Muskoka's Water Quality
An analysis of the data from your lake

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Overview

- Brief history of Lake System Health Program
- Are all the lakes the same?
- Is water quality changing?
- Is biological condition changing?
- Where do we go from here?

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Brief History

- Early 1980s District Municipality of Muskoka initiated a program to monitor the impact of land-use changes on lake water quality
- Initial focus was on chlorophyll, then phosphorus and secchi disk (transparency) measurements
- Goal was to maintain good water quality by regulating land-use changes such as shoreline development

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Results from a whole-lake experiment conducted at the Experimental Lakes Area, near Kenora, ON in 1973

Carbon & Nitrogen only

Barrier

Carbon, Nitrogen

AND PHOSPHORUS

Phosphorus is a nutrient that is the limiting factor "controlling" algal growth (e.g., chlorophyll) in aquatic ecosystems

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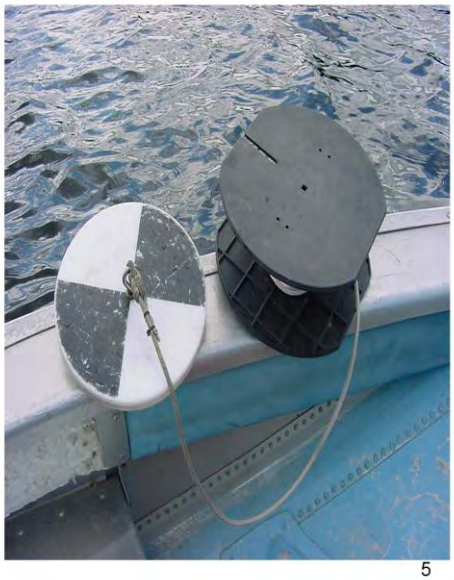
What is a Secchi Disc?

- A flat disc with alternating black & white quadrants
- Used to measure water clarity or transparency by lowering the disc into the water until it disappears
- First used in 1865 in the Mediterranean Sea
- Named after Father Pietro Secchi



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Muskoka Water Strategy (2003)

- **A framework of integrated and strategic initiatives to protect Muskoka's water resources involving:**
  - **District of Muskoka**
  - **Muskoka Watershed Council**
  - **plus a wide variety of organizations, agencies and stakeholders**

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The Muskoka Water Strategy is a framework of integrated and strategic initiatives for the protection of Muskoka's water resources. The District of Muskoka spearheads the Strategy with the support of the Muskoka Watershed Council and with involvement of a wide variety of organizations, agencies and stakeholders. The focus of the strategy is to connect and enhance existing water programs; develop new relationships and share resources with other organizations; and encourage greater community involvement in water issues in Muskoka.

The purpose of the strategy is to guide and minimize the impact of human activities on water resources; ensure human and environmental health; and preserve the quality of life in Muskoka. The underlying principles of the strategy are:

- To cover all of Muskoka and Muskoka's watersheds
- To be dynamic, flexible & responsive to change
- To build relationships and engage the community
- To respond to our heads & our hearts, and
- To make effective use of and share resources

Muskoka Water Strategy (2003)

- **Partners & Volunteers:**
  - **Ministry of the Environment – Dorset Environmental Science Centre (DESC)**
  - **Environment Canada – Ecological Monitoring and Assessment Network (EMAN)**
  - **Ontario Stewardship Rangers**
  - **Plus a significant number of formal and informal lake residents and cottagers associations**

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Muskoka Water Strategy (2003)

- Focus:
  - To connect and enhance existing water programs
  - To develop new relationships and share resources with other organizations
  - To encourage greater community involvement in Muskoka's water issues

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Muskoka Water Strategy (2003)

- **Underlying principles:**
  - **To cover all of Muskoka and Muskoka's watersheds**
  - **To be dynamic, flexible and responsive to change**
  - **To build relationships and engage the community**
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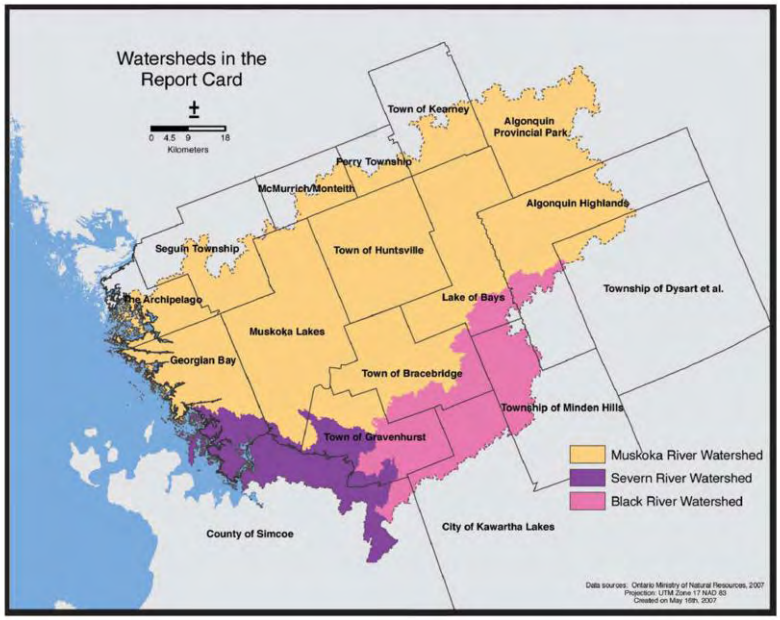
Muskoka Water Strategy (2003)



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Watersheds typically do not follow municipal boundaries. The District of Muskoka contains portions of the Muskoka River Watershed, the Severn River Watershed and the Black River Watershed.

Muskoka Water Strategy (2003)

- **Components:**
  - **Lake system health program**
  - **Muskoka Watershed Council**
  - **Communication and community involvement, and**
  - **Broader Water Initiatives**
- **Objective – to provide a holistic approach to lake system health in Muskoka (in order to maintain good water quality)**

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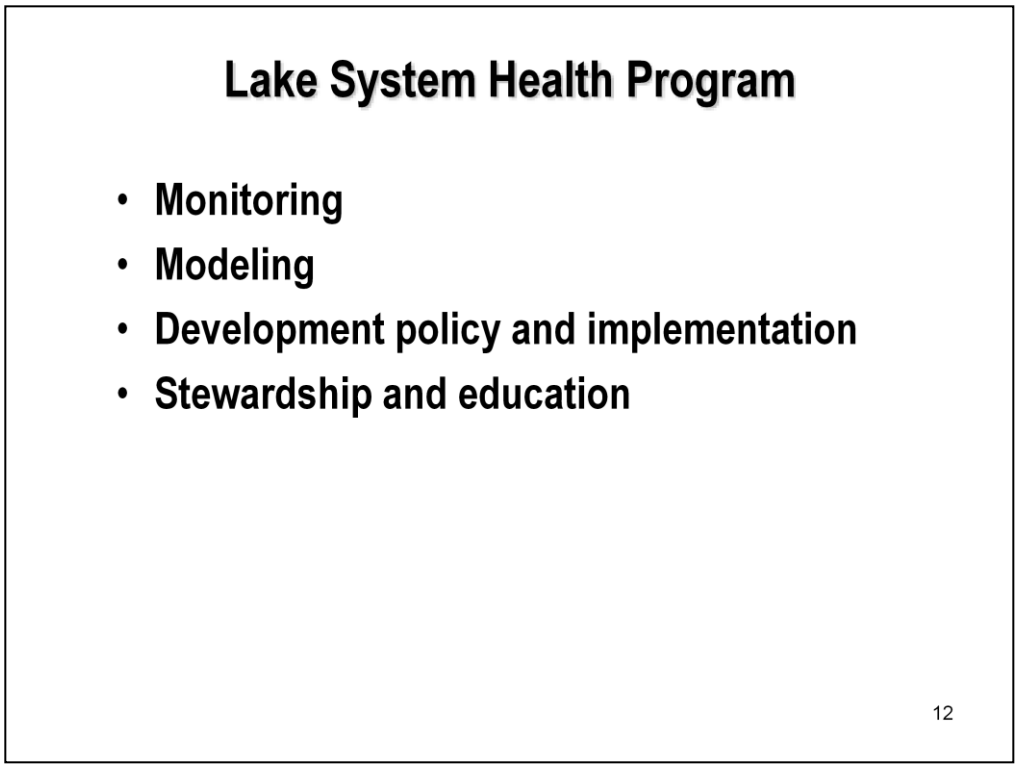
Visit http://muskokadistrict.iwebez.com/siteengine/activepage.asp?PageID=223 for more information about the Muskoka Water Strategy.



The Lake System Health program is a comprehensive program to protect our water resources. It has evolved from the review of the Muskoka recreational water quality model, which was first implemented by Muskoka District Council in the early 1980s.

Water quality in Muskoka is very good to excellent and Muskoka's objective is to continue to protect this key asset because our water resources are critical to our economy and lifestyle.

The District Municipality of Muskoka monitors lake health through recreational water quality testing, shoreline surveys, and technical assistance to lake associations interested in undertaking volunteer-based monitoring programs.

The Lake System Health program includes:

1. Working with Area Municipalities and lake communities to prepare lake-wide assessments that will identify the limits to growth for lakes.
2. Identifying lakes that have surpassed an acceptable threshold for phosphorus. On those lakes Muskoka will work with Area Municipalities, lake associations and other interested agencies to facilitate the development of remedial action programs.
3. Recognizing and better addressing the impact of stormwater from urban areas, transportation routes, municipal facilities, and site development.
4. Continuing and further enhancing education, stewardship and monitoring programs.

Monitoring

- **Muskoka's Recreational Water Quality Monitoring Program**
  - **Goal – establish a long-term record of key water quality parameters to identify trends and assist in wise management decisions to protect water quality**
  - **190 sites on 161 lakes sampled on a rotating basis**
  - **Monitor Secchi disk transparency, phosphorus, and temperature & oxygen profiles with depth**

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Muskoka has monitored recreational water quality in lakes and bays throughout Muskoka for over 25 years.

The recreational water quality monitoring program is a field based program that monitors approximately 190 sample locations on 161 lakes across Muskoka on a rotating basis depending upon development pressures and the specific characteristics of the lake.

The purpose of the recreational water quality monitoring program is to establish a long-term record of key water quality parameters so that trends in water quality can be identified.

Recreational Water Quality Monitoring Program

- **Products:**
  - **Spring phosphorus sampling in May**
  - **Secchi depths, temperature and oxygen profiles for May and August**
  - **Shoreline land use survey in June & July**
  - **Benthic macro-invertebrate sampling**
  - **Terrestrial forest plots**

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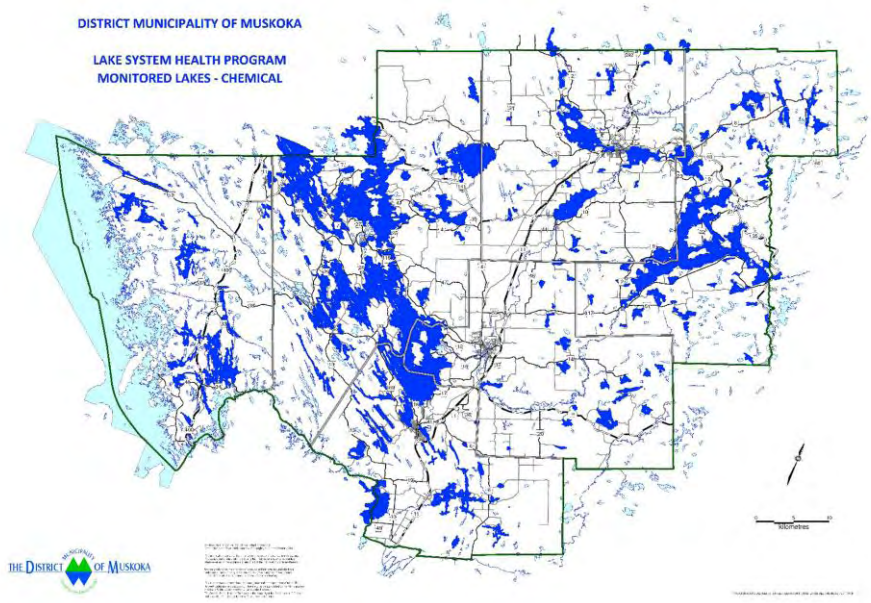
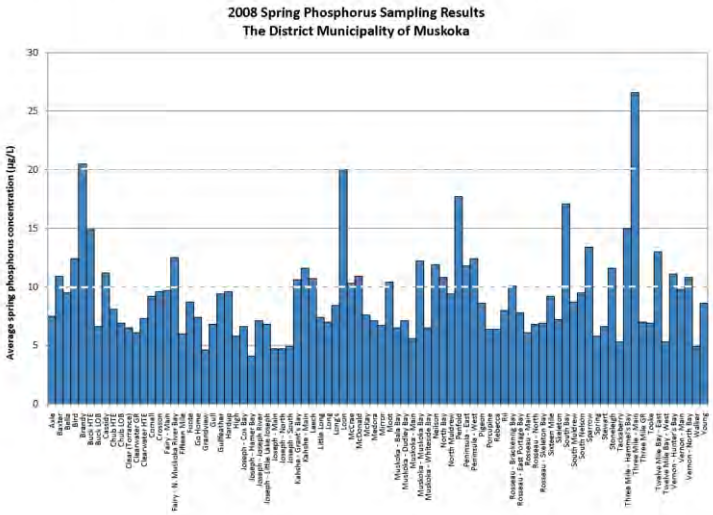
Recreational Water Quality Monitoring Program



This map identifies the 161 lakes across Muskoka that are monitored on a regular basis.

Recreational Water Quality Monitoring Program

- **Phosphorus concentrations by lake….**



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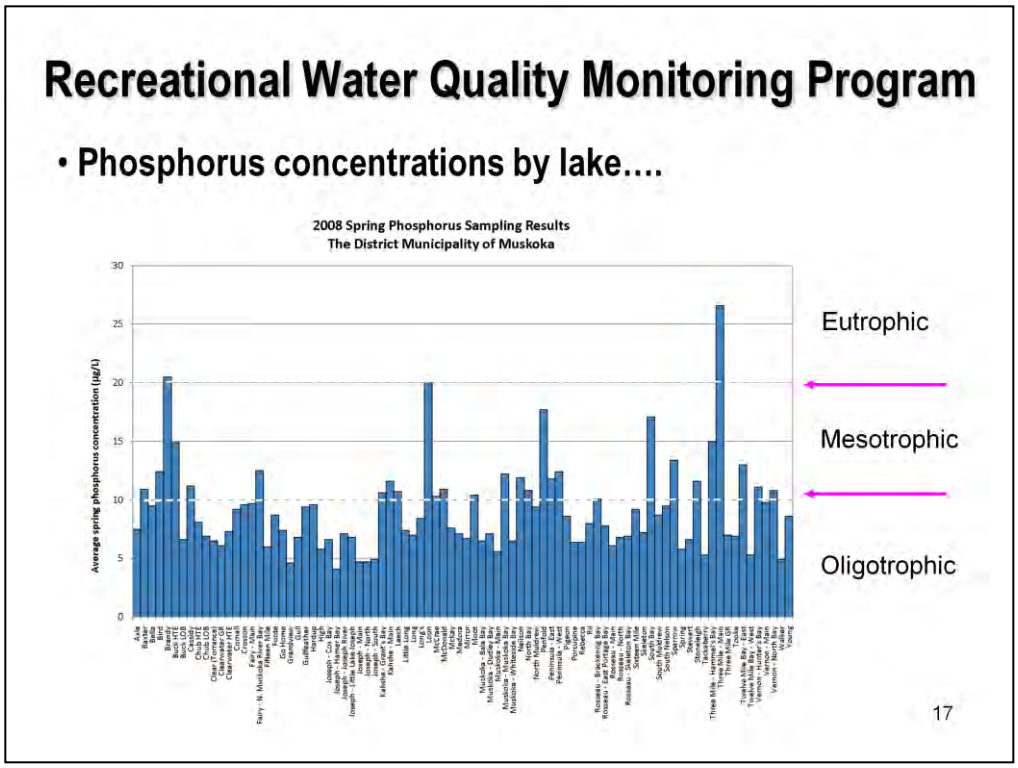


Lakes with a phosphorus concentration below 10 ug/L are considered oligotrophic (nutrient poor).

Lakes with a phosphorus concentration between 10 and 20 ug/L are considered mesotrophic (moderately enriched).

Lakes with a phosphorus concentration above 20 ug/L are considered eutrophic (nutrient rich).

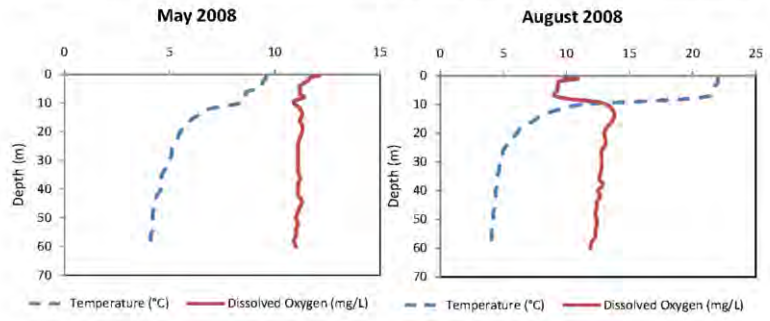
Muskoka naturally has a range of lakes in all three categories, although the majority of lakes are oligotrophic.

Recreational Water Quality Monitoring Program

- **Temperature & Oxygen Profiles**

Skeleton Lake

Municipality:	Muskoka Lakes	Watershed:	Lake Rosseau
Surface Area:	21 km^2	Watershed Area (excluding lake):	44.5 km^2
Maximum Depth:	60 m	Cold Water Fishery?	Yes
Wetland Area:	10 %	Secchi Depth (10-year average):	9.8 m
Phosphorus (10-year average 1999-2008):	4.1 µg/L	Sensitivity:	Moderate



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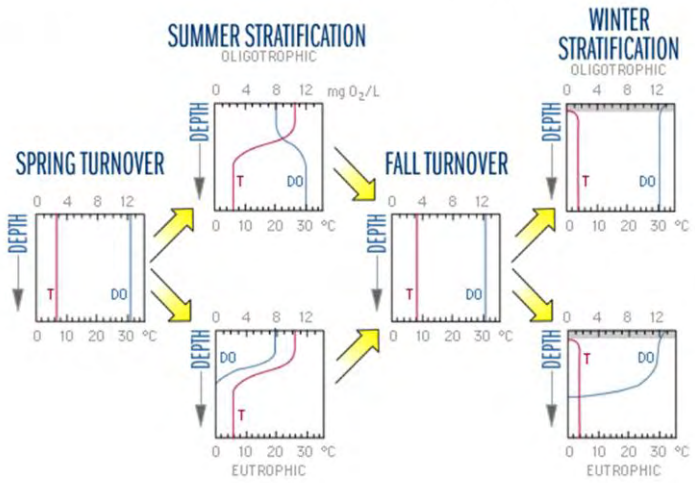
Lake Data Sheets developed for each site monitored contains information about the lake as well as temperature and depth profiles. Lake Data Sheets are available on the Muskoka Water Web (http://www.muskokawaterweb.ca/1/1.1/Text.htm).

Recreational Water Quality Monitoring Program

- **Information to assist with data interpretation:**



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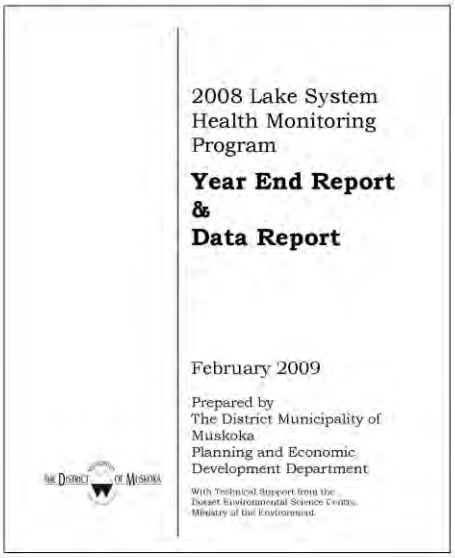
Typically temperature and dissolved oxygen profiles for oligotrophic and eutrophic lakes throughout the year.

Recreational Water Quality Monitoring Program



2008 Lake System Health Monitoring Program

Year End Report & Data Report

February 2009

Prepared by
The District Municipality of Muskoka
Planning and Economic Development Department

With Technical Support from the Dorset Environmental Science Centre, Ministry of the Environment.

2008 Lake System Health Monitoring Program
Year End Report

2008 phosphorus sampling and Secchi depth measurement results

Lake Name	Ave. Secchi (m)	Ave TP (µg/L)	Lake Name	Ave. Secchi (m)	Ave TP (µg/L)
Axle	6.3	7.5	Mirror	4.1	6.7
Baizer	4.8	10.9	Moot	7.5	10.4
Beaty	3.6	9.5	Muskoka - Hahn Bay	4.1	8.5
Bird	2.6	12.4	Muskoka - Dudley Bay	3.7	7.1
Brandy	1.4	20.5	Muskoka - Main	3.8	6.6
Buck HTE	1.5	14.9	Muskoka - Muskoka Bay	3.1	12.2
Buck LOS	4.9	5.6	Muskoka - Whiteside Bay	4.0	6.5
Clearly	2.9	11.2	Nelson	2.5	11.9
Chub HTE	2.5	8.1	North Bay	3.3	10.8
Chub LOS	2.6	8.9	North Muldrew	2.1	9.4
Clear (Tasmore)	5.3	9.5	Penhorn	1.4	17.7
Clearwater QR	4.9	8.1	Peninsula - East	3.2	11.8
Clearwater HTE	5.5	7.5	Peninsula - West	3.6	12.4
Confot	2.6	9.2	Pigeon	4.0	8.6
Crowrun	3.2	9.5	Porcupine	2.8	8.4
Fairy - Main	2.8	9.7	Rebecca	3.9	6.4
Fairy - NMRB	2.8	12.5	Ril	2.2	8.6
Fifteen Mile	6.2	6.0	Rosseau - Blackstone Bay	2.5	10.1
Foote	5.1	5.7	Rosseau - East Portage Bay	4.8	7.8
Go Home	2.6	7.4	Rosseau - Main	5.9	5.1
Grandview	7.2	4.9	Rosseau - North	5.1	6.8
Gull	2.5	8.6	Rosseau - Skeleton Bay	4.5	6.8
Gullteather	5.1	9.4	Sixteen Mile	9.5	5.2
Hardlup	4.4	9.5	Skeleton	5.3	7.2
High	5.4	5.6	South Bay	4.0	17.1
Joseph - Ook Bay	5.1	6.5	South Muldrew	2.5	8.7
Joseph - Hamer Bay	6.0	4.1	South Nelson	3.7	9.5
Joseph - Jibbeh River	5.0	7.1	Spithow	4.0	13.4
Joseph - L. Lake Joseph	4.7	6.6	Spring	4.2	5.8
Joseph - Main	5.1	4.7	Stewart	3.4	8.8
Joseph - North	5.9	4.7	Stoneleigh	1.6	11.6
Joseph - South	5.5	4.9	Tackaberry	4.9	5.2
Kitchaha - Grants Bay	2.6	10.6	Three Mile - Hammer's Bay	2.5	15.0
Kahshe - Main	2.9	11.6	Three Mile - Main	1.9	26.3
Leech	2.6	10.7	Three Mile QR	6.5	7.0
Little Long	3.3	7.4	Tower	5.1	8.9
Long	4.7	7.0	Twelve Mile Bay - East	2.8	13.9
Longa	1.8	9.9	Twelve Mile Bay - West	8.4	5.3
Loon	2.7	20.0	Vernon - Hunter's Bay	3.6	11.1
McCraw	4.1	10.3	Vernon - Main	2.8	9.8
McDonald	4.1	10.9	Vernon - North Bay	3.4	10.8
McKay	3.4	7.6	Wallen	5.2	4.9
Medora	4.3	7.1	Young	4.1	8.0

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Muskoka produces an annual report that detailing the monitoring program and the data collected for the year. Complete reports are available on the District Municipality of Muskoka website at http://muskokadistrict.iwebez.com/siteengine/activepage.asp?PageID=231.

Recreational Water Quality Monitoring Program

- Annual report contains a summary of the data collected over that year as a “snapshot in time”
- However, to fully understand changes in environmental quality it is important to track long-term trends for a given lake, as well as trends associated with the larger group of lakes

Overview

- Brief history of Lake System Health Program
- **Are all the lakes the same?**
- Is water quality changing?
- Is biological condition changing?
- Where do we go from here?

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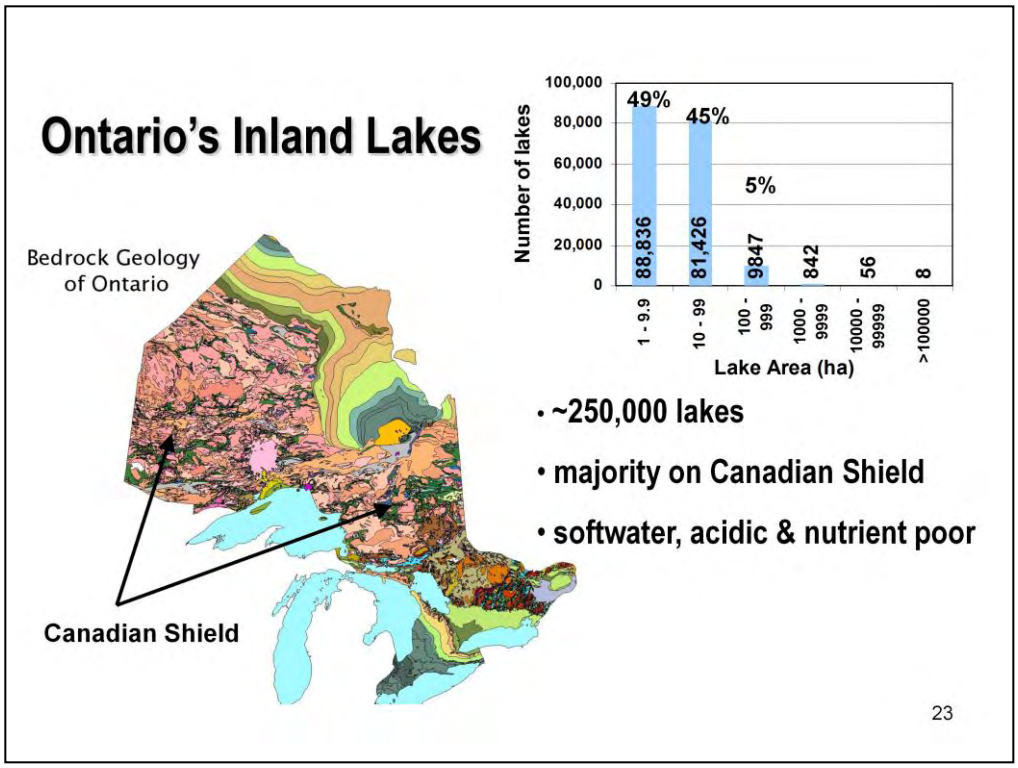
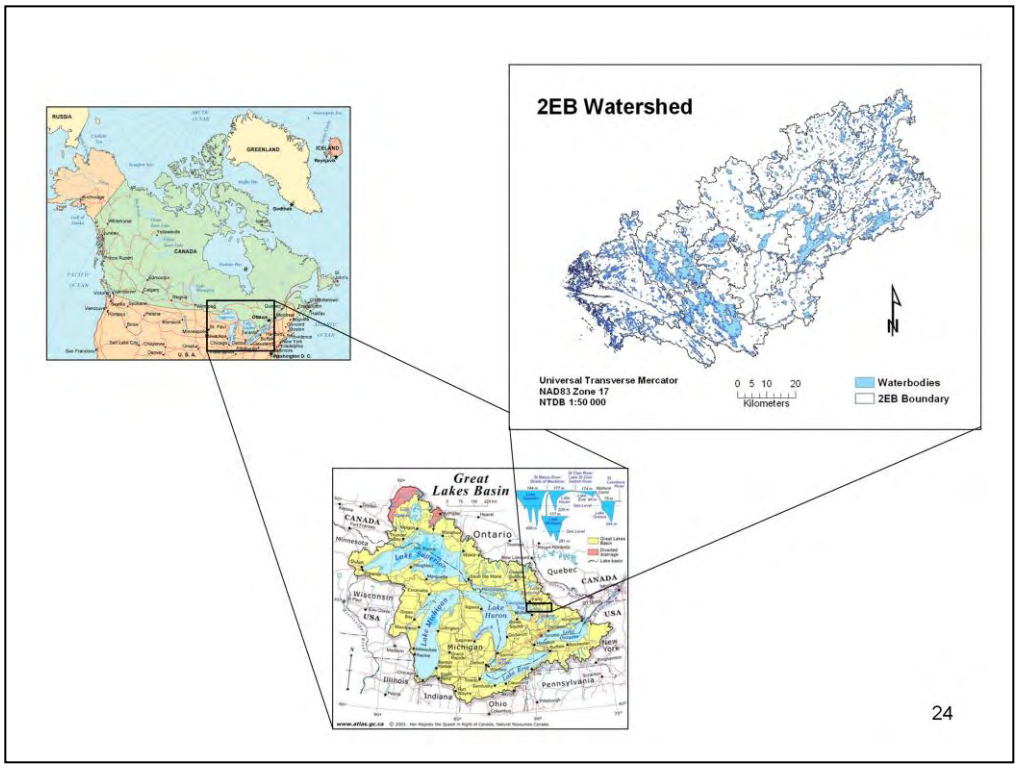
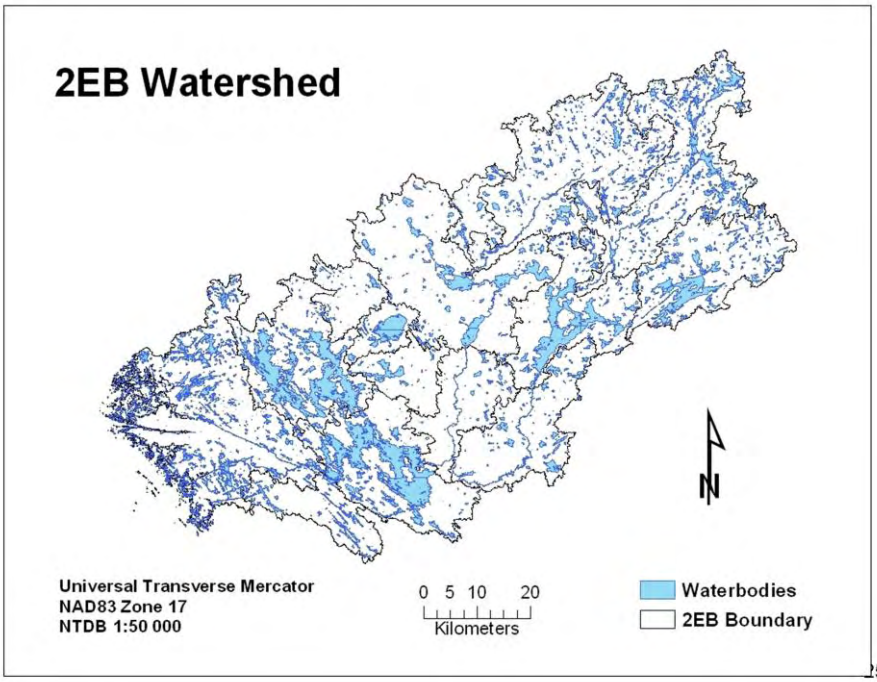


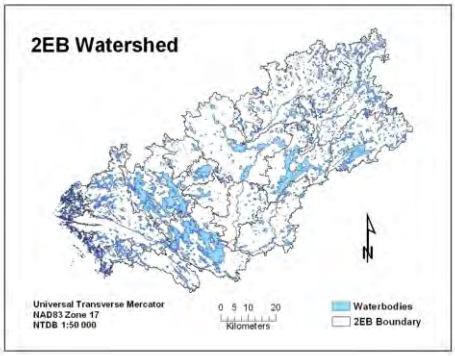
The majority of the lakes in Ontario are between 1 and 99 hectares in size, are located on the Canadian Shield, and are generally acidic and nutrient poor.

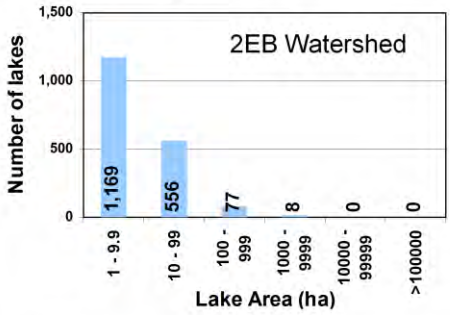


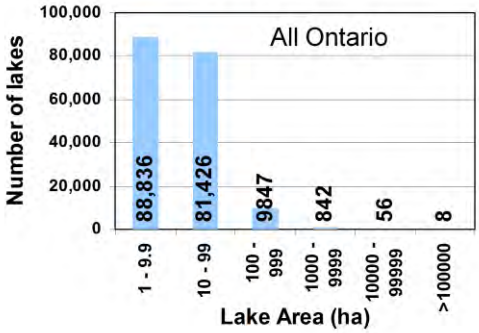
The District Municipality of Muskoka consists primarily of the Muskoka River Watershed (2EB Watershed).


2EB Watershed
N
Universal Transverse Mercator
NAD83 Zone 17
NTDB 1:50 000
0 5 10 20
Kilometers
Waterbodies
2EB Boundary

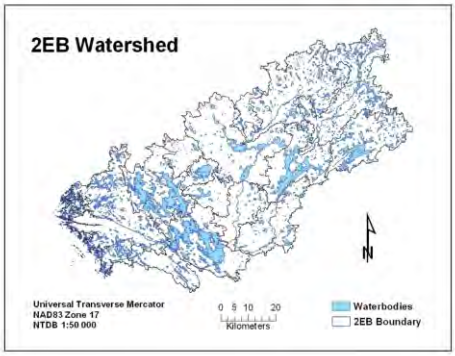
Distribution of lakes by surface area (ha)

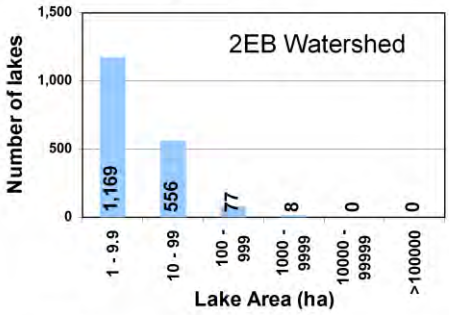


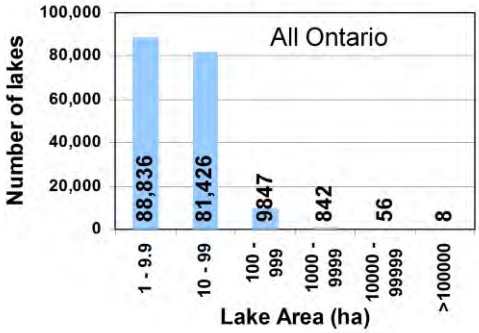




Distribution of lakes by surface area (ha)

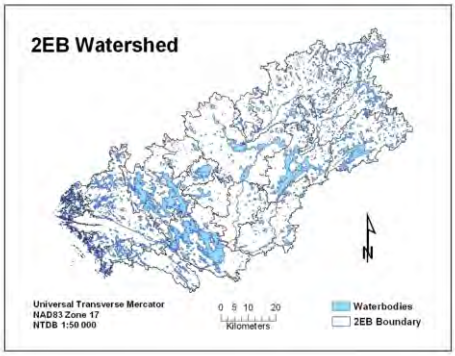


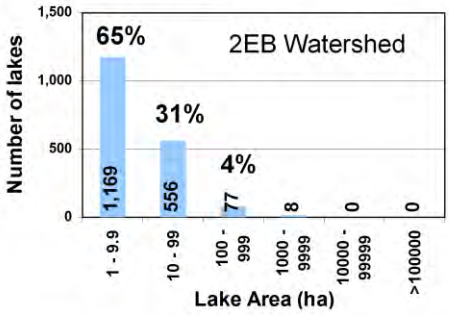


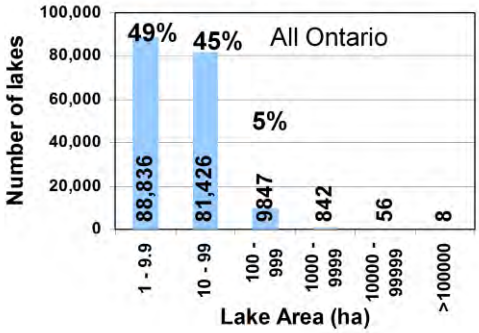


2EB area = 574,000 ha
Lake area = 75,665 ha
Lake area (2EB) = 13.2%
Lake area (Ontario) = 17%

Are all the lakes the same? - No







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Are all the lakes the same?

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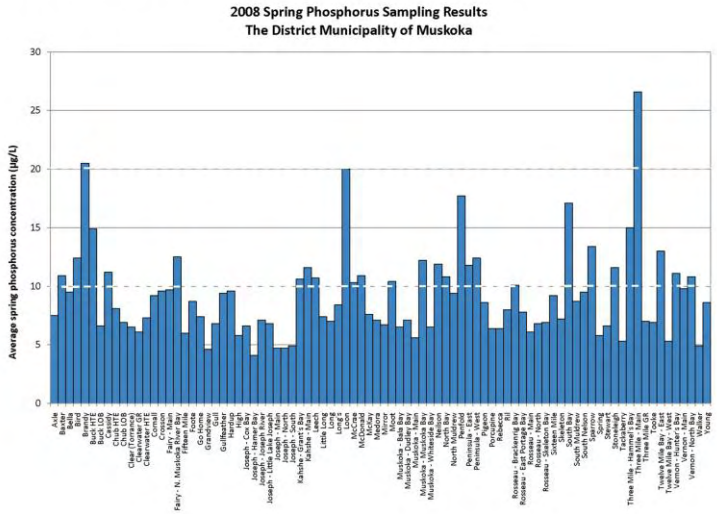

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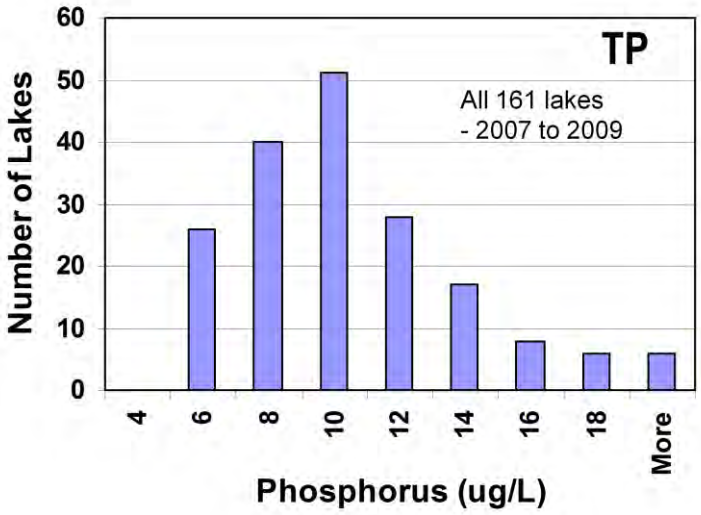

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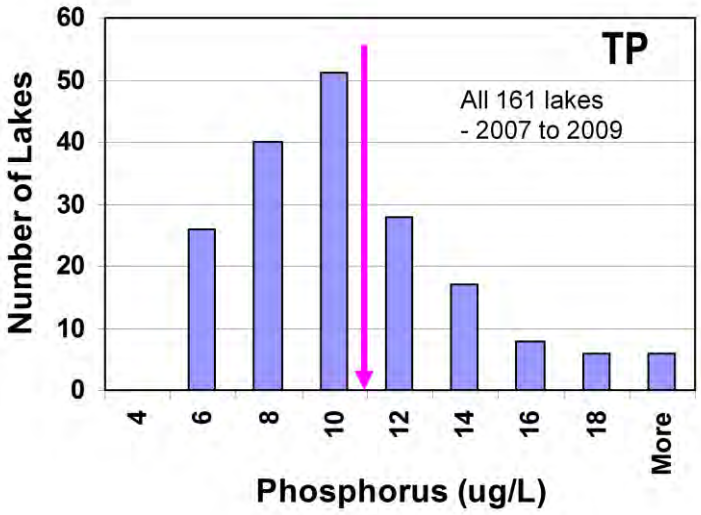

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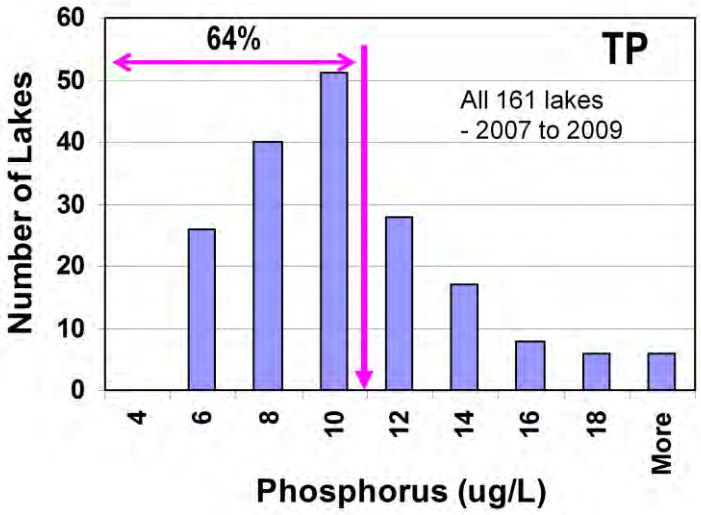
Are all the lakes the same?



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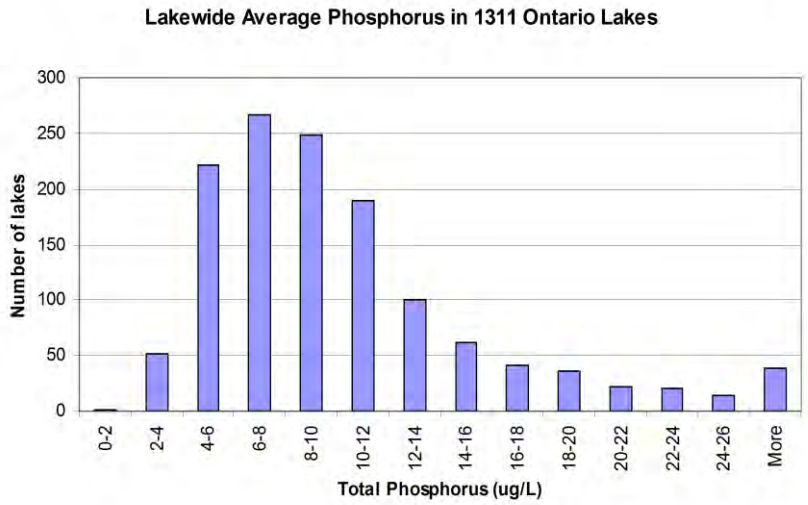
Distribution of phosphorus concentrations for Ontario lakes based on Lake Partner data



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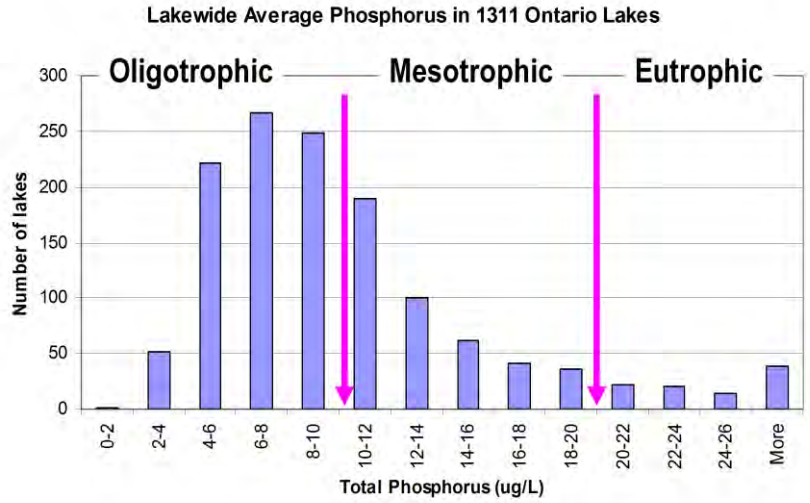

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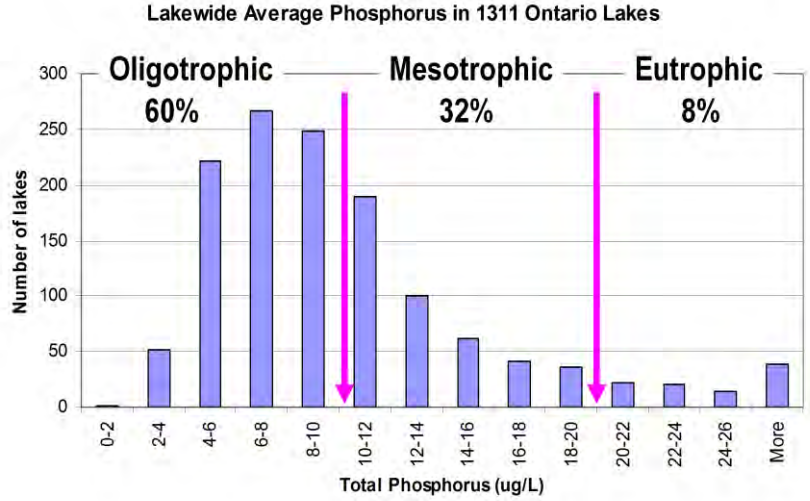

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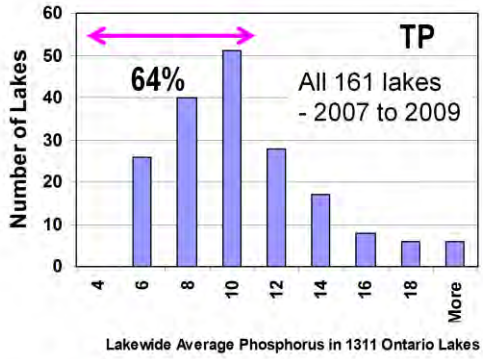

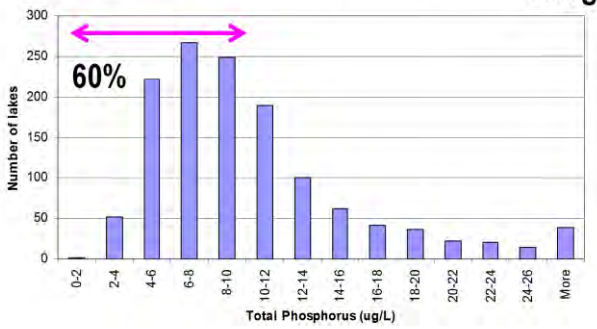

Histogram for phosphorus concentration based on the 161 Muskoka lakes is similar to the histogram for 1311 Lake Partner Program lakes from across Ontario (with slightly more Muskoka lakes in the 8-10 ug/L category).

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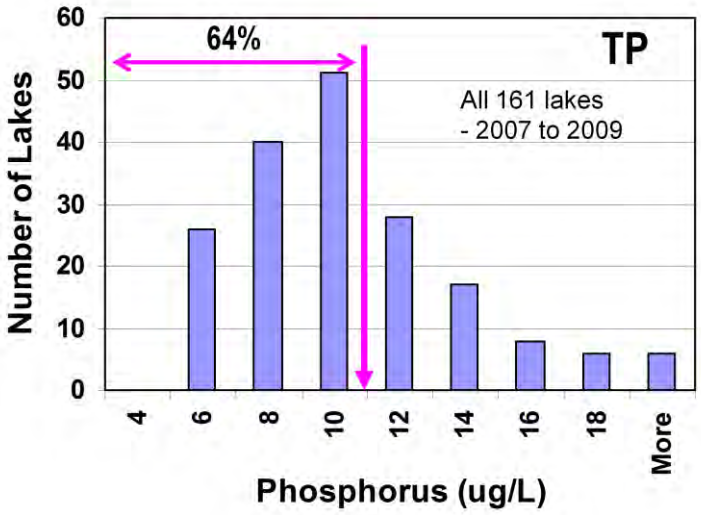
Are all the lakes the same? - No



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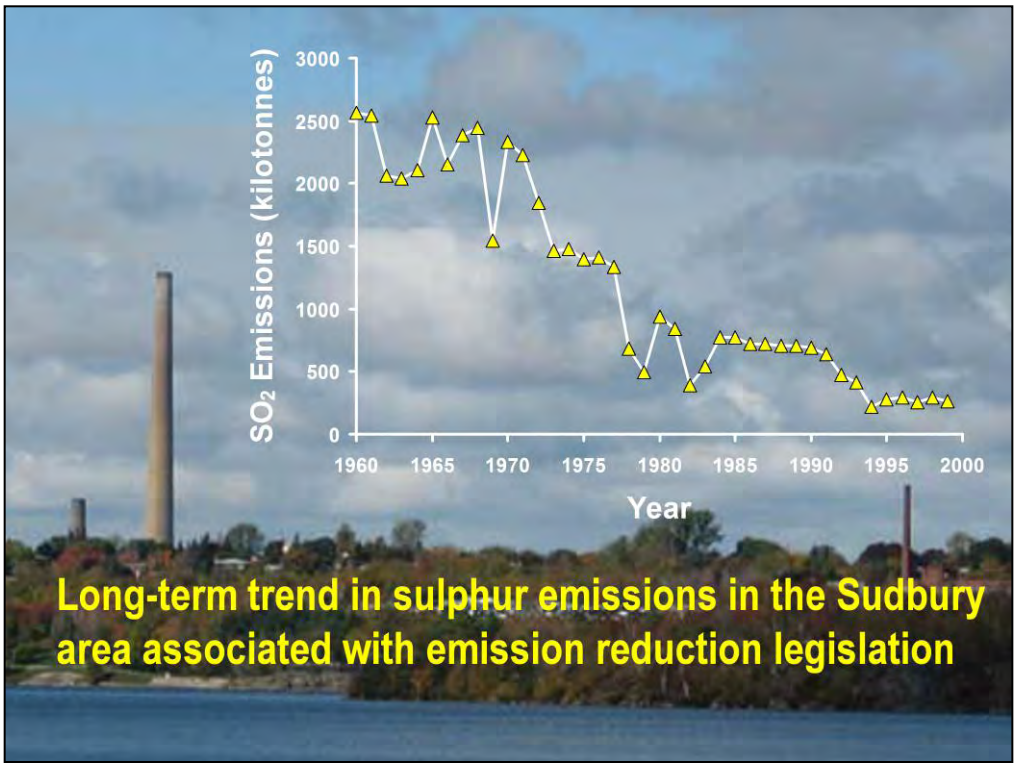
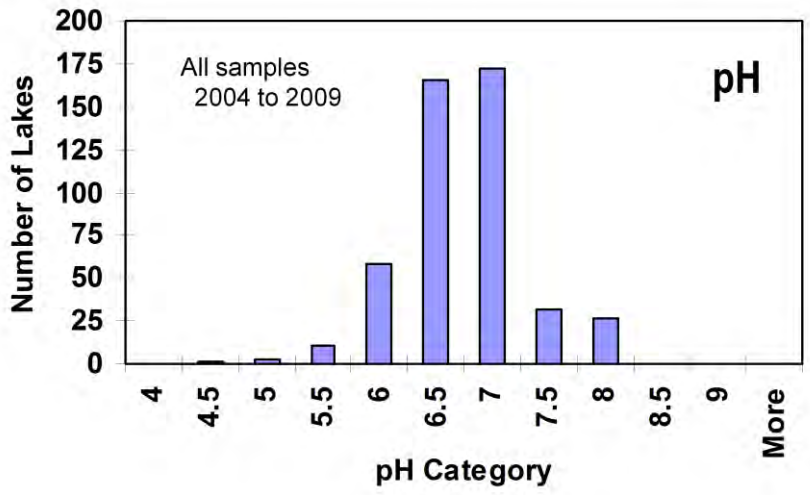


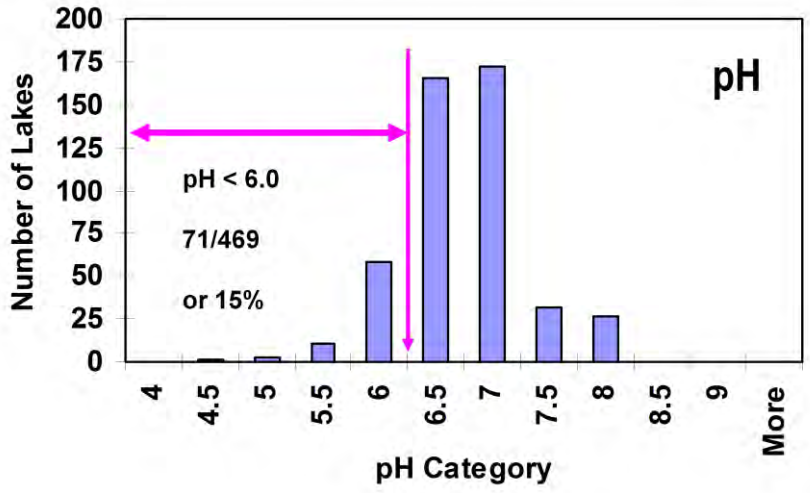
Long-term trend in sulphur emissions in the Sudbury area associated with emission reduction legislation

Are all the lakes the same?



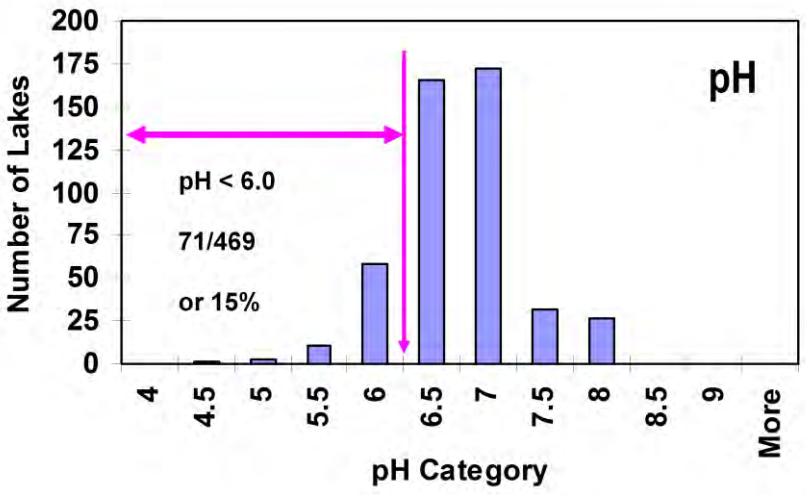
39

Are all the lakes the same?



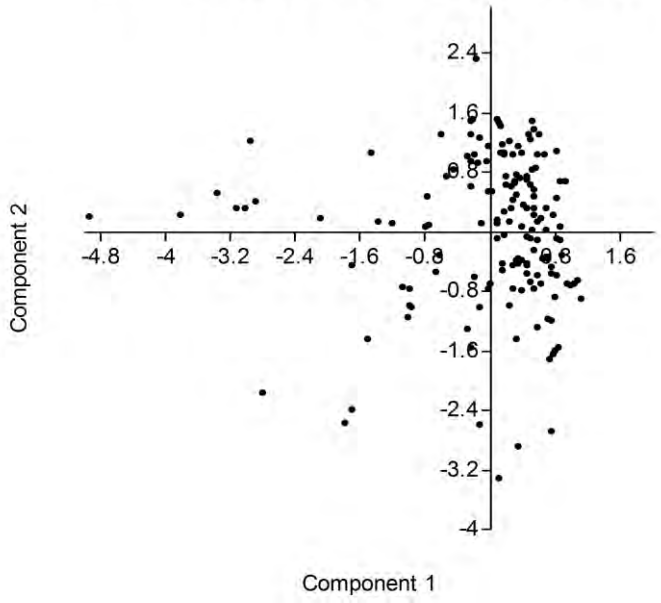
40

Are all the lakes the same? - No



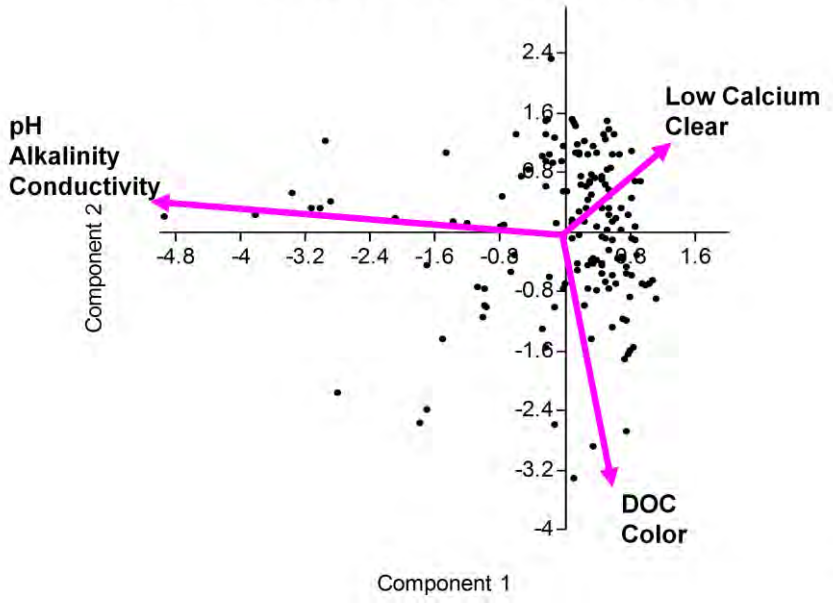
41

Are all 161 lakes the same?



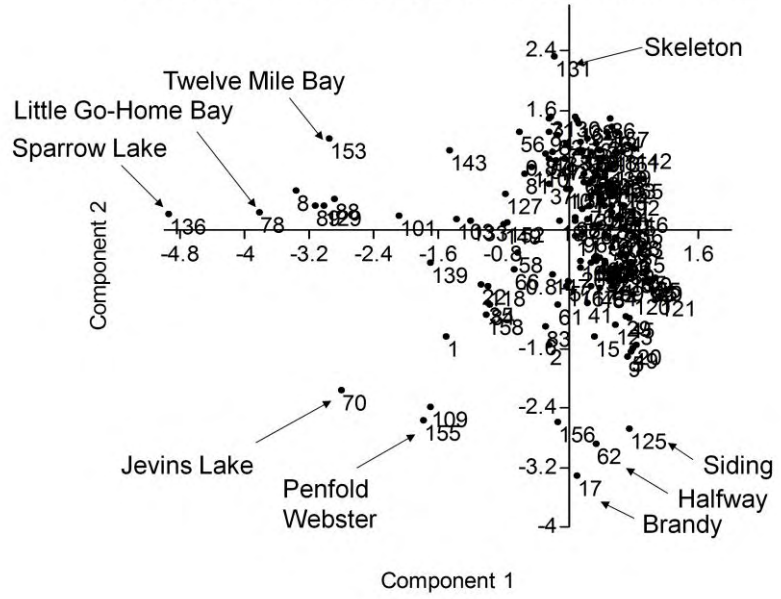
42

Are all 161 lakes the same?

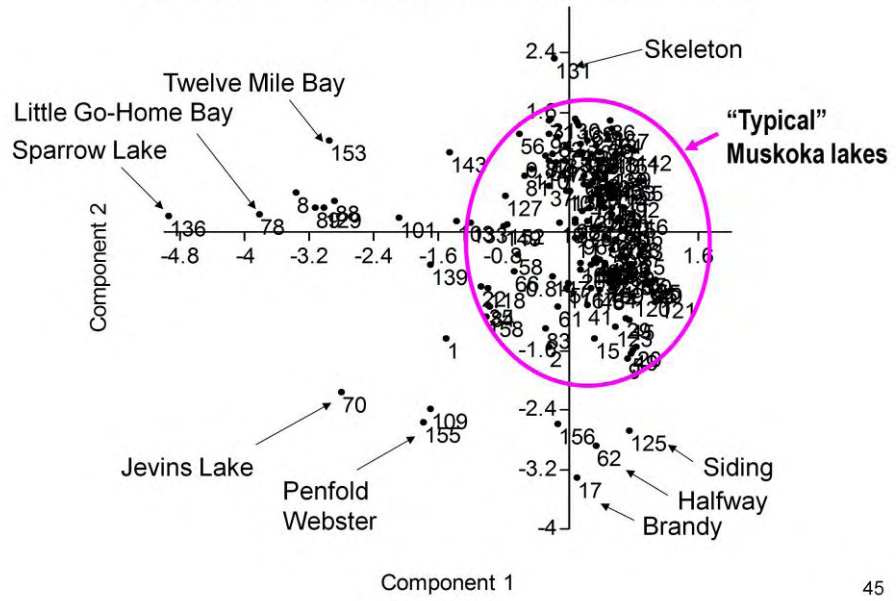


43

Are all 161 lakes the same? - No



Are all 161 lakes the same? - No



Overview

- Brief history of Lake System Health Program
- **Are all the lakes the same?**
- Is water quality changing?
- Is biological condition changing?
- Where do we go from here?

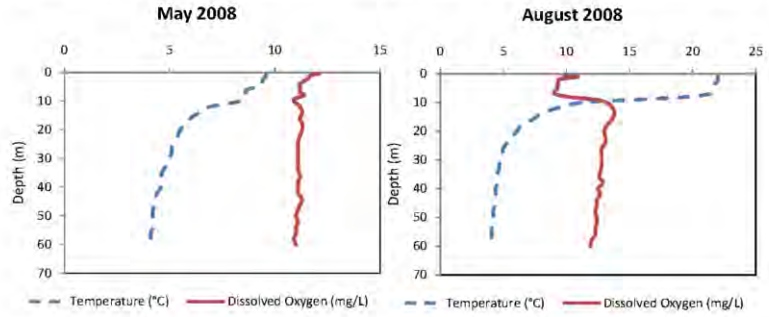
46

Recreational Water Quality Monitoring Program

- **Temperature & Oxygen Profiles**

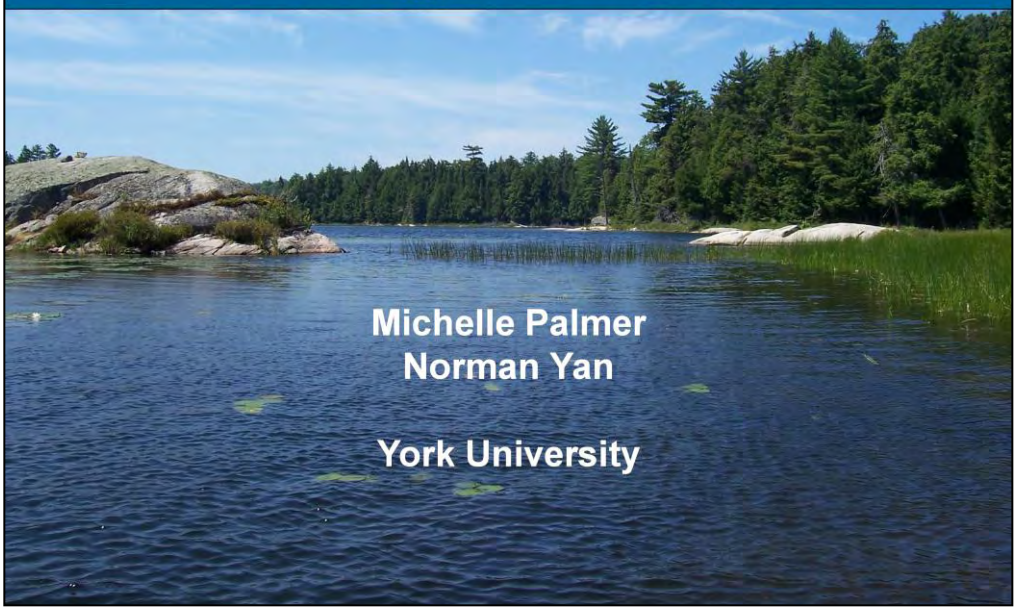
Skeleton Lake

Municipality:	**Muskoka Lakes**	Watershed:	**Lake Rosseau**
Surface Area:	**21 km²**	Watershed Area (excluding lake):	**44.5 km²**
Maximum Depth:	**60 m**	Cold Water Fishery?	**Yes**
Wetland Area:	**10 %**	Secchi Depth (10-year average):	**9.8 m**
Phosphorus (10-year average 1999-2008):	**4.1 µg/L**	Sensitivity:	**Moderate**



47

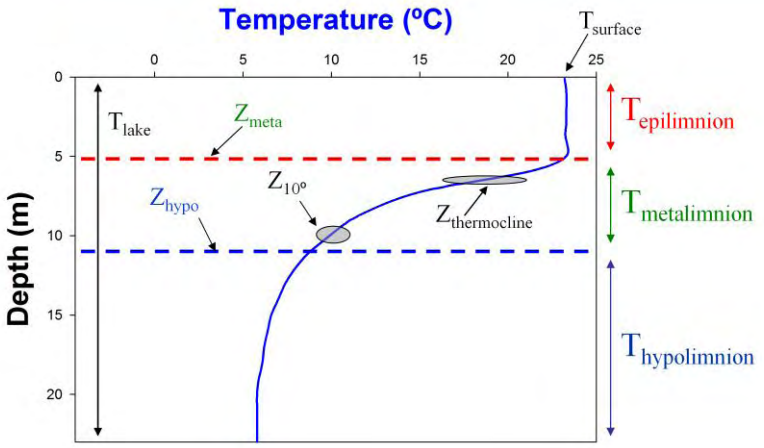
Temporal Patterns in Lake Physics for Two Long-Term Study Areas



Michelle Palmer
Norman Yan

York University

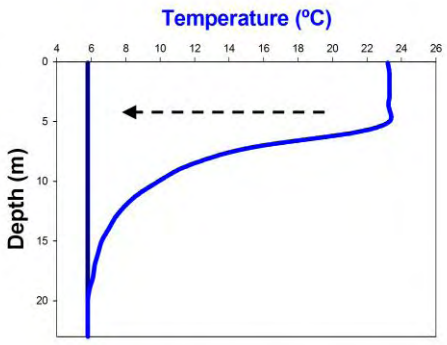
Thermal Structure



49

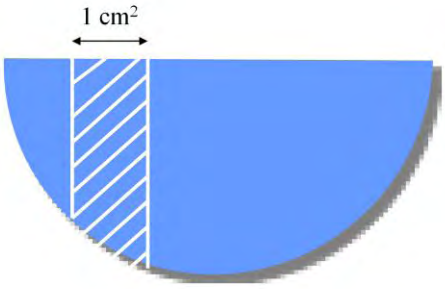
Thermal Structure

Stability (Idso 1973)



$$W_S = \frac{g}{A_0}\int_{z_0}^{z_m}\left(z - z_{\bar{\rho}}\right)\left(\rho_z - \bar{\rho}\right)A_z\,dz$$

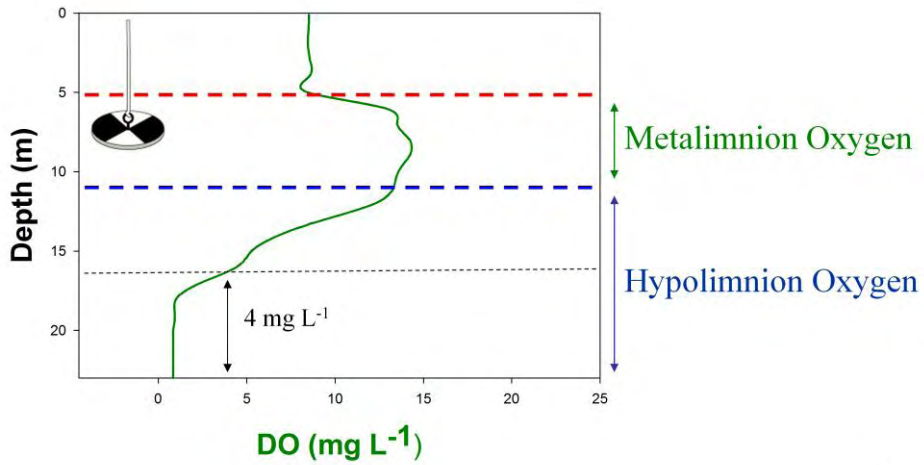
Heat Content (Cole 1994)



$$H = \frac{1}{A_0}\int_{z_0}^{z_m} V\,T_{\bar{x}}\,\rho_{T_{\bar{x}}}\,C_{T_{\bar{x}}}$$

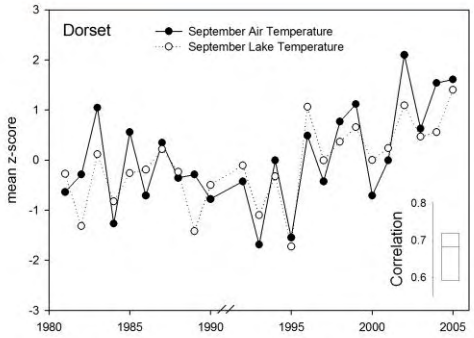
50

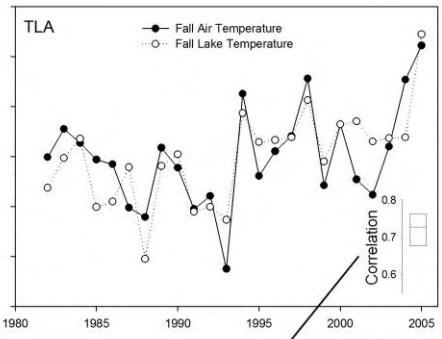
Clarity & DO Structure



51

Lake Warming – Climate Correlates





- 44% of variation related to lake area
- air and lake temperature more correlated in small lakes

52

Overview

- Brief history of Lake System Health Program
- **Are all the lakes the same? - No**
- Is water quality changing?
- Is biological condition changing?
- Where do we go from here?

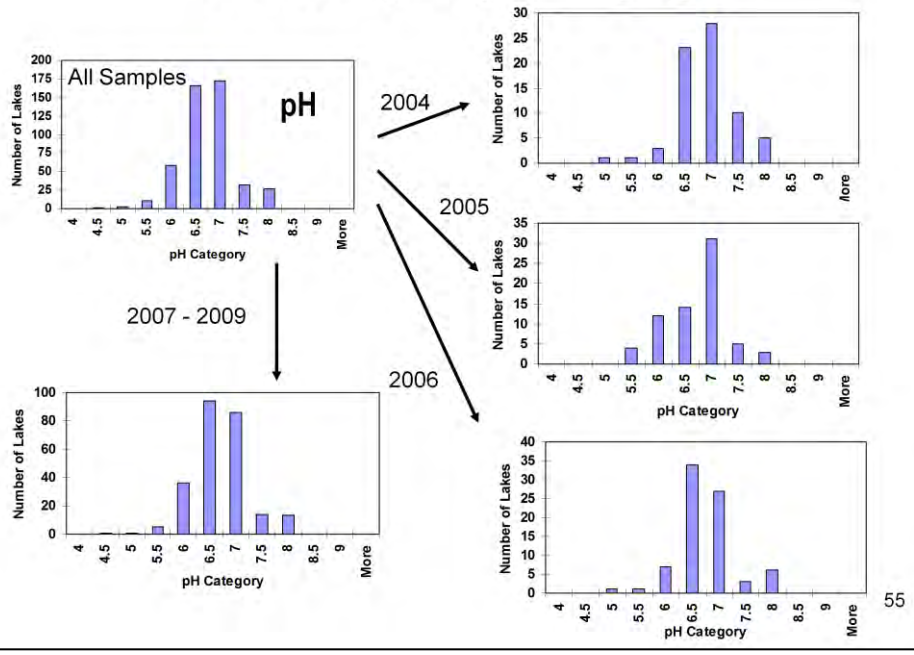
53

Overview

- Brief history of Lake System Health Program
- Are all the lakes the same?
- **Is water quality changing?**
- Is biological condition changing?
- Where do we go from here?

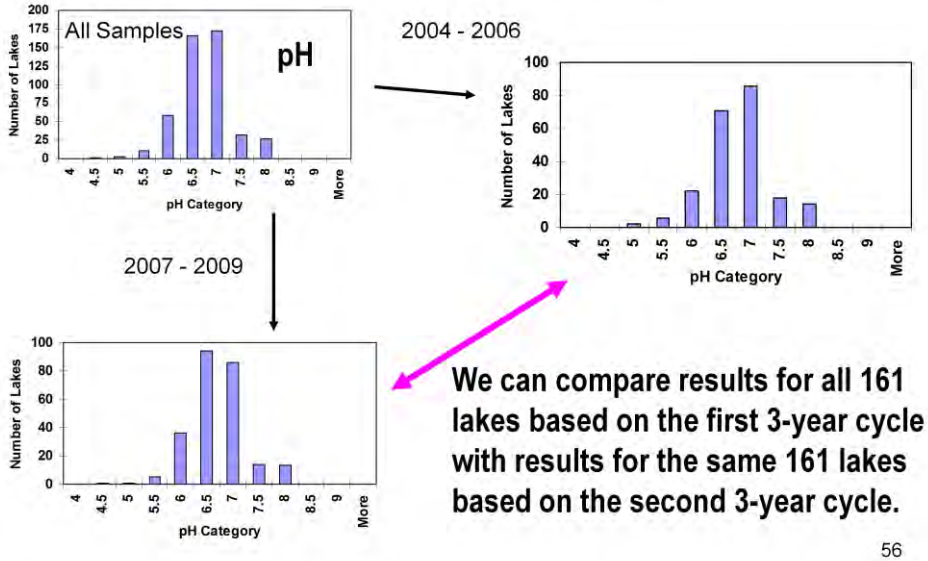
54

Is water quality changing?



55

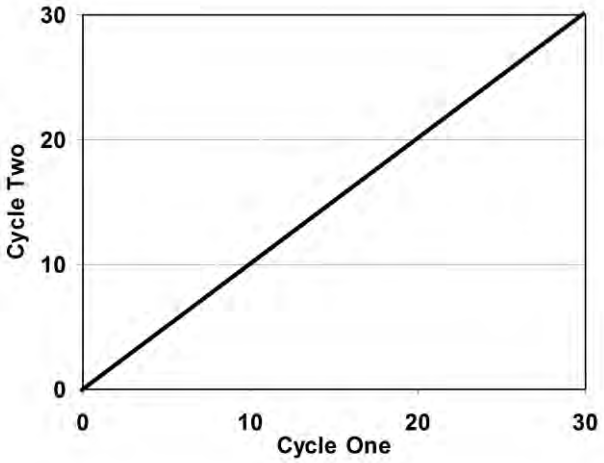
Is water quality changing?



We can compare results for all 161 lakes based on the first 3-year cycle with results for the same 161 lakes based on the second 3-year cycle.

56

Is water quality changing?

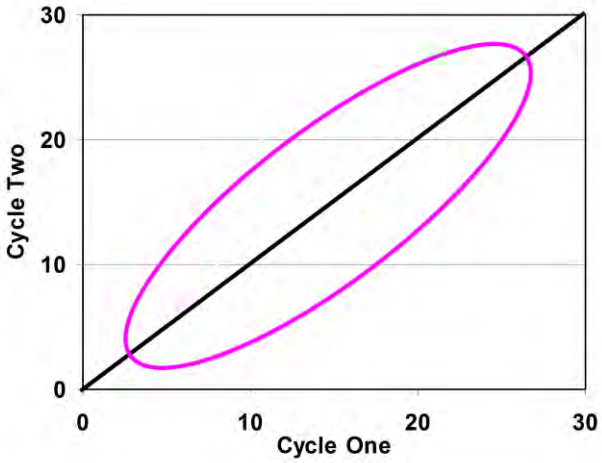


Cycle One – 2004-6
Cycle Two – 2007-9

r = ?
Intercept = 0 (?)
Slope = 1 (?)

57

Is water quality changing?

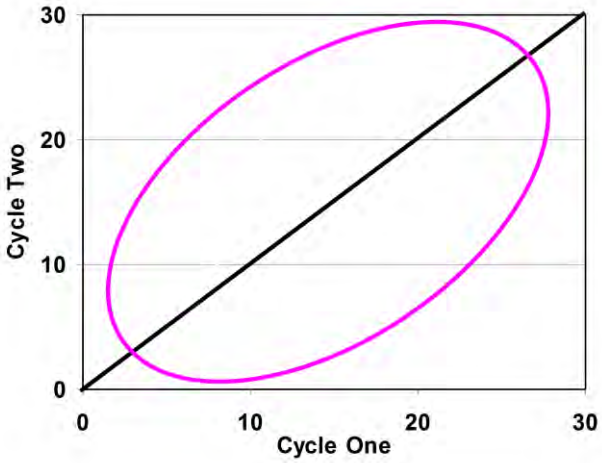


Cycle One – 2004-6
Cycle Two – 2007-9

r = precision
Intercept = 0 (?)
Slope = 1 (?)

58

Is water quality changing?



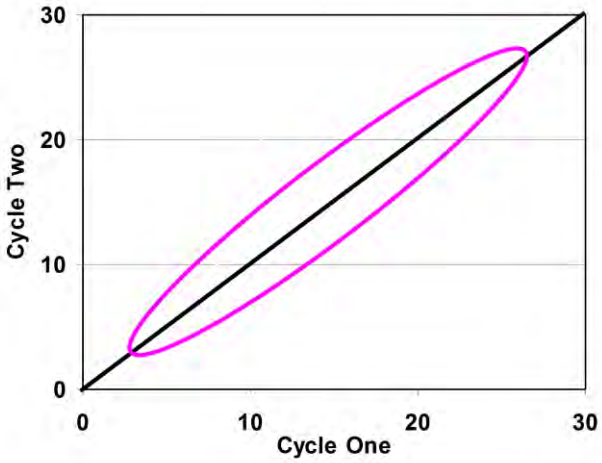
Cycle One – 2004-6
Cycle Two – 2007-9

$r \rightarrow 0$

Intercept = 0 (?)
Slope = 1 (?)

59

Is water quality changing?

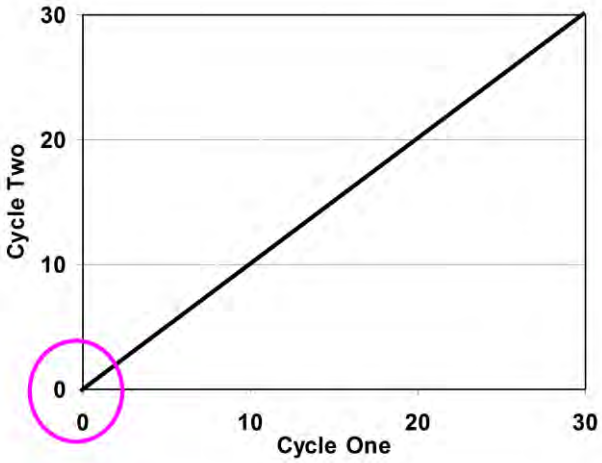


Cycle One – 2004-6
Cycle Two – 2007-9

$r \longrightarrow 1$
Intercept = 0 (?)
Slope = 1 (?)

60

Is water quality changing?

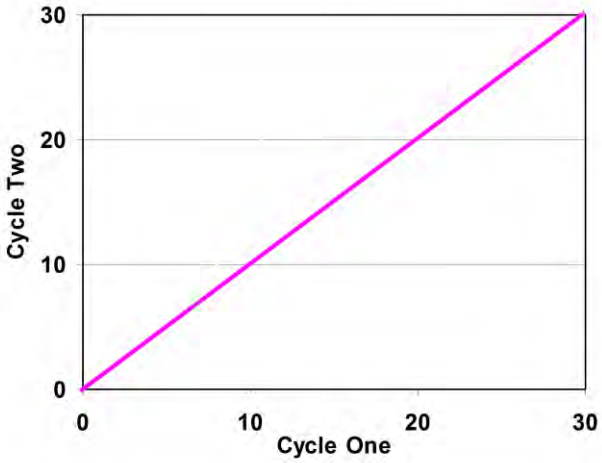


Cycle One – 2004-6
Cycle Two – 2007-9

r = ?
Intercept = 0 (bias)
Slope = 1 (?)

61

Is water quality changing?

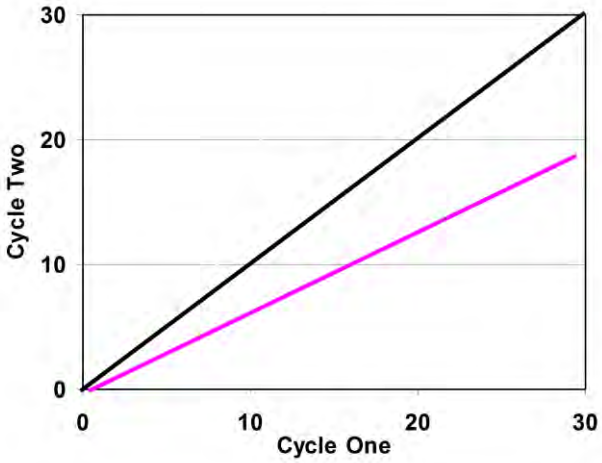


Cycle One – 2004-6
Cycle Two – 2007-9

r = ?
Intercept = 0 (?)
Slope = 1 (bias)

62

Is water quality changing?



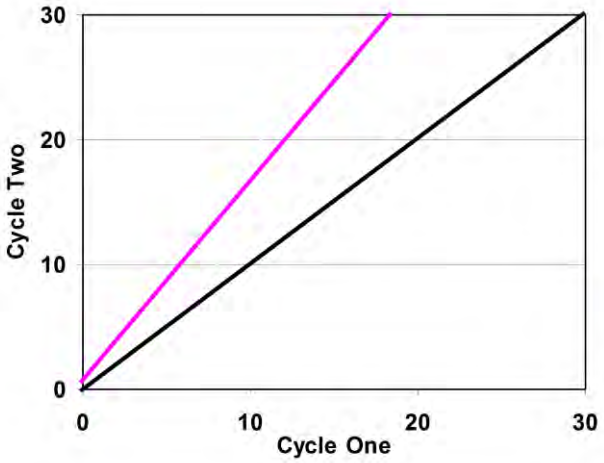
Cycle One – 2004-6
Cycle Two – 2007-9

r = ?
Intercept = 0 (?)
Slope < 1 (?)

Cycle Two < Cycle One

63

Is water quality changing?

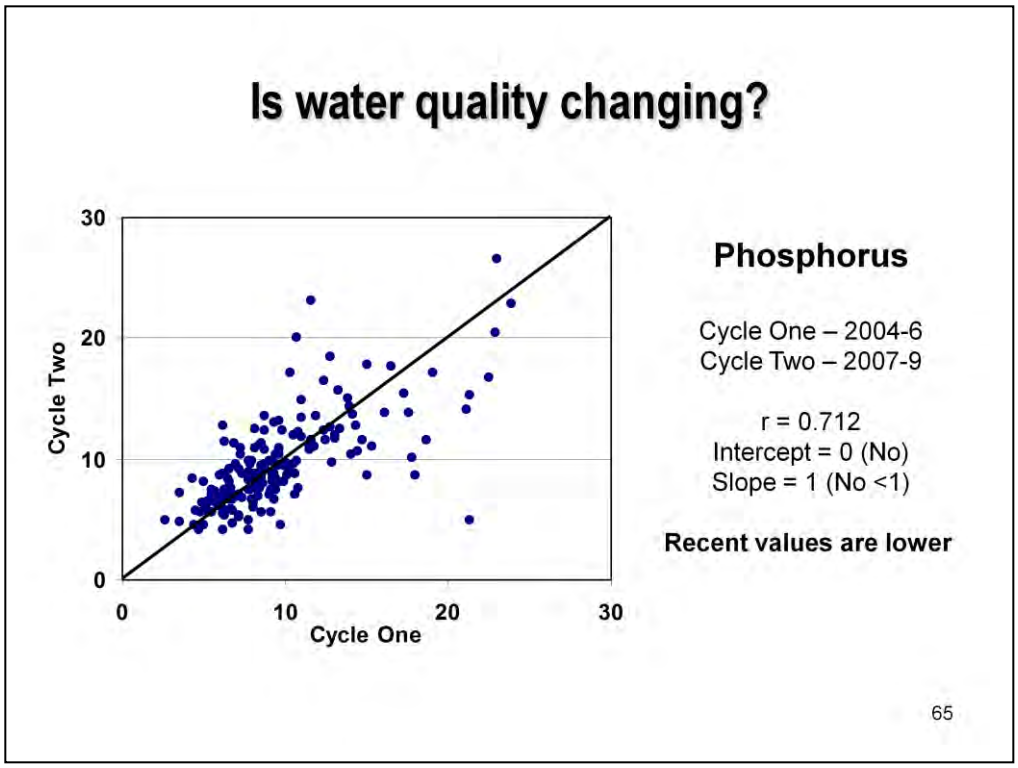


Cycle One – 2004-6
Cycle Two – 2007-9

r = ?
Intercept = 0 (?)
Slope > 1 (?)

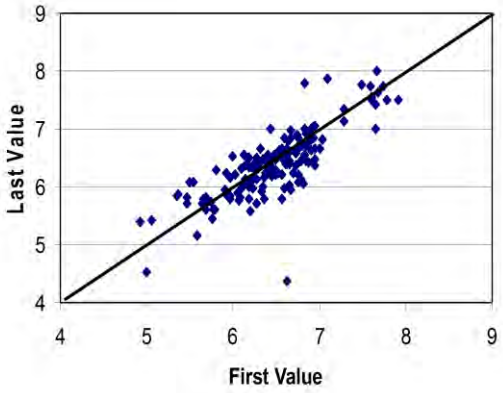
Cycle Two > Cycle One

64



Phosphorus concentrations seem to be decreasing over time.

Is water quality changing?



pH

First Value – 2004-6
Last Value – 2007-9

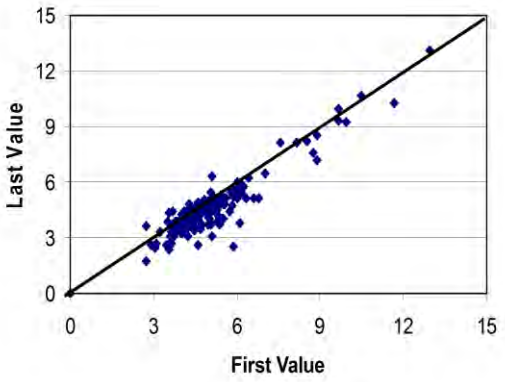
r = 0.954
Intercept = 0 (Yes)
Slope = 1 (Yes)

Recent values are ~same

66

pH concentrations seem to be staying the same over time.

Is water quality changing?



Sulphate

First Value – 2004-6
Last Value – 2007-9

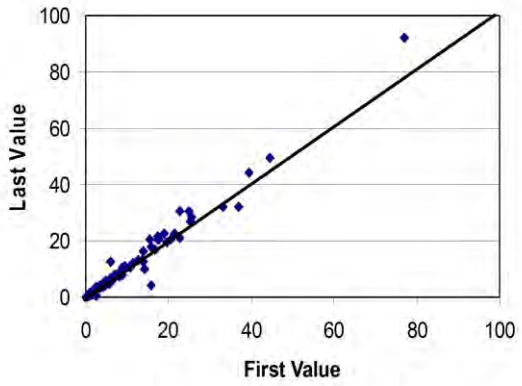
r = 0.942
Intercept = 0 (Yes)
Slope = 1 (No <1)

Recent values are lower

67

Sulphate concentrations seem to be decreasing over time.

Is water quality changing?



Chloride

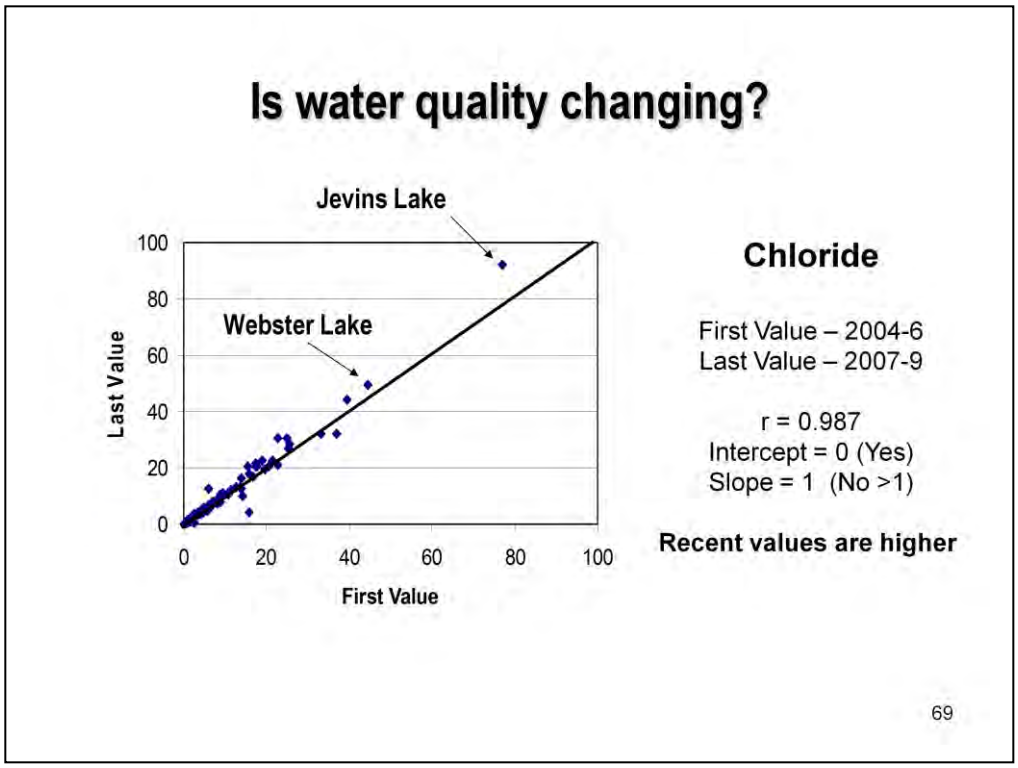
First Value – 2004-6
Last Value – 2007-9

r = 0.987
Intercept = 0 (Yes)
Slope = 1 (No >1)

Recent values are higher

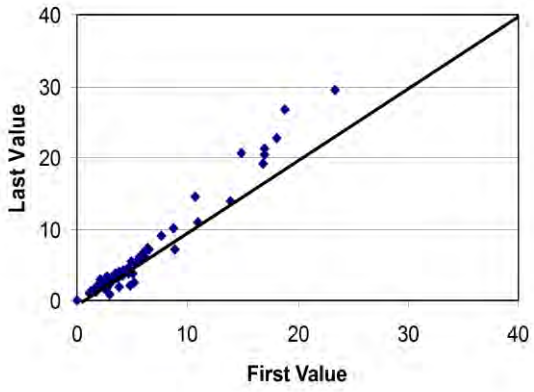
68

Chloride concentrations seem to be increasing over time.



Many of the lakes with high chloride concentrations are adjacent to major transportation corridors.

Is water quality changing?



Calcium

First Value – 2004-6
Last Value – 2007-9

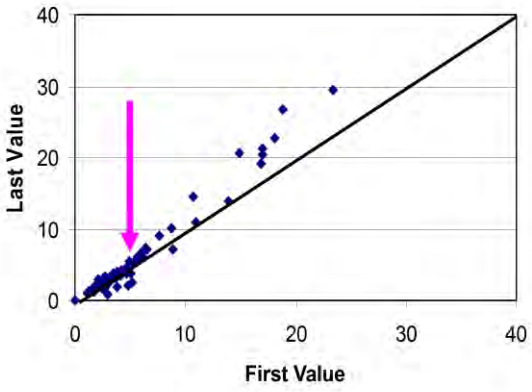
r = 0.984
Intercept = 0 (No)
Slope = 1(No >1)

Recent values are higher

70

Calcium concentrations seem to be increasing over time , BUT...

Is water quality changing?



Calcium

First Value – 2004-6
Last Value – 2007-9

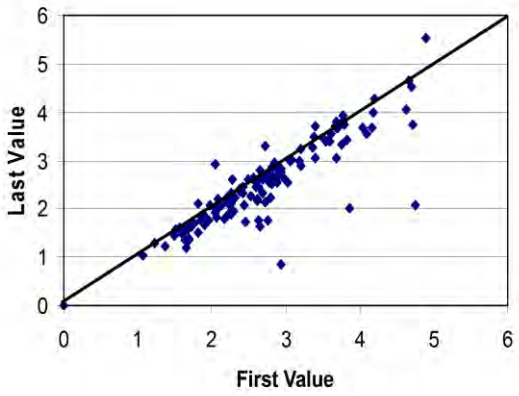
r = 0.984
Intercept = 0 (No)
Slope = 1 (No)

Recent values are higher

71

...taking a closer look at lakes with calcium concentrations below 5 mg/L indicate that...

Is water quality changing?



Calcium (<5 mg/l)

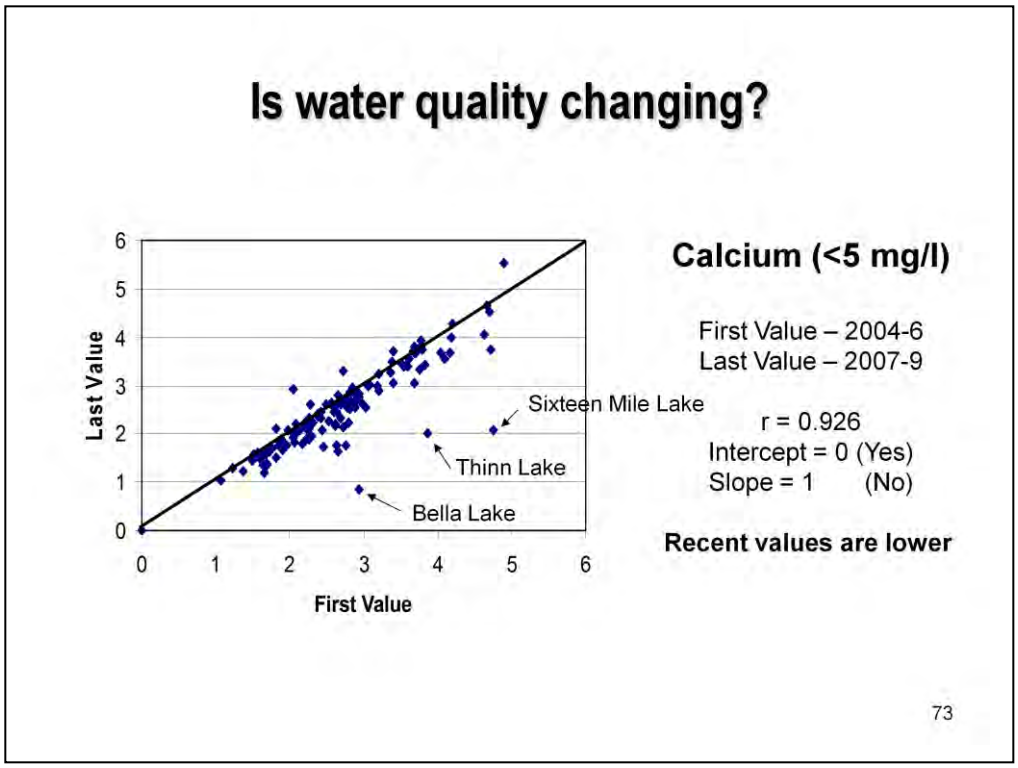
First Value – 2004-6
Last Value – 2007-9

r = 0.926
Intercept = 0 (Yes)
Slope = 1 (No <1)

Recent values are lower

72

...calcium concentrations in lakes below 5 mg/L are actually decreasing over time. The majority of the lakes in Muskoka fall into this category.



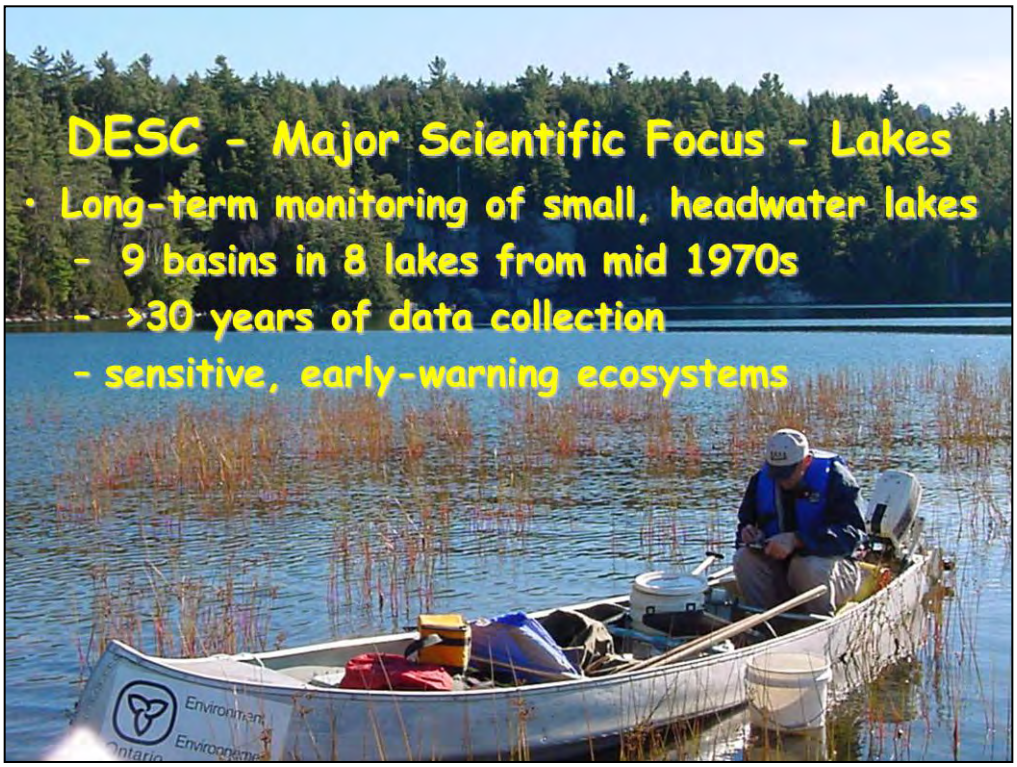
Some lakes have had a large decrease in calcium concentrations over time.

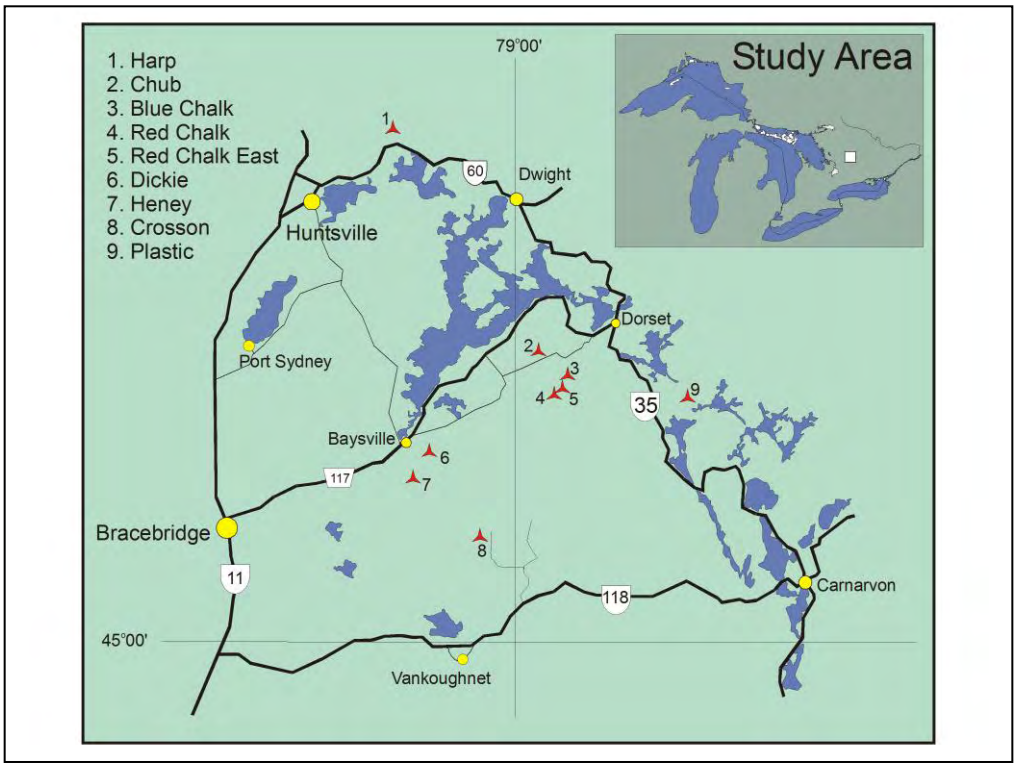
Overview

- Brief history of Lake System Health Program
- Are all the lakes the same?
- **Is water quality changing? - Yes**
- Is biological condition changing?
- Where do we go from here?

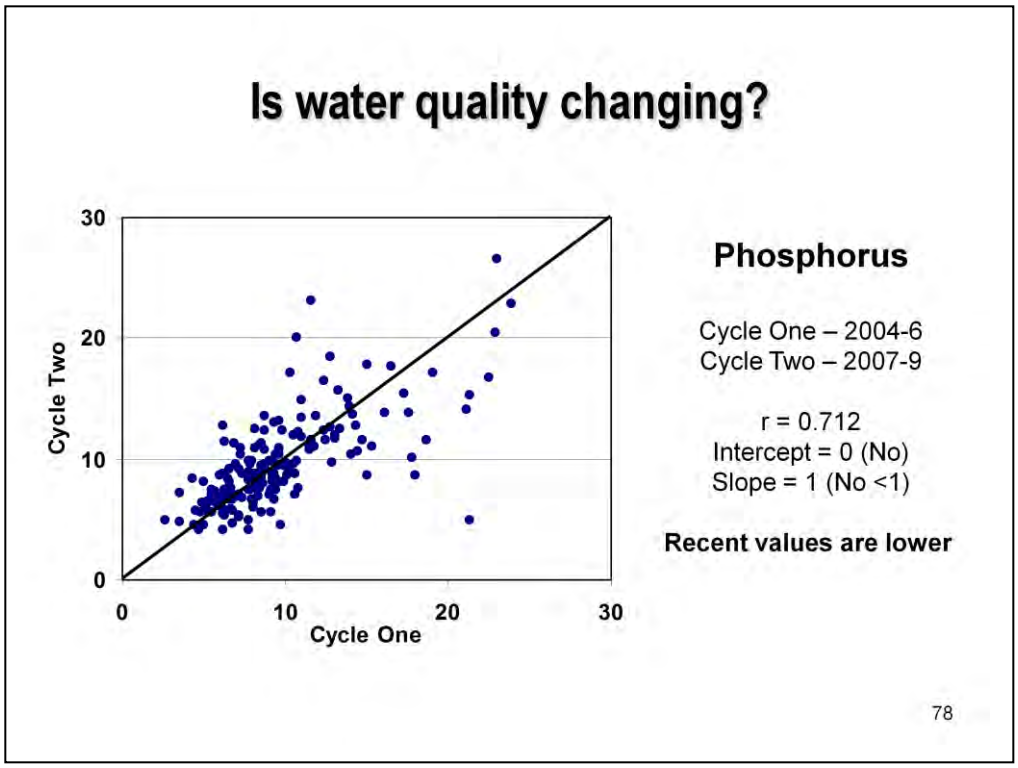
74

Protecting our environment. Ontario

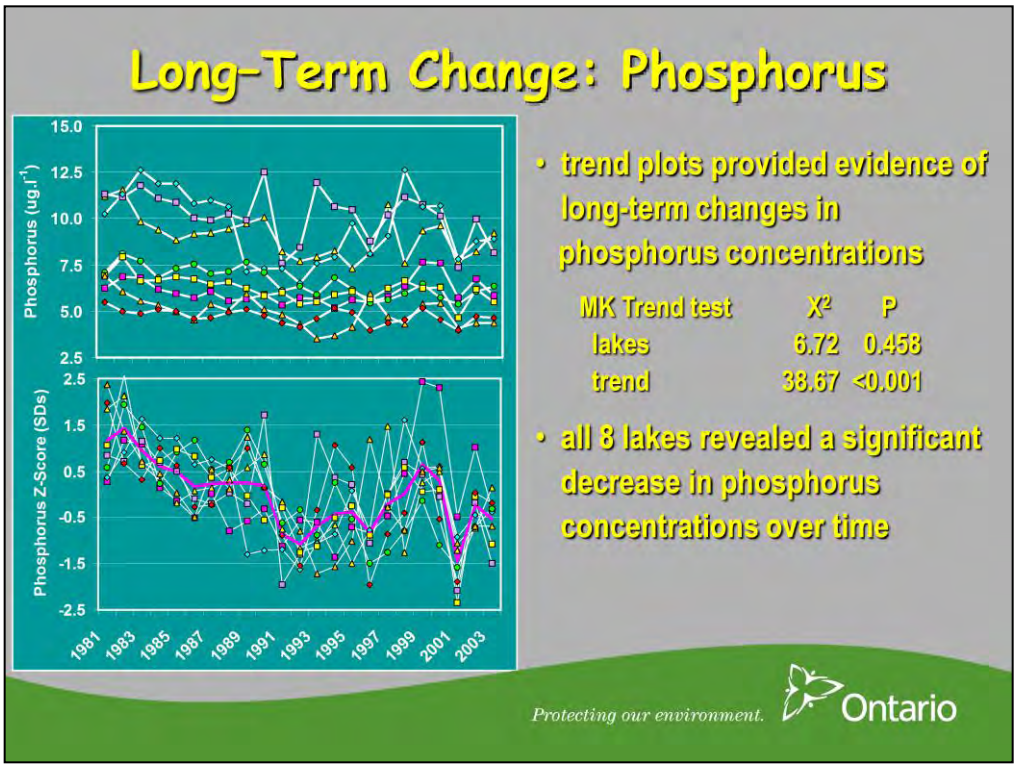

DESC - Major Scientific Focus - Lakes
• Long-term monitoring of small, headwater lakes
- 9 basins in 8 lakes from mid 1970s
- >30 years of data collection
- sensitive, early-warning ecosystems



DESC has intensively studied 9 lakes in our area for over 30 years (A Lakes).

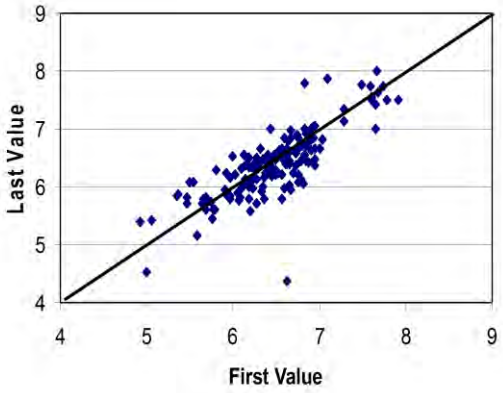


Muskoka's data indicating a decrease in phosphorus concentrations over time...



…is similar to that seen in the 9 lakes studied by DESC.

Is water quality changing?

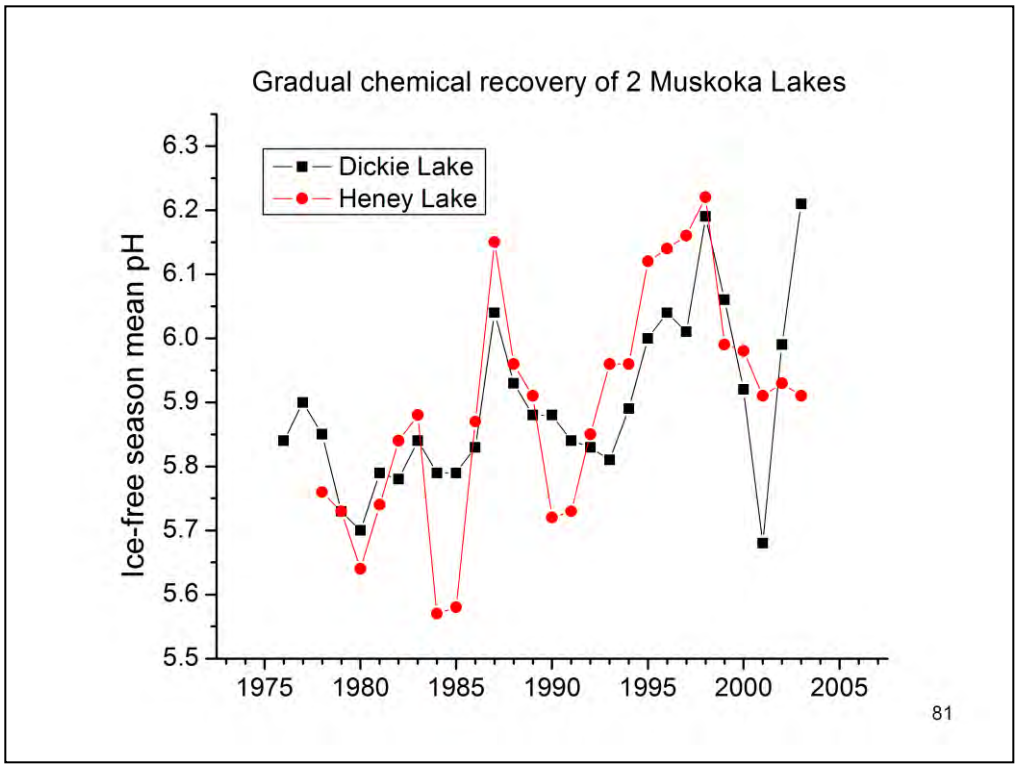


pH

First Value – 2004-6
Last Value – 2007-9

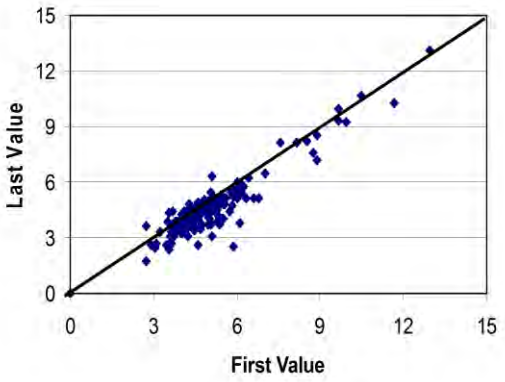
r = 0.954
Intercept = 0 (Yes)
Slope = 1 (Yes)

Recent values are ~same



This slide presents detailed data for 2 of the DESC lakes to show how variable pH has been over time. There is a long-term increase like the other DESC lakes, but for short periods (e.g., a couple of years in a row) there have been big increases and big decreases. We now know that these jumps are related to climate and droughts; however, the take-home message is that pH changes quite a bit from year to year and you need a long-term data set to see clear long-term changes. The 6 years of data for the 161 District lakes are probably too short a period to get a clear indication of pH changes.

Is water quality changing?



Sulphate

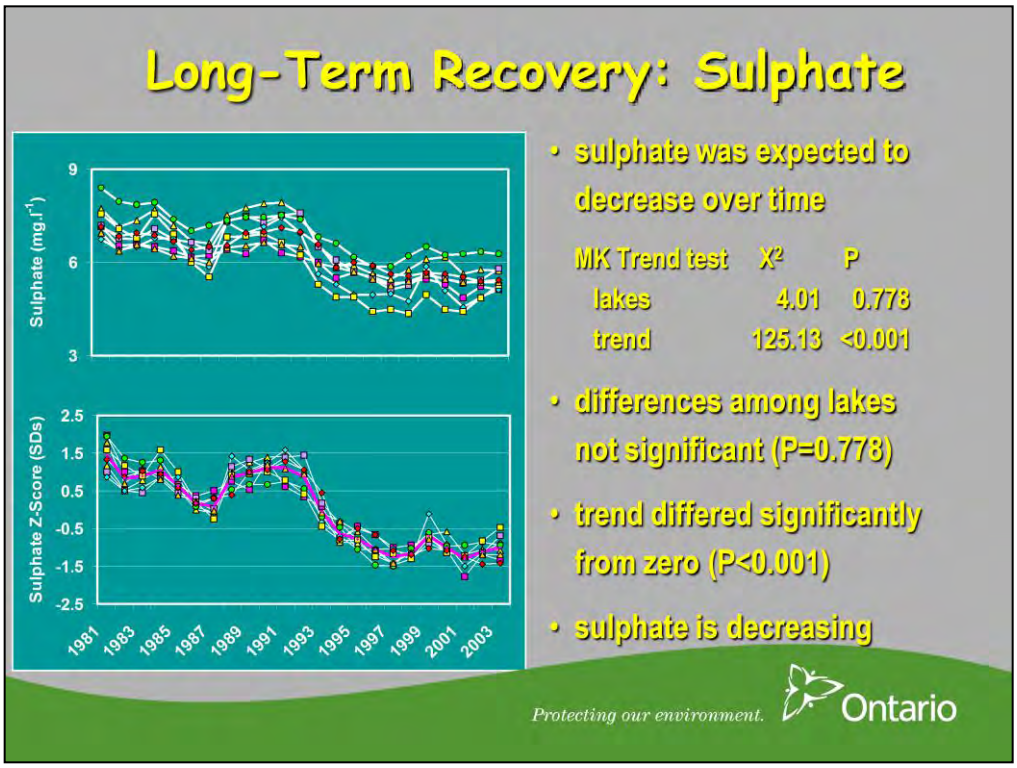
First Value – 2004-6
Last Value – 2007-9

r = 0.942
Intercept = 0 (Yes)
Slope = 1 (No <1)

Recent values are lower

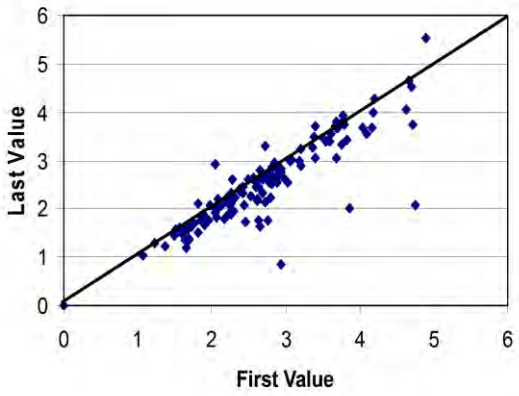
82

Muskoka's data indicating a decrease in sulphate concentrations over time...



…is similar to that seen in the 9 lakes studied by DESC.

Is water quality changing?



Calcium (<5 mg/l)

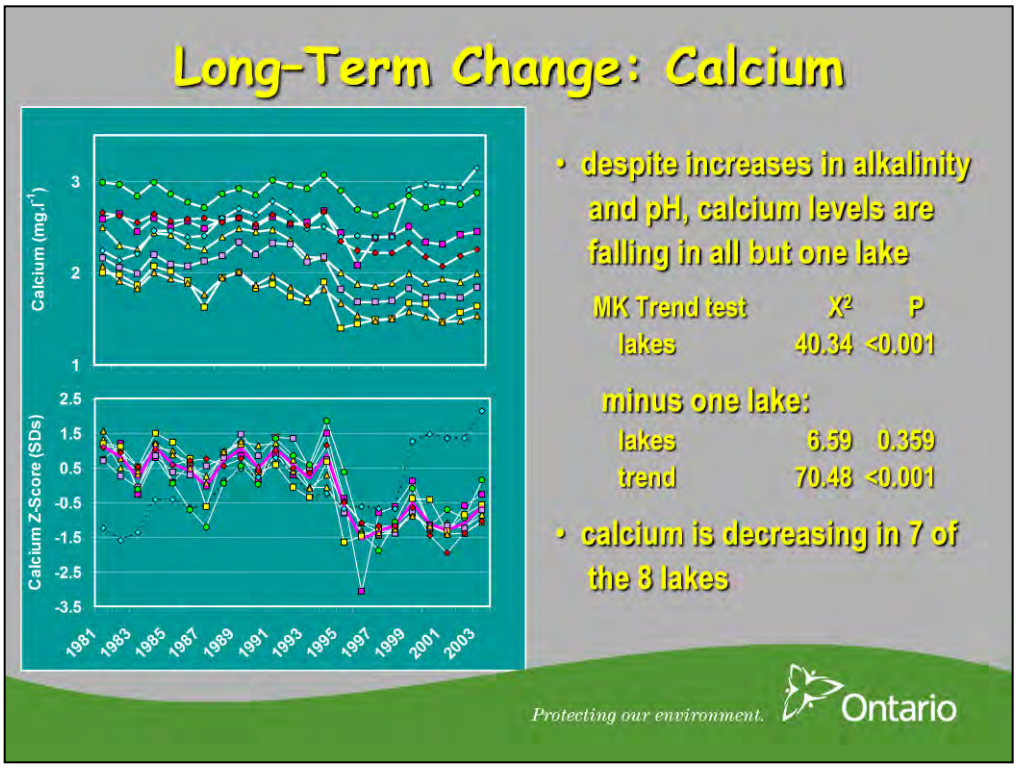
First Value – 2004-6
Last Value – 2007-9

r = 0.926
Intercept = 0 (Yes)
Slope = 1 (No <1)

Recent values are lower

84

Muskoka's data indicating a decrease in calcium concentrations over time...



…is similar to that seen in 7 of lakes studied by DESC.

Overview

- Brief history of Lake System Health Program
- Are all the lakes the same?
- **Is water quality changing? - Yes**
- Is biological condition changing?
- Where do we go from here?

86

Overview

- Brief history of Lake System Health Program
- Are all the lakes the same?
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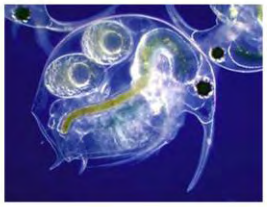
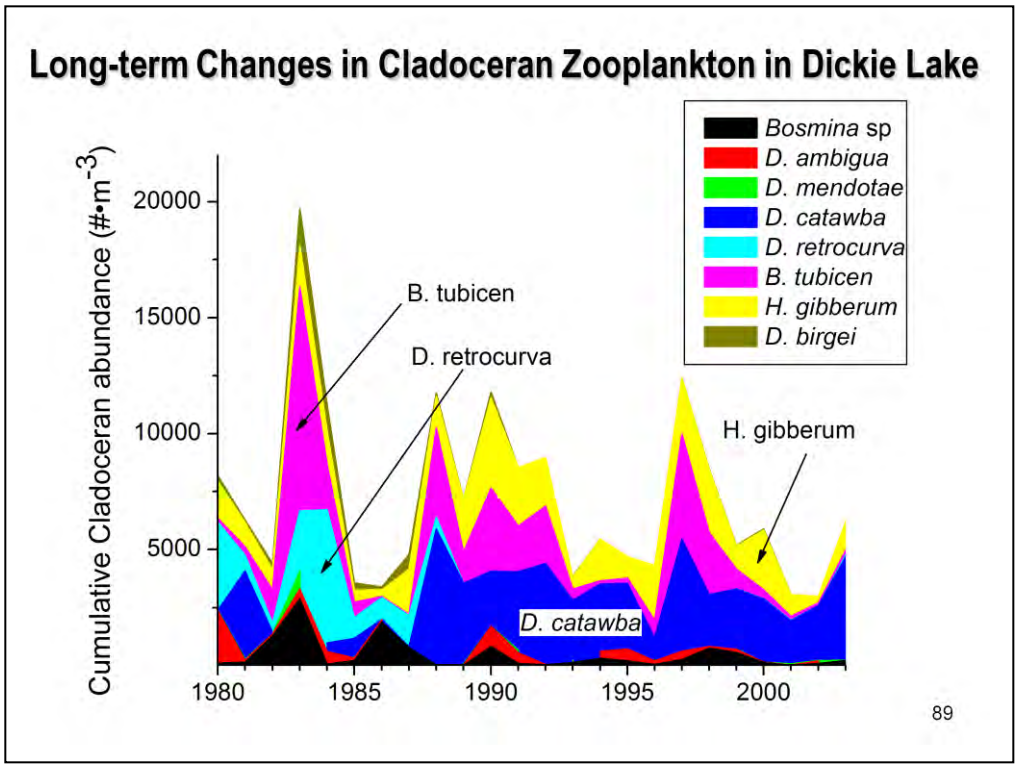
87

Overview

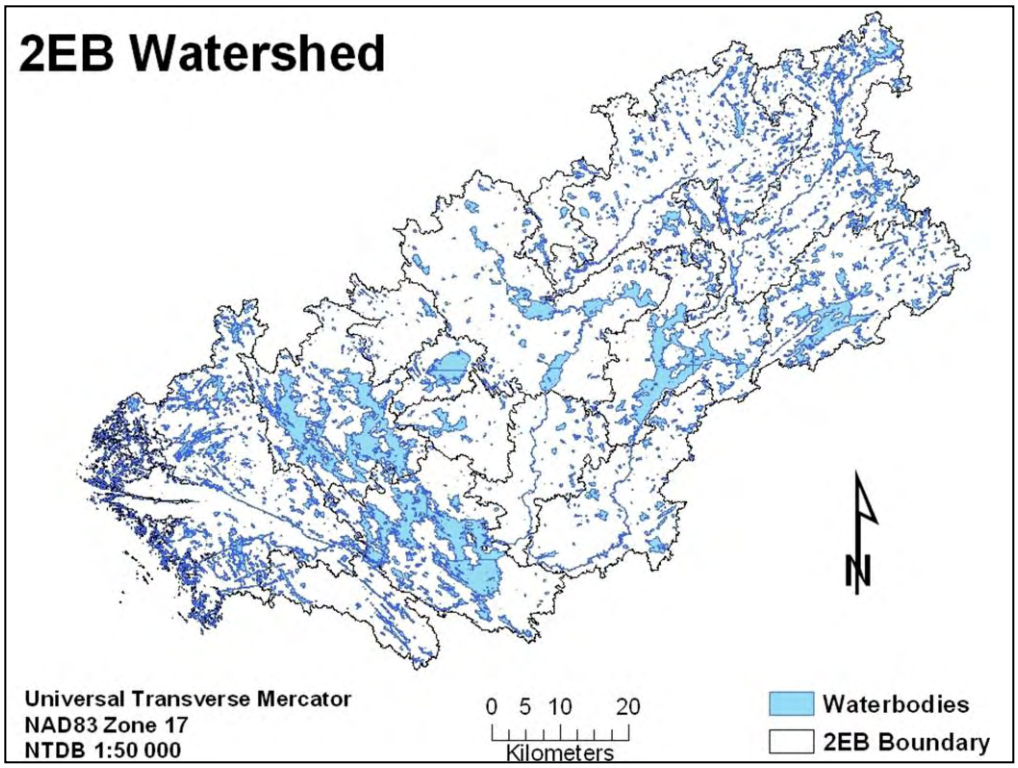
- Brief history of Lake System Health Program
- Are all the lakes the same?
- Is water quality changing?
- **Is biological condition changing?**
- Where do we go from here?

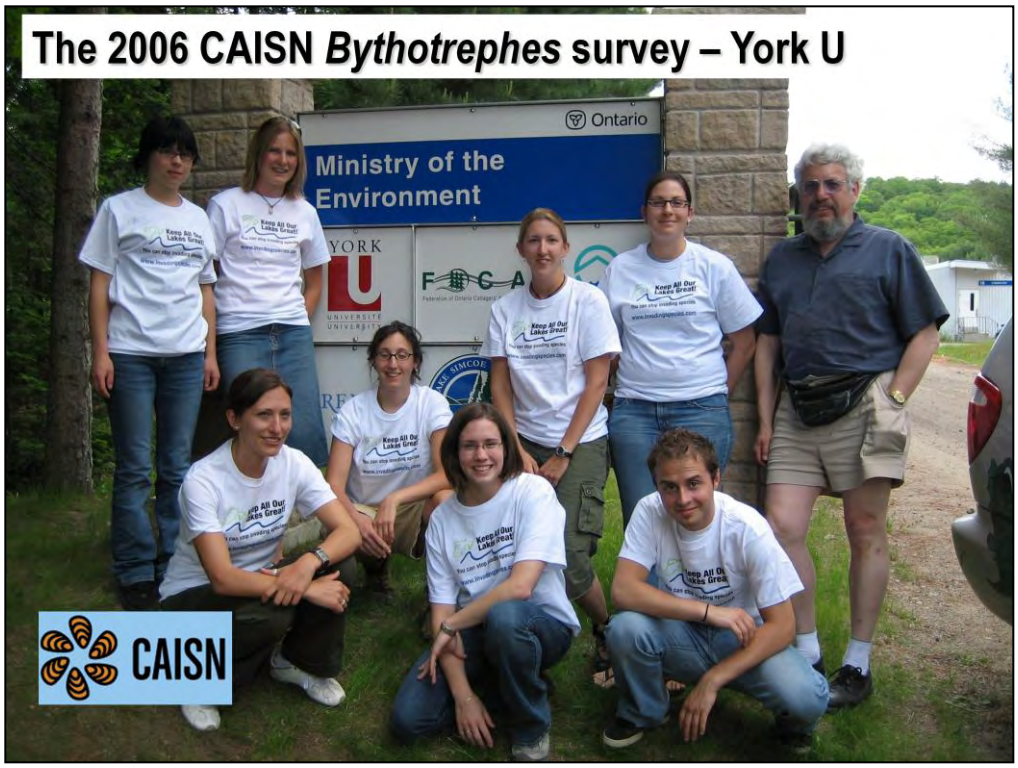


88



Note: No interesting patterns in the Copepoda, but there are for the Cladocera.


2EB Watershed
N
Universal Transverse Mercator
NAD83 Zone 17
NTDB 1:50 000
0 5 10 20
Kilometers
Waterbodies
2EB Boundary


The 2006 CAISN *Bythotrephes* survey – York U
Ontario
Ministry of the Environment
YORK
CAISN

*Bythotrephes**

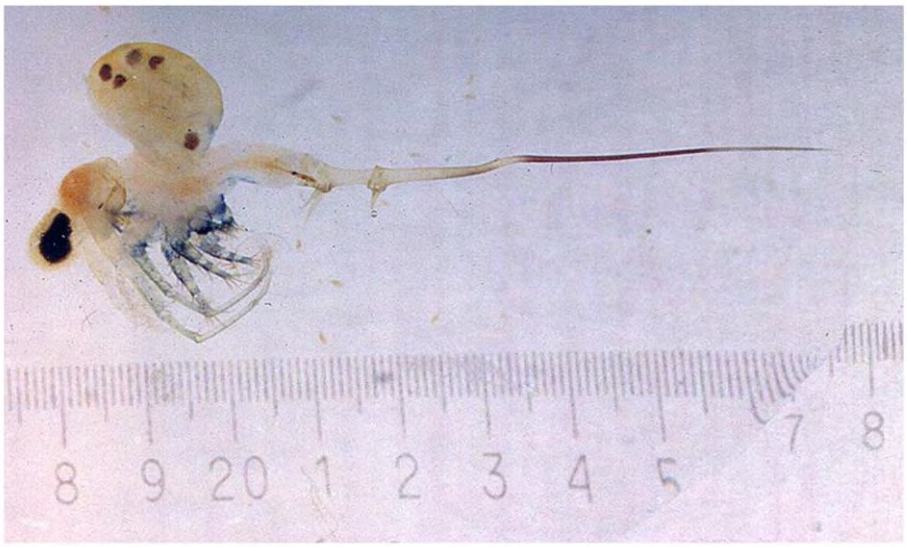


*photo by B. O'Neill, MOE

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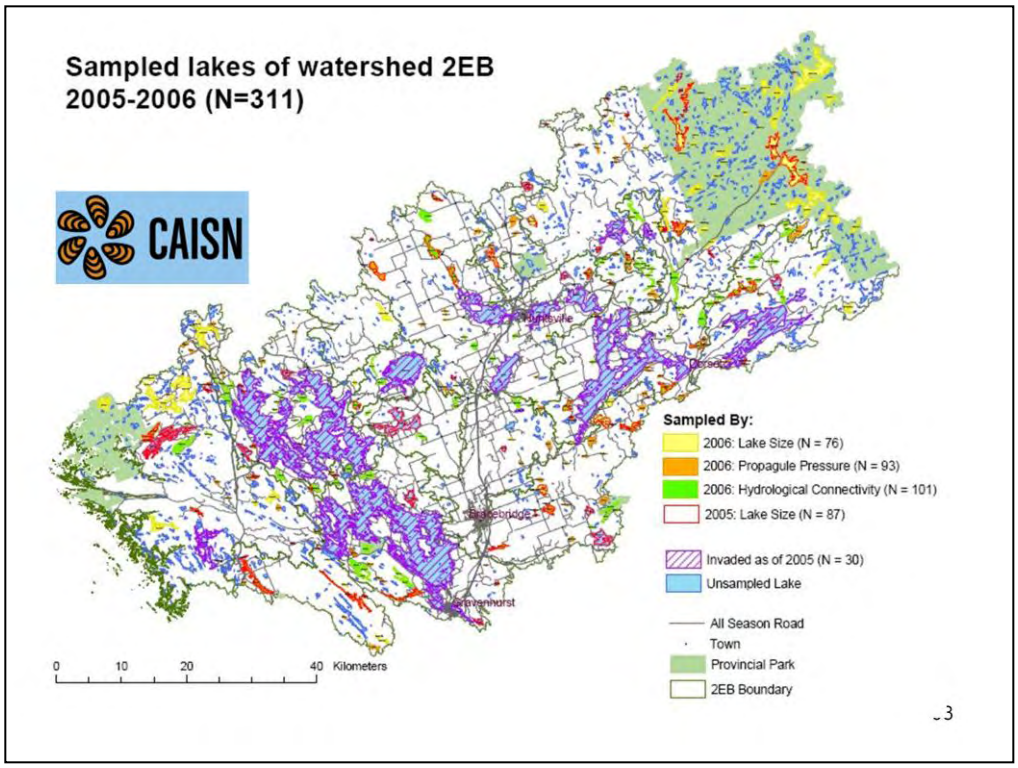
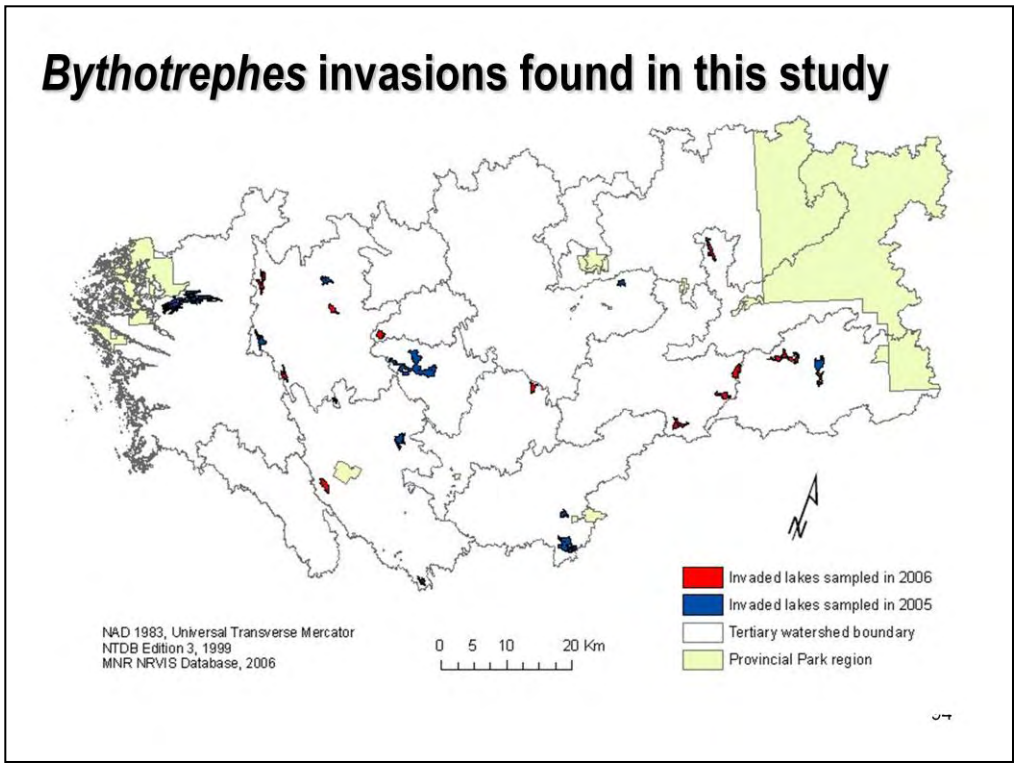
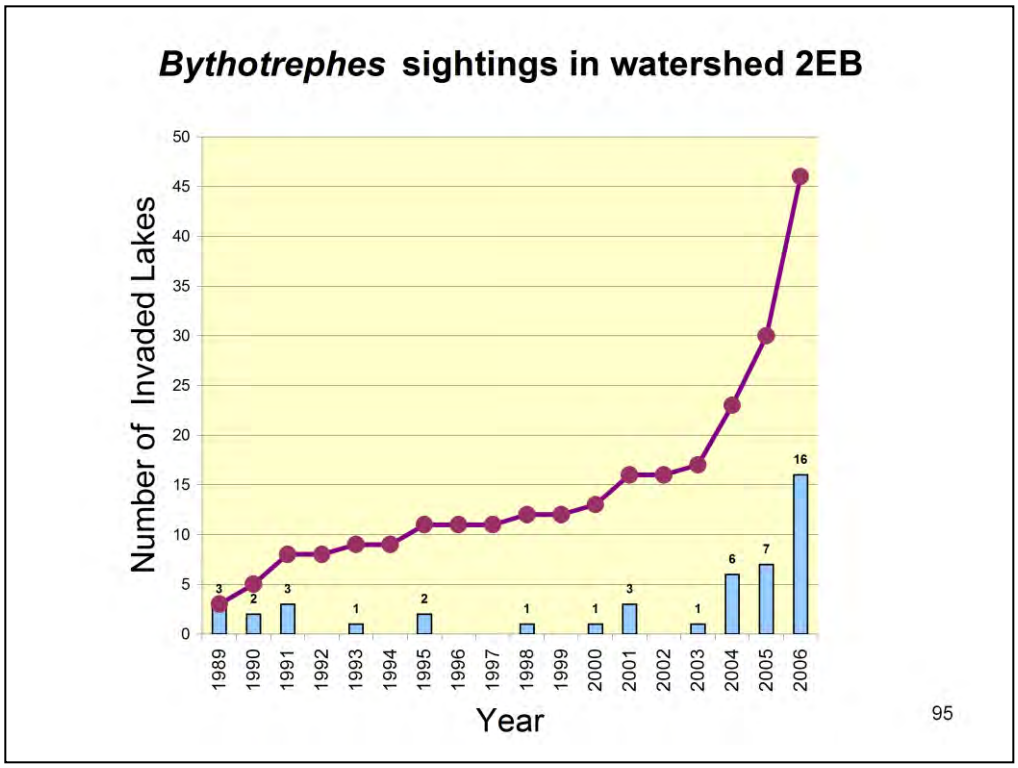
The spiny water-flea, an aquatic invasive species found in many Muskoka lakes.

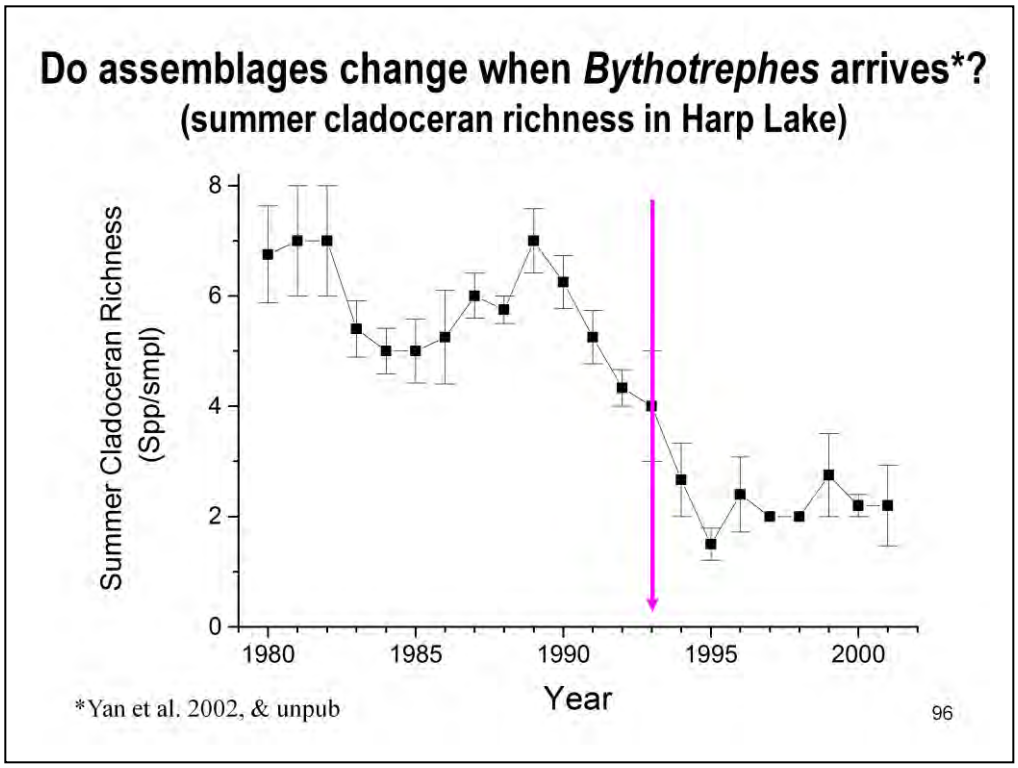

Sampled lakes of watershed 2EB
2005-2006 (N=311)
CAISN
Sampled By:
2006: Lake Size (N = 76)
2006: Propagule Pressure (N = 93)
2006: Hydrological Connectivity (N = 101)
2005: Lake Size (N = 87)
Invaded as of 2005 (N = 30)
Unsampled Lake
All Season Road
Town
Provincial Park
2EB Boundary
0 10 20 40 Kilometers



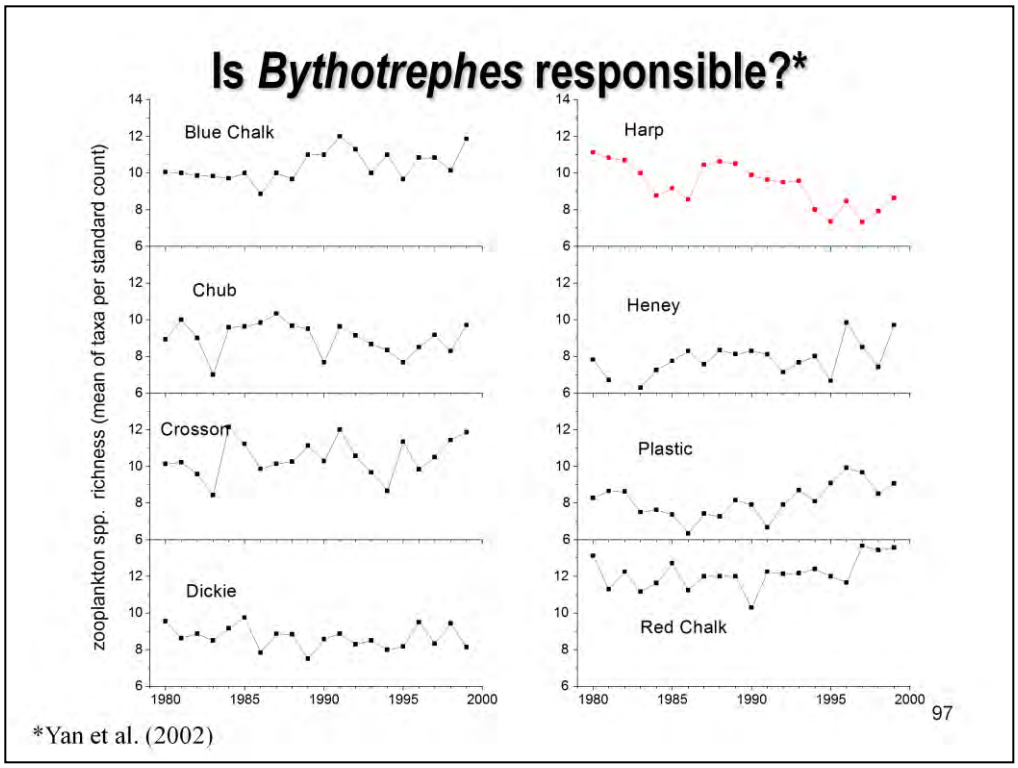
1. The results of the distribution of Bythotrephes can be seen on this map
2. To orient you:
    1. Georgian bay of lake Huron is on the southwest area of this map
    2. Algonquin park is to the northeast
3. Invaded areas are indicated by red or blue, sampled in 2005 and 2006 respectively
    1. They are spread out across the entire study area, with the exception of Algonquin Park, and all other provincial parks, which have no invaded lakes thus far
4. In general, the invaded lakes varied widely in the target variables of size, spatial location, and hydrology but also in chemistry, physical aspects, and human use



The number of invaded lakes has increased in recent years in the Muskoka River Watershed.

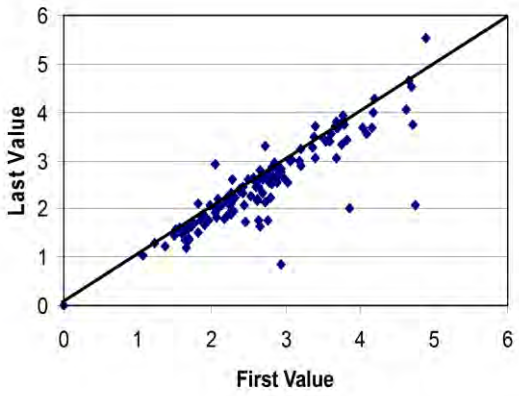


This is July + Aug mean (with SE) of Cladocera in Harp Lake. Note the invasion was certain by 1993, but probably happened 2-3 years earlier.



We can treat our A-lake data like a BACI-designed experiment. Only in the invaded lake does overall crustacean richness decline.

Is water quality changing?



Calcium (<5 mg/l)

First Value – 2004-6
Last Value – 2007-9

r = 0.926
Intercept = 0 (Yes)
Slope = 1 (No <1)

Recent values are lower

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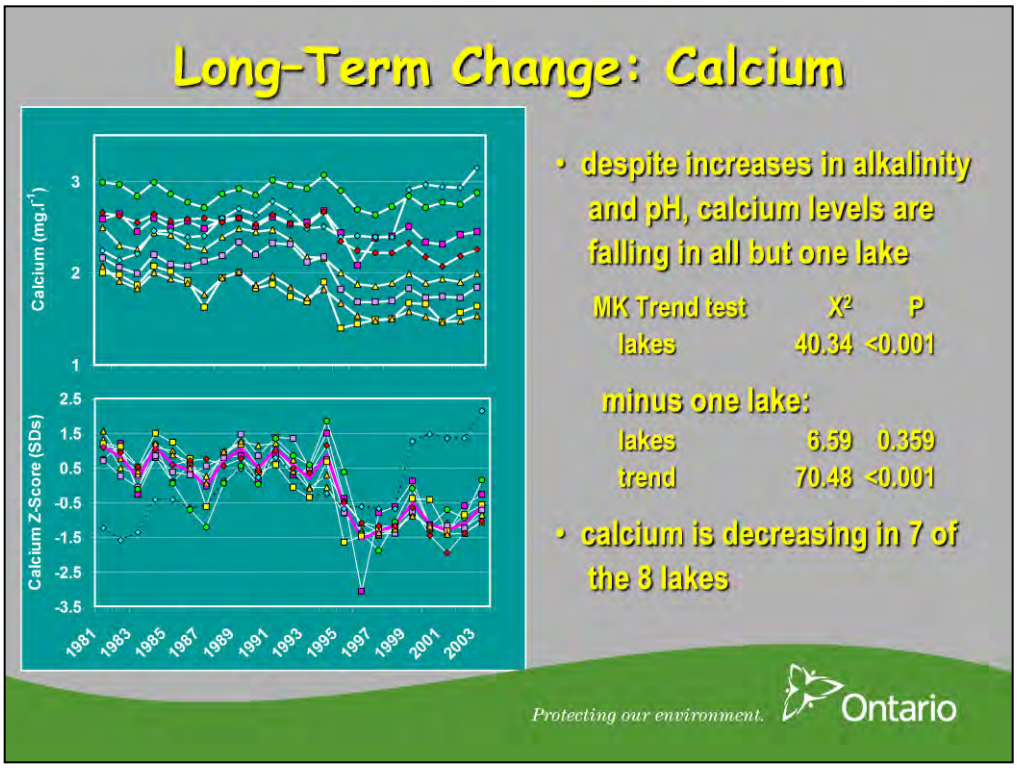
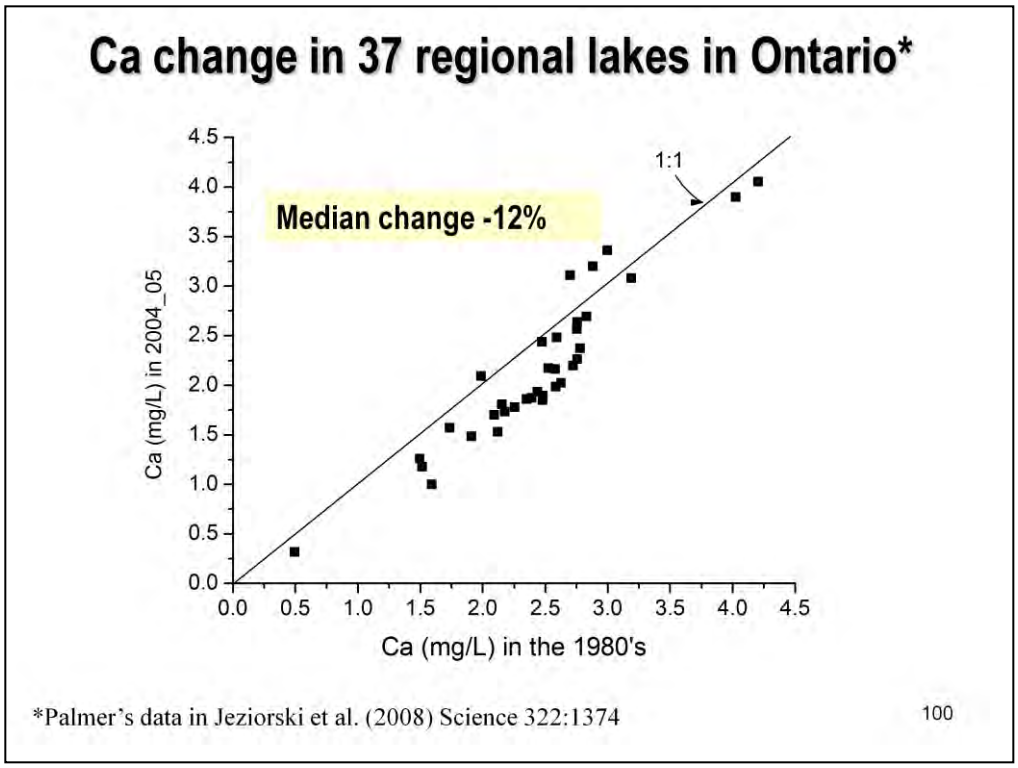
Muskoka's calcium data.



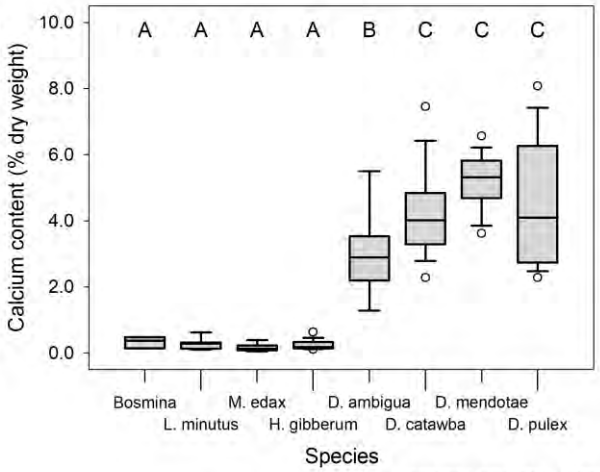
DESC's calcium data.



The same pattern has also occurred across the region. Palmer resampled 47 lakes, and 37 of these are not included in the A lakes in the early to mid-1980s, then resampled them in 2004/5. Ca had declined significantly in the region with only 4 of the 37 lakes above 1:1 line. The average decline was 12%, less than the decline in the A lakes measured from the mid 1970s, but the amount of decline was a similar 13% in the A lakes if measured from the mid-1980s.

Field work on Ca in Crustacean Zooplankton

- **Significant differences between major taxonomic groups**
- ***Daphnia* spp. have much higher [Ca] than non-daphniids**
- **Positive relationship between ambient [Ca] and animal [Ca]**



(Jeziorski and Yan, 2006)

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Calcium is critical for aquatic life.

Critical Calcium Concentrations

- 1.5-2.0 mg/L for native daphniids
- ~1.5 mg/L for gammarids
- ~2.5-3 mg/L for native crayfish
- but we need more lab and field data to define damaging thresholds

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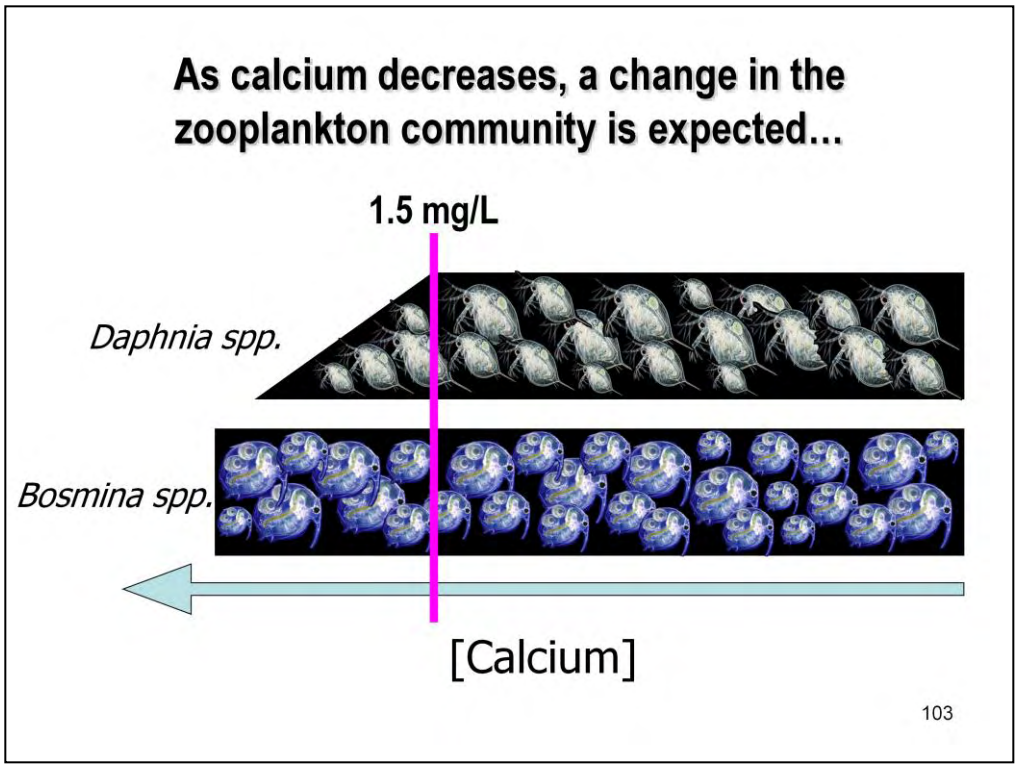
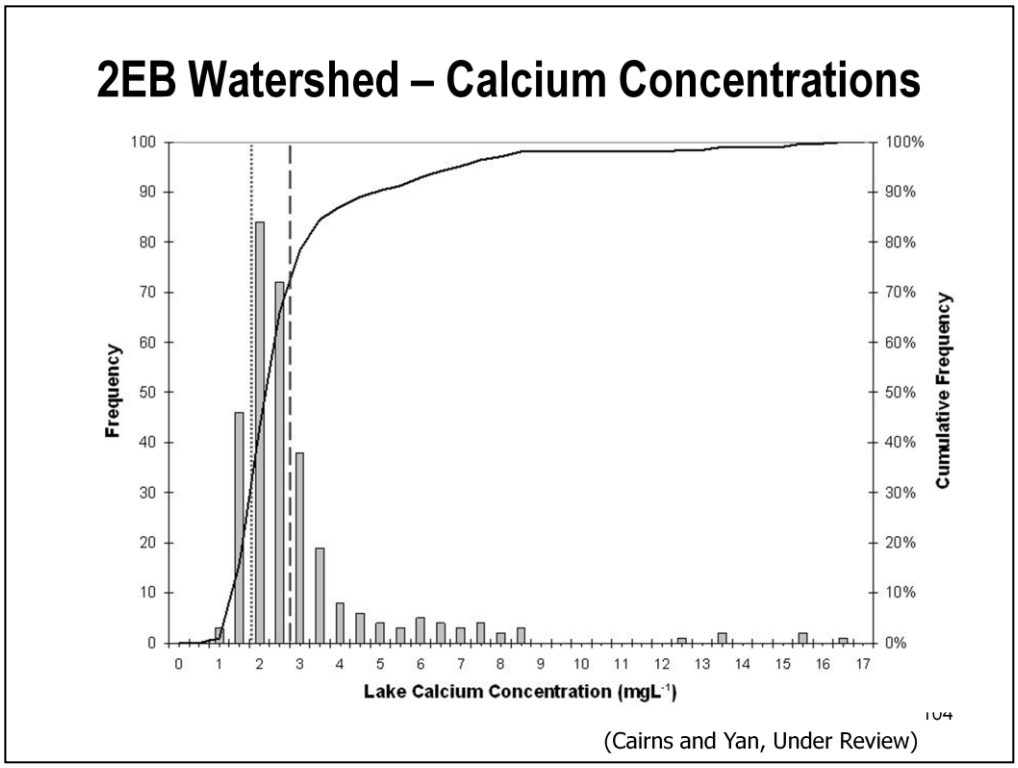
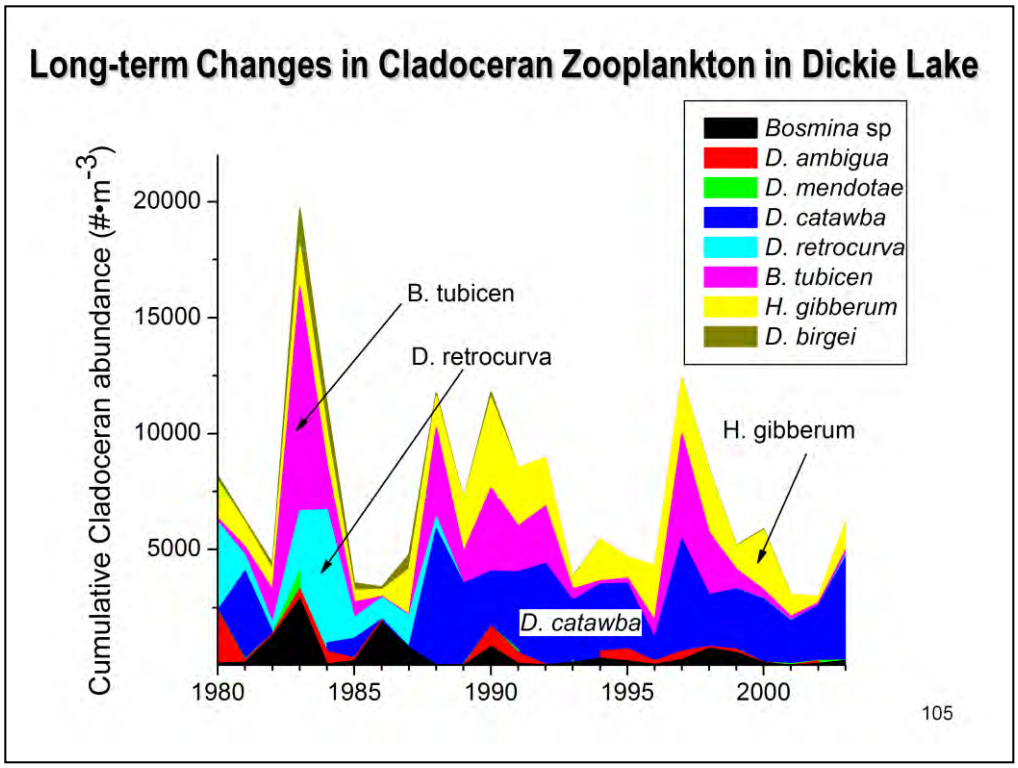
Zooplankton form the basis of the food chain in our lakes.



Some species require more calcium than others. As calcium concentrations decline in our lakes, we will see a shift in the species found from those that require higher concentrations of calcium to those that do not.



The majority of the lakes in the Muskoka River Watershed have a calcium concentration below 3 mg/L.



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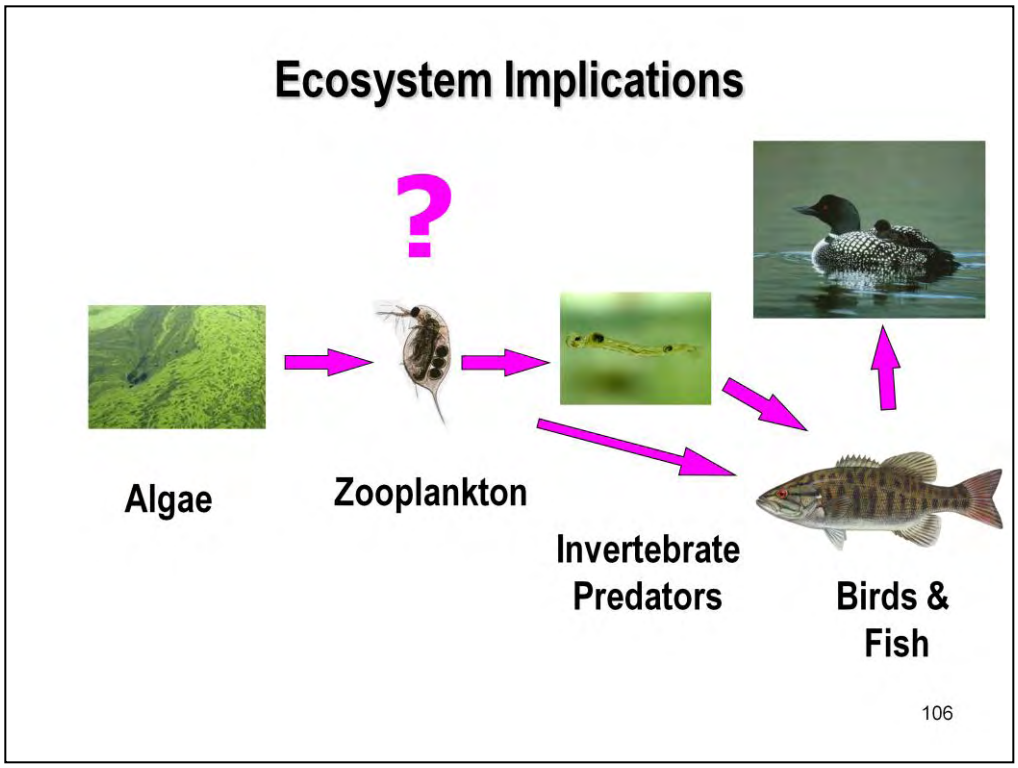
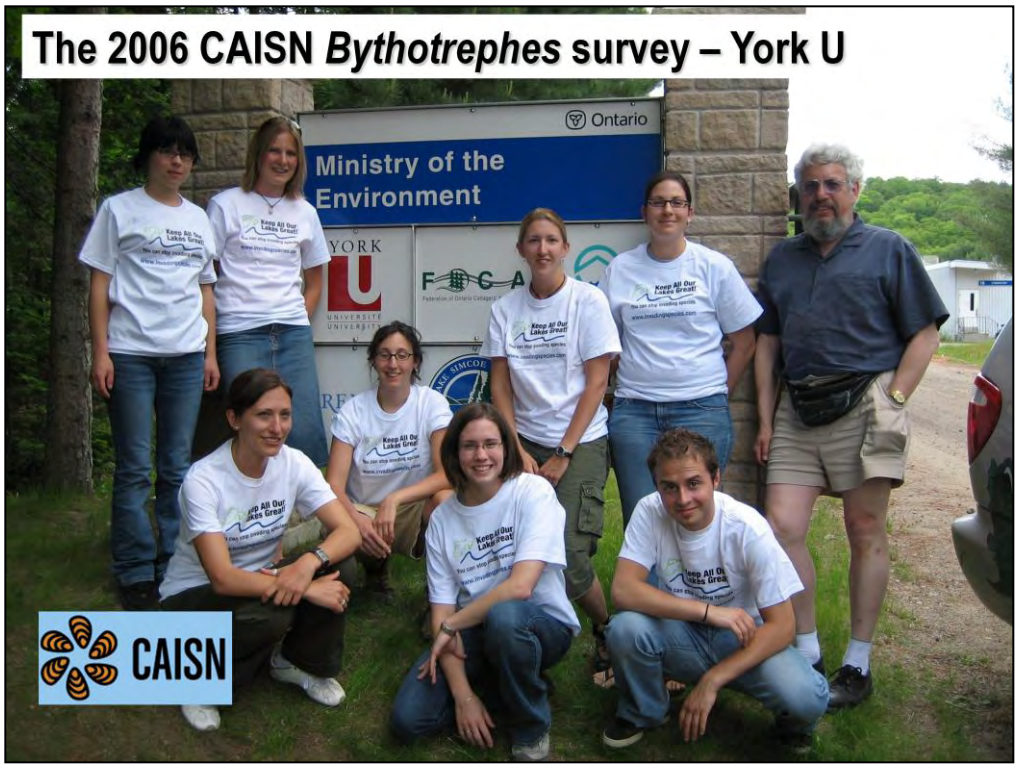


What impact will changing one component of the aquatic food web have on the other components?


The 2006 CAISN *Bythotrephes* survey – York U
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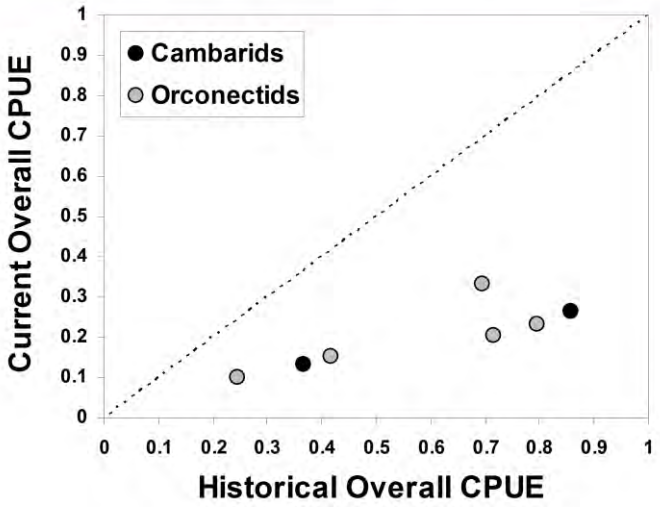
YORK
FOCA
CAISN

Broad-scale crayfish survey

Tertiary watershed image adapted from Phair et al 2005.

- Total of 100 lakes across 8 tertiary watersheds (from David et al 1997)
- Historical data from an M.O.E. survey conducted between 1989 and 1994
- Lakes were re-sampled from 2005 to 2007

Results: Declining Abundance



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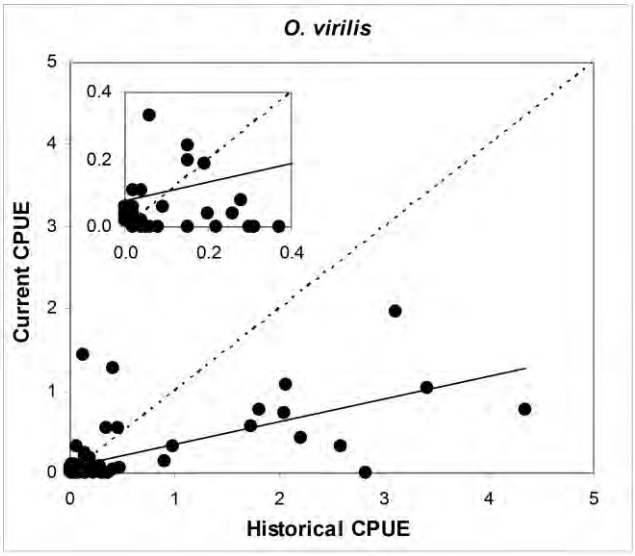
Changes in Crayfish Catches



Slope = 0.28

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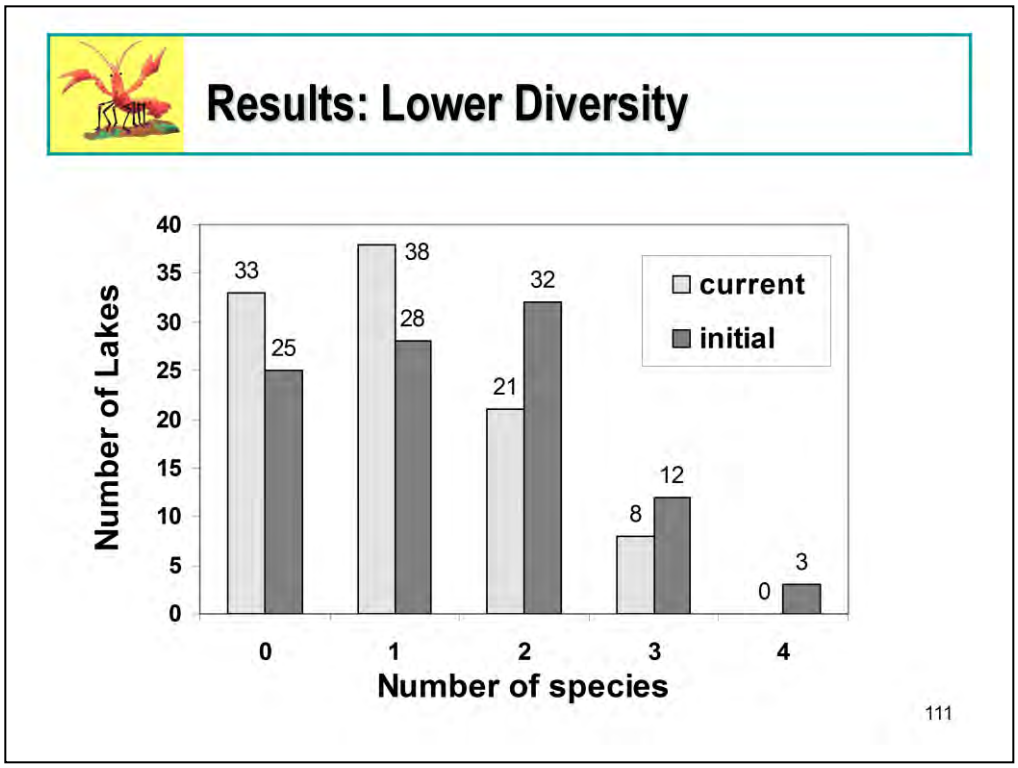
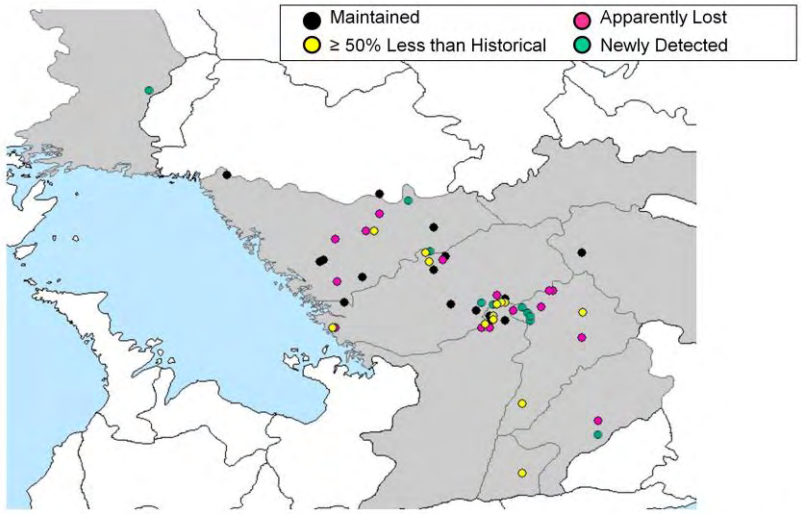


Study results indicate that the there are less crayfish in the study area as well as fewer species found.

Orconectes virilis



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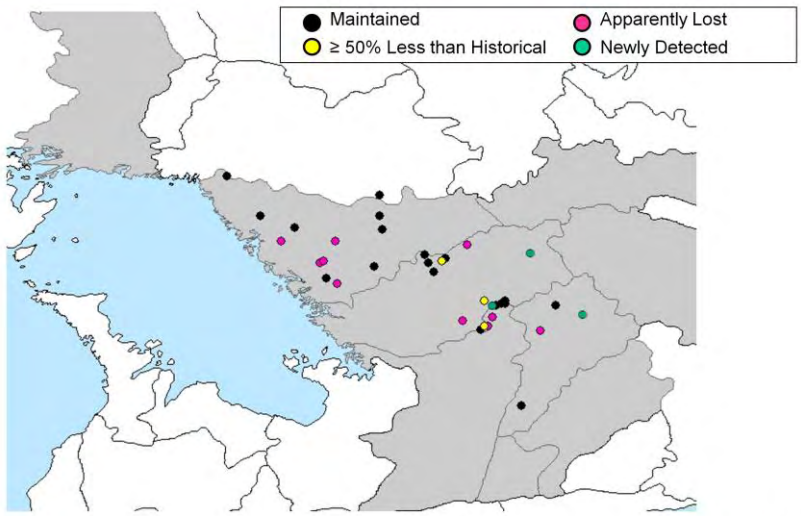
Orconectes propinquus



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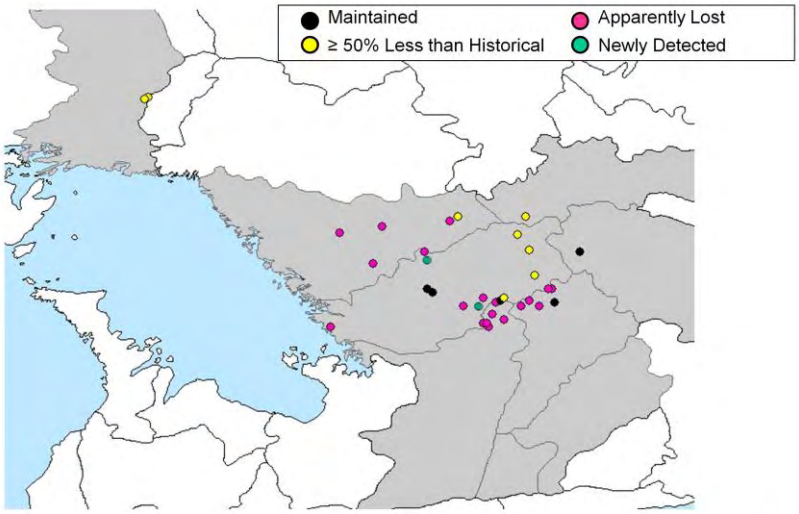
Cambarus bartonii



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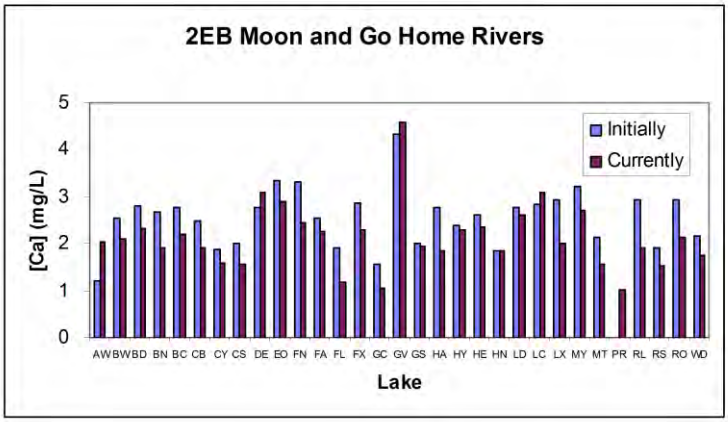
Changes in Lake Calcium in Watershed 2EB



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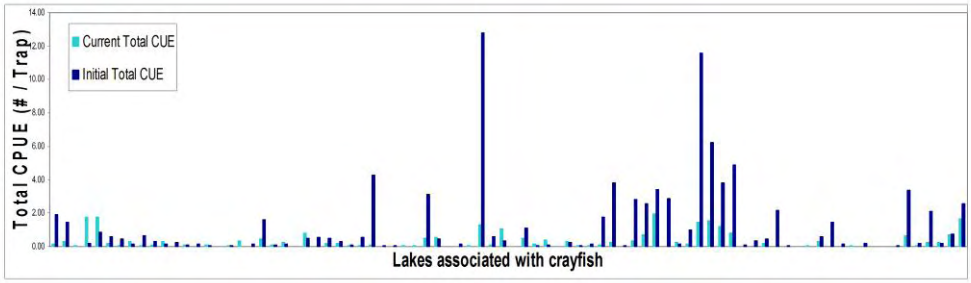
Declining Abundance



- Abundances in 63 % of the lakes have decreased

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Results Summary

- Declines in crayfish relative abundance are widespread
- Population losses have implications for both crayfish community diversity and species distributions

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Overview

- Brief history of Lake System Health Program
- Are all the lakes the same?
- Is water quality changing?
- **Is biological condition changing? - Yes**
- Where do we go from here?

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Overview

- Brief history of Lake System Health Program
- **Are all the lakes the same?- No**
- **Is water quality changing? - Yes**
- **Is biological condition changing? - Yes**
- Where do we go from here?

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Overview

- Brief history of Lake System Health Program
- Are all the lakes the same?
- Is water quality changing?
- Is biological condition changing? - Yes
- **Where do we go from here?**

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Where do we go from here?

- Become familiar with Muskoka's Lake System Health Program
  - visit the web site, read the reports & flyers
- Download the Ministry's Water Quality in Ontario Report
- Visit the FOCA & OFAH web sites
- Get involved - join the Lake Partner Program & become a lake steward

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Muskoka's Lake System Health Program -
http://muskokadistrict.iwebez.com/siteengine/ActivePage.asp?PageID=230

MOE's Water Quality in Ontario report (28 MB) - http://www.ene.gov.on.ca/publications/6926e.pdf

Federation of Ontario Cottagers' Association - http://www.foca.on.ca/index.php

Ontario Federation of Anglers and Hunters - http://www.ofah.org/

Lake Partner Program - http://www.ene.gov.on.ca/en/water/lakepartner/index.php


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• Co-authors
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