

Lake Ontario Collaborative Group



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The Dynamic Nature of Lake Ontario's Nearshore and its Connection with Tributaries

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Environmental Monitoring
and Reporting Branch

Lake Ontario Collaborative Group Symposium
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Outline

Themes: the Dynamic Nearshore

- Basis in lake hydrodynamics
- Basis in watershed drivers
- Basis in lake ecology
- Basis in water resource and water quality management

Physics of the Open Lake Forcing the Nearshore

- Circulation in the coastal boundary layer
- Episodic Onshore – offshore mixing

Watershed and Shoreline Forcing of the Nearshore

- Urban Rivers
- Discharges to the Nearshore

Biology of the Nearshore as a Driver of Water Quality

- Proliferation of Benthic Algae



Predominance of Alongshore Circulation at the Coastline

Alongshore Circulation (lake currents moving parallel to shoreline):

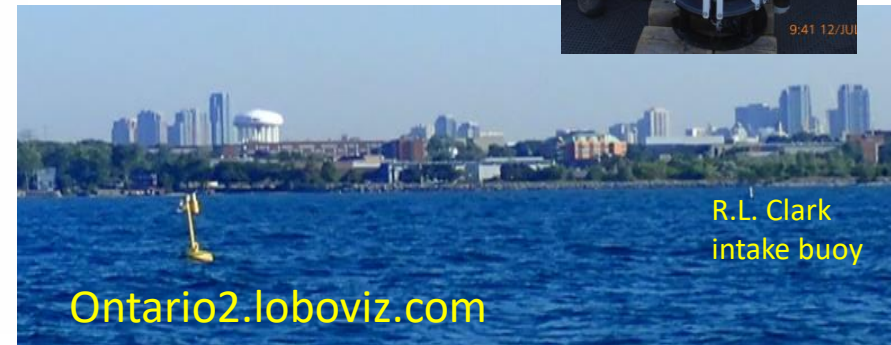
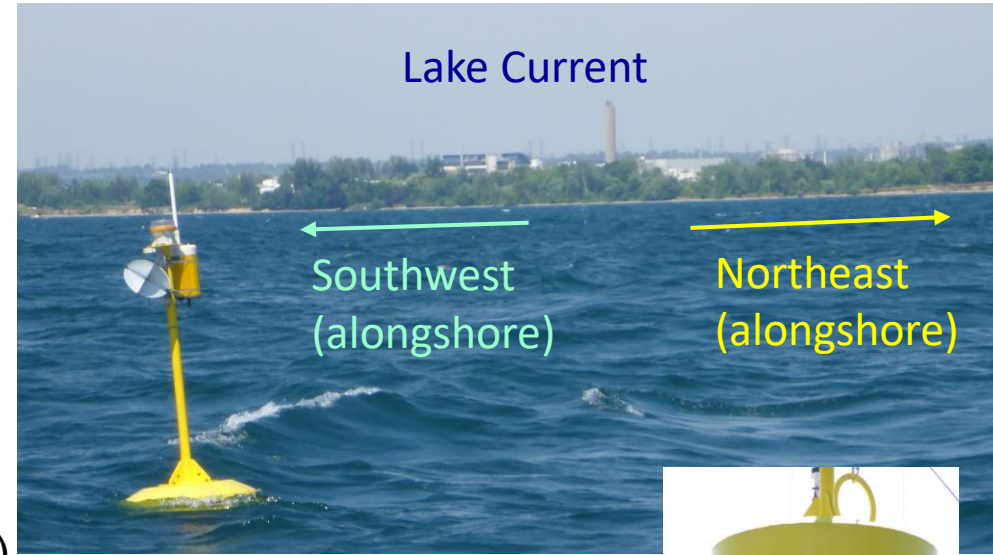
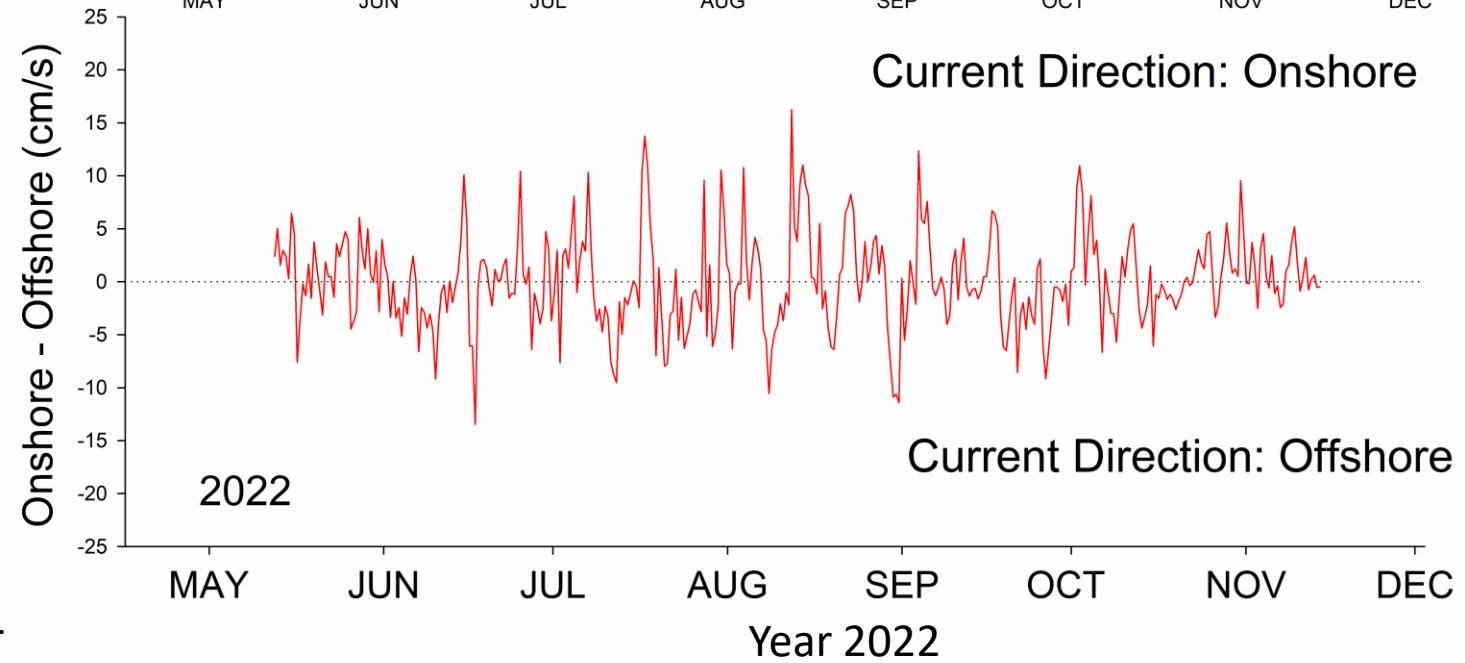
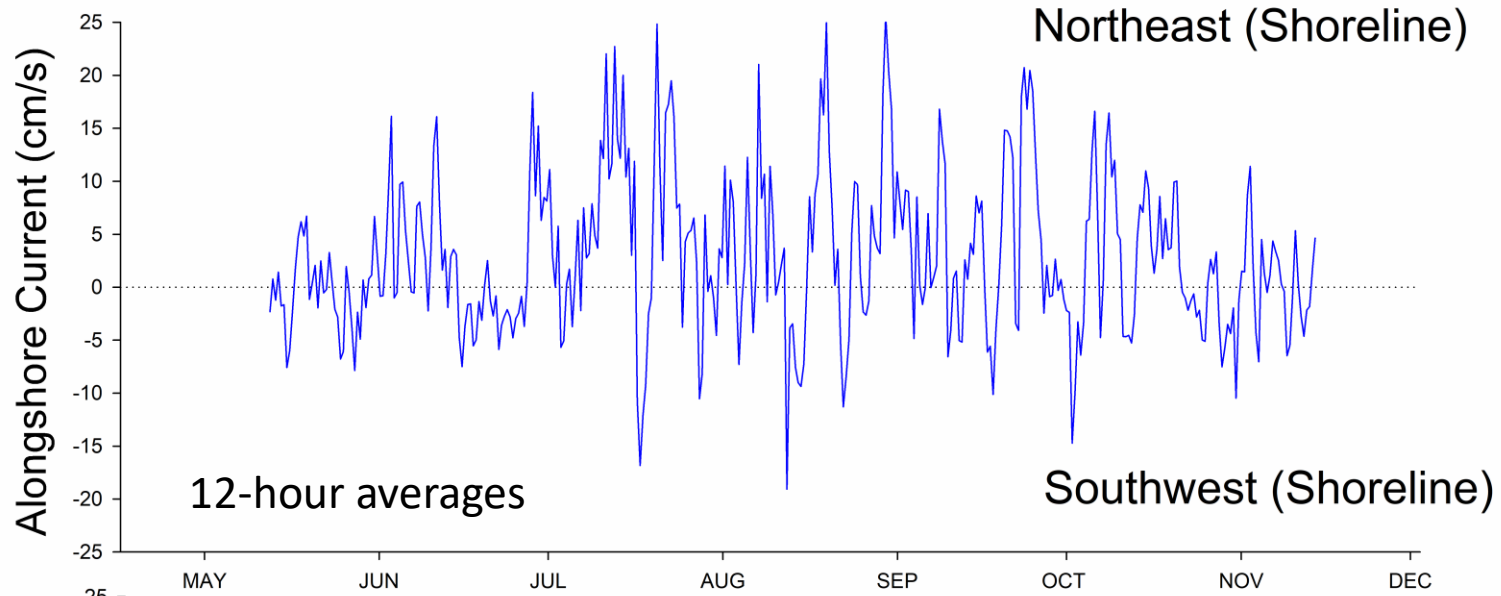
- Majority of the time
- Frequent reversals of shoreline direction on the order of days
- Strongest current mid-shore
- Feature extends to about 5 km offshore



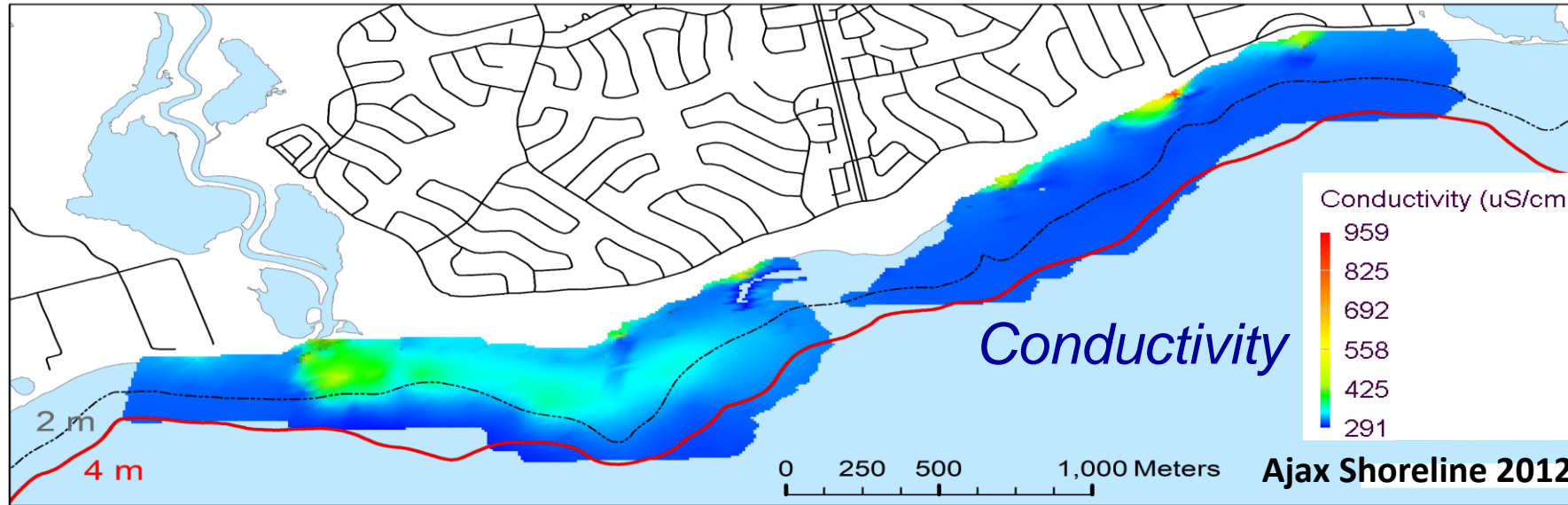
Implications:

- Discharges most frequently move along the shoreline
- Over days reversing shore-parallel currents smear loadings along the shoreline on either side of the discharge
- Less dispersal and dilution of loading offshore

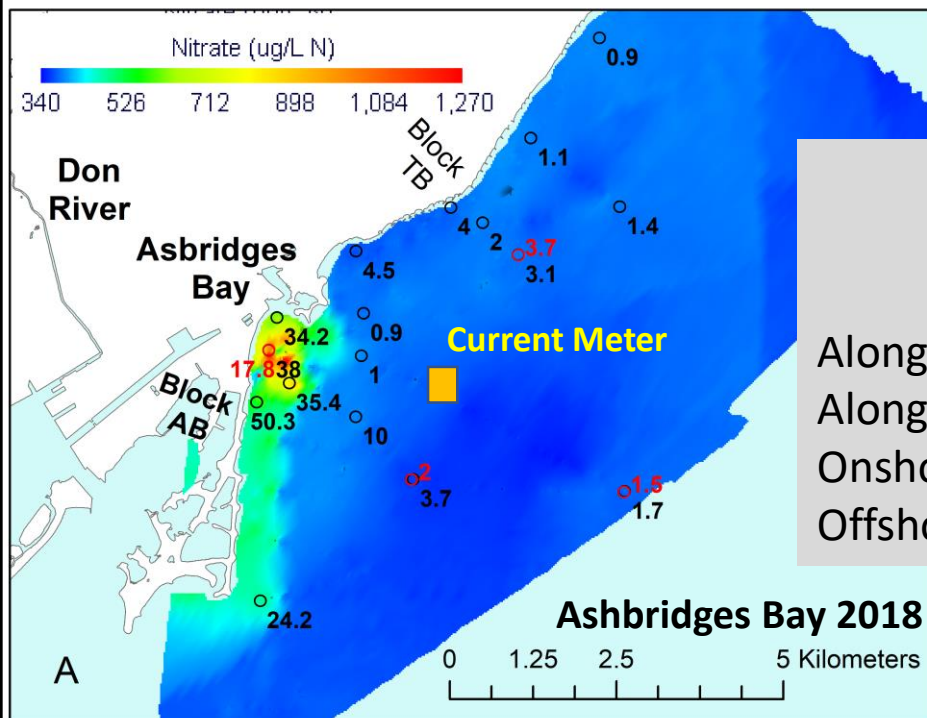
Typical Nearshore Current on North Shore of Lake Ontario



Alongshore Mixing of Shore Discharges

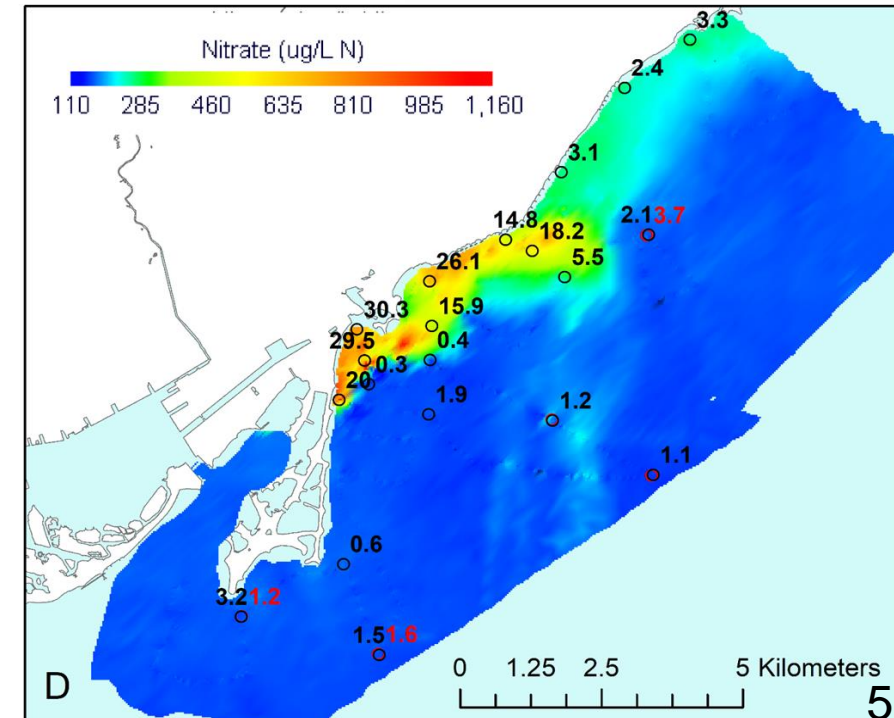


Shoreline and outfall discharges most frequently orient along shoreline



Near Surface Lake Currents

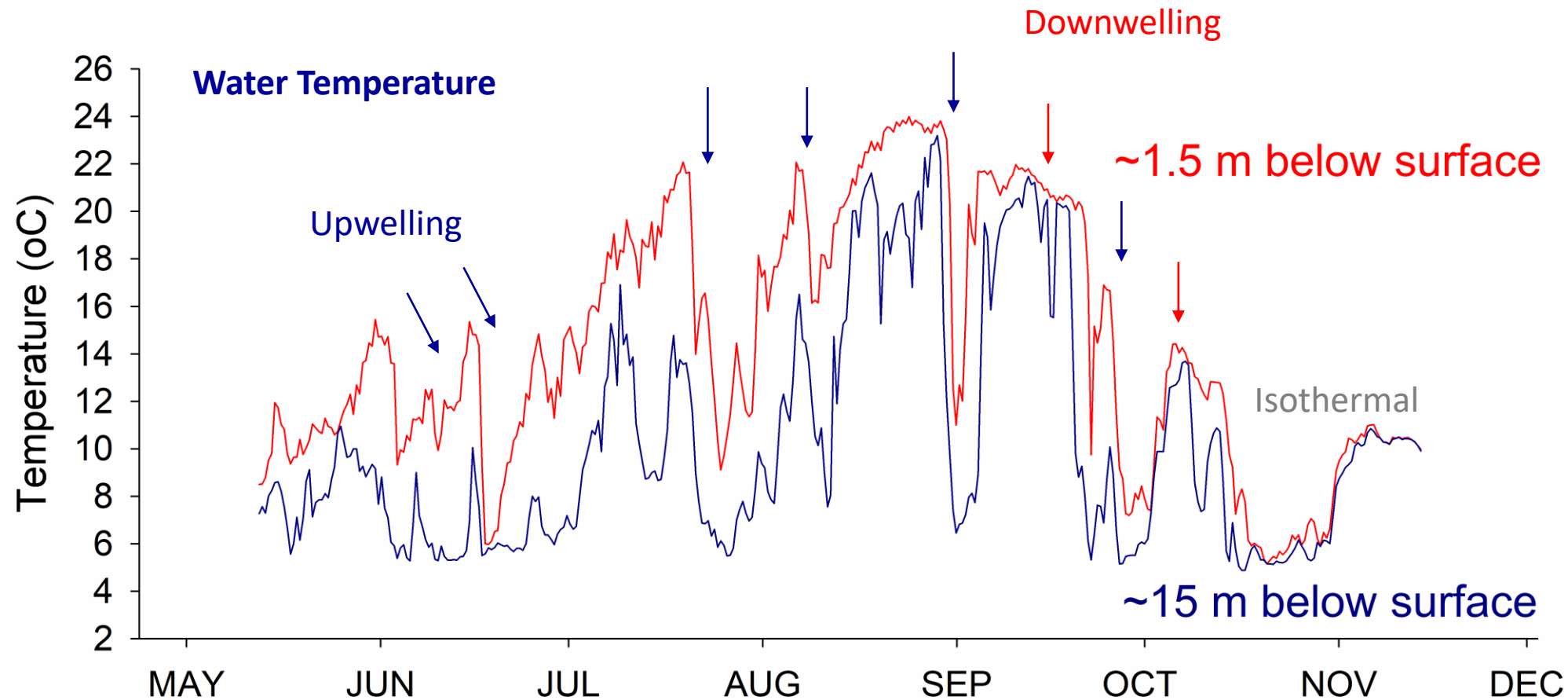
	% time	average speed (cm/s)
Alongshore - east	34	15.0
Alongshore - west	47	16.5
Onshore	9	9.4
Offshore	13	9.7



Upwelling and Downwelling: Periodic Strong Flushing of the Nearshore

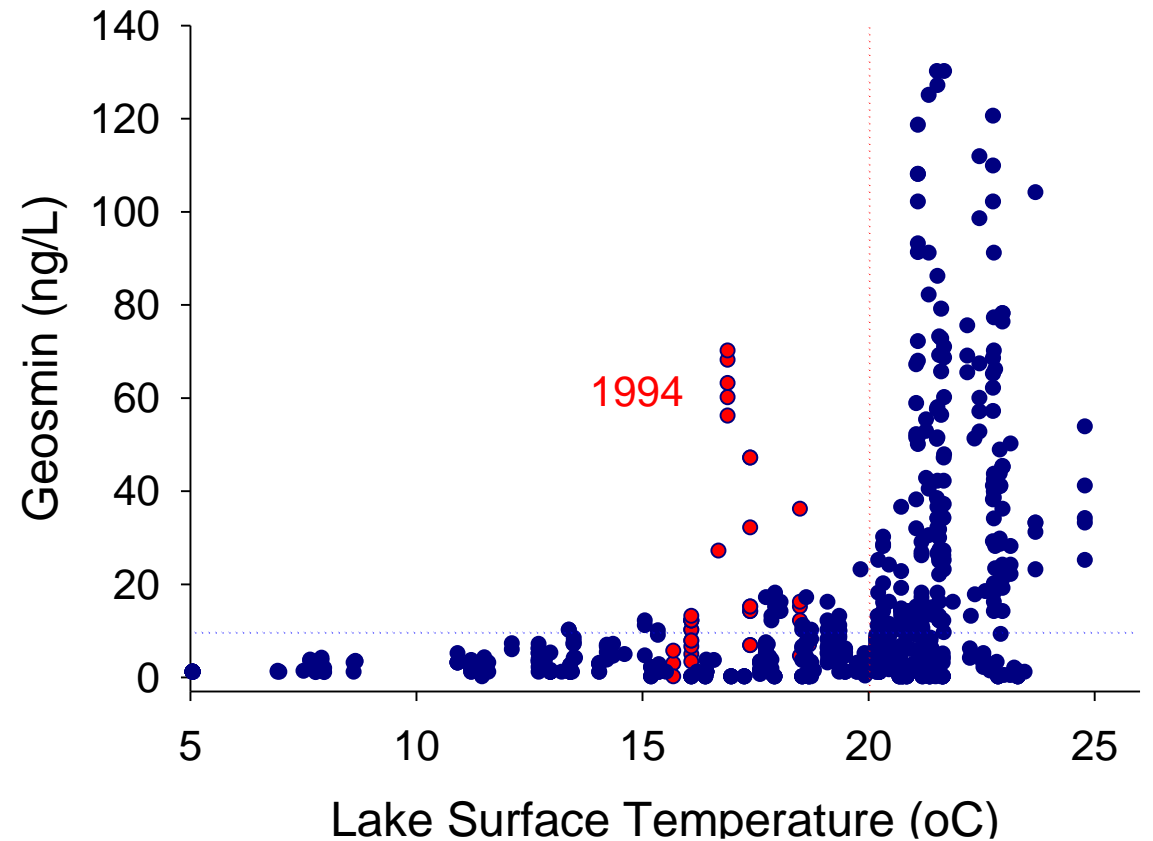
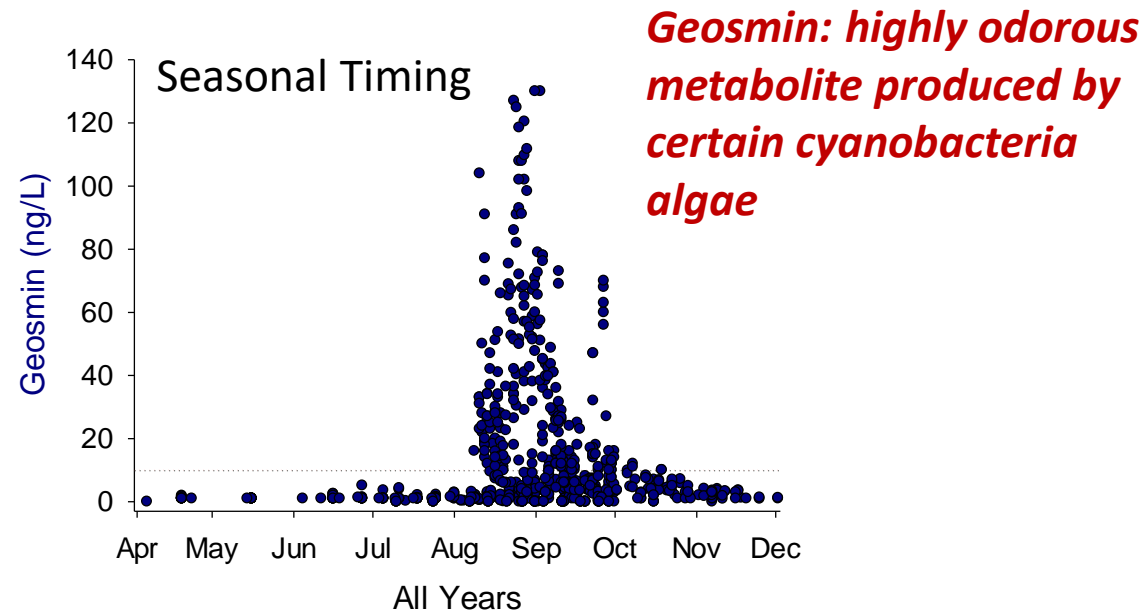
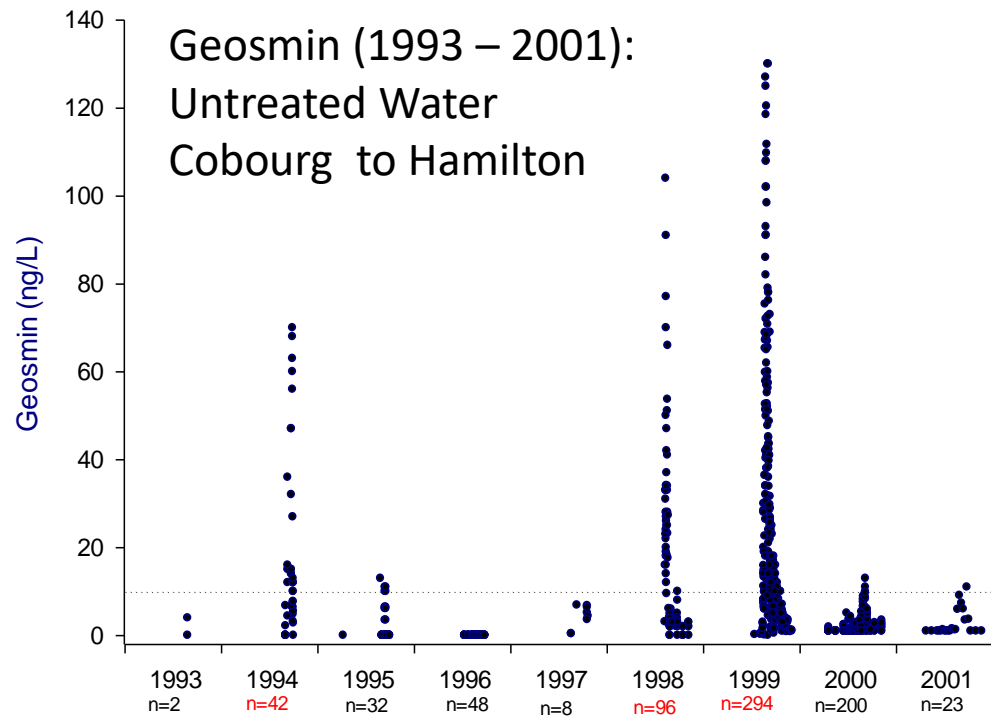
Upwelling – cold deep offshore water circulates inshore (winds offshore)

Downwelling – warm offshore surface water circulates inshore (winds onshore)

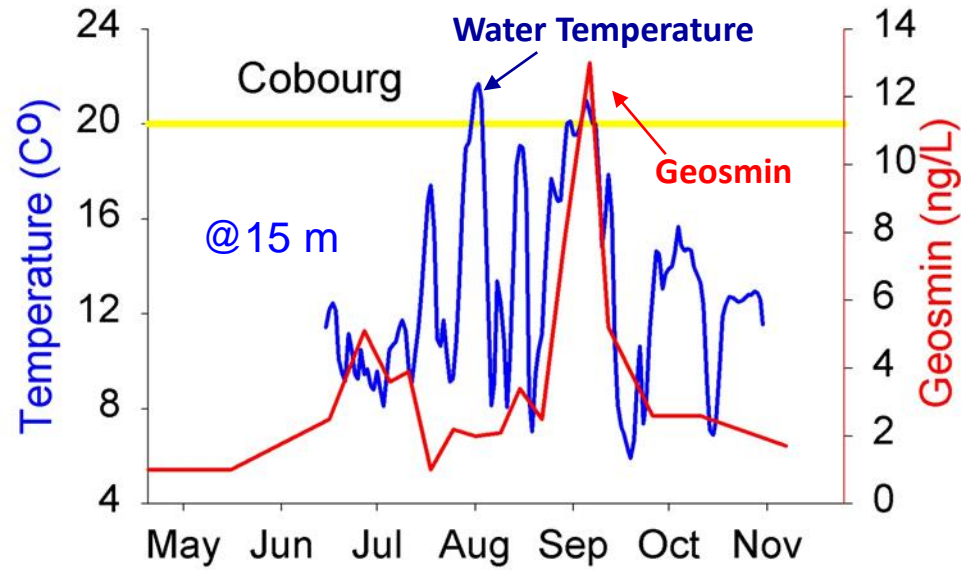


Geosmin-Related Drinking Water Taste and Odour

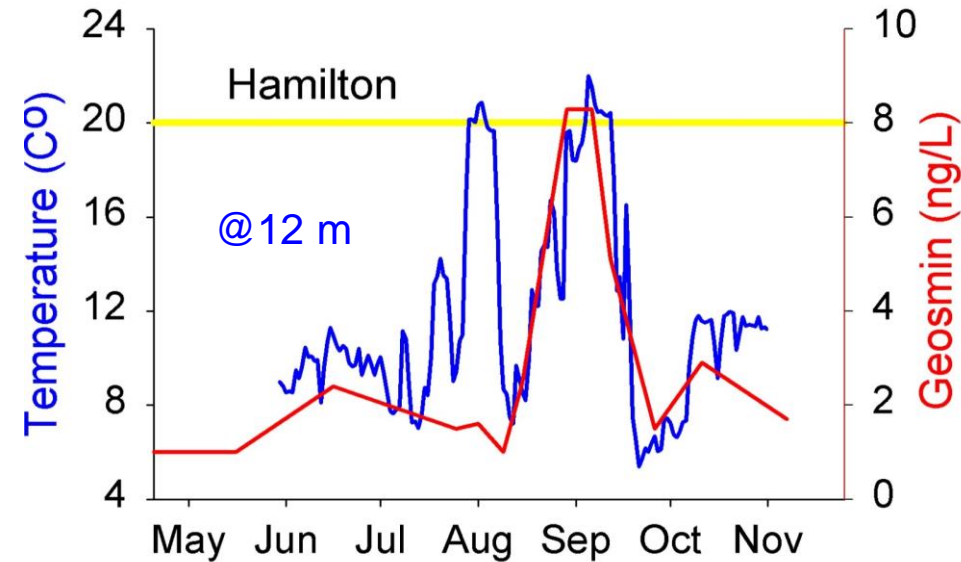
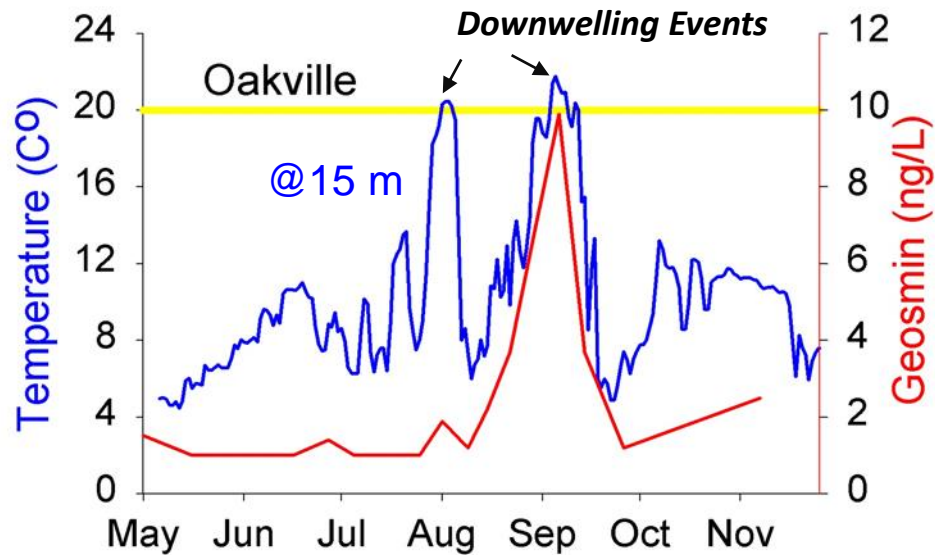
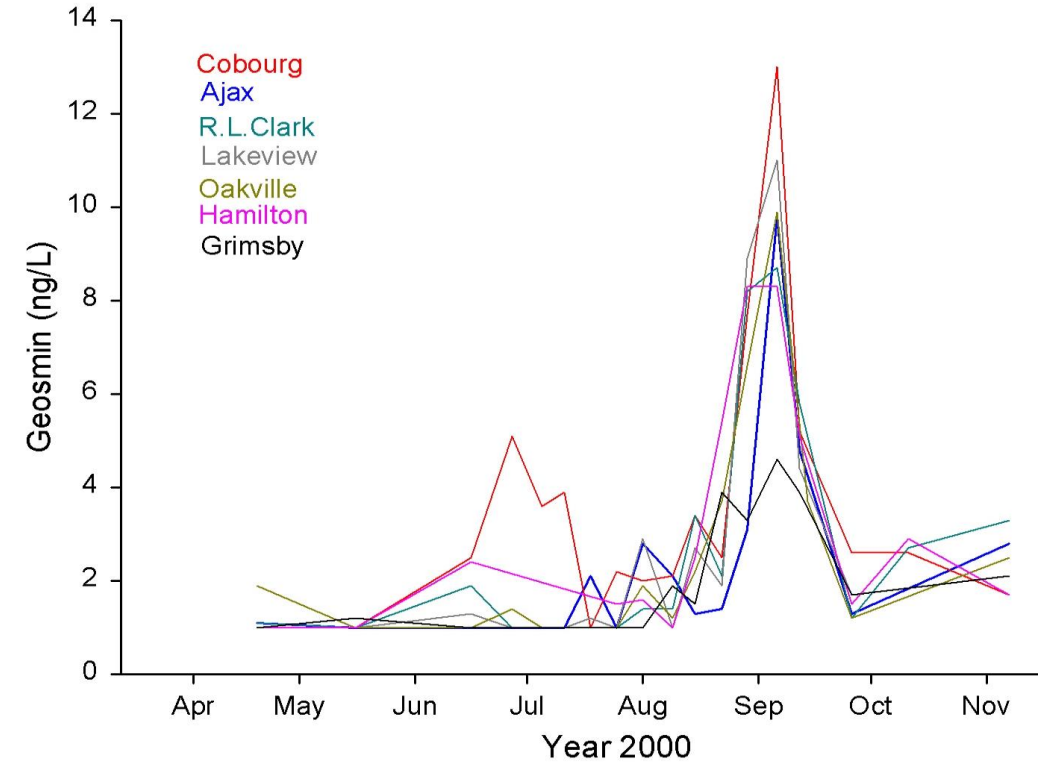
Problematic Taste and Odour Caused by Geosmin Linked to Offshore Downwelling Events in late 1990s



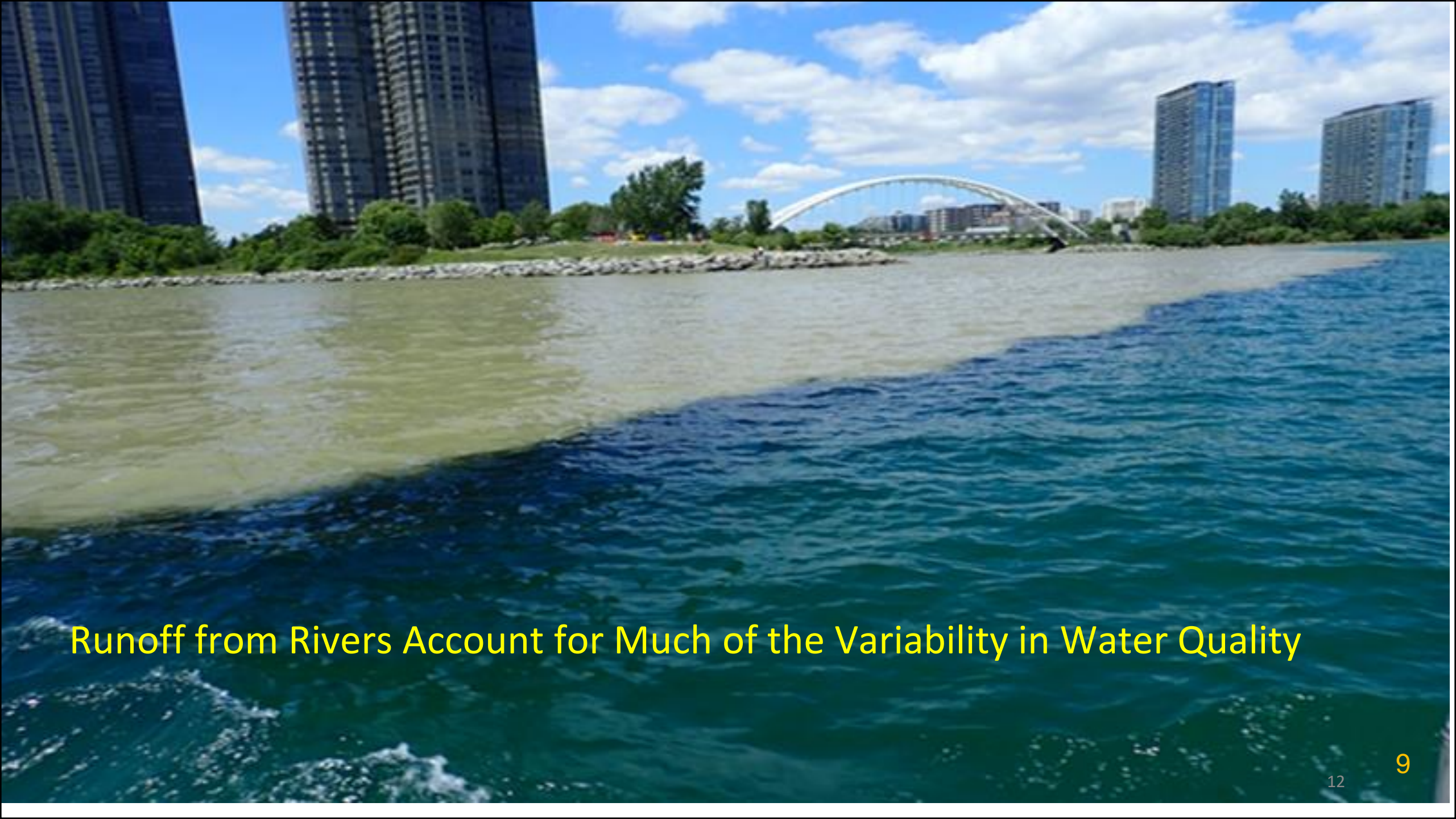
Geosmin peaks during late summer downwelling event



Synchronous Geosmin Peaks Across North Shore



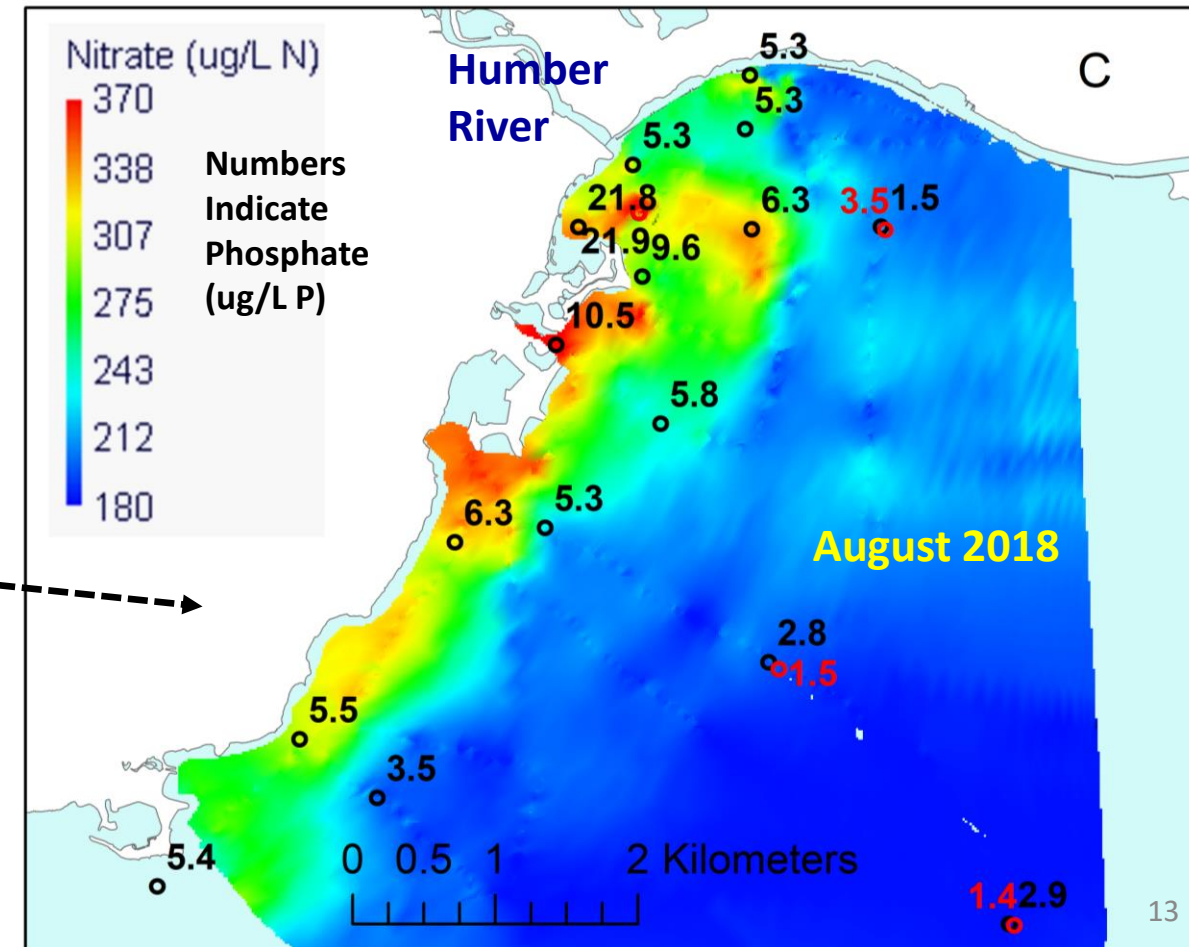
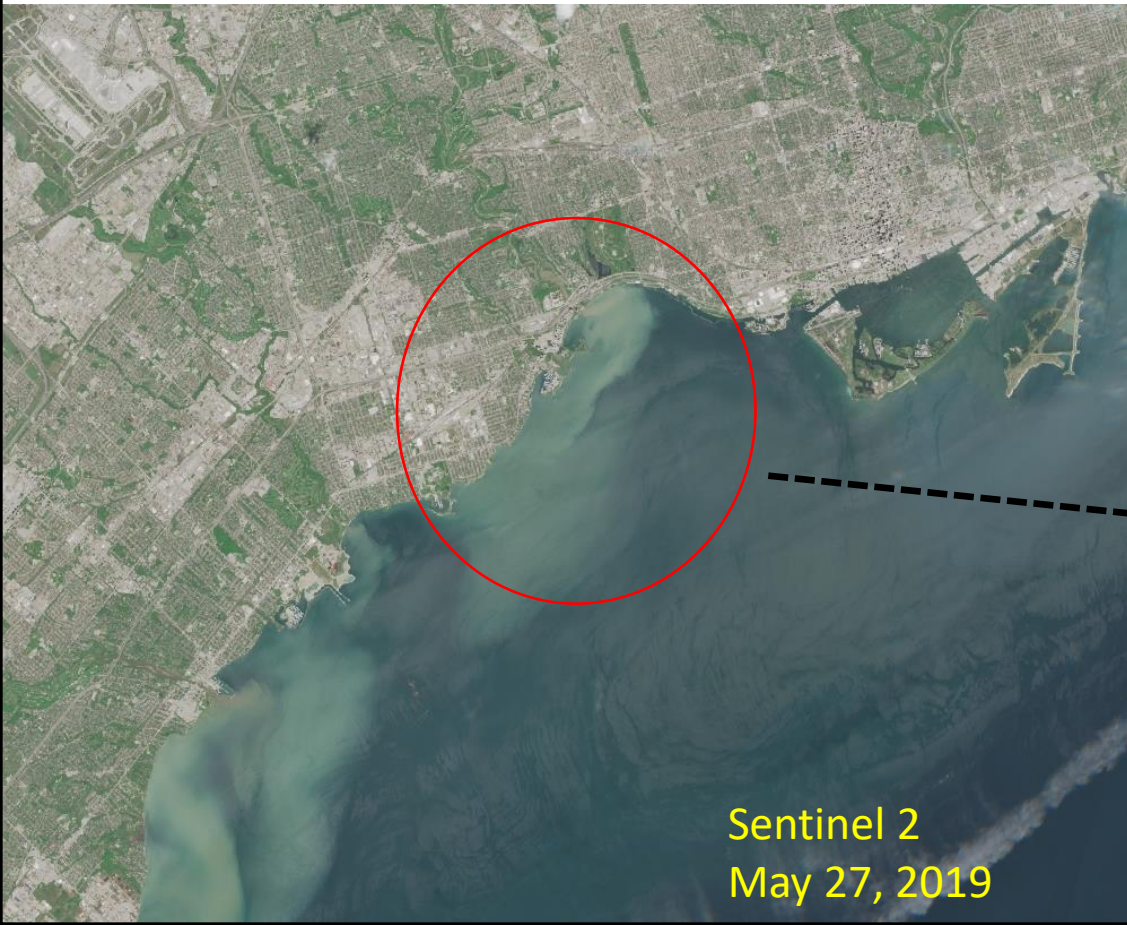
Late summer downwelling brings offshore surface water with Geosmin-producing phytoplankton to water intake depths



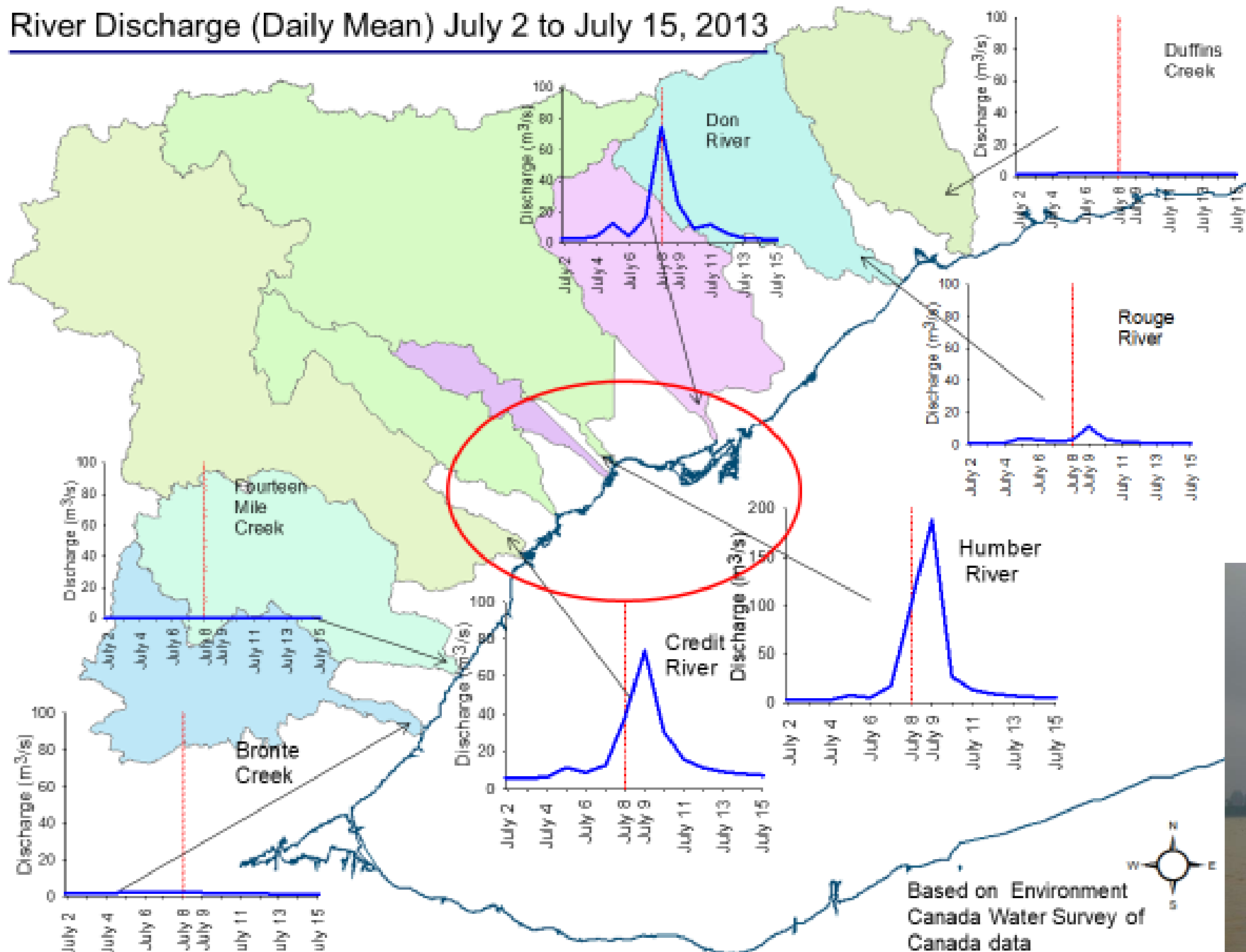
Runoff from Rivers Account for Much of the Variability in Water Quality

Mixing of River Discharges Shapes Character of the Nearshore

- Larger Rivers have broader spatial ranges of influences on nearshore
- However, smaller watercourses can have localized acute effects on water quality
- Very episodic but over time chronic influence with repeated patterning



River Discharge (Daily Mean) July 2 to July 15, 2013



Unpredictable but Expected:

Strong impacts of river discharge events on nearshore water quality are extremely variable over time and in spatial range

Weather and nearshore water quality intimately linked through rivers

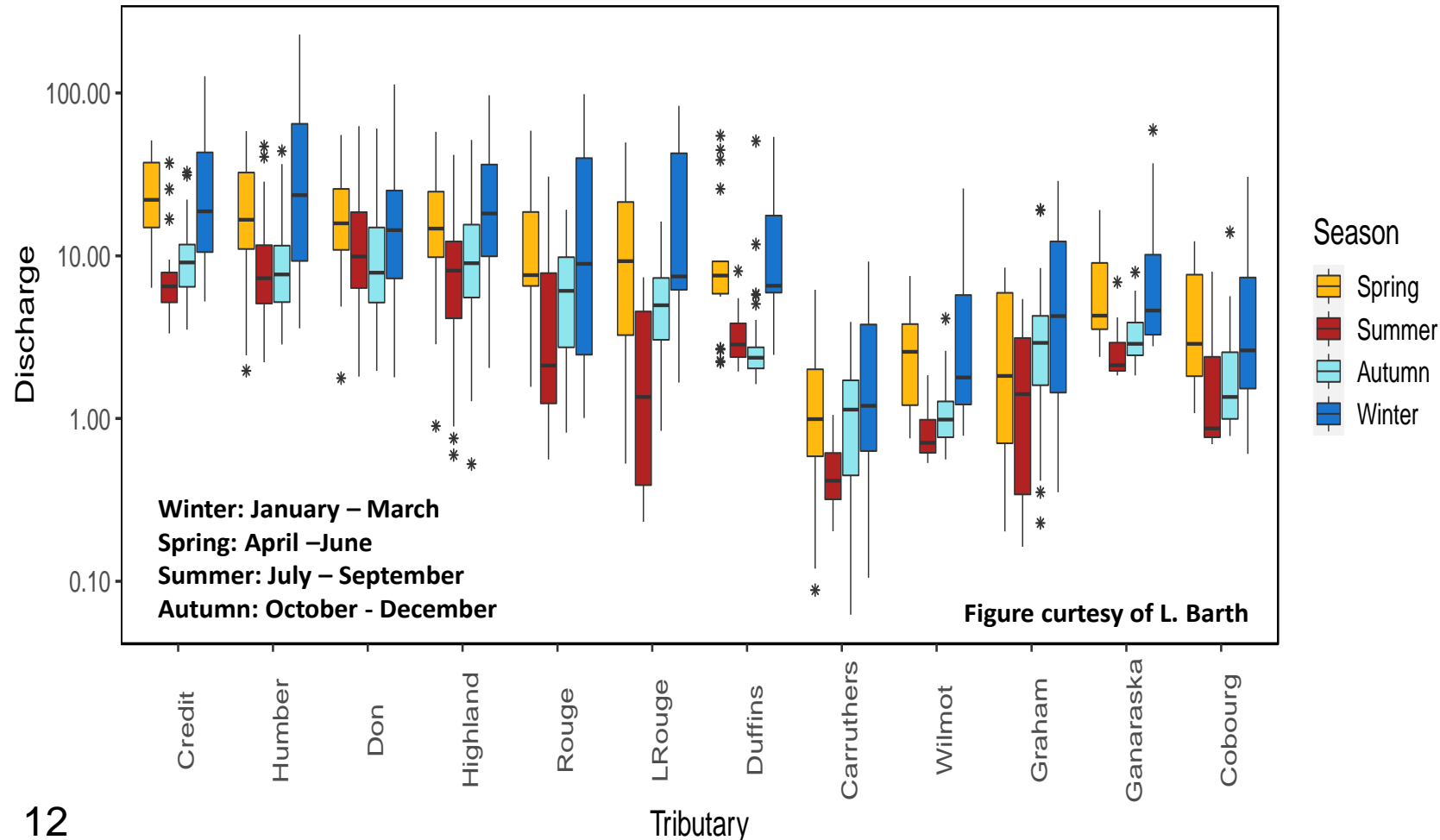
Localized Summer Storm with Significant Lake Impacts



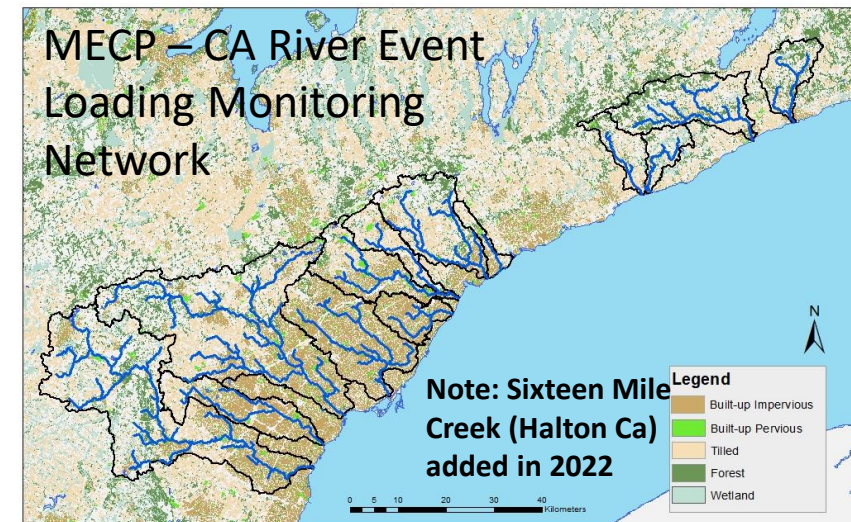
Based on Environment Canada Water Survey of Canada data

Strong Seasonal Pattern in River Influence Linked to Hydrologic Cycle

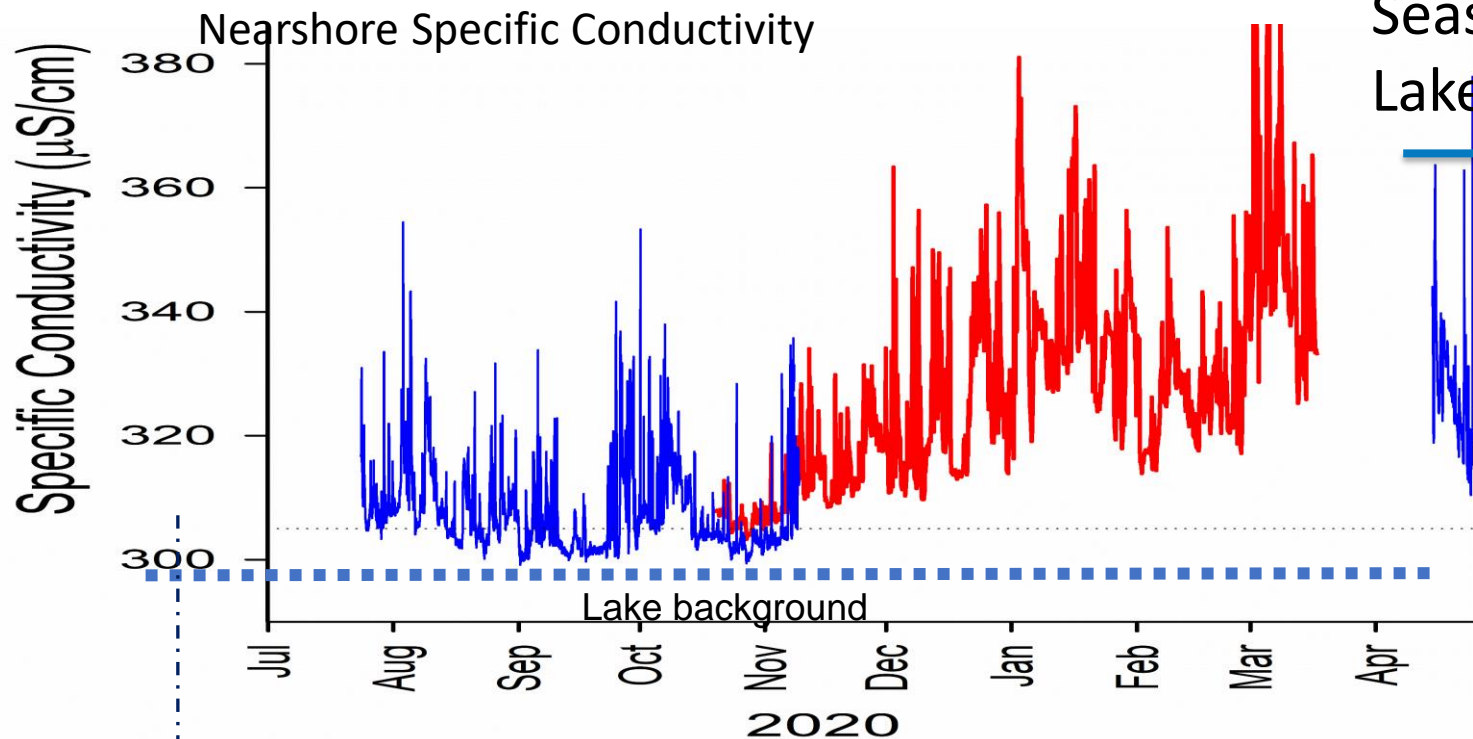
Higher accumulative river discharge volumes from **winter to spring** impacts nearshore water quality more strongly in Spring and likely the Winter?



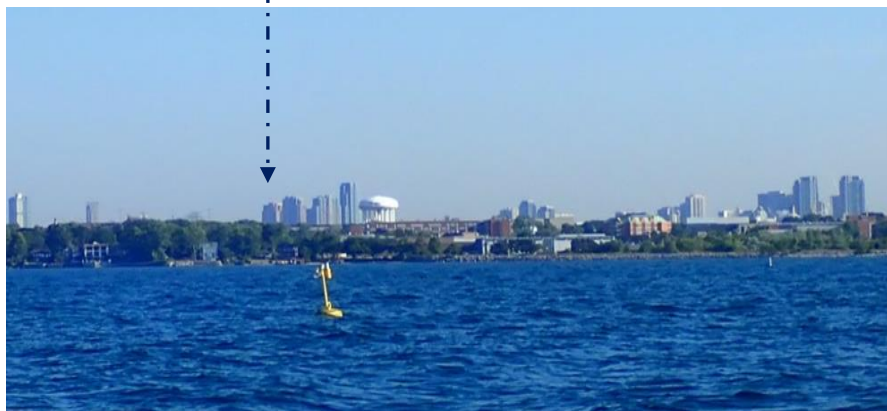
Changing seasonality of weather presents a challenge to understanding nearshore water quality: more year-round information needed.



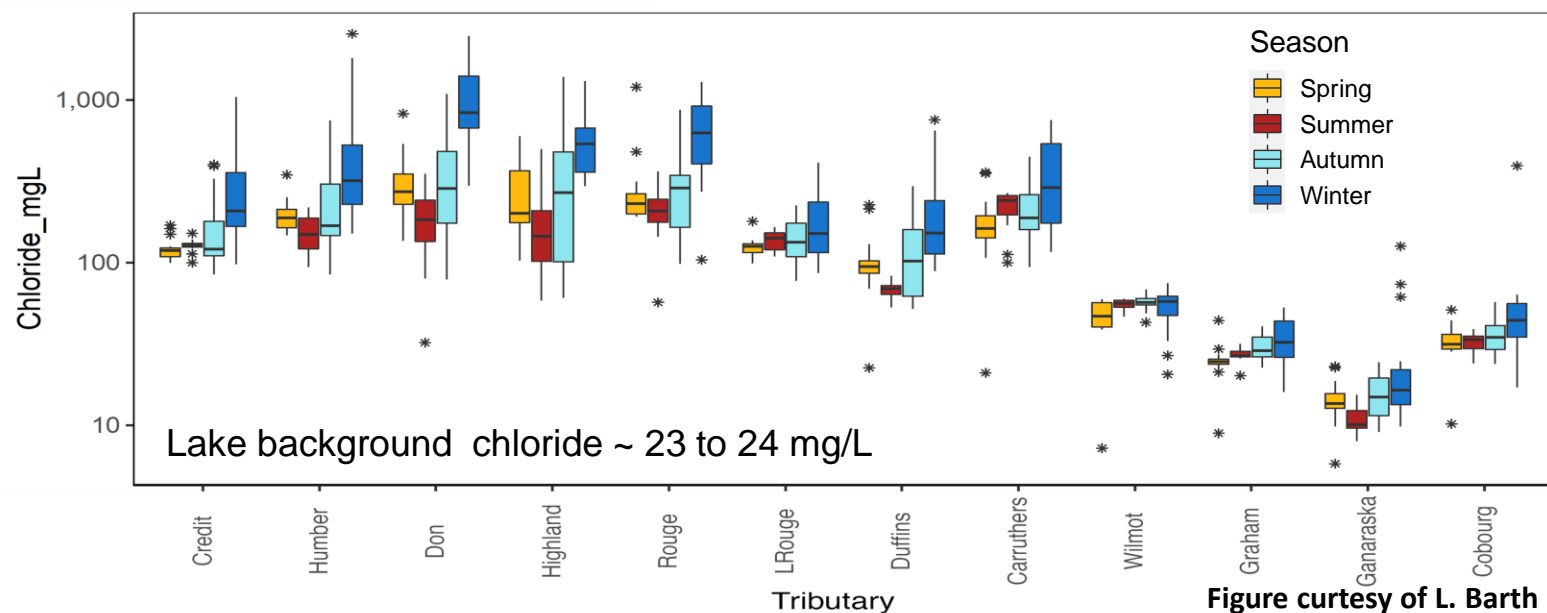
Seasonal Pattern in River Chloride and Lake Conductivity as Chloride Surrogate



Winter salt loading to rivers in combination with increased accumulative river discharge volumes leads to striking north shore changes in nearshore salt levels



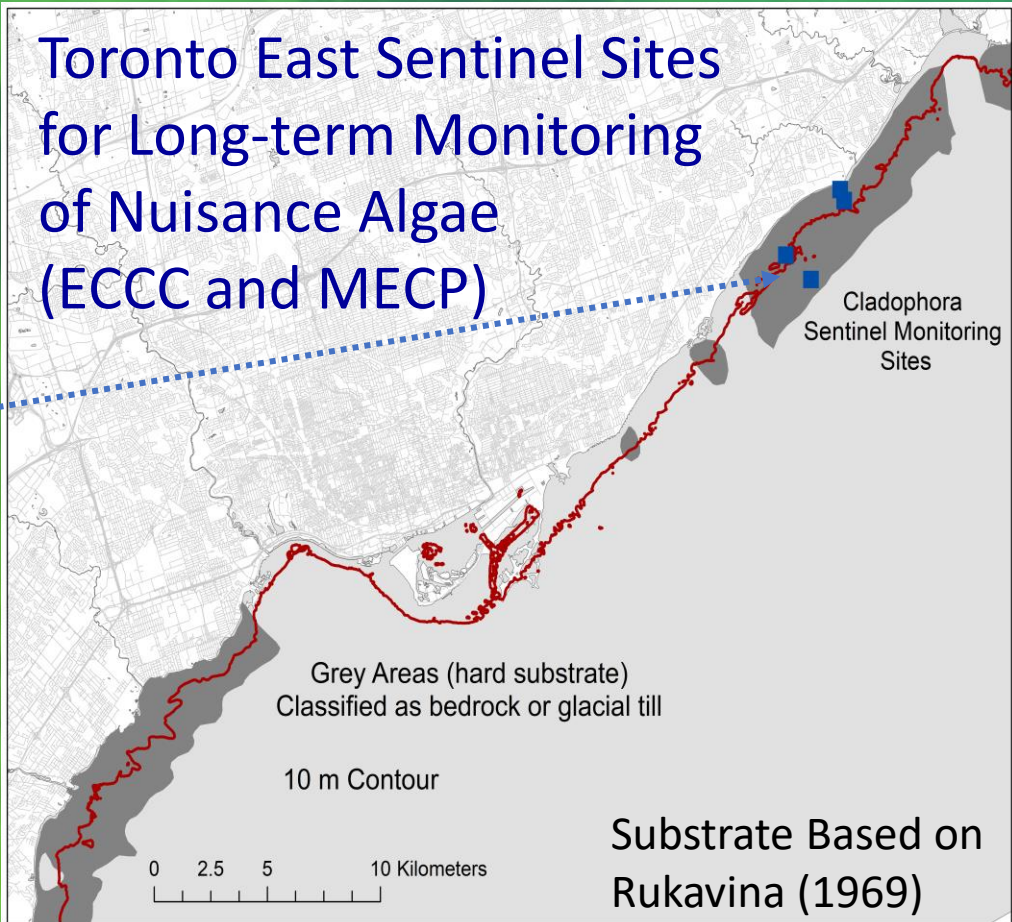
Chloride concentrations in Rivers



Lakebed of the North Shore of Lake Ontario as a Water Quality Concern

Ecology of nearshore changed radically with the invasion of dreissenid mussels in 1990. One outcome was proliferation of algae on the nearshore lakebed

Lawns of green algae:
Cladophora overlain by clouds
of metaphytic *Spirogyra*

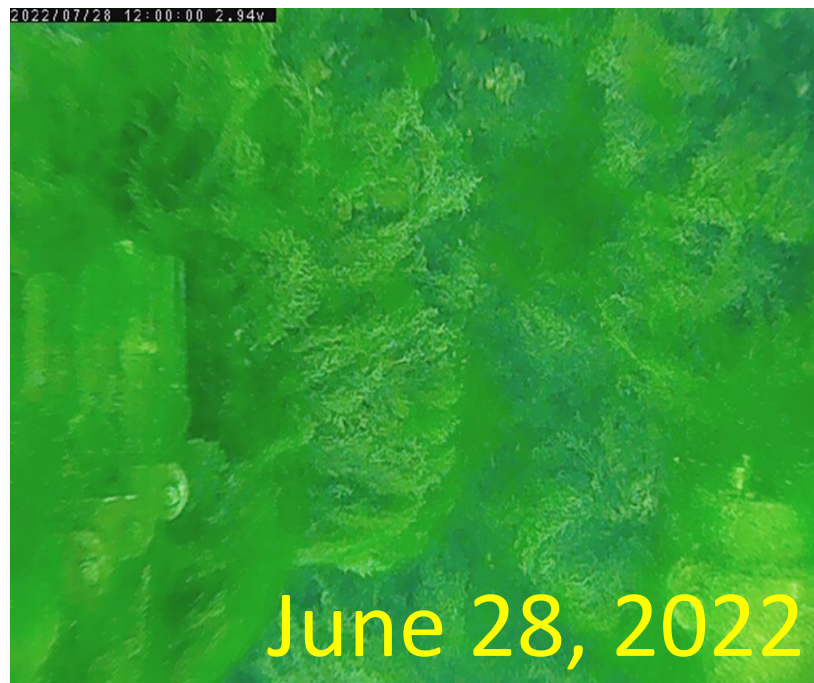
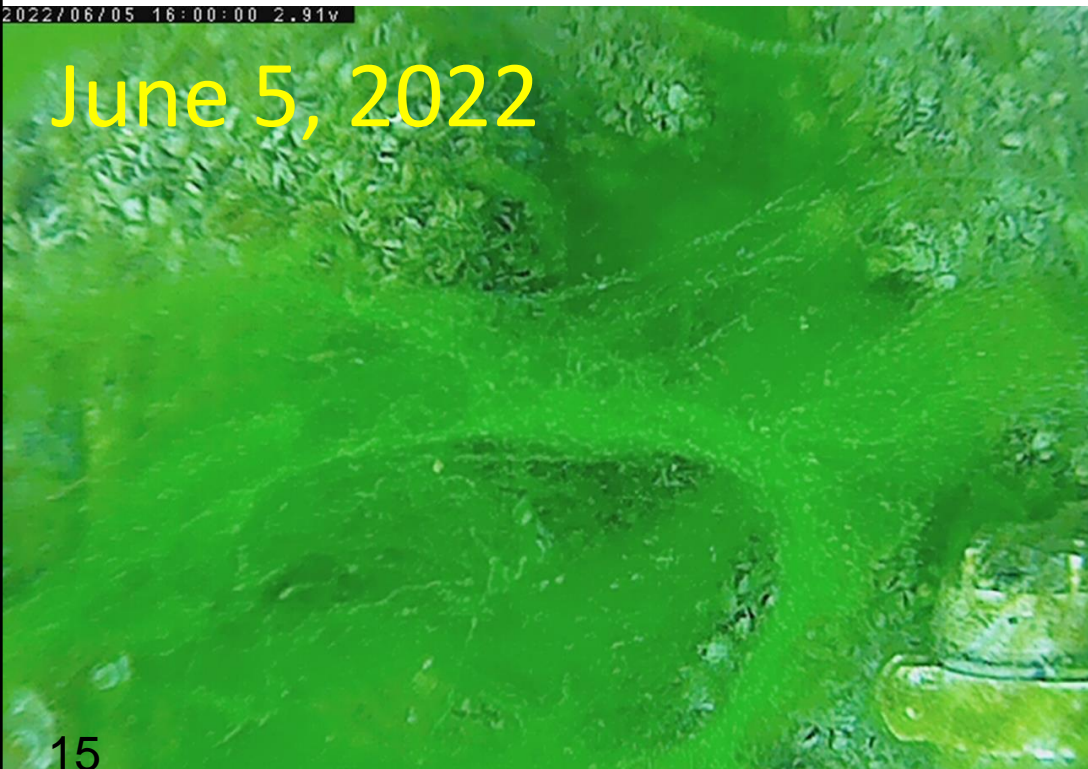




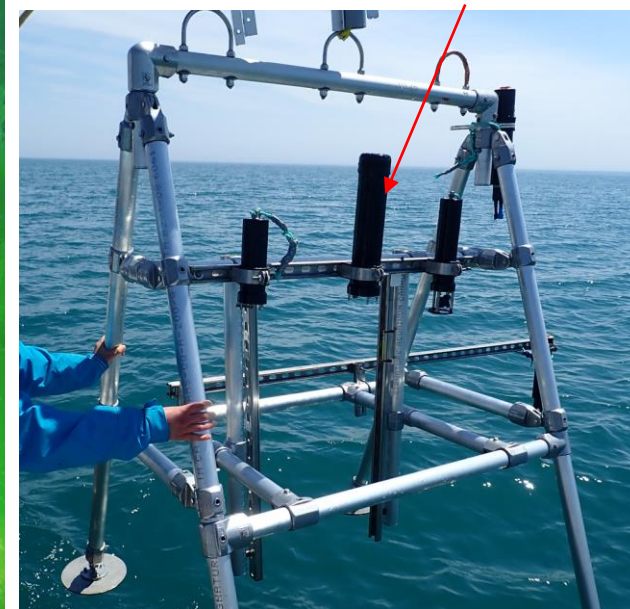
Metaphytic Green Algae *Spirogyra* (mostly)

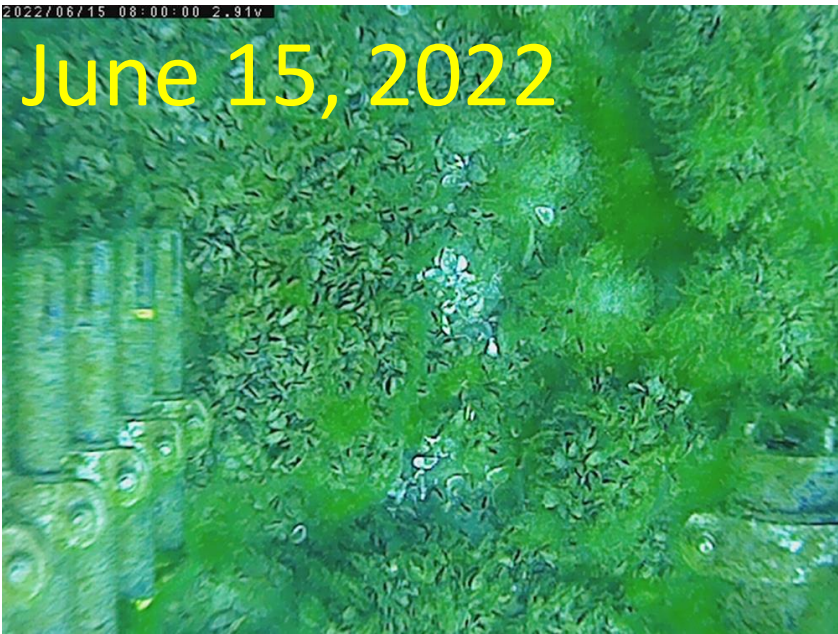
- Delicate unattached free-floating clouds of filaments
- Develops in early summer and peaks in early July
- Wide distribution and extensive cover to depths of 20m
- Susceptible to being moved around by lake currents

Metaphyton: neutrally buoyant, unattached clouds of filaments that lie on and above the lakebed



Time lapse camera





June 15, 2022



July 11, 2022



July 8, 2022



August 8, 2022




Green Algae *Cladophora*

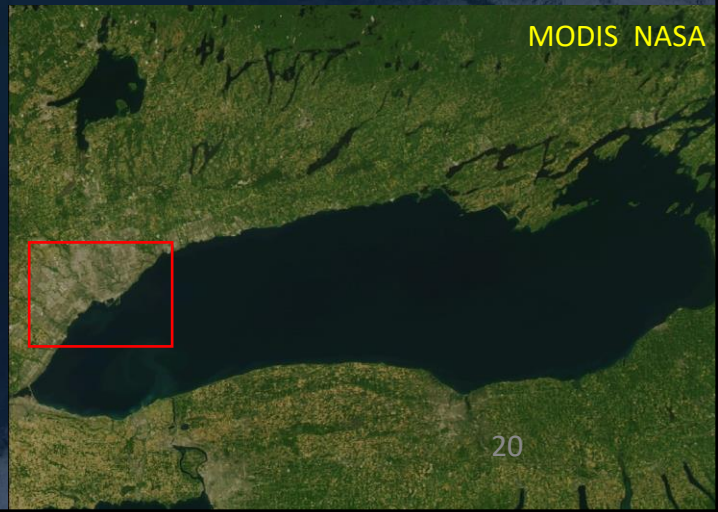
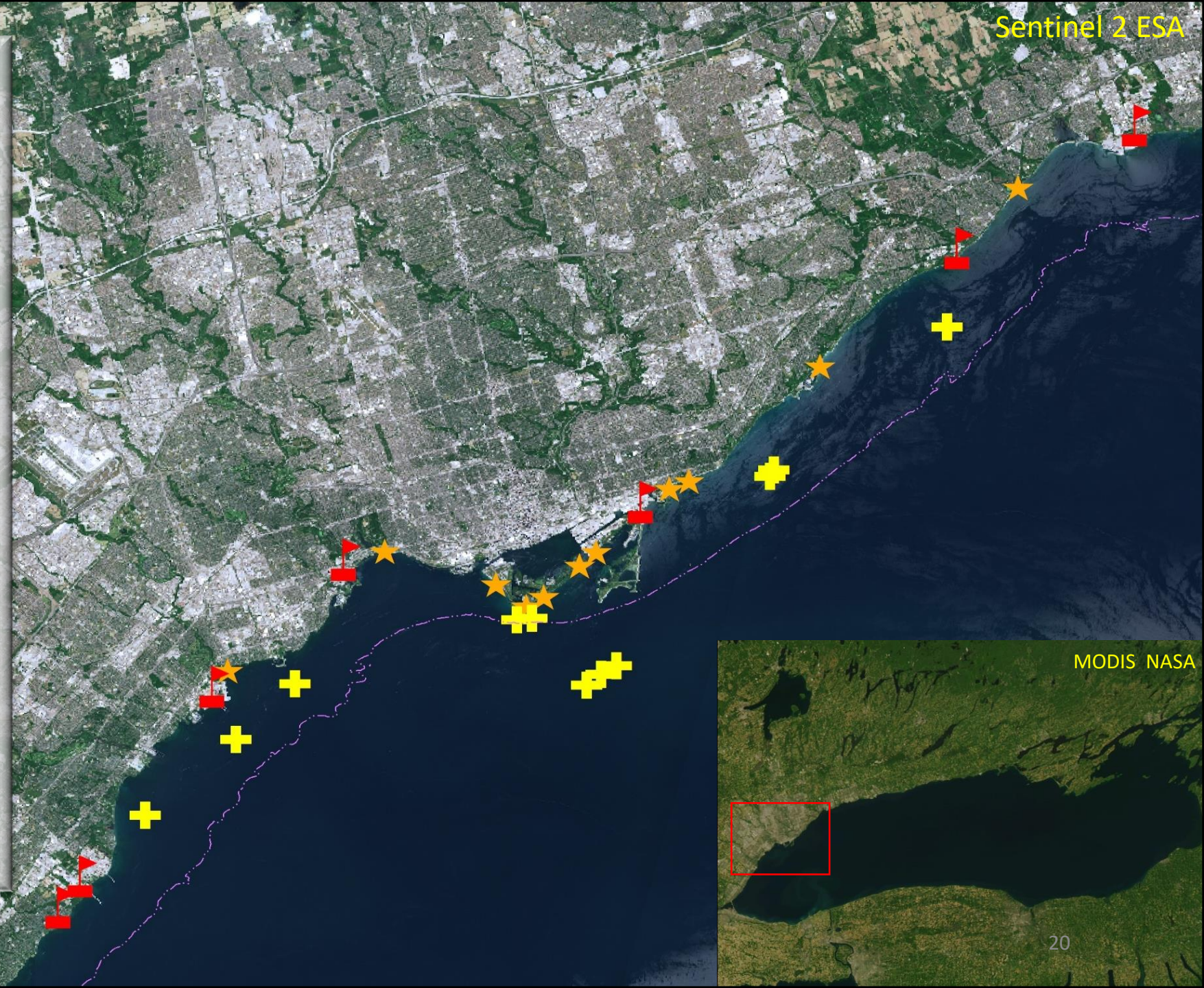
- Widely distributed and abundant on hard lakebed
- Strong seasonal growth pattern
- Coarse, branched filaments firmly attached to lakebed
- Storms and periodic die-back wash algae onshore fouling beaches



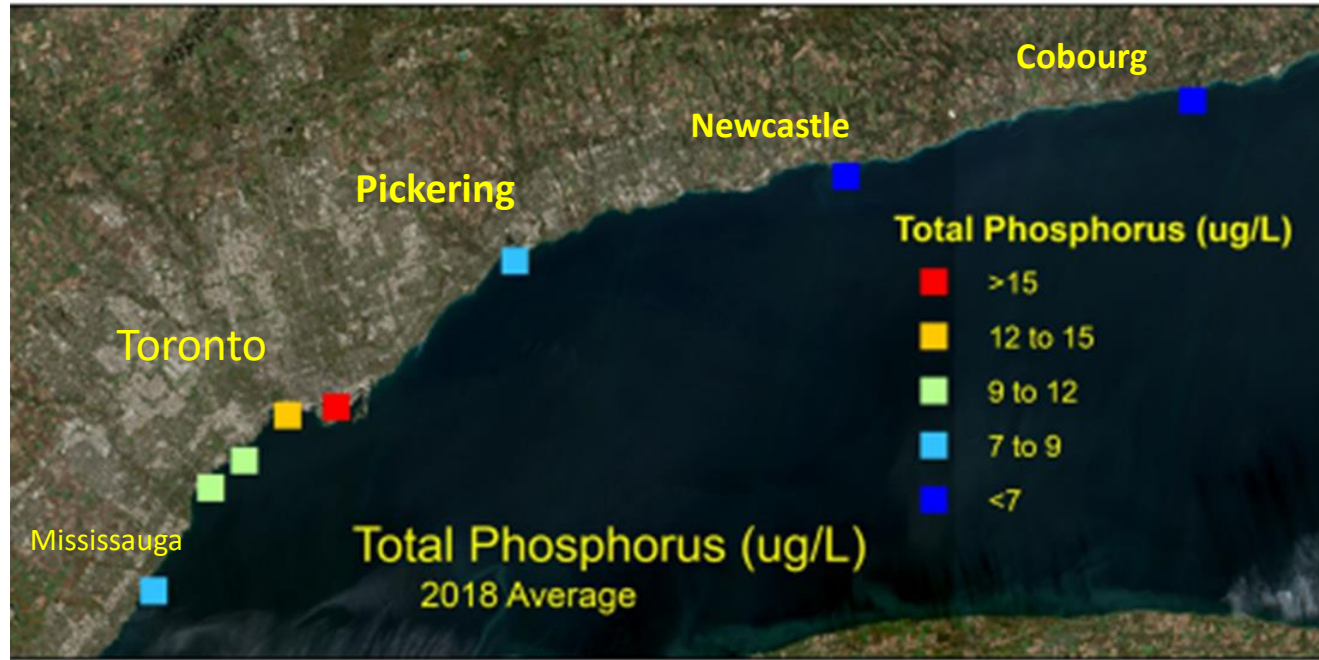
August 31, 2022

Water Resources

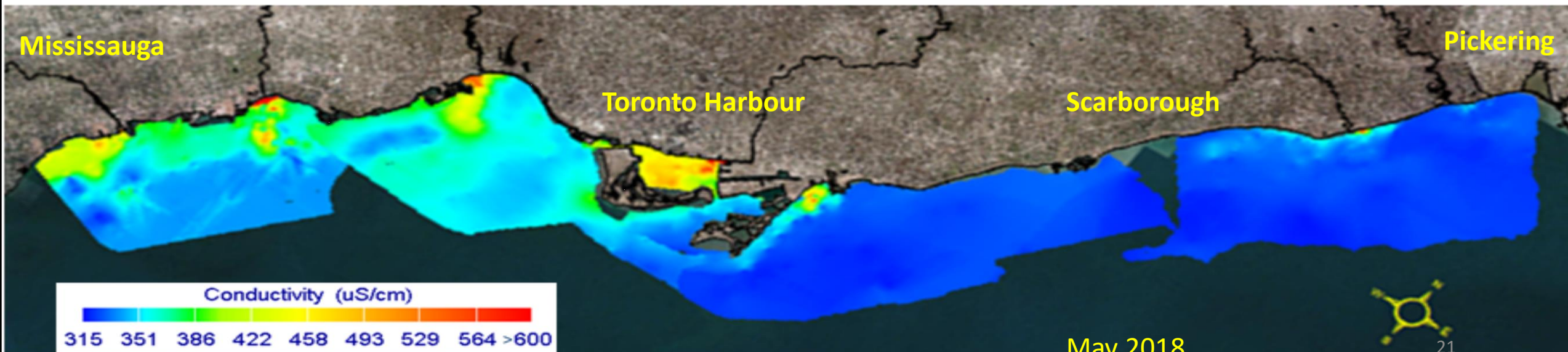
- Population of ~ 3.5 million
- ~ 60 km of coastline
- 4 wastewater treatment plant outfalls 
- 7 rivers
- >100 shoreline stormwater outfalls
- 5 Drinking Water Intakes 
- 11 Official Beaches 
- One AOC - Toronto Region



Nearshore Water Quality is Influenced by Adjacent Lands



- Outcomes for water resources and effects on nearshore ecology and broader lake must be front of mind



May 2018

Acknowledgements

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