Responding to the threat of road salt in Muskoka

Norman Yan and Robin Valleau with

Arran Brown (York U and FMW)

Martha Celis-Salgado, Shelley Arnott, John Smol (Queens U)

Ryan Sorichetti, Andrew Paterson, Jim Rusak (MECP)

and Tim Kearney (FMW and CNLA)

Friends of the Muskoka Watershed

PEARL Paleoecological Environmental Assessment & Research Laboratory

NSERC CREATE abate algal bloom assessment through technology & education

Ontario

YORK UNIVERSITÉ UNIVERSITY redefine THE POSSIBLE.

DESC DORSET ENVIRONMENTAL SCIENCE CENTRE

CANADIAN NURSERY LANDSCAPE ASSOCIATION

Queen's UNIVERSITY

Objectives

1. to demonstrate that:
   - Cl levels in Ontario lakes are rising because of road salt
   - The CWQG for Cl might not provide appropriate protection for Muskoka lakes
   - To suggest a guideline that might provide such protection
   - To seek evidence of ecological damage in Muskoka lakes linked to Cl toxicity (Robin's research)

2. To indicate how we might follow logical steps in an environmental management process to solve this problem

Setting the stage:
What scientific knowledge is needed to protect our lakes?

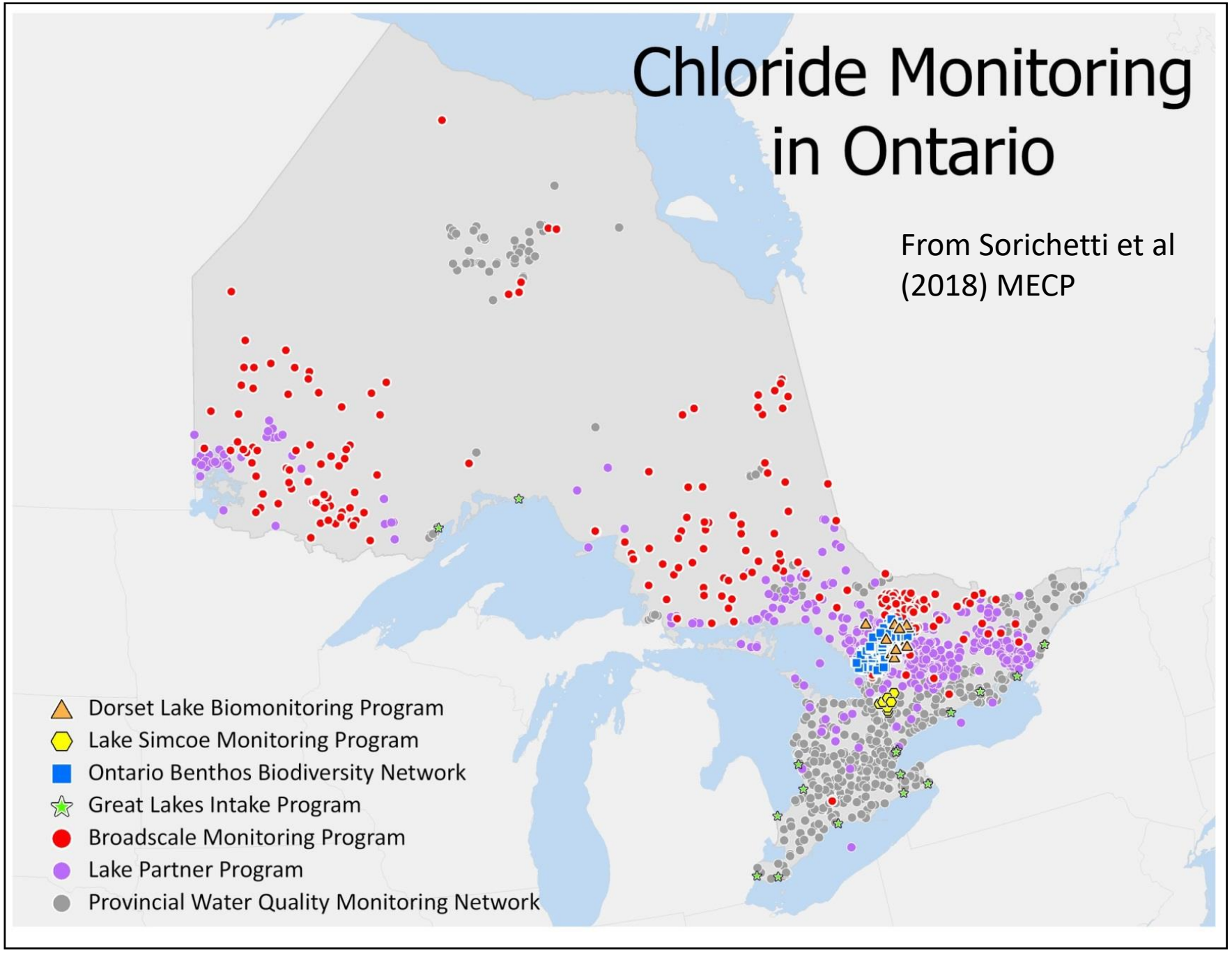
- Assessment
  - Description of what we value and want to protect
  - Detection of a problem or threat, by comparing indicators with targets

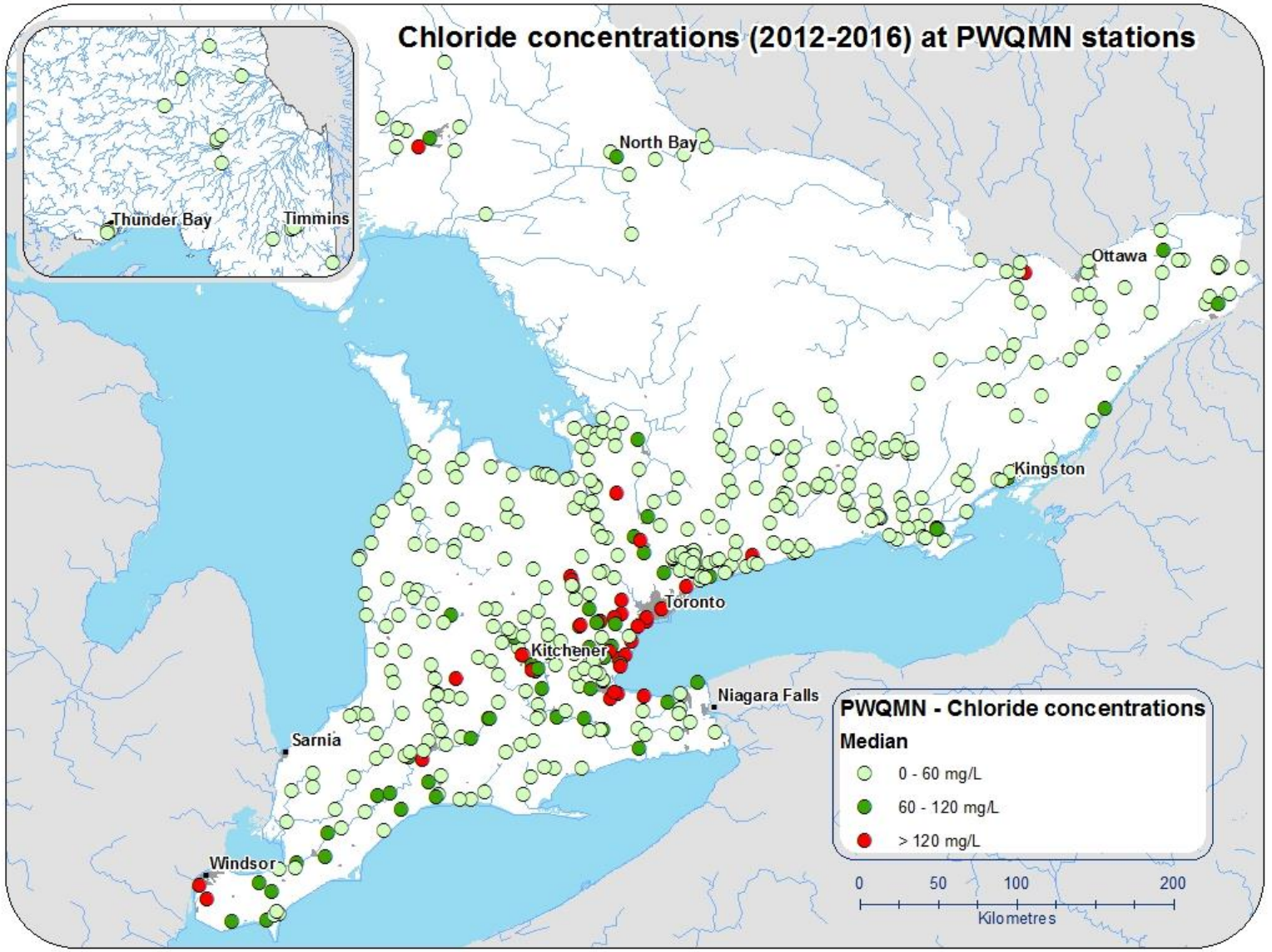
- Remediation/Prevention
  - Diagnosis of the cause of the problem or threat
  - Modelling of linkage of cause with effect
  - Prognosis of alternative plans of action
  - Re-assessment of indicators after the remedial interventions are in force

1: Decade-long Environmental Trends in Muskoka

- Improving
  - Acid rain, lead pollution, DDT, phosphorus
- Uncertain
  - Mercury, pharmaceuticals, plastic pollution, nano-particles, development pressures
- Worsening
  - invading species, climate change, **road salt, calcium decline**

We add 5-7 million t/yr of salt to Canada's roads *


Chloride Monitoring in Ontario
From Sorichetti et al (2018) MECP
Dorset Lake Biomonitoring Program
Lake Simcoe Monitoring Program
Ontario Benthos Biodiversity Network
Great Lakes Intake Program
Broadscale Monitoring Program
Lake Partner Program
Provincial Water Quality Monitoring Network



Median [Cl]

0 – 60 mg/L

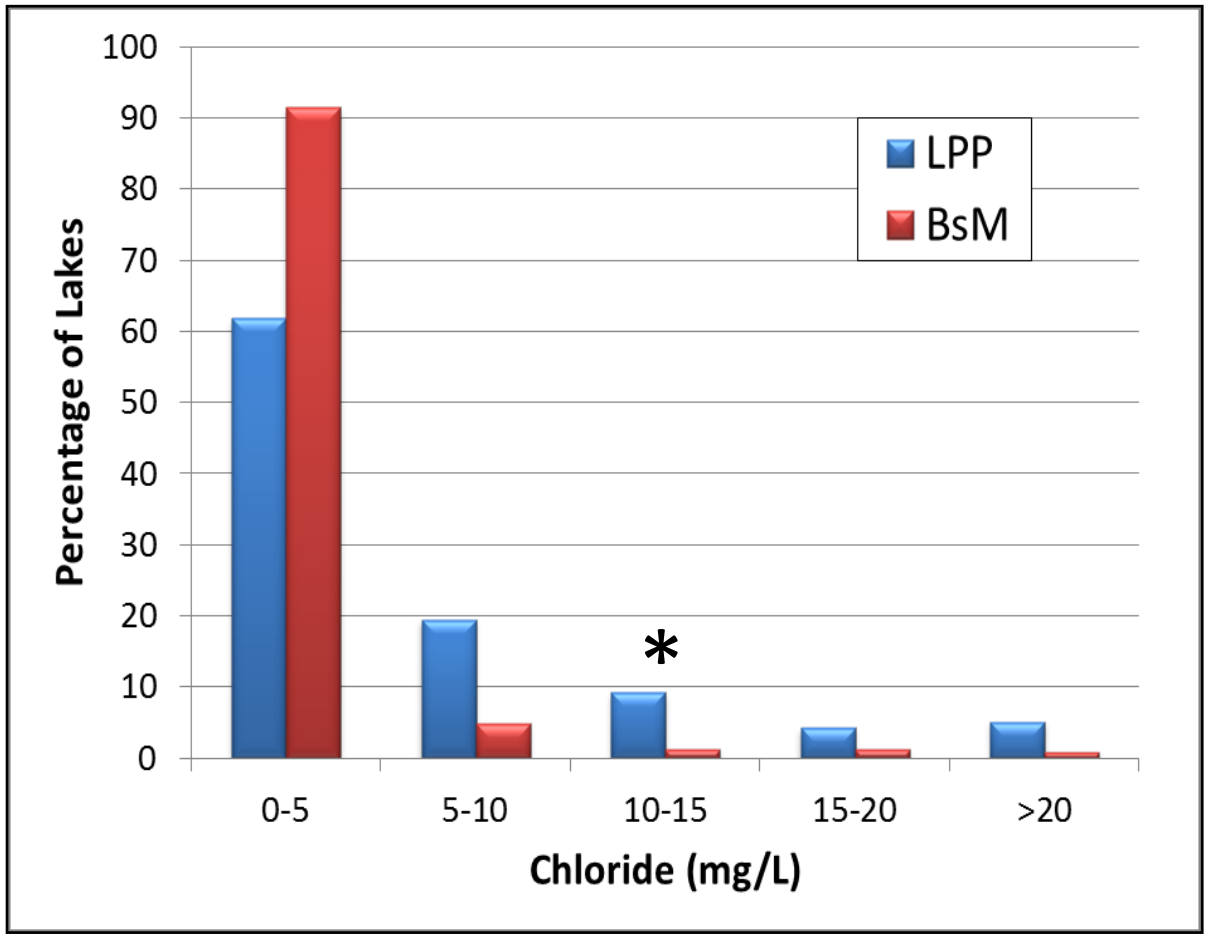
60 – 120 mg/L

> 120 mg/L

Provincial Water Quality Monitoring Network (PWQMN)
from Sorichetti et al. (2018) MECP

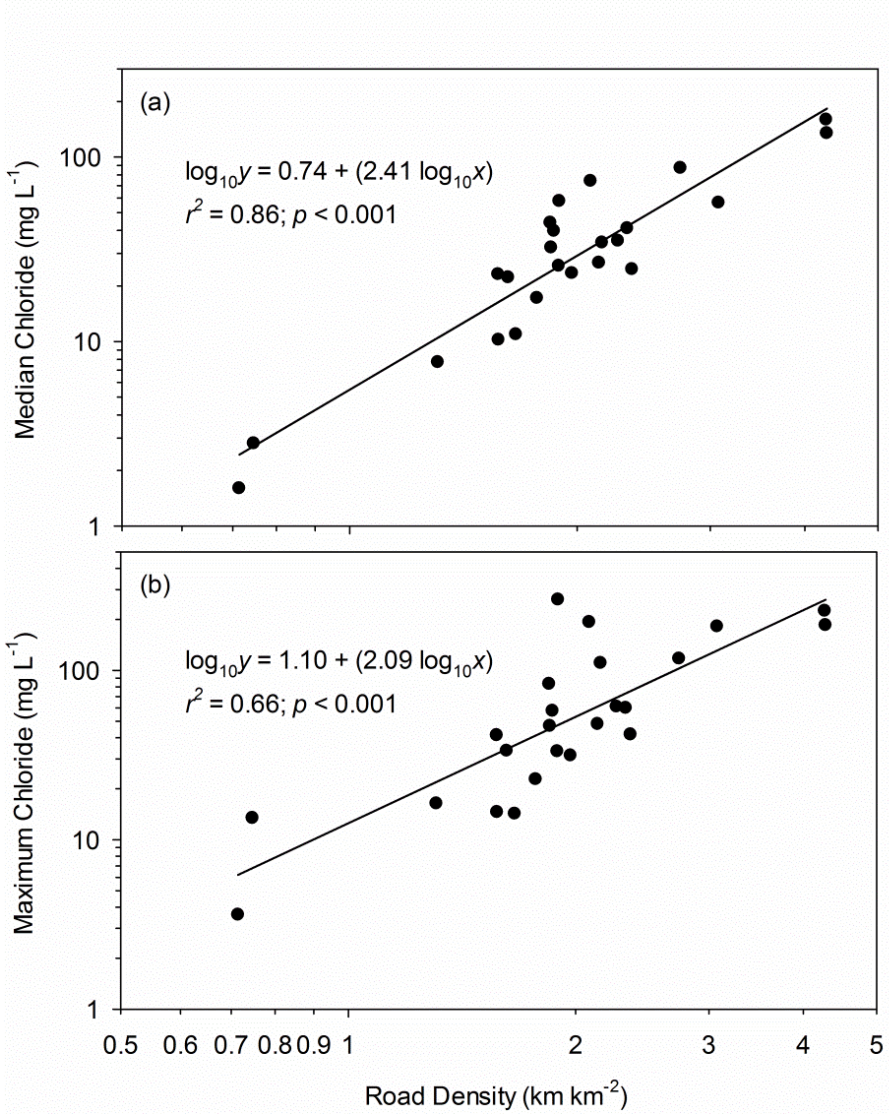
Are such high levels of Cl widespread or only in the GTA?

- Lake Partner Program (LPP) in 2015; Broadscale Monitoring program (BsM) in 2008
- Cl in 690 lakes across Ontario from 2013-2016
- All LPP and BsM lakes in Ontario have Cl concentrations below Canadian Water Quality Guideline of 120 mg/L
- But remote lakes of the BsM program have much lower Cl levels



LPP (MECP Dorset); BsM (MNRF)

Are we responsible for high Cl levels in waters? In S ON stream Cl correlates with road density*



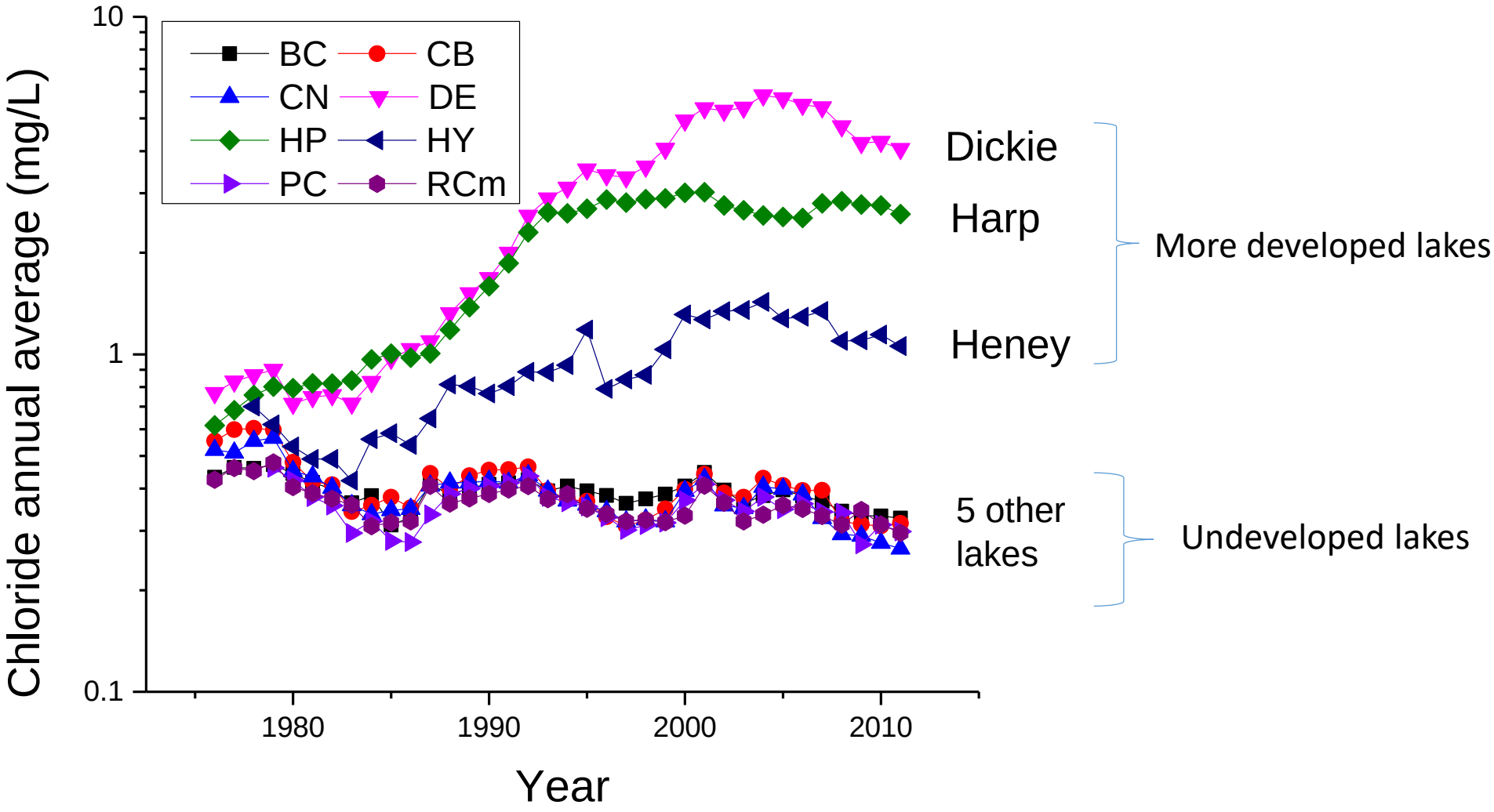
High population density leads to high road density

Median and **maximum** chloride concentrations positively and significantly correlated to road density

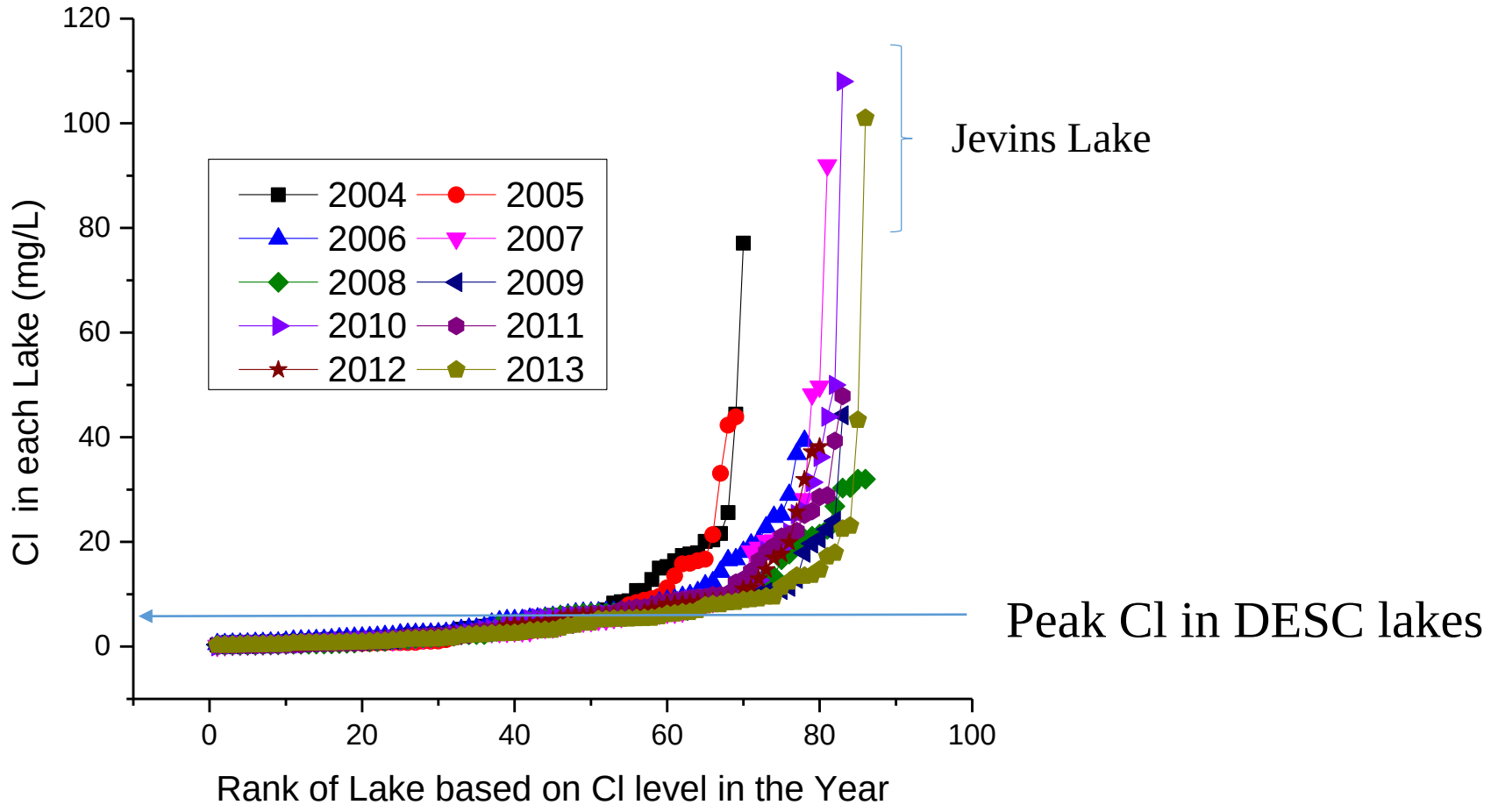
Todd & Kaltenecker (2012) – *Environ. Poll.

What about in Muskoka
The Dorset Environmental Science Centre (DESC)

Have Cl levels changed in the DESC's study lakes?

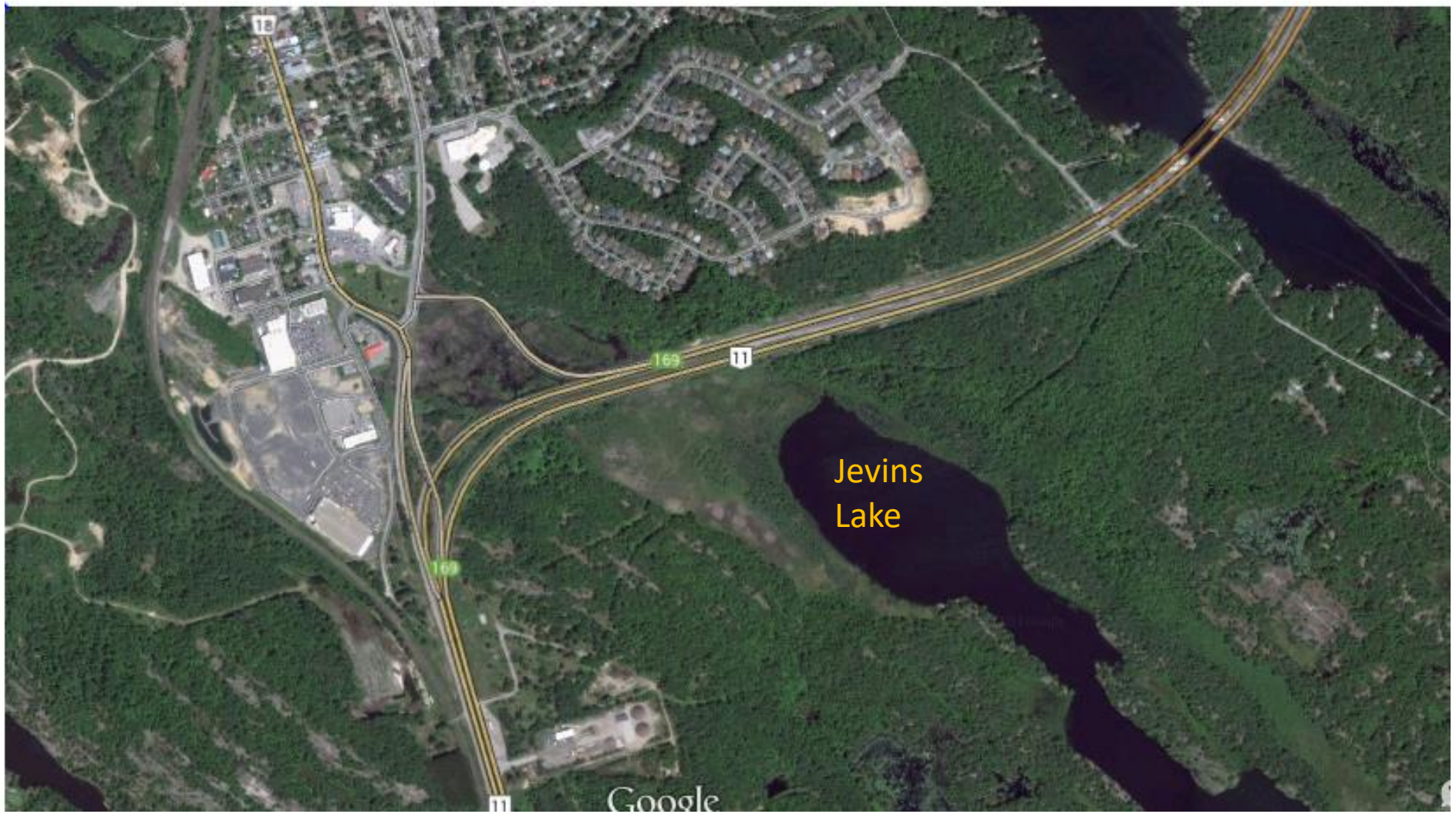


Do the DESC data reflect the range of Cl* in Muskoka?

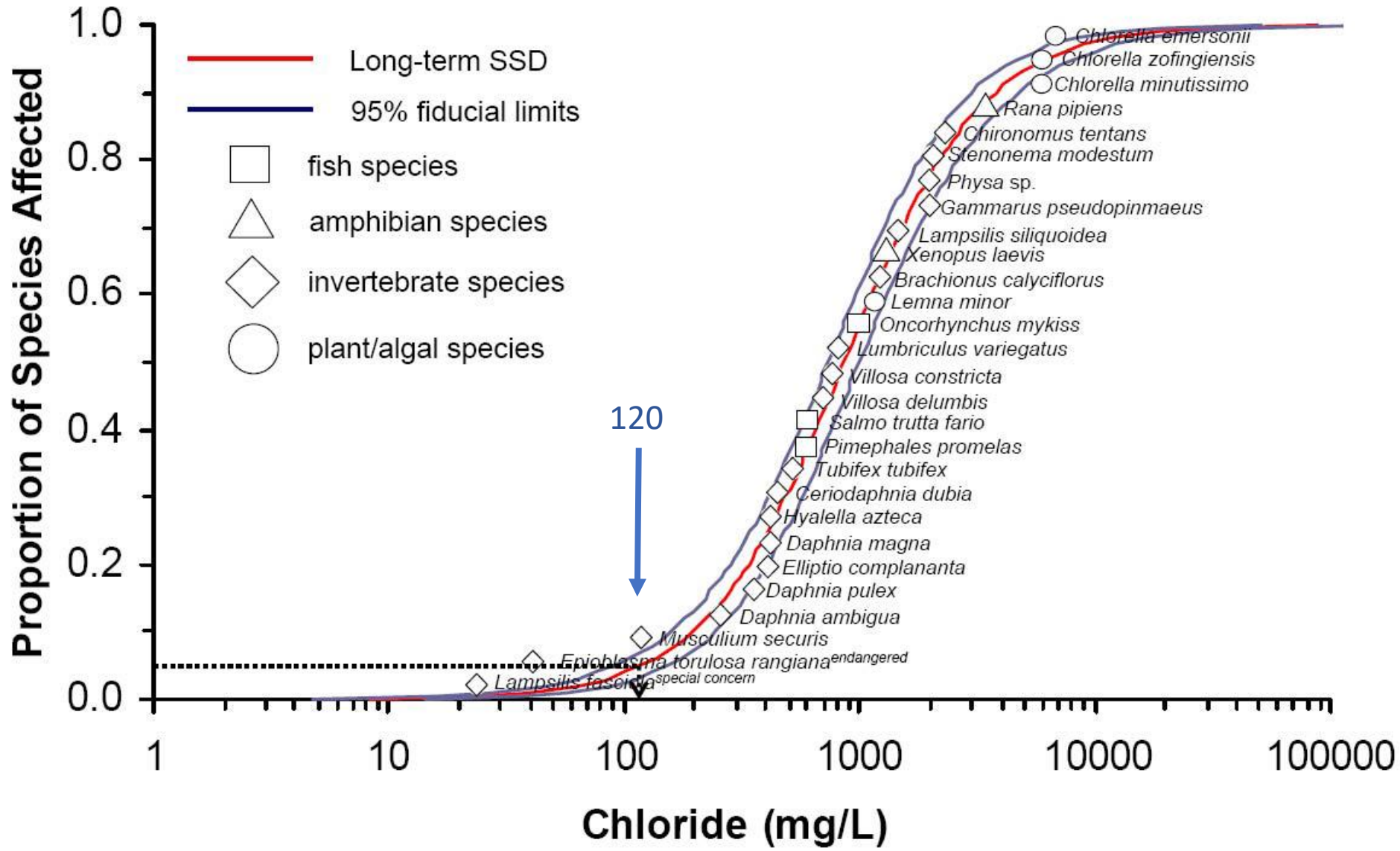


*data from Rebecca from DMM Water Quality Monitoring Program

Jevins Lake in Gravenhurst



What is the Canadian Water Quality Guideline for chronic exposure to Chloride?
Species Sensitivity Distribution (SSD) from 28 studies on Cl toxicity



Does the chronic CWQG for Cl protect Muskoka lakes?

- Pluses
  - It's published
  - It was set in Canada, by Environment Canada
  - It uses a well-established procedure, the 5th percentile of a fit to the SSD
  - It is based on toxicity results for 28 freshwater species, including both plants and animals, vertebrates and invertebrates
  - The model used to interpolate the CWQG fits the data well
- Minuses
  - It is based entirely on lab studies under ideal rearing conditions for the species
  - It has not been tested in soft, nutrient-poor media that typify Muskoka lakes, but water hardness and food sufficiency may well influence sensitivity to Cl
  - Nor has it been tested in the field

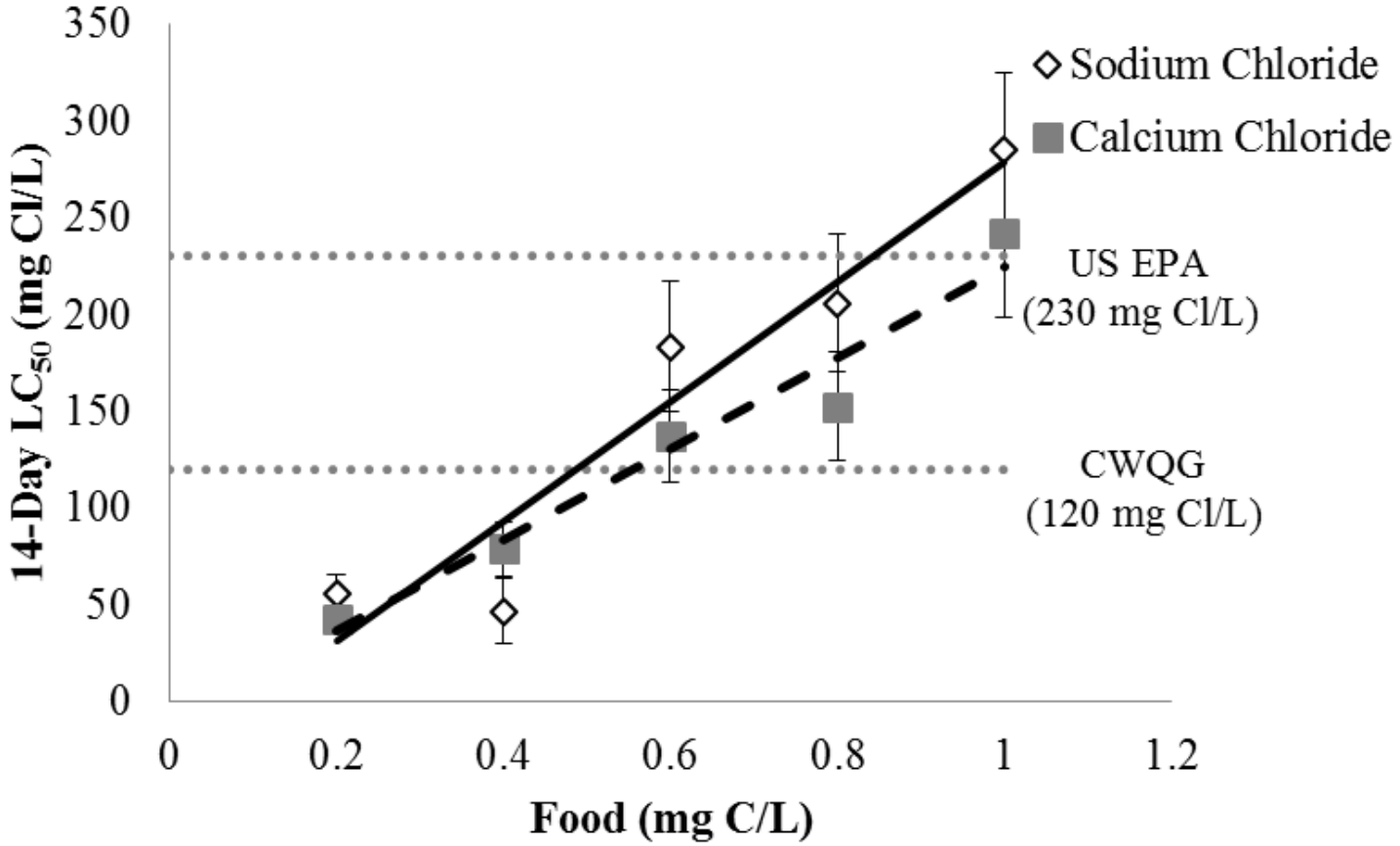
- Might the guideline be based on excellent work under the wrong conditions for Muskoka?

Arran Brown's MSc research*

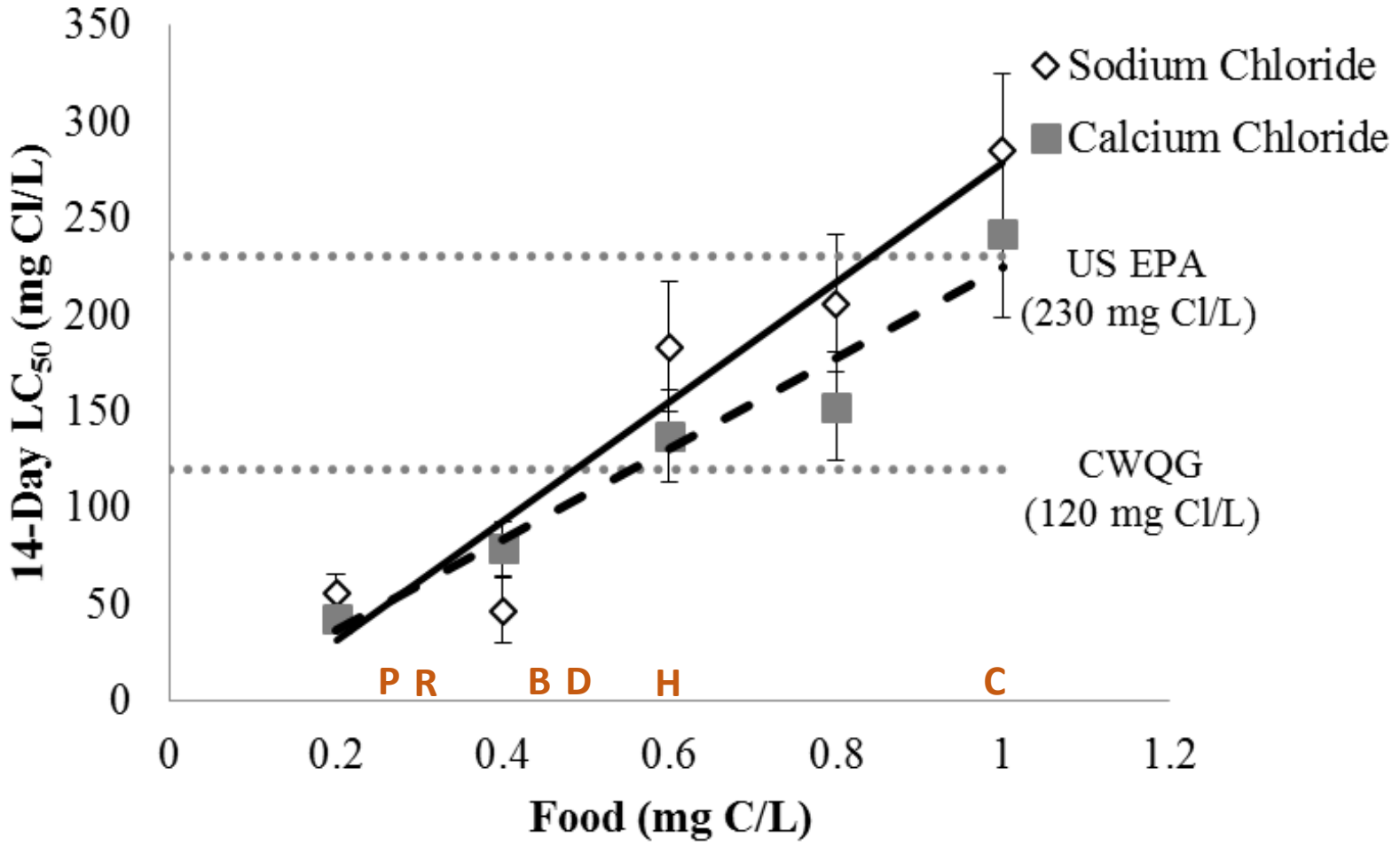
- 14 day chronic Cl toxicity assays using an Ontario clone of *Daphnia* in a chemically defined soft-water medium
- Run with $CaCl_2$ and NaCl
- Used food quantity that ranged from oligotrophic to eutrophic conditions, the former typical of Muskoka lakes, the latter typical of regulatory toxicology assays

*Brown & Yan. 2015. Food quantity affects the sensitivity of *Daphnia* to road salts. ES&T

Influence of food quantity on chloride toxicity to one *Daphnia* in soft-water*



And what are the food levels in Muskoka lakes?



Lake code

P – Plastic
R – Red Chalk
B – Blue Chalk
D – Dickie
H – Heney
C - Chub

And Brown and Yan

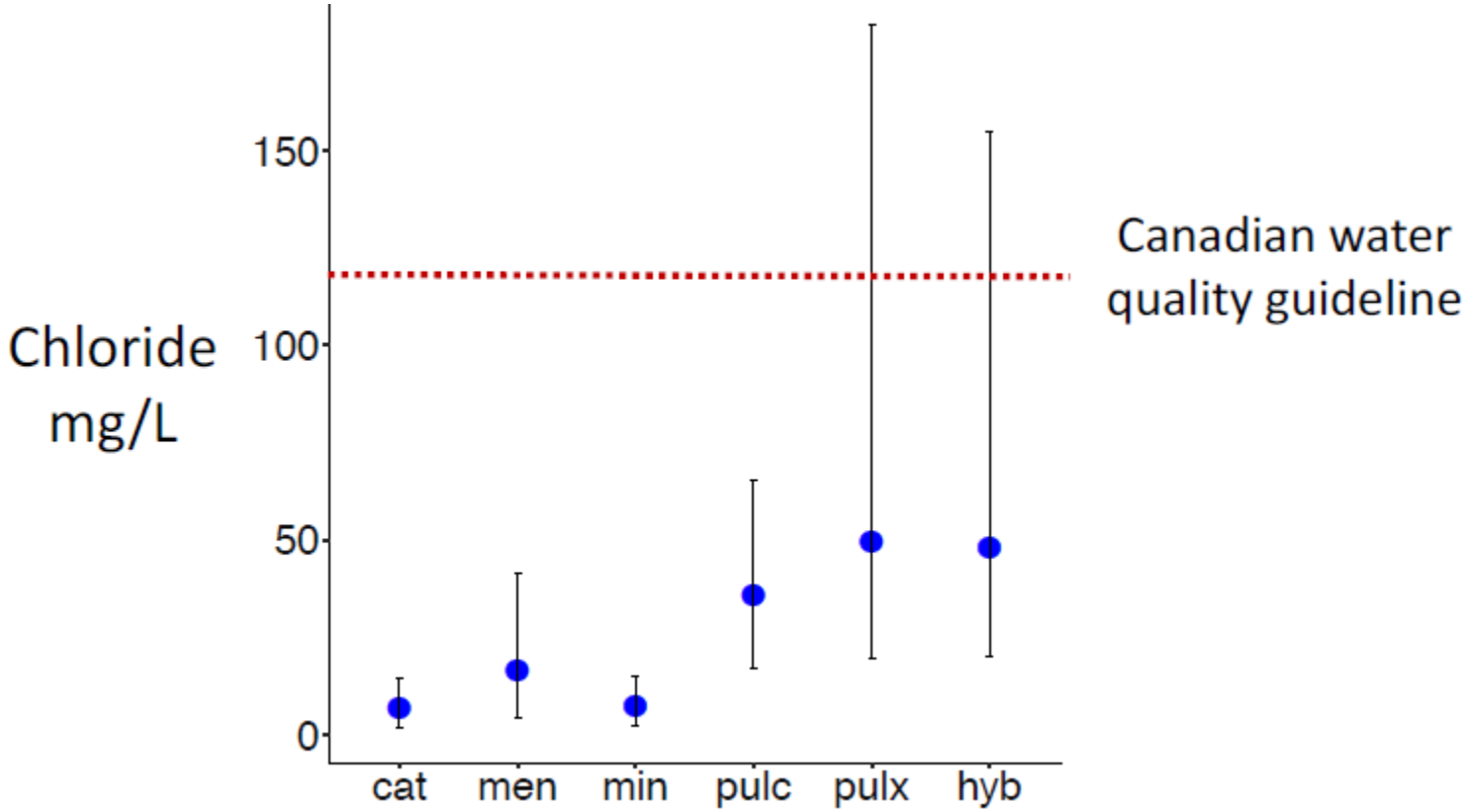
- used only one daphniid line
- A hybrid of *Daphnia pulex* and *pulicaria*
- Which was isolated from a Sudbury lake exposed to a century of smelter pollutants

- **Might other lines or species isolated from uncontaminated, soft-water lakes in Muskoka differ in sensitivity to road salt?**

21 day LC_{50} for Cl in soft-water at high food* for 9 Dorset vs. the Sudbury line of *D. pulicaria*

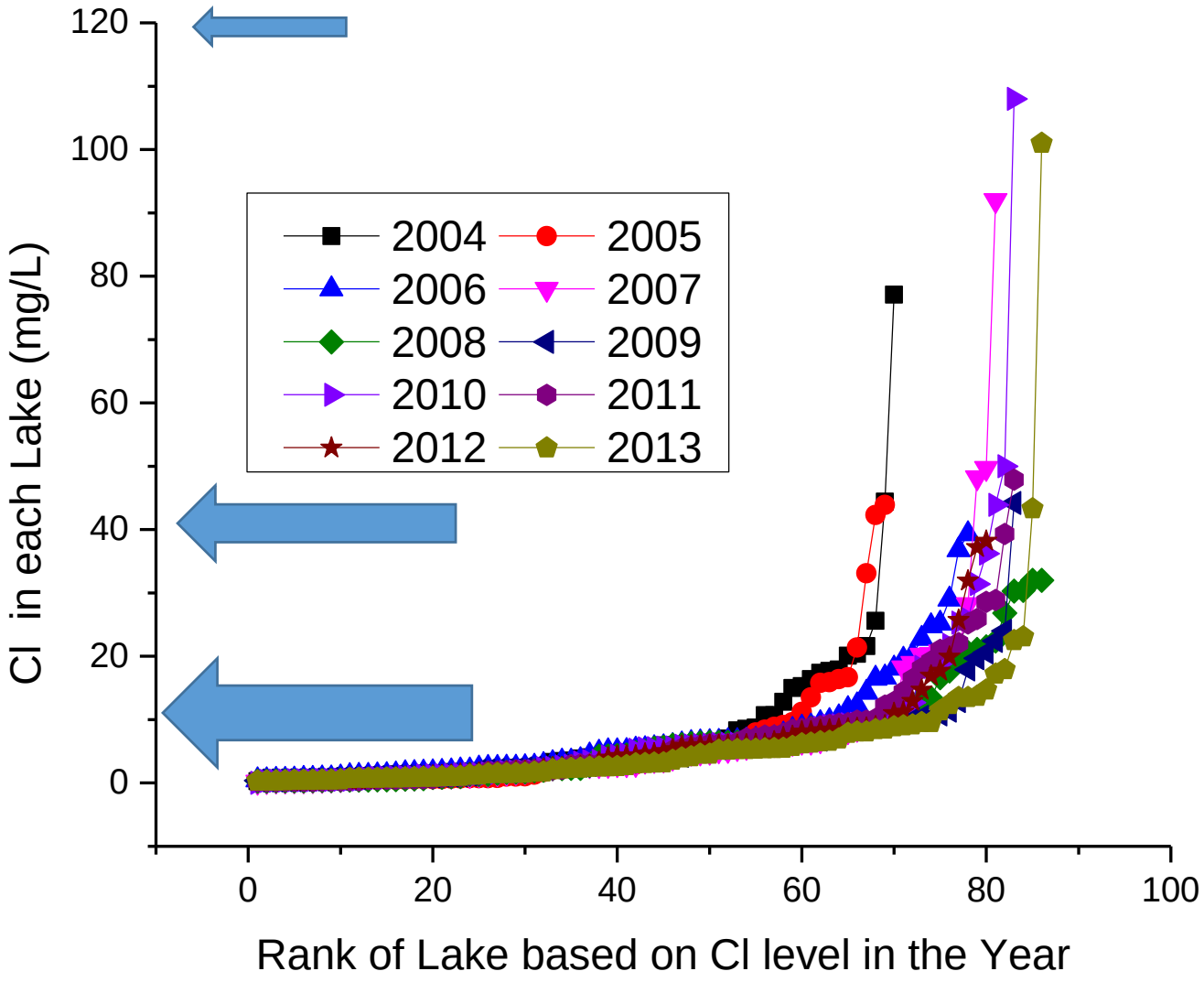
*Martha Celis-Salgado and Shelley Arnott (in prep)

And *Daphnia pulicaria* is a relatively tolerant daphniid 21 day LC_{50} in soft-water at high food*



* Arnott, Celis-Salgado, Smol, Paterson, Rusak, Brown, Yan in prep

Might Cl levels be toxic in Muskoka lakes?



120 mg/L, Cdn Water Quality Guideline for Cl

40 mg/L, Brown & Yan LC_{50}

~10 mg/L Arnott et al. in prep

But this is all work in the lab.

Is there any proof of actual ecological damage in Muskoka lakes from road salt?

Using paleolimnology to assess the effects of road salt on lakes within the Muskoka River Watershed

Robin Valleau

Queen's University

Department of Biology

PEARL Paleoecological Environmental Assessment and Research Laboratory

Muskoka

- Development in the Muskoka area began in 1868
- HWY 11 built in the 1920s
  - Upgraded and opened to public in 1927
- Salt application began 1950
- HWY 11 upgrade late 1960 and early 1970

Picture: Newly-completed Hwy 11 Diversion between Gravenhurst and Bracebridge showing new zone markings, 1/2 mile north of Airport Road. Photograph taken on September 8, 1950.

Objectives

I. Assess whether biological changes have occurred in the MRW with known road salt additions
II. Assess variability in cladoceran and Zooplankton community structure across gradients of salt and food availability
III. Determine salt tolerances of littoral Cladocera taxa using bioassays

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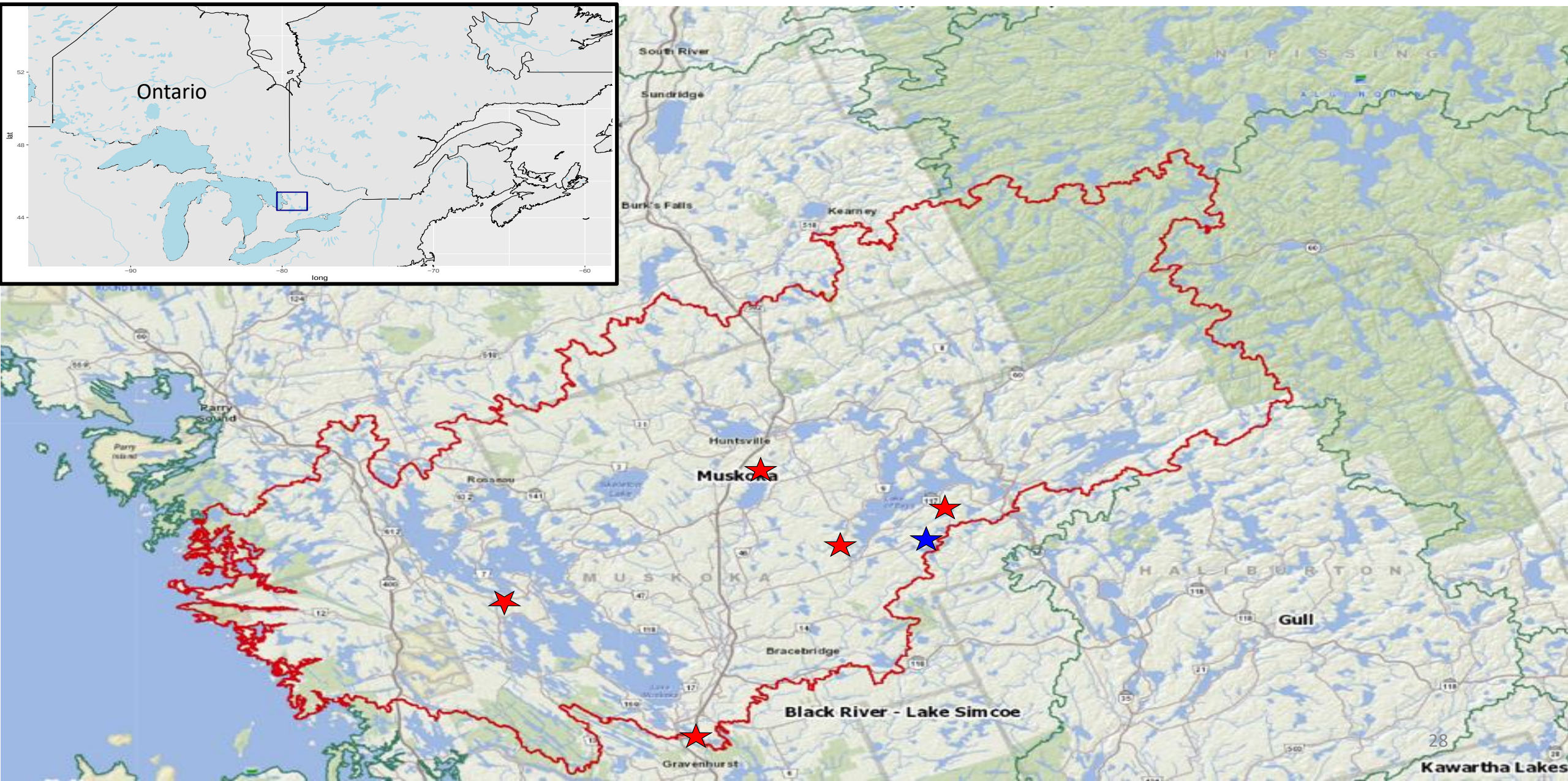
The Muskoka River Watershed



Ada Lake (33 mg/L)

Penfold Lake (45 mg/L)

Jevins Lake (91 mg/L)

Wolfkin Lake (38 mg/L)

Tooke Lake (46 mg/L)

Heney Lake * (1 mg/L)

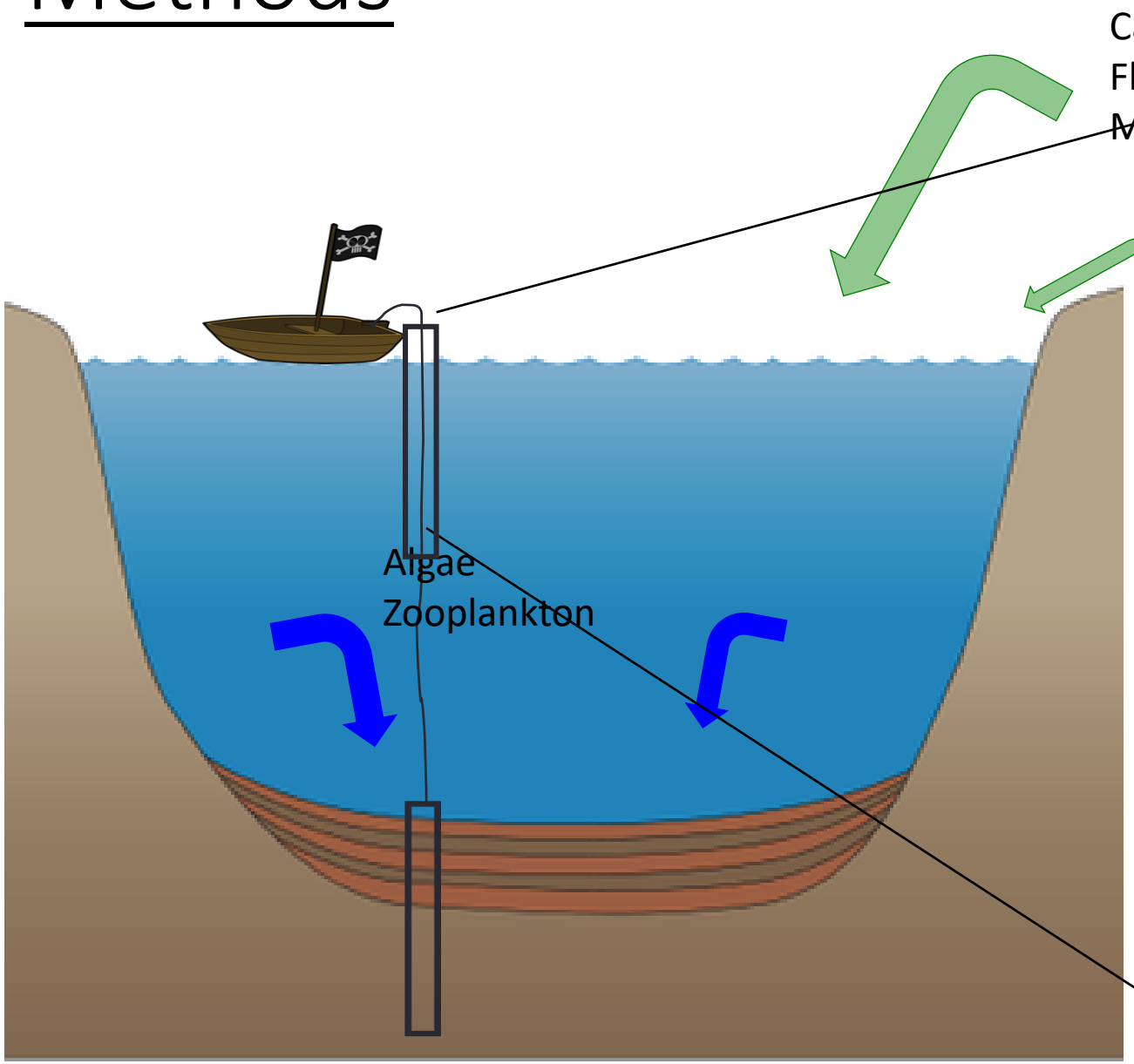
Chloride Concentration

Low

High

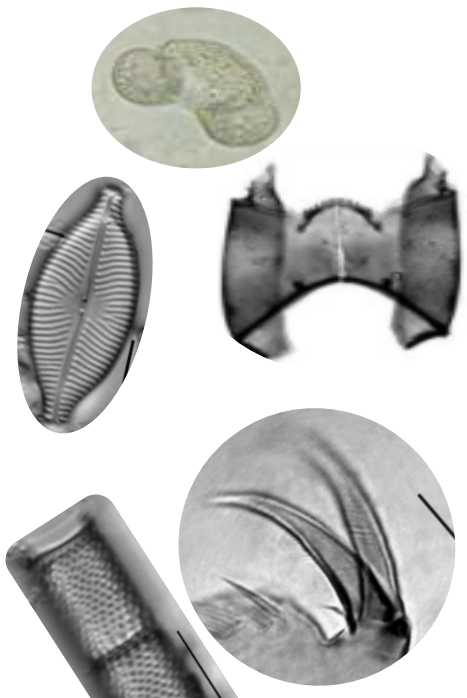
Jevins Lake

Methods



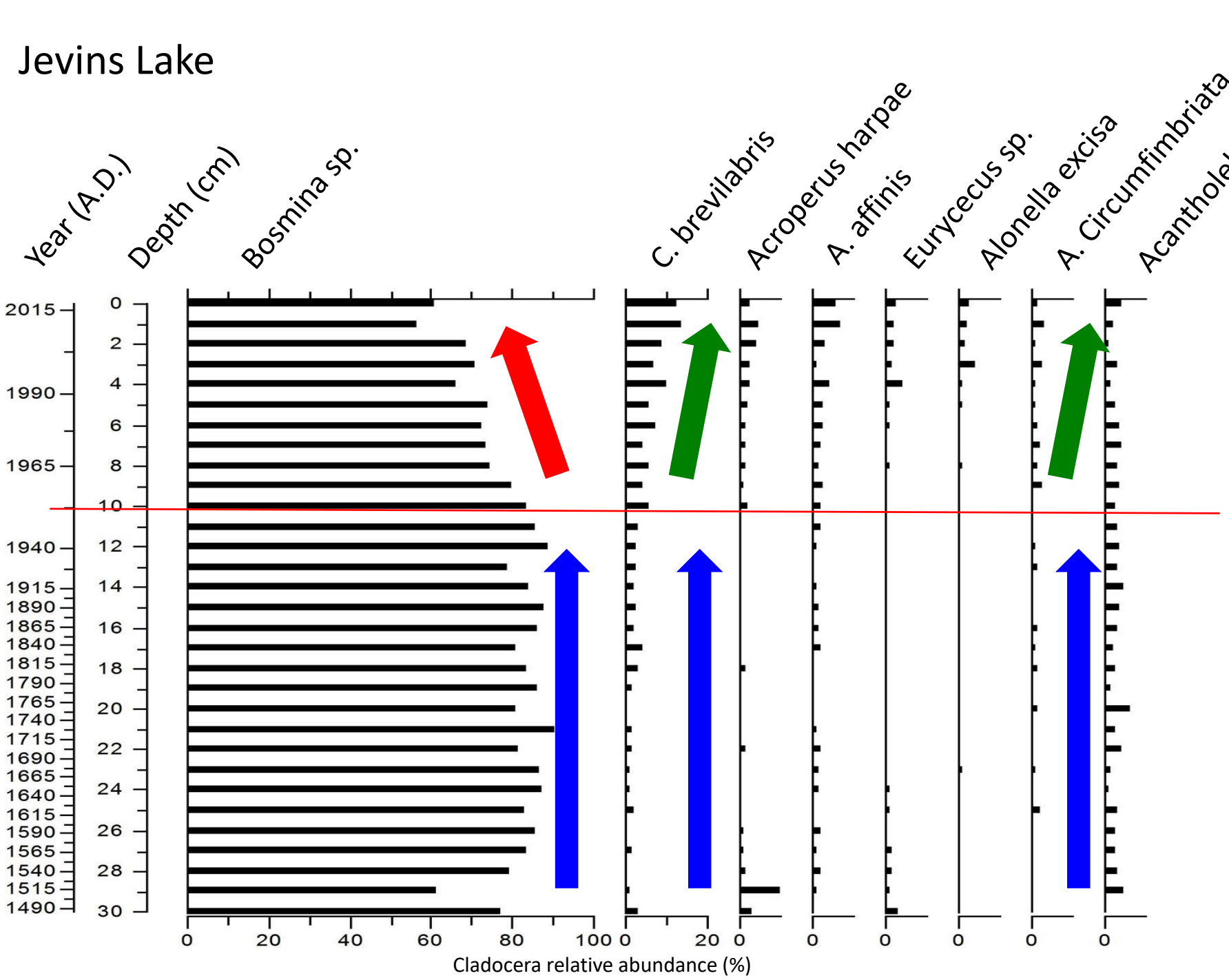
Present

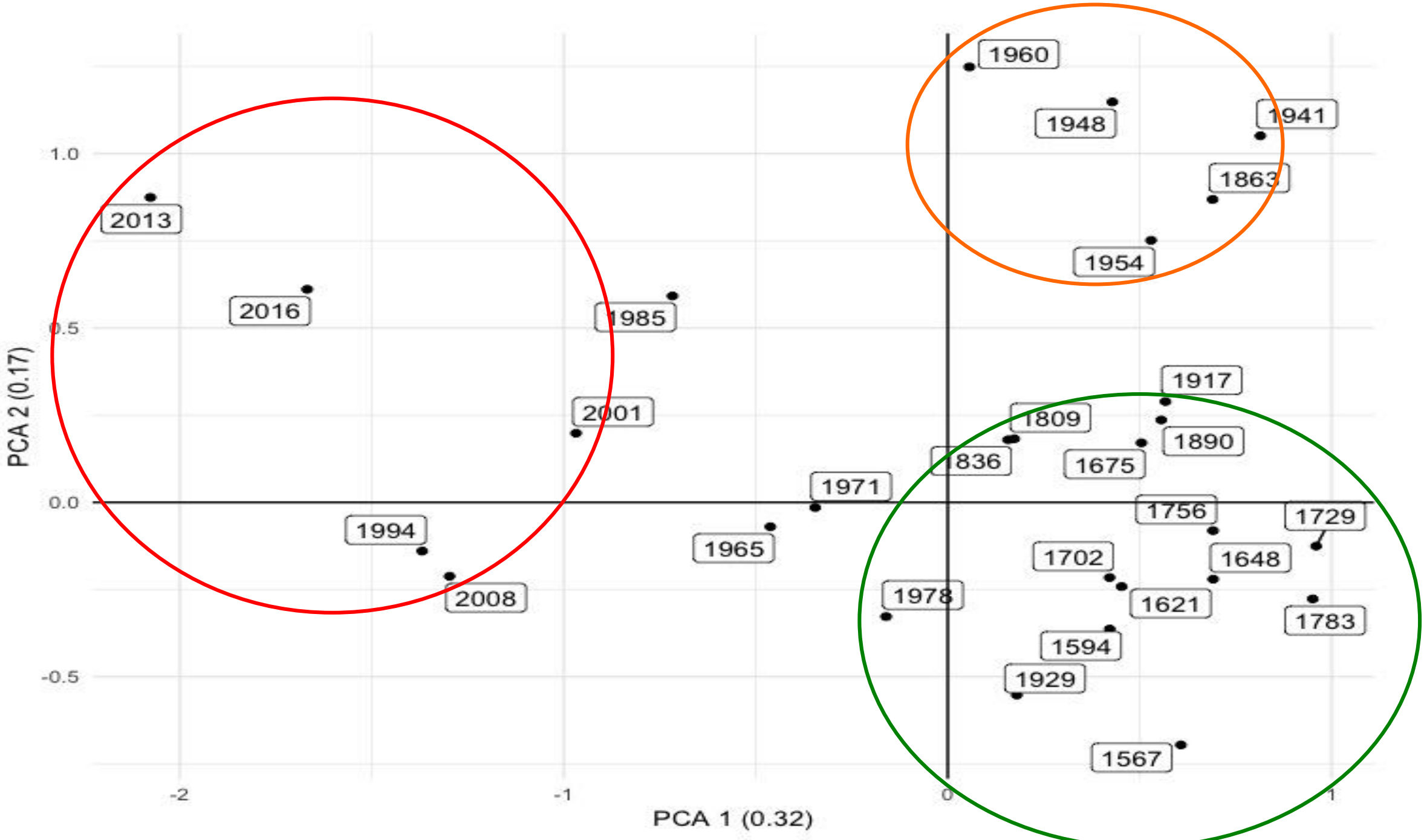
Continuous record

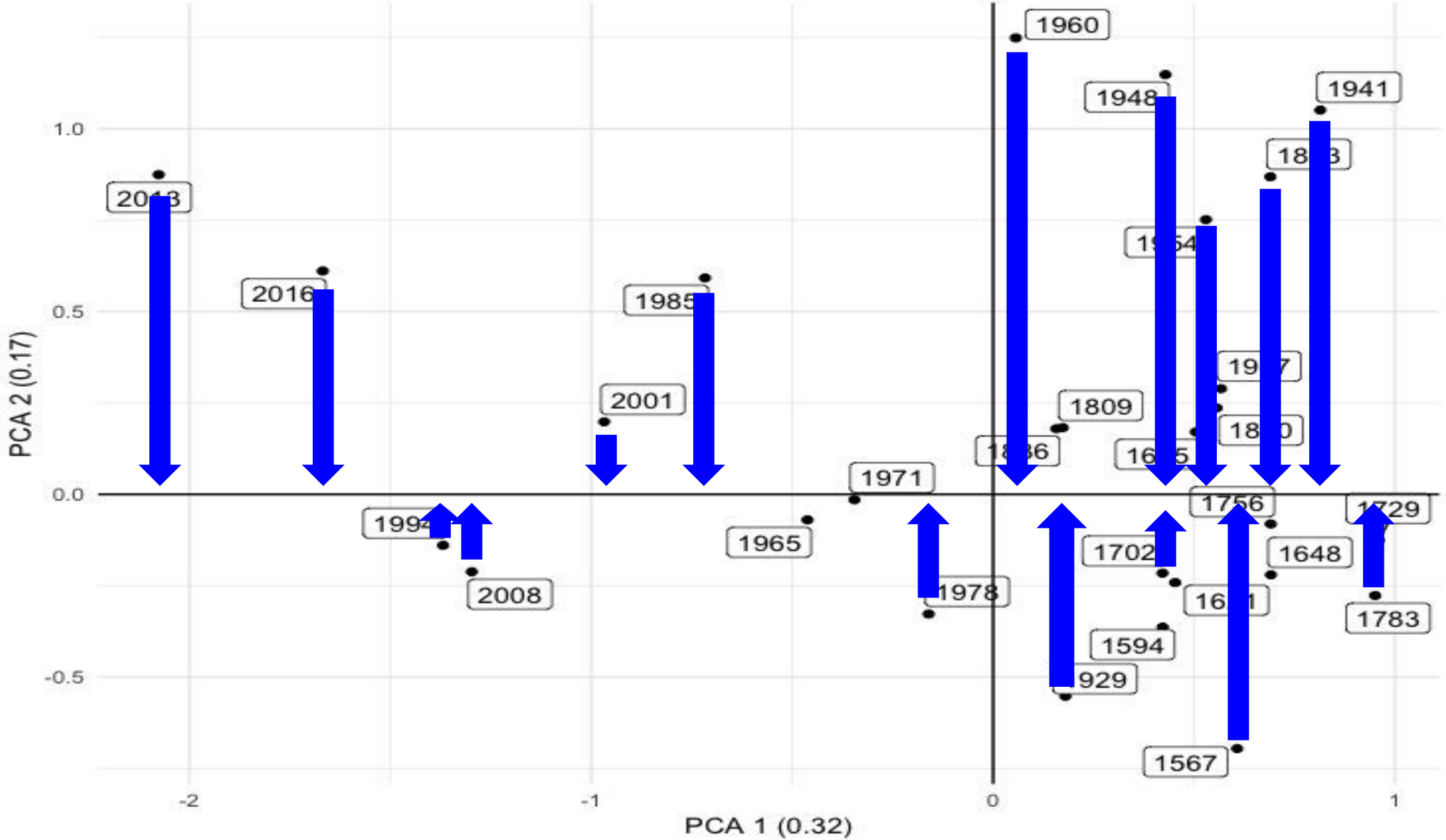


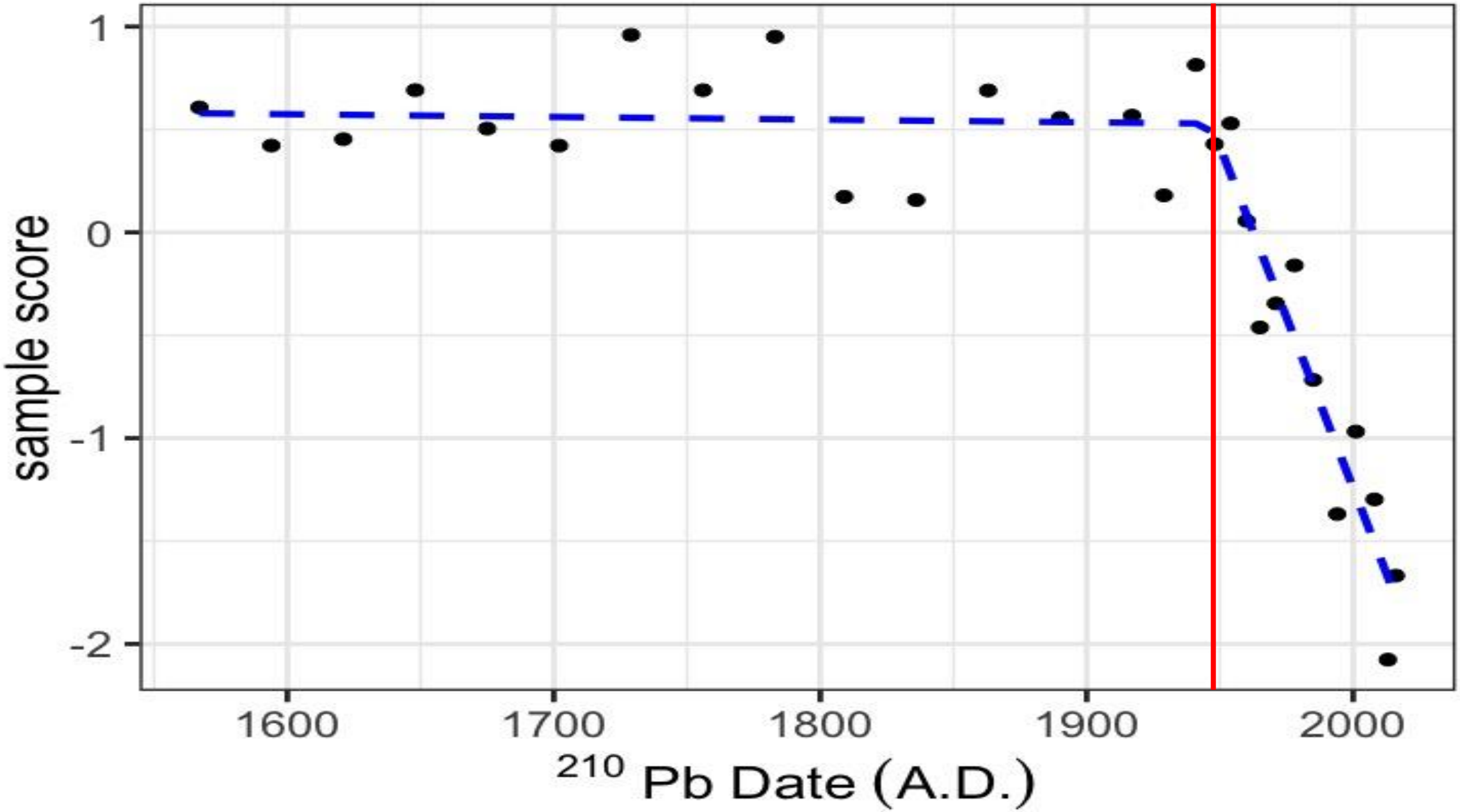
Past

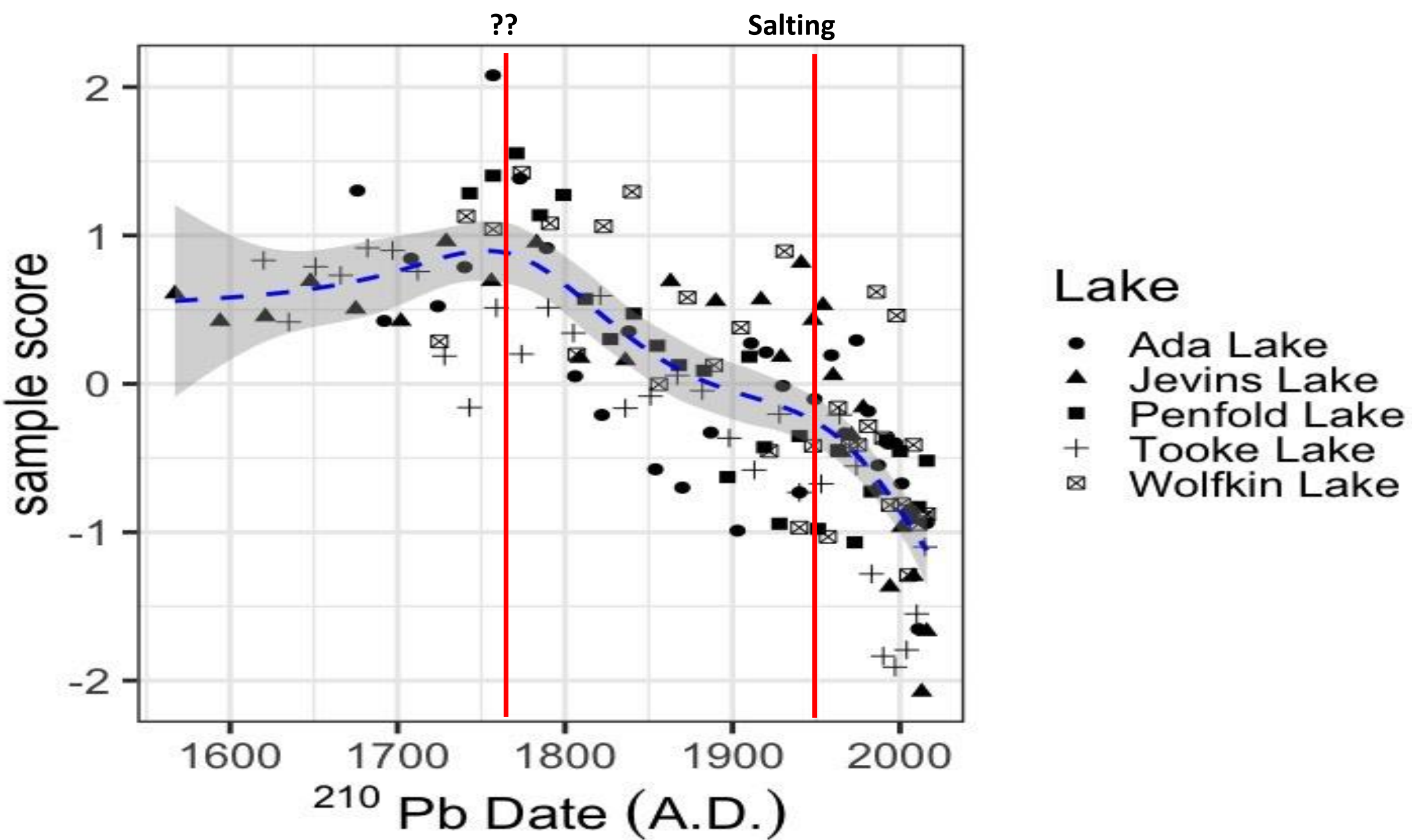
Jevins Lake


Year (A.D.)
Depth (cm)
Bosmina sp.
C. brevilabris
Acroperus harpae
A. affinis
Eurycecus sp.
Alonella excisa
A. Circumfimbriata
Acantholebris curvirostris
2015
1990
1965
1940
1915
1890
1865
1840
1815
1790
1765
1740
1715
1690
1665
1640
1615
1590
1565
1540
1515
1490
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
0
20
40
60
80
100
0
20
0
0
0
0
0
0
Cladocera relative abundance (%)


1960
1948
1941
1863
1954
2013
2016
1985
2001
1994
2008
1965
1971
1917
1809
1890
1675
836
1756
1729
1702
1648
1621
1978
1783
1594
1929
1567
1.0
0.5
0.0
-0.5
-2
-1
0
1
PCA 2 (0.17)
PCA 1 (0.32)


1960
1948
1941
1809
1971
1965
1985
2001
2016
2008
1978
1702
1648
1594
1567
1783
1756
1729
1.0
0.5
0.0
-0.5
-2
-1
0
1
PCA 2 (0.17)
PCA 1 (0.32)


1
0
-1
-2
sample score
1600
1700
1800
1900
2000
210 Pb Date (A.D.)


??
Salting
2
1
0
-1
-2
sample score
1600
1700
1800
1900
2000
210 Pb Date (A.D.)
Lake
Ada Lake
Jevins Lake
Penfold Lake
Tooke Lake
Wolfkin Lake

Is it Road Salt?

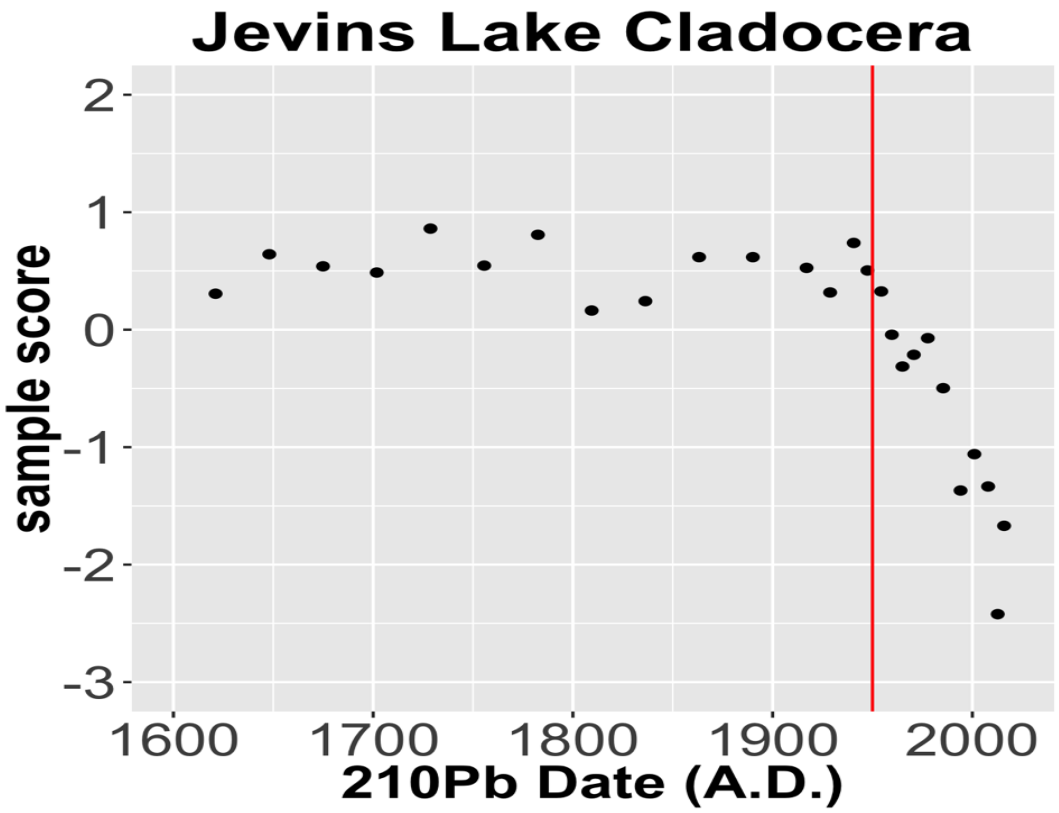
Heney Lake

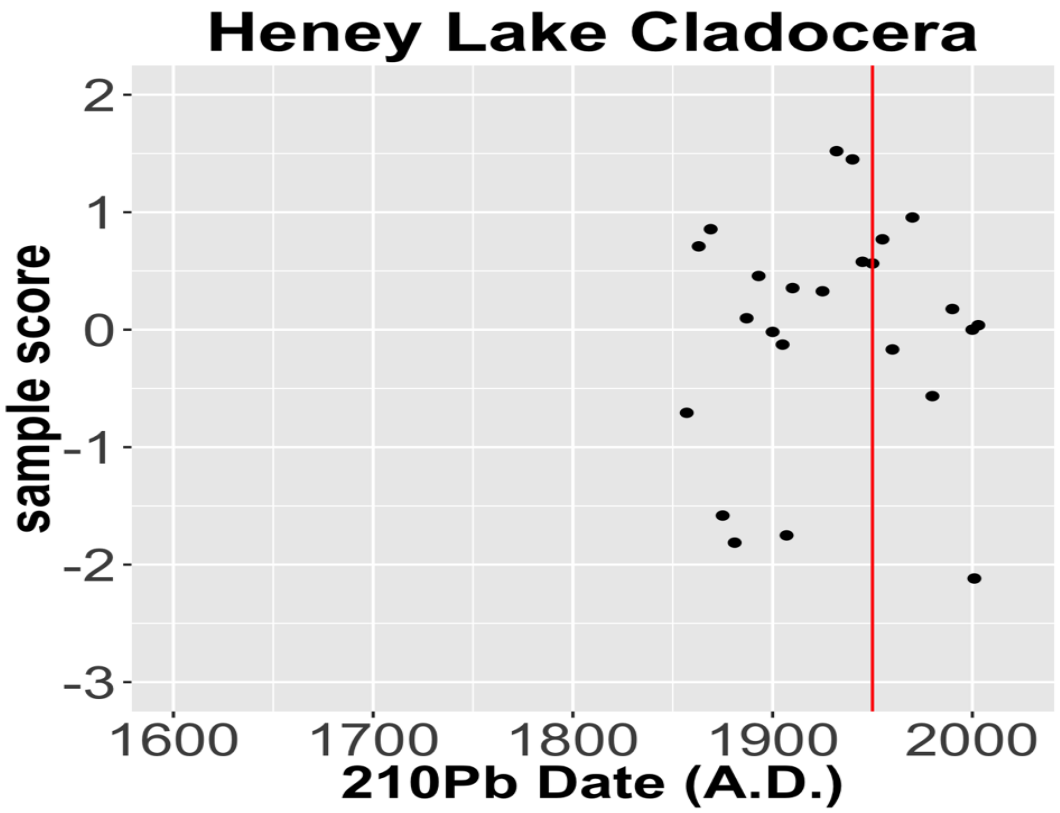
- Muskoka, Ontario
- Monitored long term by the District of Muskoka and the MOECC
- Similar physical and chemical characteristic
  - Size, depth,

  Calcium, TP

	Heney	Jevins
Area ($km^{2)}$	0.22	0.36
Depth (m)	5.8	3
Chloride (mg/L)	0.94	90.9

PCA axis 1 Scores





Objectives

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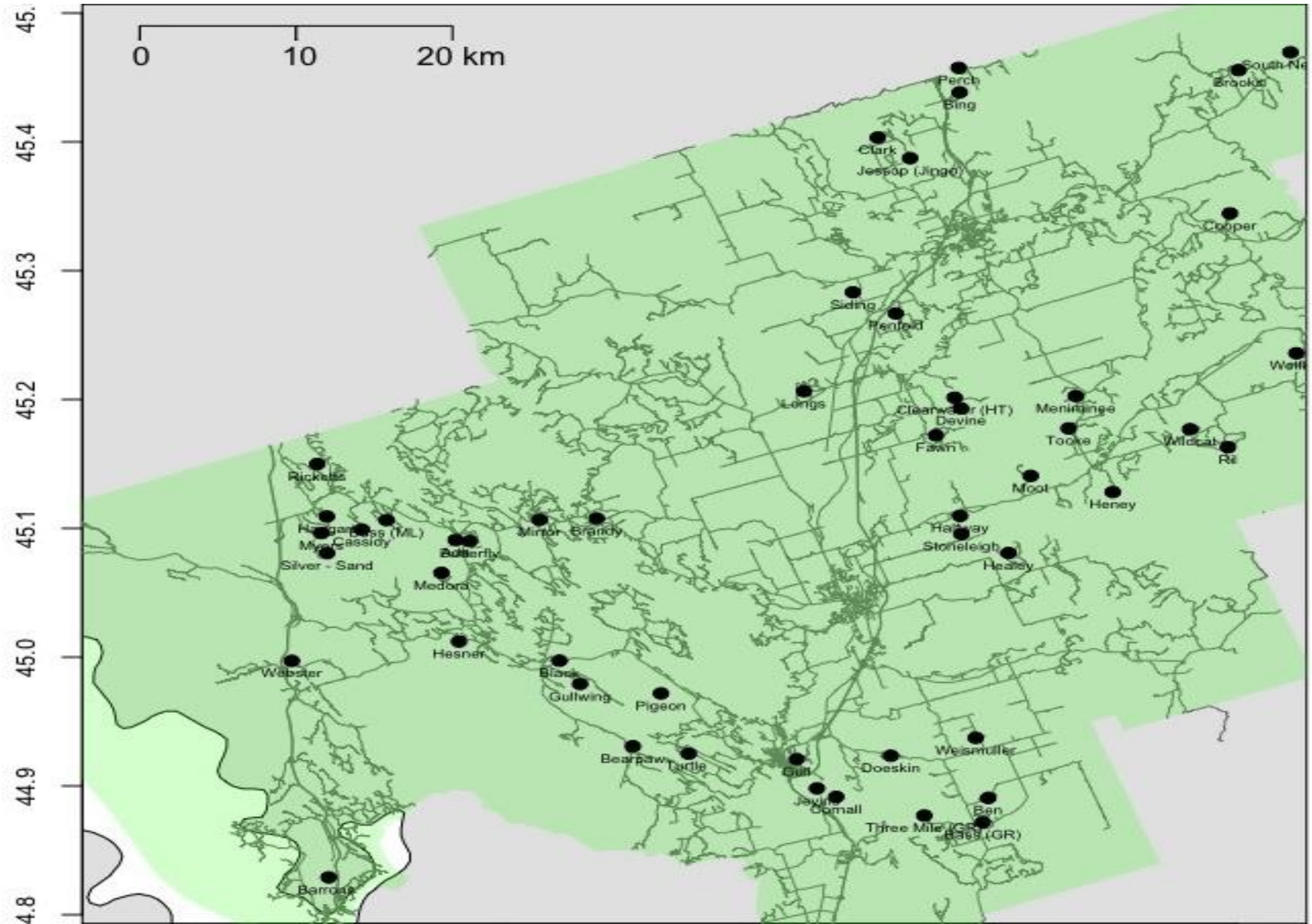
Background

- Multiple stressors
  - Food availability, acidification and recovery and climate
- The toxicity of a chemical to aquatic organisms is negatively influenced by food quantity
  - Most MRW lakes have particulate food concentrations between 0.1 - 0.5 mg C/L


0
10
20 km
45.4
45.3
45.2
45.1
45.0
44.9
44.8
Perch
Sing
Clark
Jessop (Jingo)
Cooper
Siding
Penfold
Longs
Devine
Fawn
Tooke
Mool
Heney
Rickaby
Silver - Sand
Medora
Minor
Brandy
Stoneleigh
Healey
Hesner
Webster
Gullwing
Pigeon
Bearpaw
Turtle
Gull
Doeskin
Weismuller
Comall
Ben
Three Mile
Barrows

Field Survey

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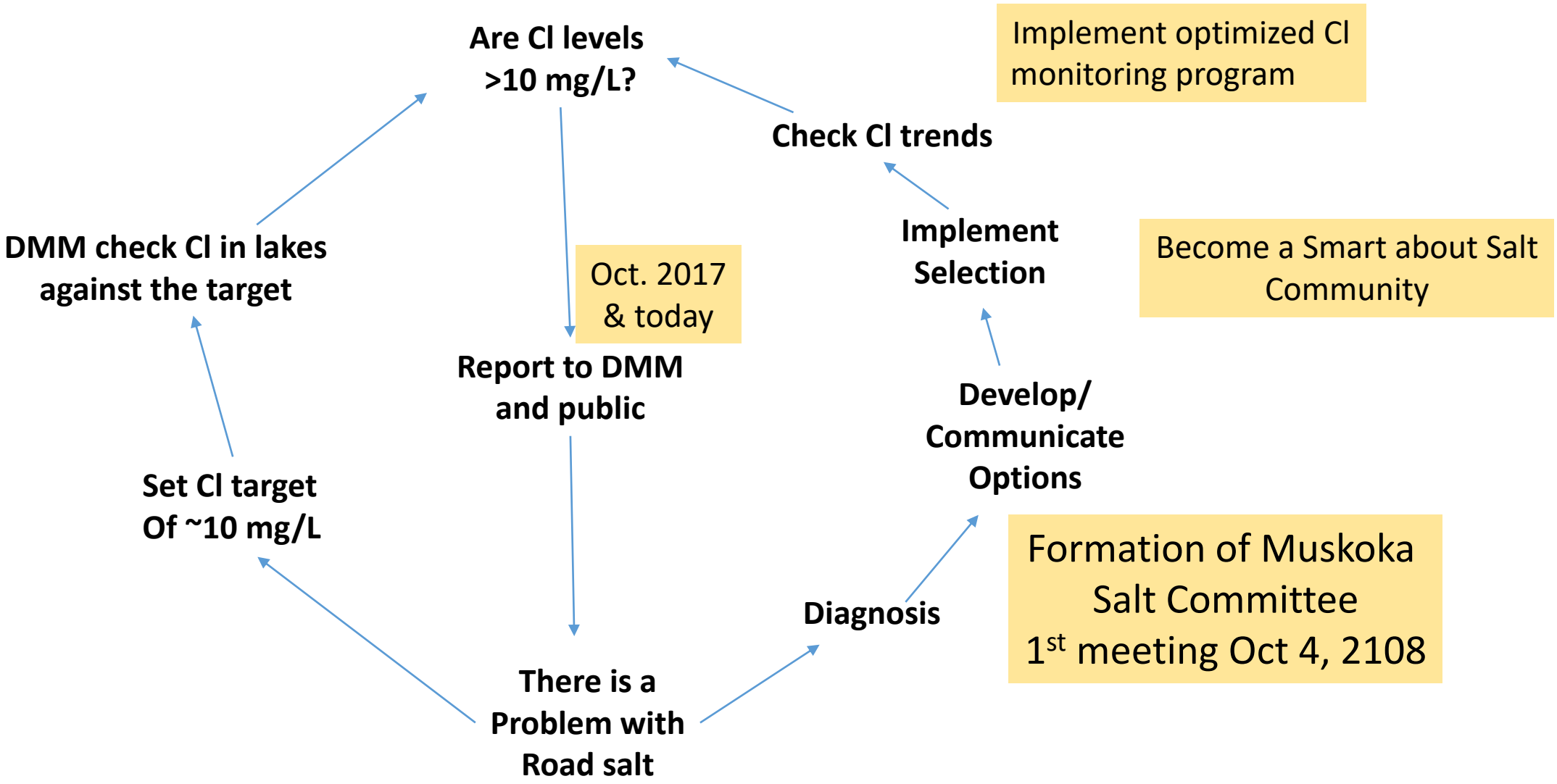
Background

- Test animals will be dominant shallow water species
- Used to corroborate findings from the paleolimnological and field studies

Conclusions

- Road salt does not stay put. It migrates into our waters
- At GTA river mouths, Cl is now often above the chronic CWQG of 120 mg/L
- In Muskoka, Cl levels in undeveloped lakes have fallen by ~40%
- Levels are not above 120 mg/L in Muskoka, but
- this guideline will not protect typical Muskoka lakes
- We propose a Muskoka-relevant guideline of ~10 mg/L
- Many lakes are approaching or already exceed this level
- Most highly impacted lakes show changes in zooplankton assemblages that coincide with known road salt application

Solving the road salt problem with a local for management plan



Objectives of the Muskoka Salt Working Committee

- Implement the 

program in Muskoka
- Understand how much we need to reduce salt levels by
  - Assembling all salt data from Muskoka waters
  - Establishing trends in these data
  - Designing an optimal Cl monitoring program
  - Quantifying salt loads to the environment from all sources
  - Reviewing Cl toxicity data to develop a Muskoka-based Cl guideline
- Evaluate alternative actions based on best practices outlined in the Lake Simcoe Region Conservation Authority salt reduction strategy, the Smart about Salt Program, and latest developments in non-additive de-icing technologies