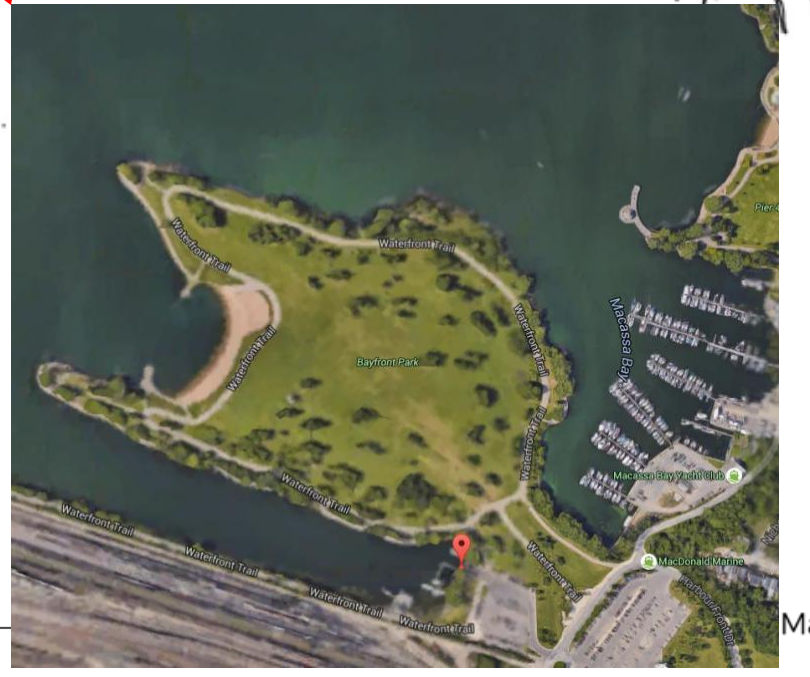


Biomass appears to originate offshore in Hamilton Harbour

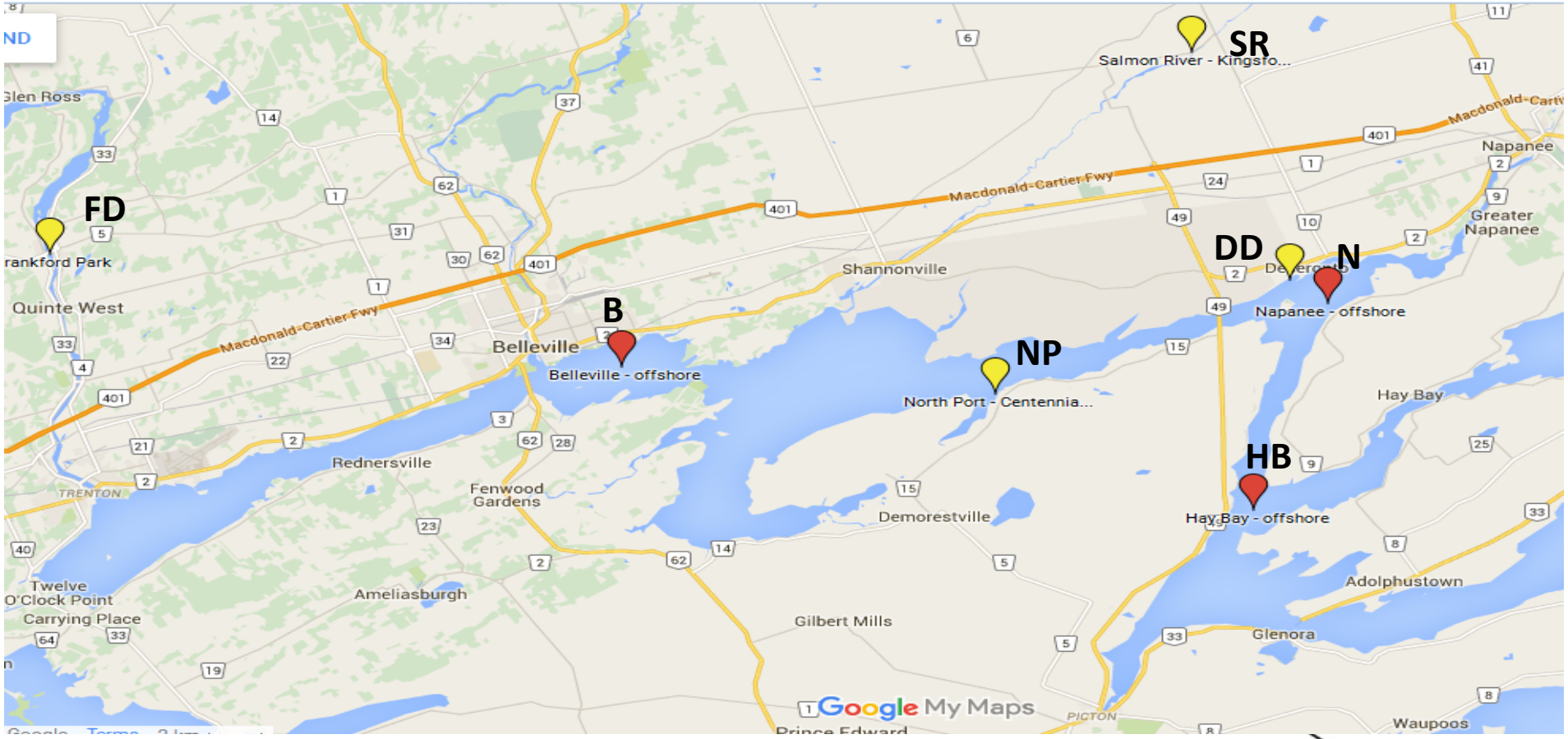


Hamilton Harbour





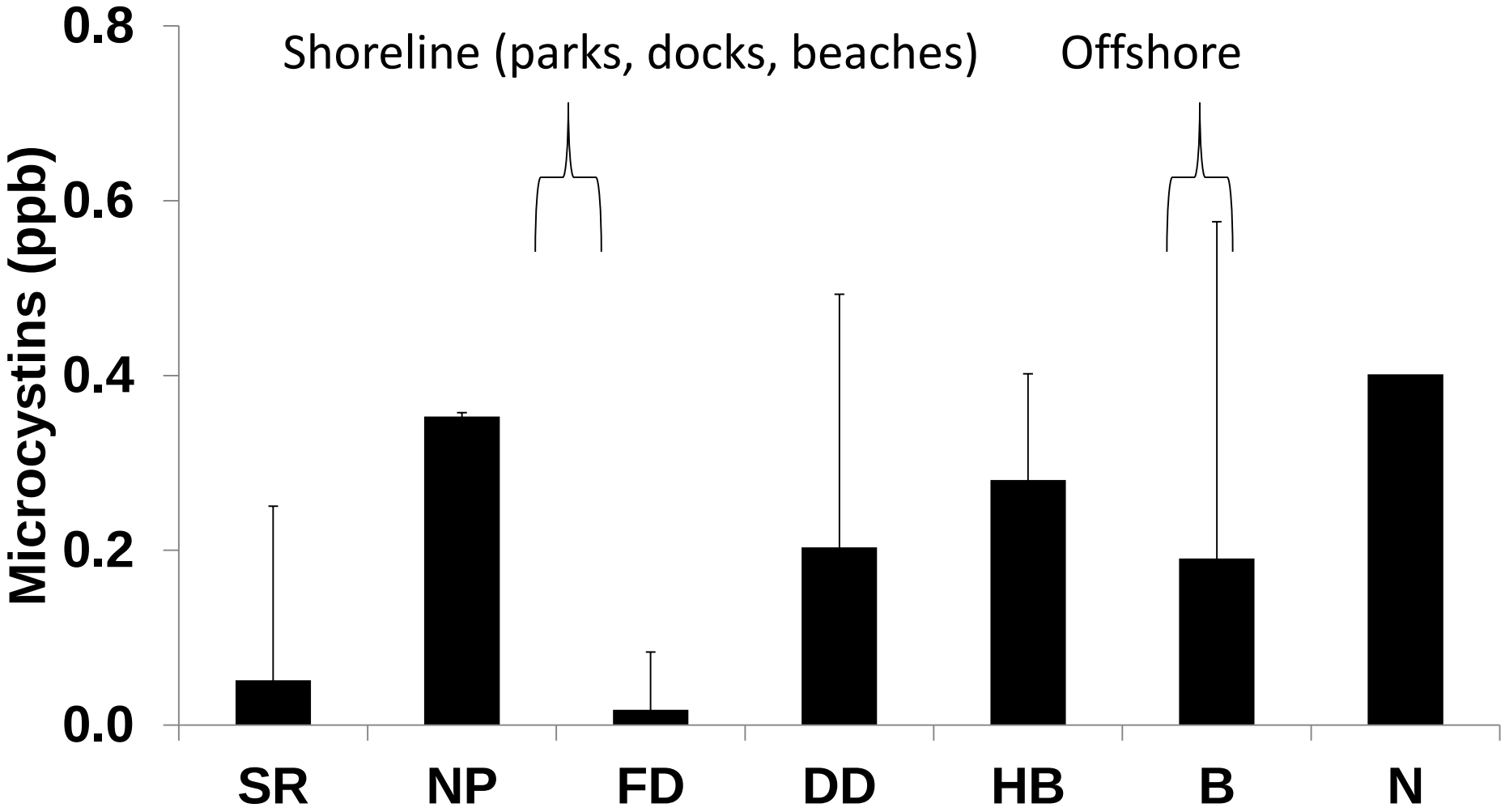
Bay of Quinte



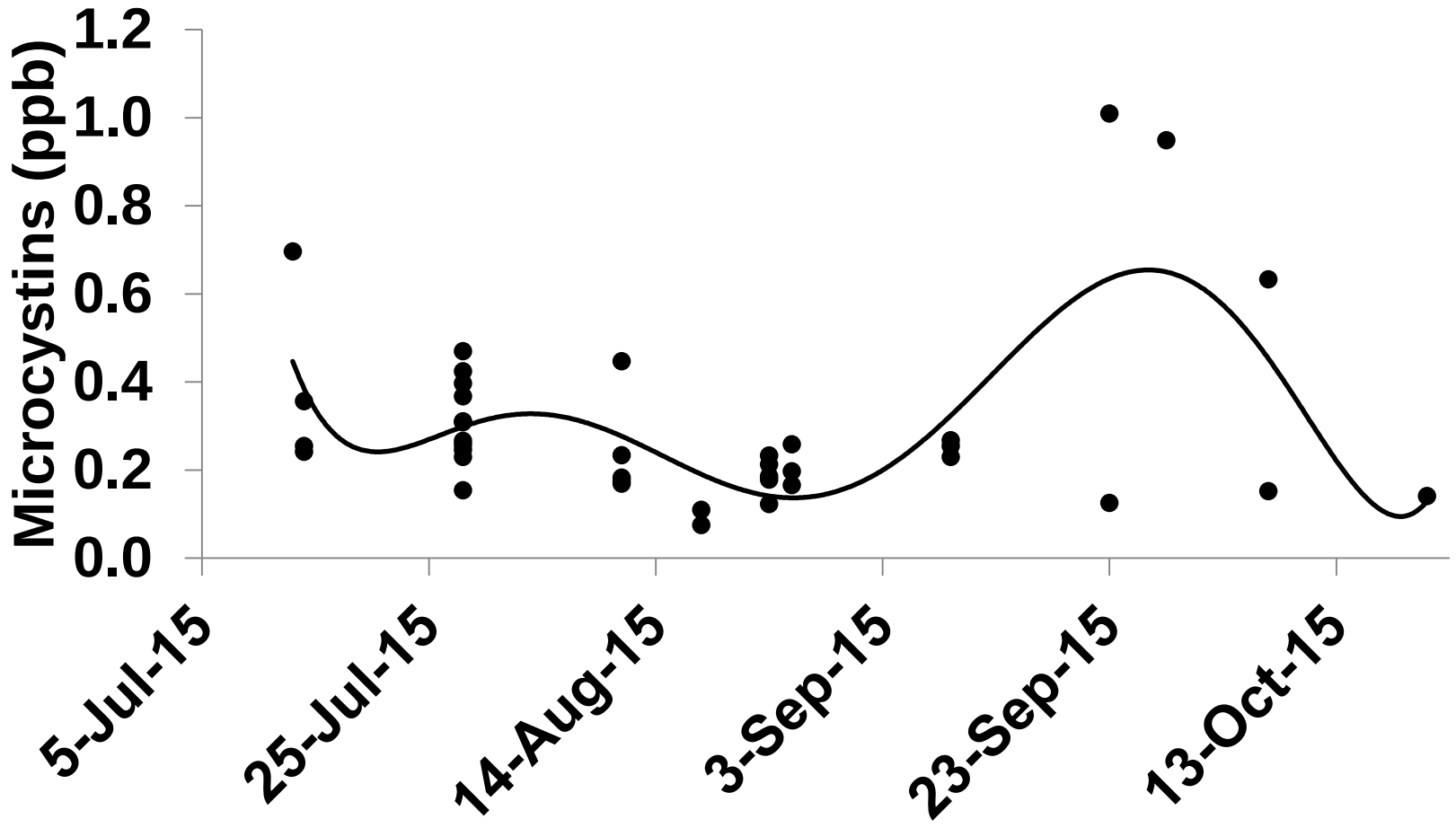
Yellow – shoreline (parks, docks, beaches)
Red - offshore

Non-targeted sampling

→ MC concentrations below Health Canada DW (1.5 ppb) and RW (20 ppb) guidelines



Peak in microcystins late summer, early autumn (similar to Hamilton Harbour)



Targeted sampling

→ MC concentrations above Health Canada DW (1.5 ppb) and RW (20 ppb) guidelines

July 6th, 2015

desmethylmicrocystin-RR	4.9
Microcystin-RR	39.
Microcystin-LA	130
desmethylmicrocystin-LR	28.
Microcystin-LR	190
Microcystin-LF	0.20
Microcystin-LY	1.4
Microcystin-HilR	4.8
Microcystin-LW	0.20
Microcystin-YR	15.
Microcystin-HtyR	2.0
Microcystin-WR	7.9
Microcystins (total)	1812.8

August 26th, 2015

desmethylmicrocystin-RR	0.50
Microcystin-RR	5.7
Microcystin-LA	5.5
desmethylmicrocystin-LR	0.67
Microcystin-LR	9.6
Microcystin-LF	0.50
Microcystin-LY	0.50
Microcystin-HilR	0.50
Microcystin-LW	0.50
Microcystin-YR	0.81
Microcystin-HtyR	0.50
Microcystin-WR	0.50
Microcystins (total)	14.6

LCMSMS ~420 ppb	~420 ppb	~27 ppb
ELISA	~1800 ppb	~15 ppb

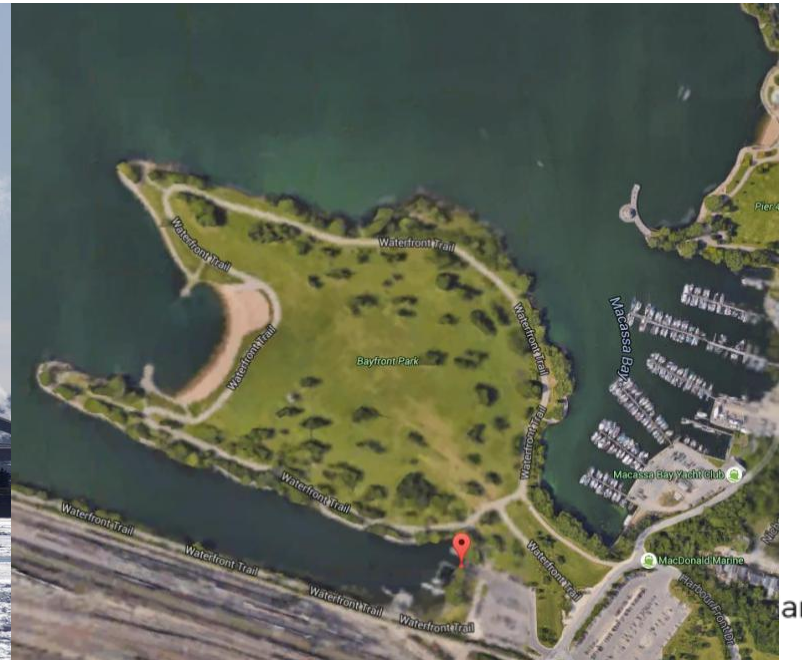
ELISA overestimates concentration by >4X → semi-quantitative only especially when scum/bloom or high DOM sample

Conclusions and recommendations

- Targeted and non-targeted approaches are both important in assessing prevalence and toxicity of harmful/toxic cyanobacterial proliferations
  - No exceedance of Health Canada drinking (1.5 ppb) and recreational (20 ppb) water guidelines unless notified by public to sample – important role for remote monitoring and educated citizens
- Late summer, early autumn toxic cyanobacterial blooms
- ELISAs are quick and easy but should only be used as a screening method rather than for quantitation

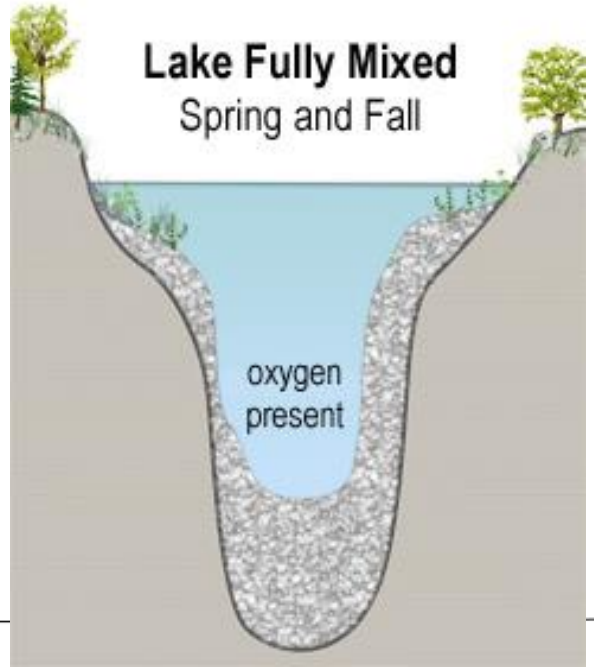
Phosphorus (P) drives biomass but…

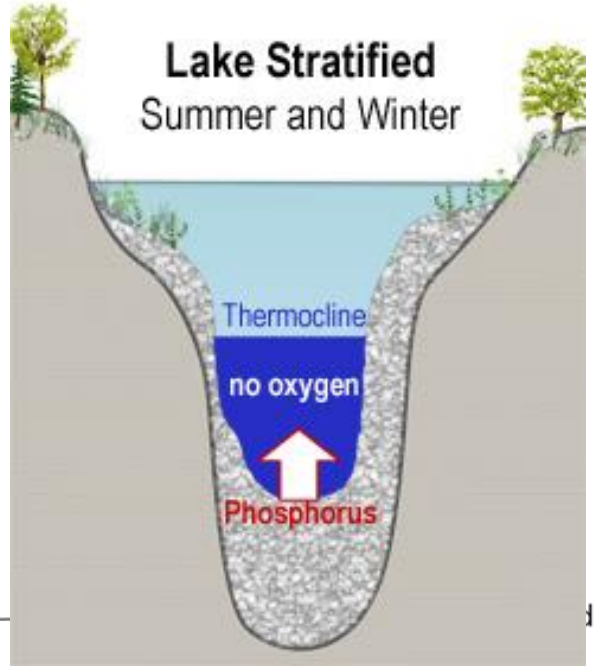
- Decoupling of external P loads and biomass/blooms
  - Anthropogenic inputs (e.g. glyphosate, trace metals e.g. iron)
  - Benthic (e.g. sediment) cyanobacteria
  - Climate (circulation patterns, water column stability, ice cover, elevated temperatures)
  - Invasive species (e.g. Dressenids and nutrient cycling)



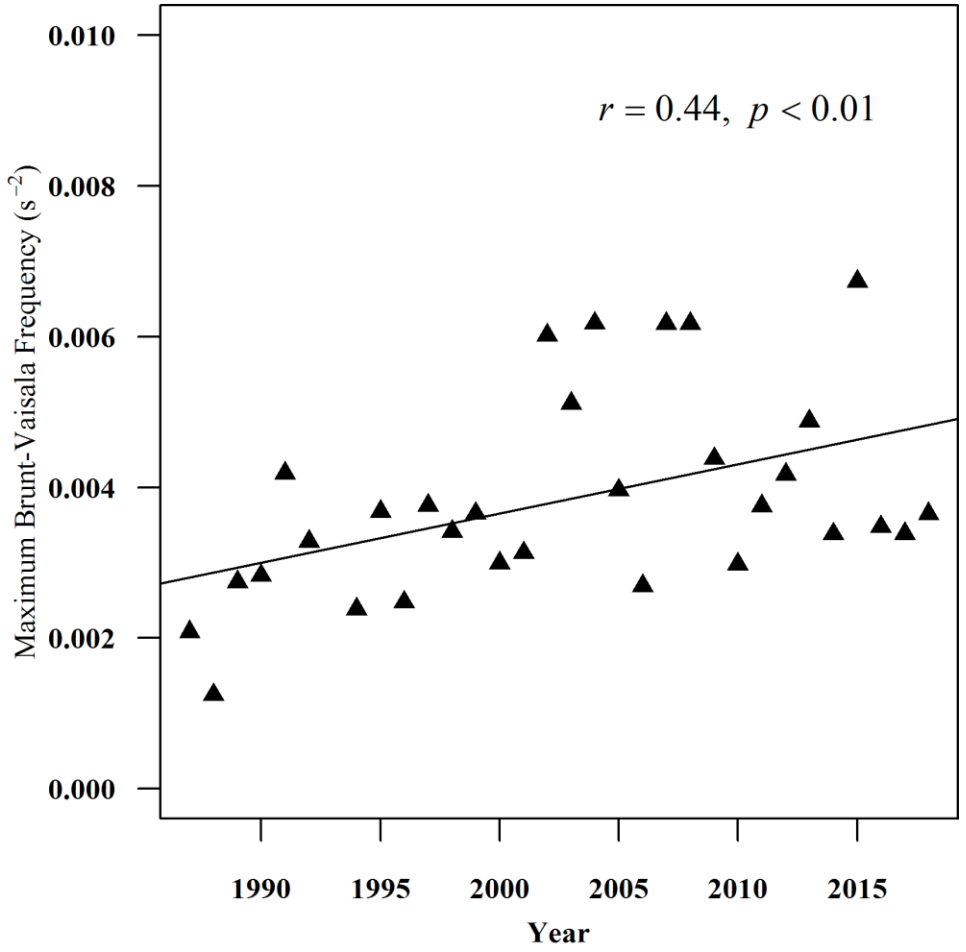
Phosphorus (P) drives biomass but…

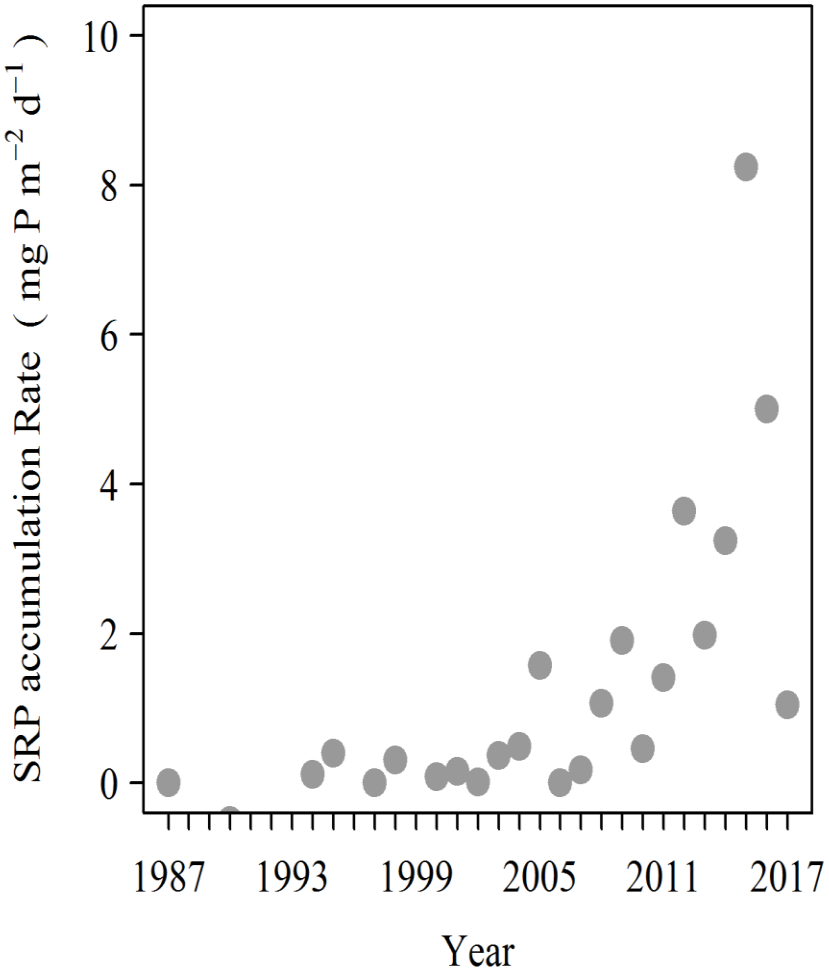
- Decoupling of external P loads and biomass/blooms
  - Internal loading → P and trace metals leaking from sediments under stable water column and low/no oxygen
    - Sediment P entrainment into surface during mixing/upwelling
    - Cyanobacteria migrate to access sediments (buoyancy regulation, low light adaptation)





Increasing water column stability and P efflux from sediments in Hamilton Harbour





Summary on P as a driver

- P control remains the most ***effective (and practical)*** management lever to reduce eutrophication symptoms
- ***Further reductions*** of P inputs will reduce the ***risk*** of ***larger and more frequent*** blooms
- Internal loading, climate change and interaction with Lake Ontario will delay/complicate recovery trajectory
- Expectations may need some recalibration….

Criteria for impairment updates ongoing by the RAPs as well as considerations for re-designations…

Current status of the environmental challenges

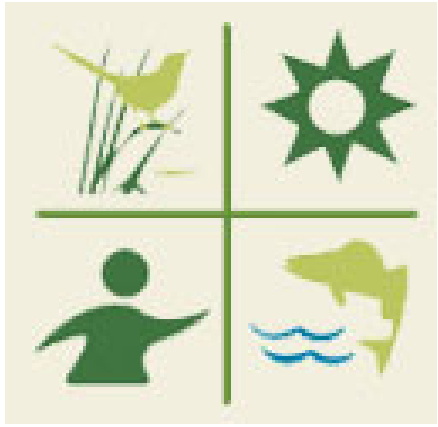
Bay of Quinte
Remedial Action Plan

STATUS: RESTORED
3 - Degradation of fish and wildlife populations
4 - Fish tumours and other deformities
6 - Degradation of benthos (underwater bugs)
7 - Restrictions on dredging activities
14 - Loss of fish and wildlife habitat
10 - Beach closings

STATUS: SUBMITTED FOR REDESIGNATION APPROVAL
9 - Restrictions on drinking water consumption or taste and odour problems

STATUS: REDESIGNATION PROCESS UNDERWAY
1 - Restriction on fish and wildlife consumption
8 - Eutrophication or undesirable algae
11 - Degradation of aesthetics

STATUS: IMPAIRED
13 - Degradation of phytoplankton and zooplankton populations



HAMILTON HARBOUR
REMEDIAL ACTION PLAN

BUI 10
BEACH CLOSINGS
CRITERIA UPDATE

HAMILTON HARBOUR
REMEDIAL ACTION PLAN

FEBRUARY 2020

Great Lakes HABs Collaborative

Lake Superior Update

Co-authors and Contributors:

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Matt Hudson, Matt Cooper (Northland College)

Nathan Wilson (Lakehead University)

Outline

- Bloom coordination by the Lake Superior Partnership Working Group (Algal Bloom Subgroup)
- Bloom history and distribution in Lake Superior
- Bloom research updates
- Conclusions

Lake Superior Partnership – Bloom Coordination

1854 Treaty Autho
Bad River Band of
Bay Mills Indian Co
Chippewa-Ottawa
Environment and C
Fisheries and Ocea
Fond du Lac Band
Grand Portage Ban
Great Lakes Indian
Keweenaw Bay Inc
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Minnesota Depart
Minnesota Pollutic
National Oceanic ar

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and Forestry
and Climate Change
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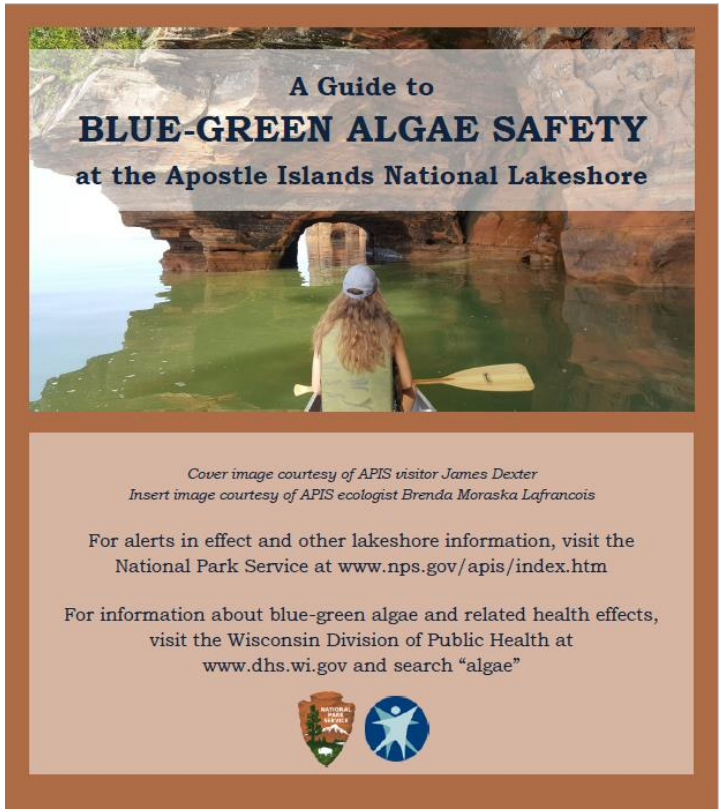
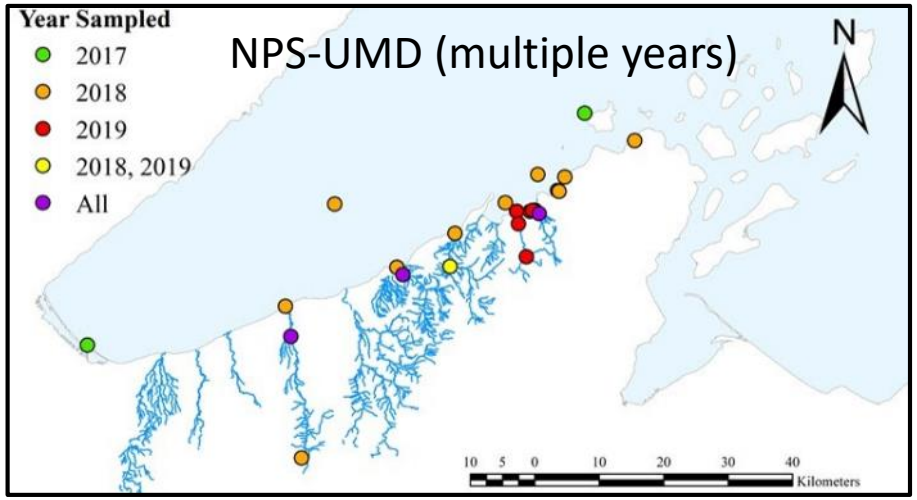
Lake Superior Partnership – Bloom Coordination

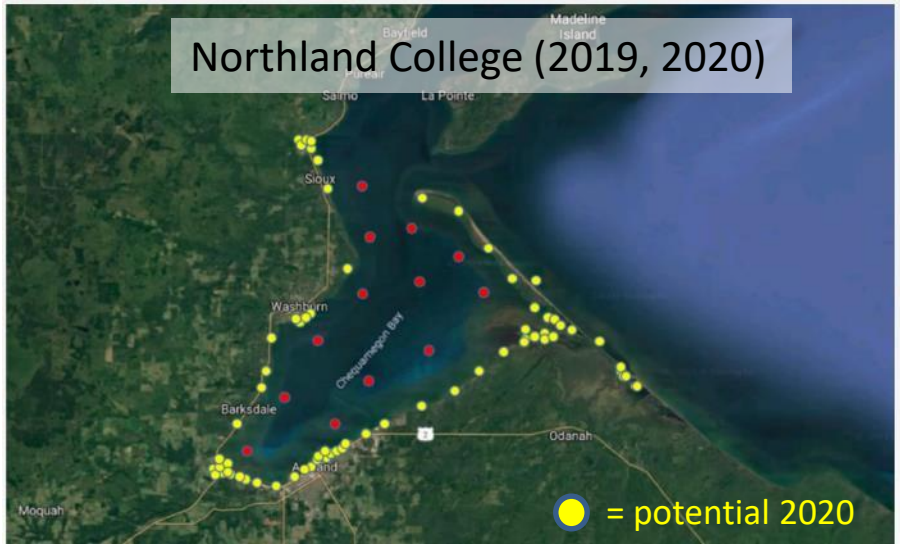
- Algal bloom meeting during the Oct 2018 State of Lake Superior Meeting
- Lake Superior Partnership "Algal Bloom Subgroup" developed
- Monthly phone calls
- Focal areas
  - Monitoring and research coordination
  - Rapid response coordination, including points-of-contact lists
  - Outreach/ed and citizen engagement



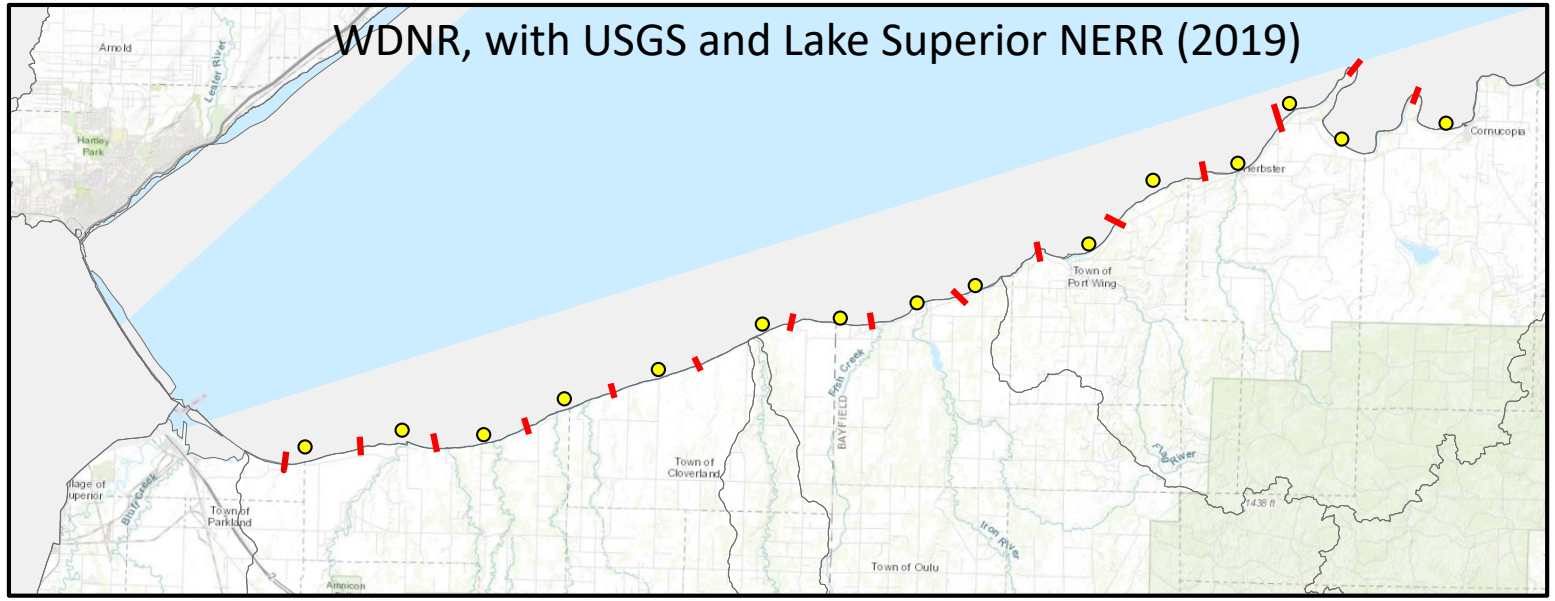
Lake Superior HABs – Monitoring Coordination



NPS-UMD (multiple years)

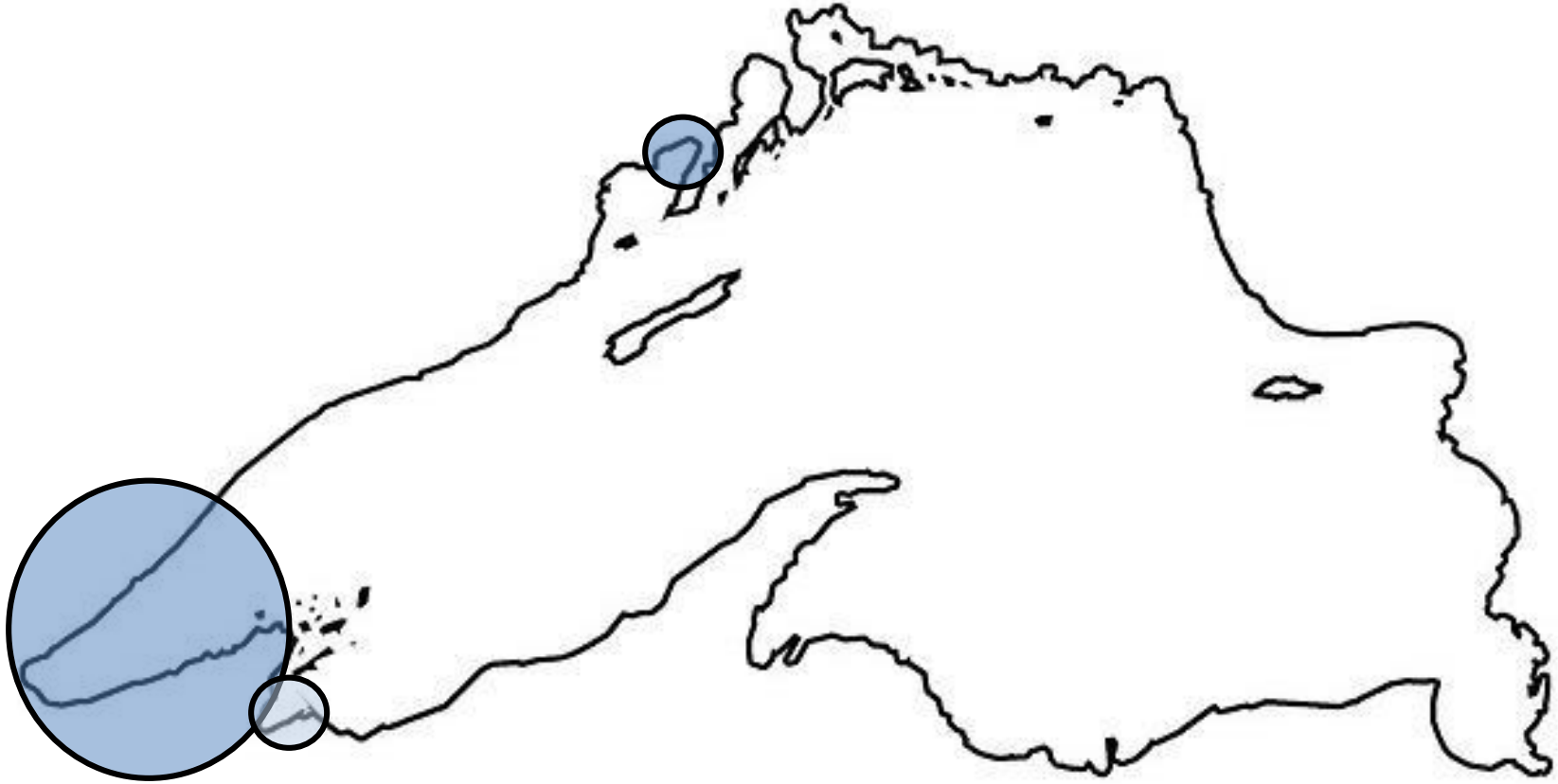


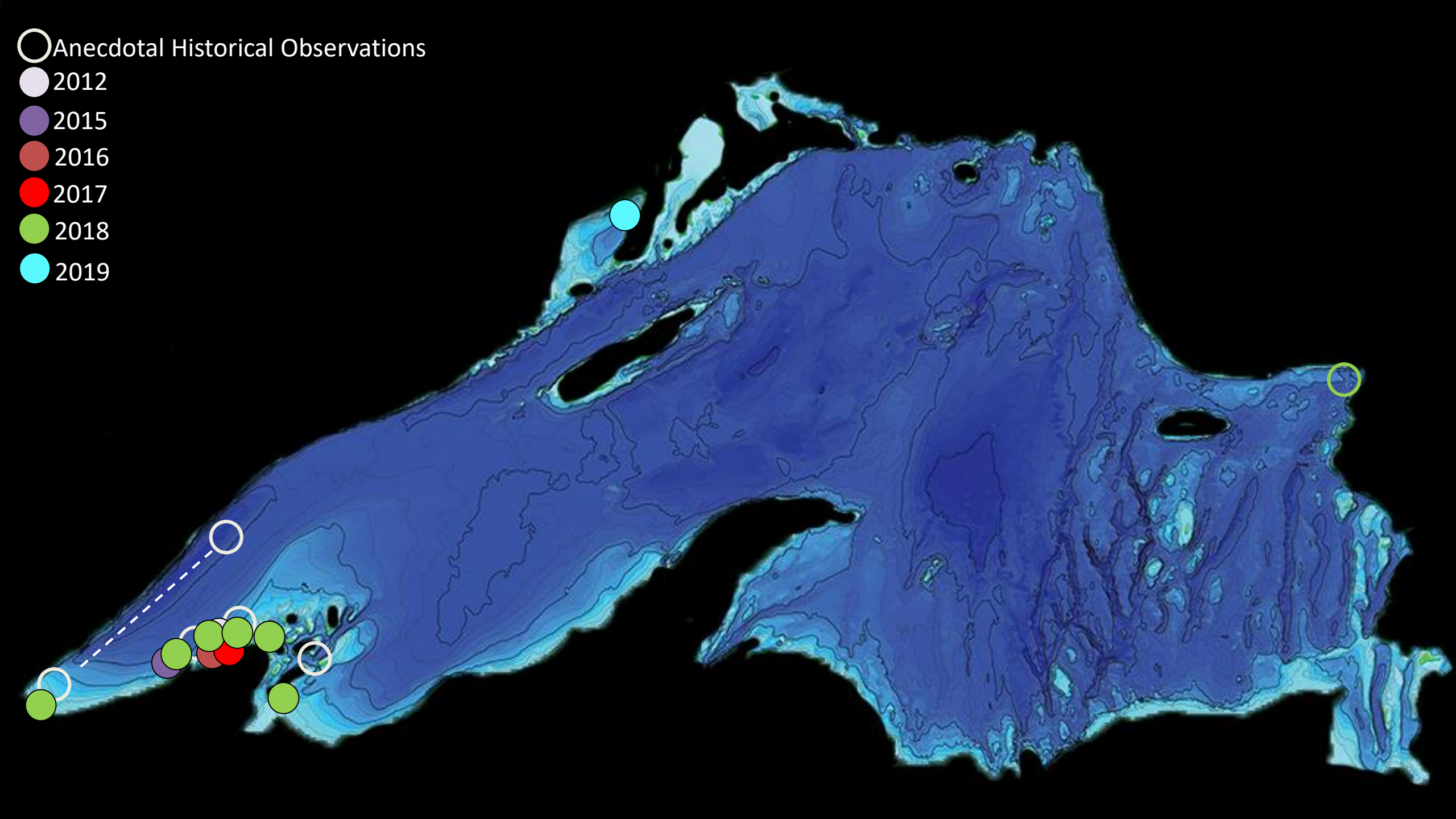
Northland College (2019, 2020)



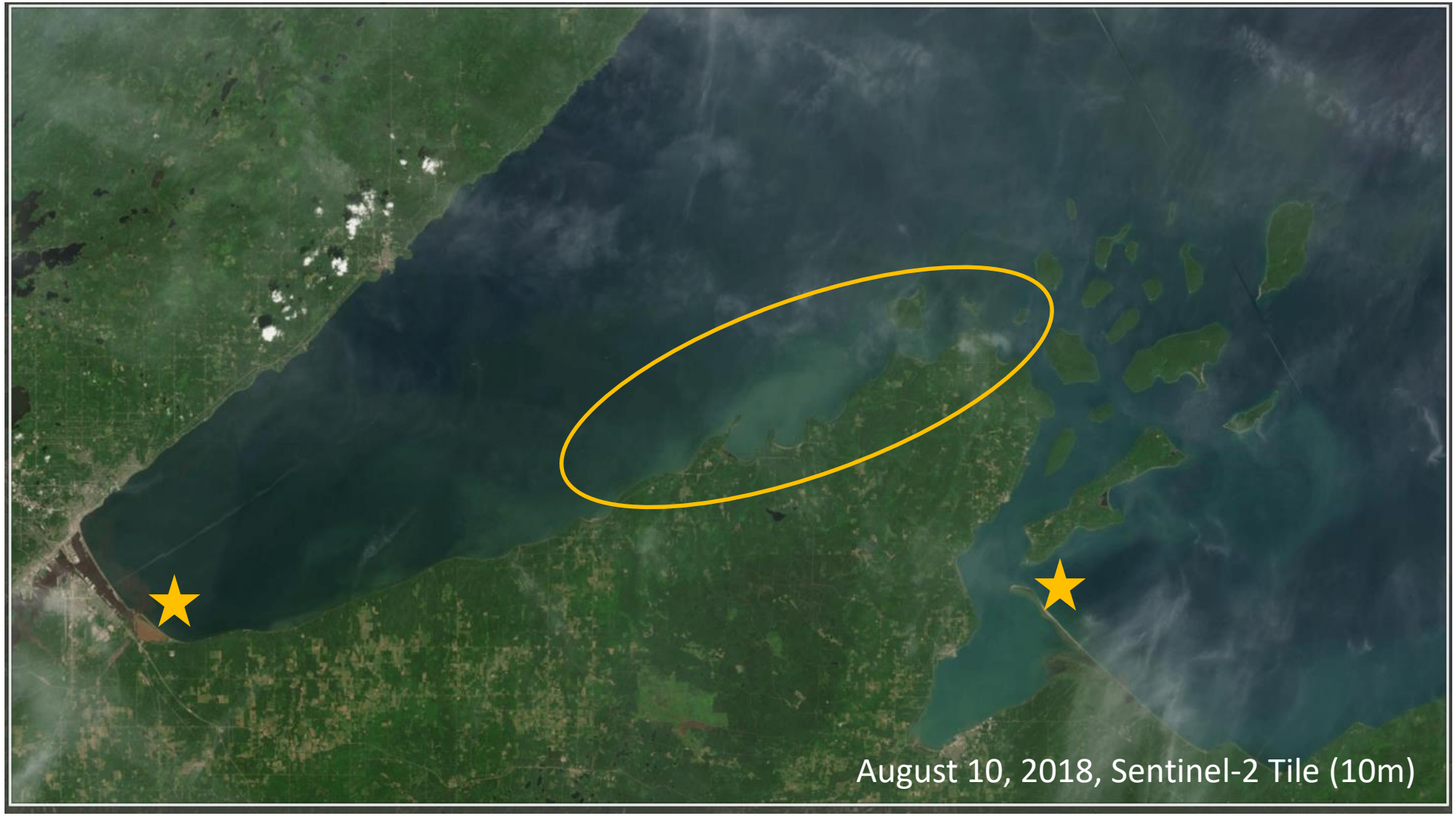
WDNR, with USGS and Lake Superior NERR (2019)

Lake Superior Bloom History




Anecdotal Historical Observations
2012
2015
2016
2017
2018
2019

Largest Lake Superior Bloom – 2018 Spatial Extent



Imagery: Planet Team (2017). Planet Application Program Interface: In Space for Life on Earth. San Francisco, CA. https://api.planet.com

Lake Superior Blooms – South Shore Observations


Sea Caves, 2017


Sea Caves, 2016


Little Sand Bay, 2018 (NPS photo)


Meyers Beach, 2016


Corny Beach, 2018

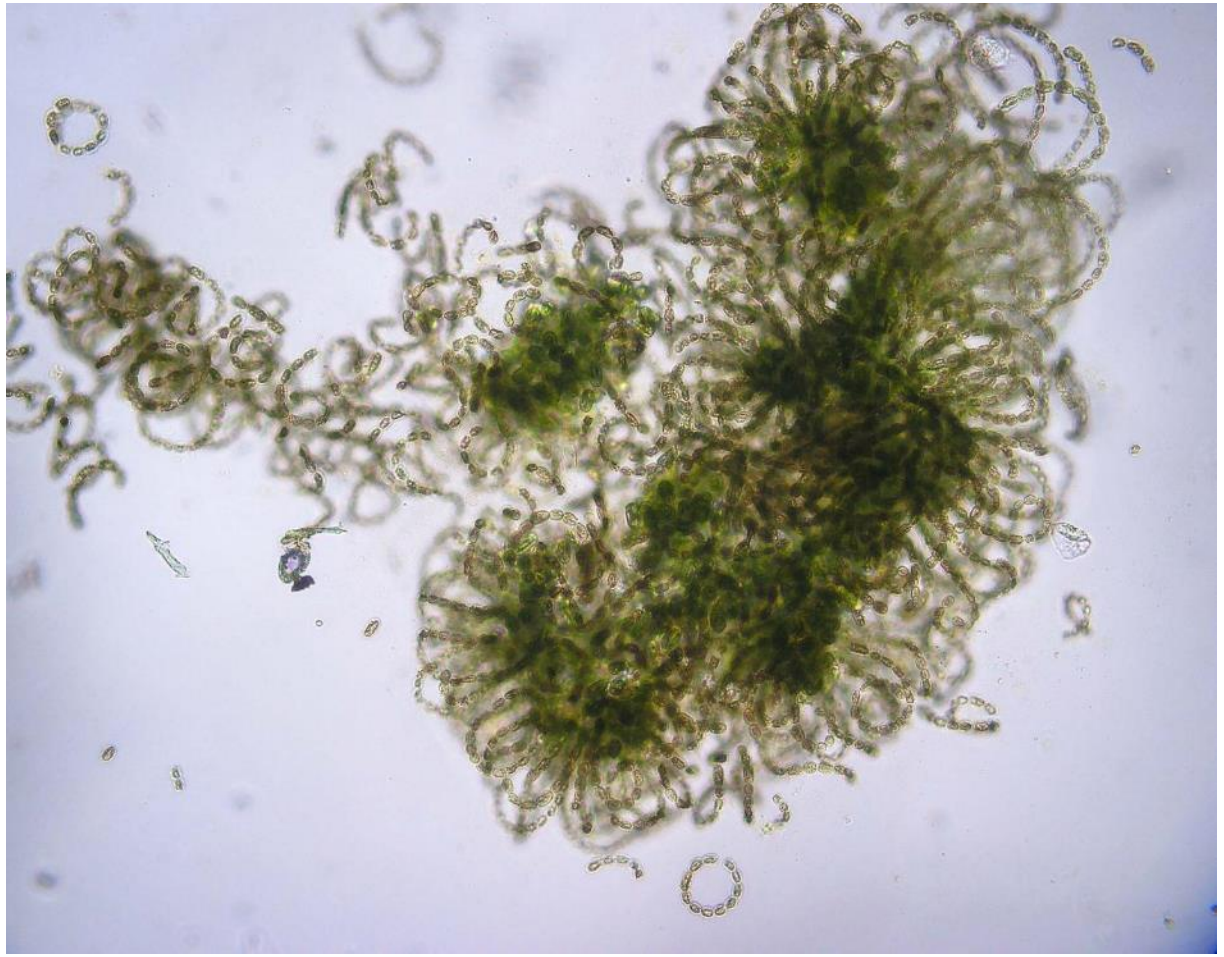

Barkers Island, 2018 (Kait Reinl)

Lake Superior Blooms – North Shore Observations

- Amethyst Harbour near Thunder Bay, Ontario in September, 2019
- Along shore and into open water
- Very calm water; surface temps reaching 15C
- Potential drinking water concern due to water intakes
- Possible high P in local stream and well
- Unclear if previous blooms occurred or if future blooms expected

Lake Superior HABs Research – Species ID

- Blooms in multiple Lake Superior locations dominated by *Dolichospermum lemmermannii*
  - Filamentous species of cyanobacterium
  - Potential toxin producer
  - Found in atypical bloom environments; cold or temperate climates, deep clear lakes
  - Expanding elsewhere, including Italian Alps

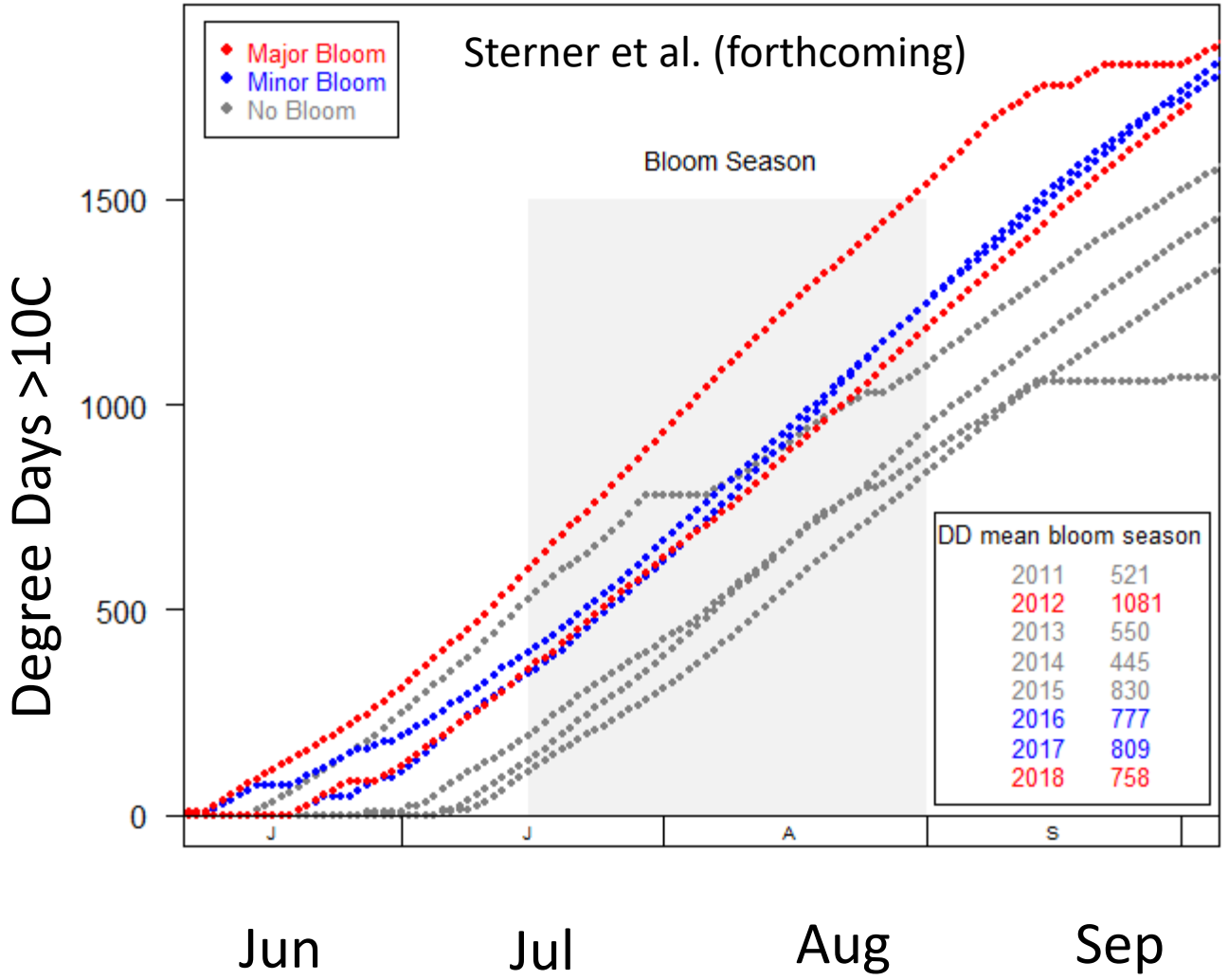


Lake Superior HABs Research – Toxin Analysis

- Toxins analyzed by WDPH in 2012 and 2017, and by UWM in 2018.
- To date, no samples above health thresholds.
- However – small sample set, toxin list not extensive in 2012 or 2017, and health standards not available for many toxins.

Lake Superior HABs Research – Bloom Drivers

- Biggest blooms happened in warm years
- Biggest blooms followed historic rainfall events (but lagged several weeks)

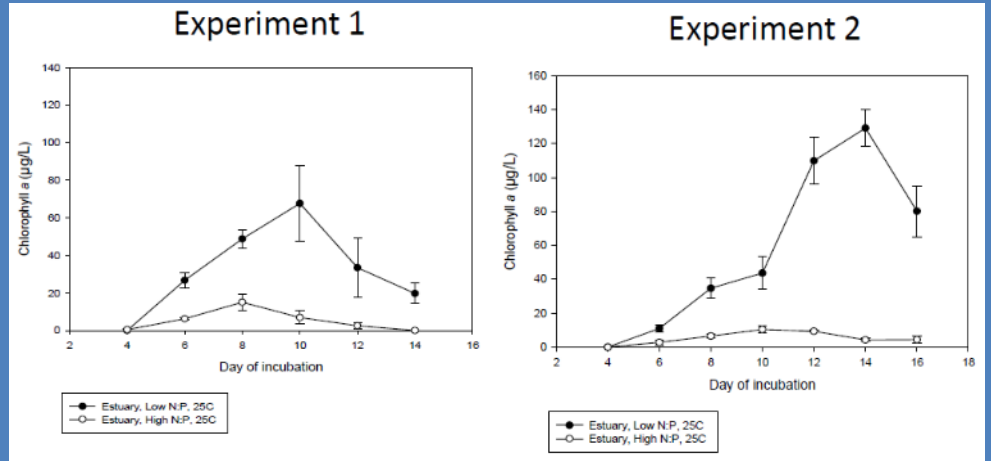


Lake Superior HABs Research – Bloom Drivers

- Experiments by UMD-LLO and Northland College suggest **upland sources**
- Conditions promoting growth include **warm temps and enhanced phosphorus** (low N:P)

		Lake	Harbor	Rivers
High molar N:P (50)	15°C	18 Combinations of Location x Nutrient x Temp		
	20°C			
	25°C			
Low molar N:P (1.5)	15°C			
	20°C			
	25°C			

Harbor and river samples responded most (Reinl et al. in prep)



Estuary samples responded most (Cooper et al. in prep)

Lake Superior HABs – Conclusions

- Emergence of HABs in Lake Superior continues to surprise
  - Repeat occurrences in some areas
  - New locations popping up
- Upland connections, but distinct from other lakes
  - Source watersheds relatively undeveloped
- Future blooms likely
  - Low ice cover → increasing summer surface water temps
  - Increasing precip and runoff
- Lake Superior Partnership role

Great Lakes HABs Collaborative

Linking Science and Management
to Reduce Harmful Algal Blooms

Thank you for joining us!