Over-salting our lakes

Dr. Shelley Arnott

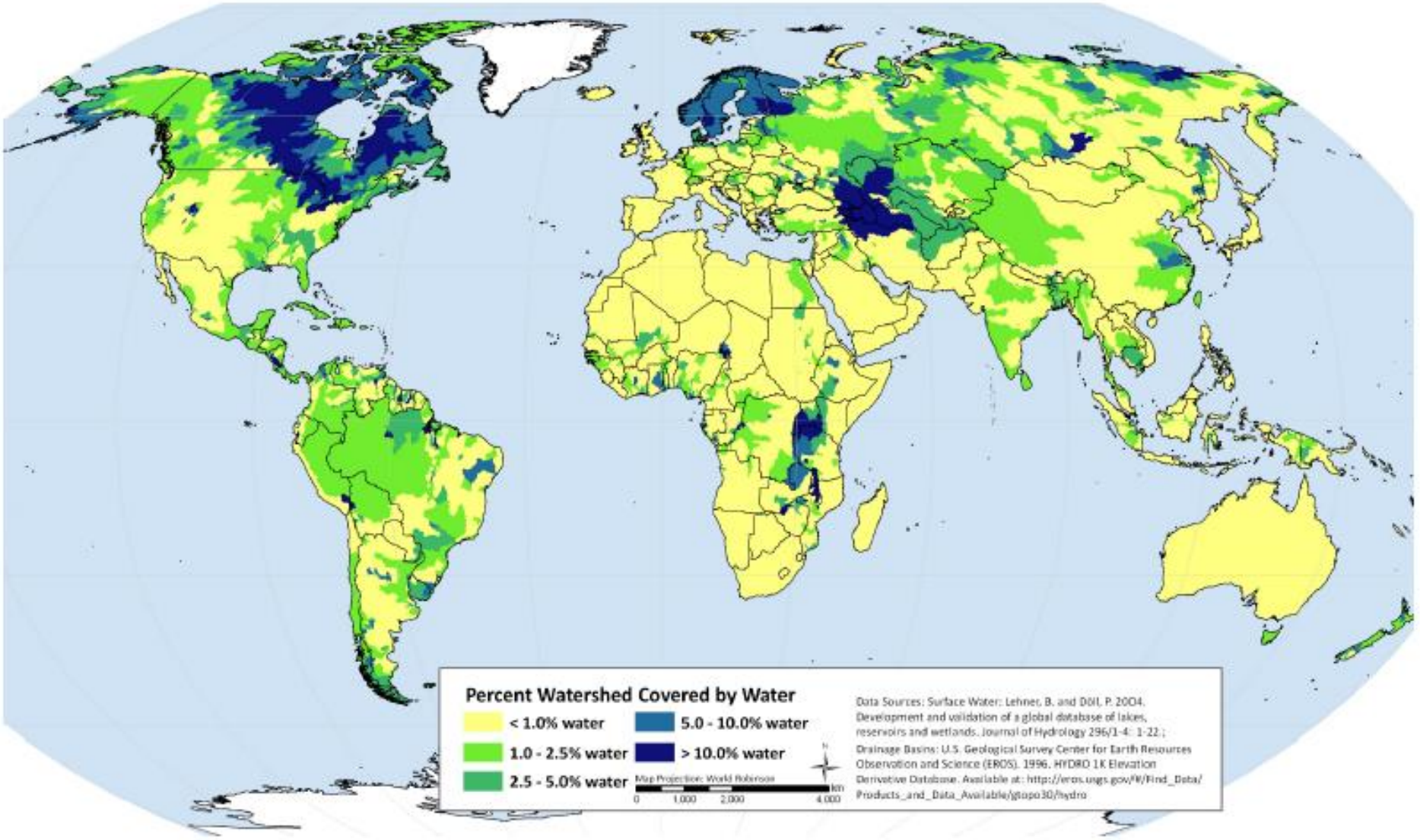
- Professor, Biology Department
- Queen's University

Over-salting our lakes: Why we need to reduce road salt use

Shelley E Arnott, Martha Celis-Salgado,
Alex McClymont, Danielle Greco, and Robin Valleau
Queen's University

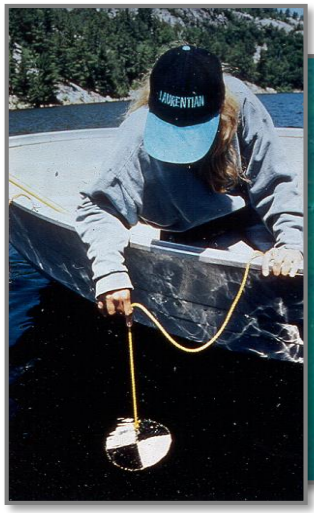
Canada is rich in freshwater resources

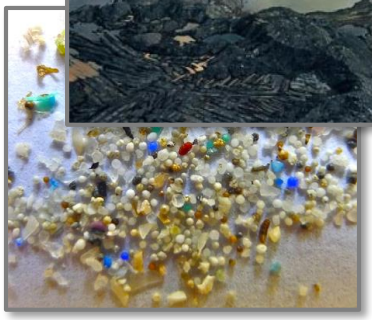
20% of world's freshwater is in Canada



Freshwater Services

Freshwater lakes are facing many challenges

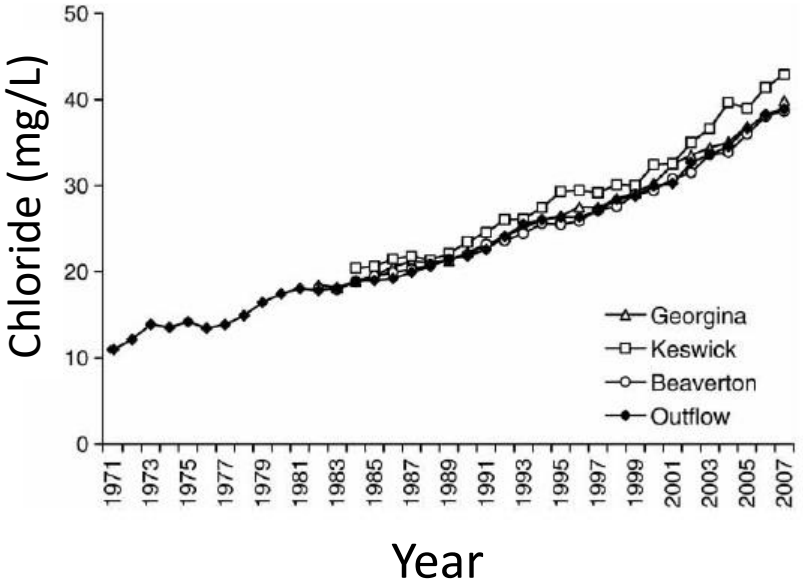




Habitat Alteration

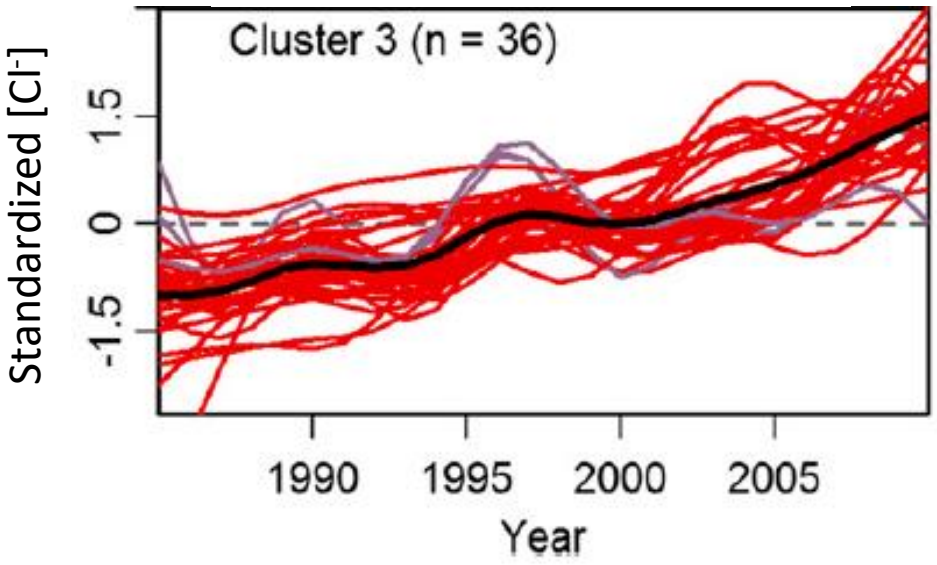
Chloride concentration is increasing in freshwater lakes and streams

Lake Simcoe



Also see Winter et al. 2011

North American lakes

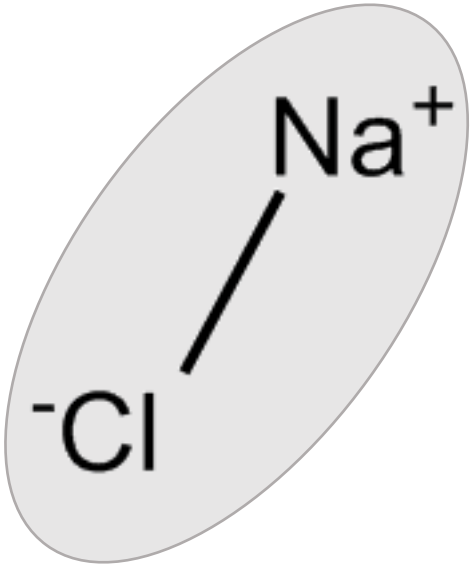


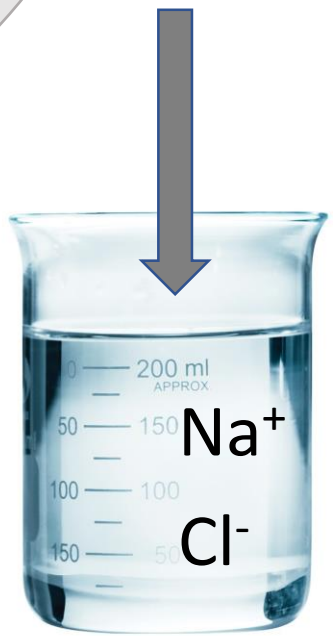
Dugan et al. 2017

Road salt – sodium chloride

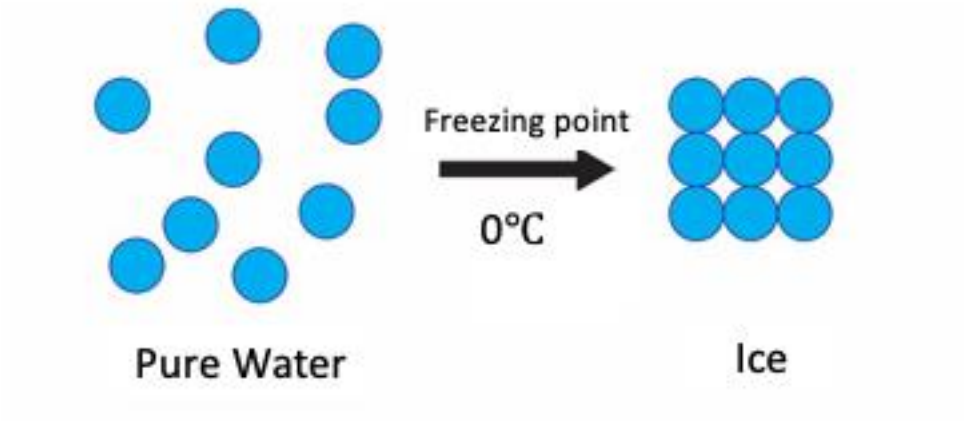
7 million tonnes applied to roads and parking lots each winter in Canada

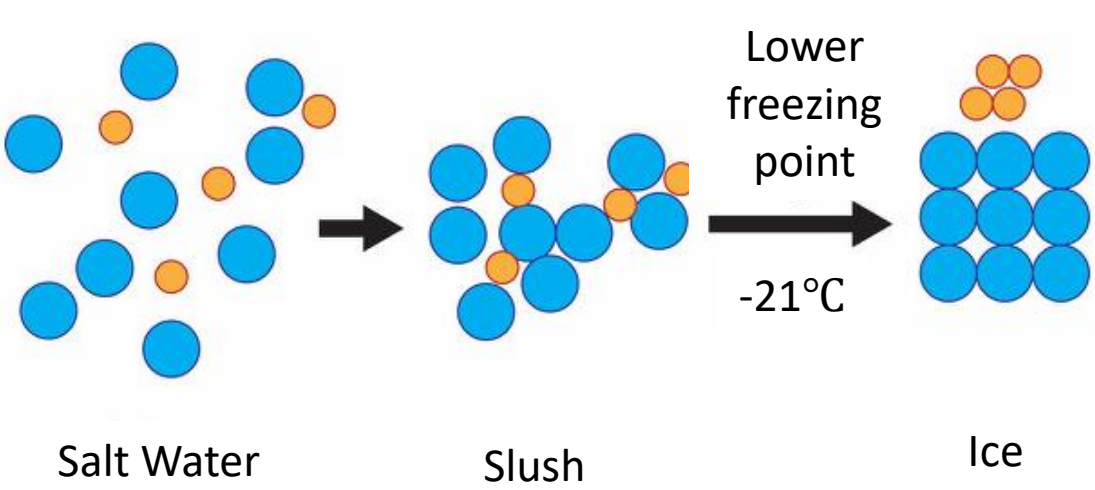
What happens to salt when it hits the roads?





Salt lowers the freezing point of water





Chloride movement through watersheds

Application of road salt to impervious surfaces

Direct Cl transport overland or piped flow

Streams and lakes

Soil water

Groundwater

Oswald et al. 2019 Sci. Tot. Env 652:278

Should we be concerned about salt?

- Ecological impacts in waterways
  - Loss of sensitive species, with small invertebrates most effected
- Loss of ecosystem services
  - Increased algal production
  - Drinking water

Road salt is corrosive and damages infrastructure

- Estimate cost to infrastructure, vehicles, household items ~ $4.8 billion/year

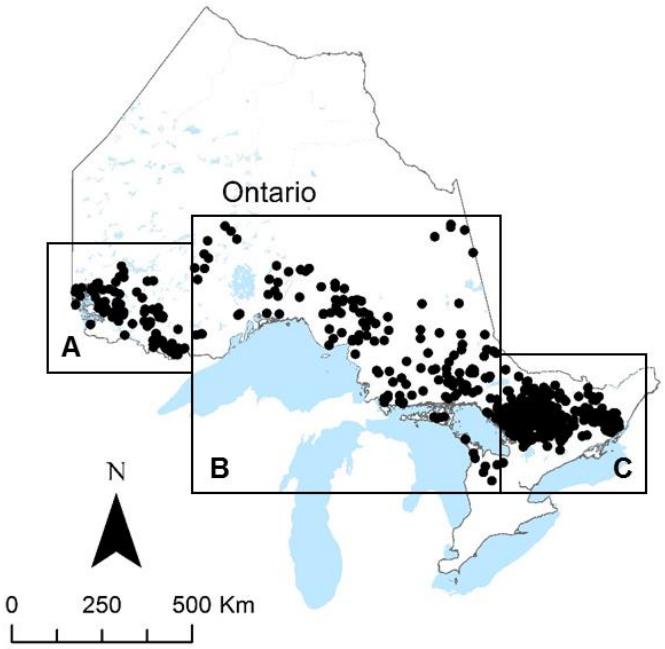
$847/year in car degradation

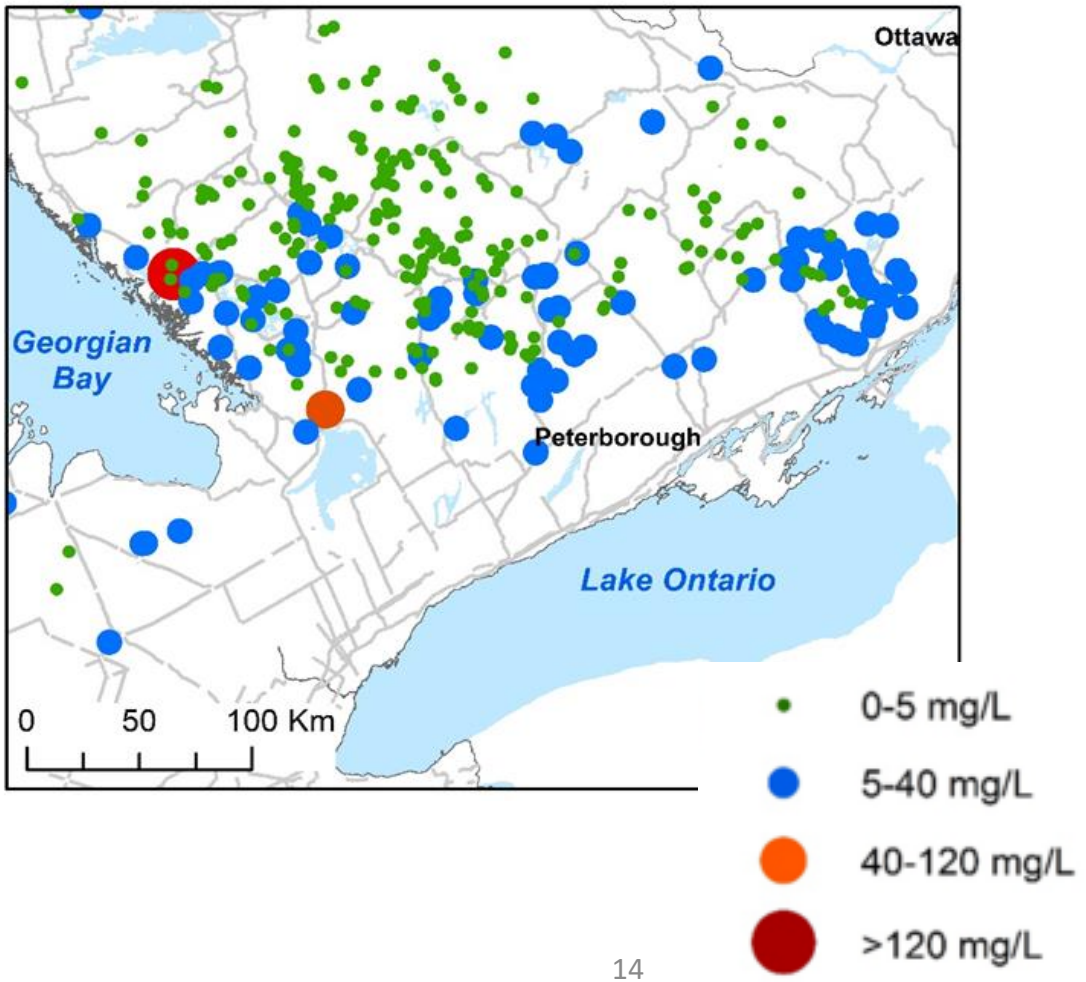
$4.2 billion in repairs for the Champlain Bridge in Montreal

$12 million/year in repairs for the Gardiner Expressway

Human lives - 2012 collapse of the Algo Centre Mall in Elliot Lake

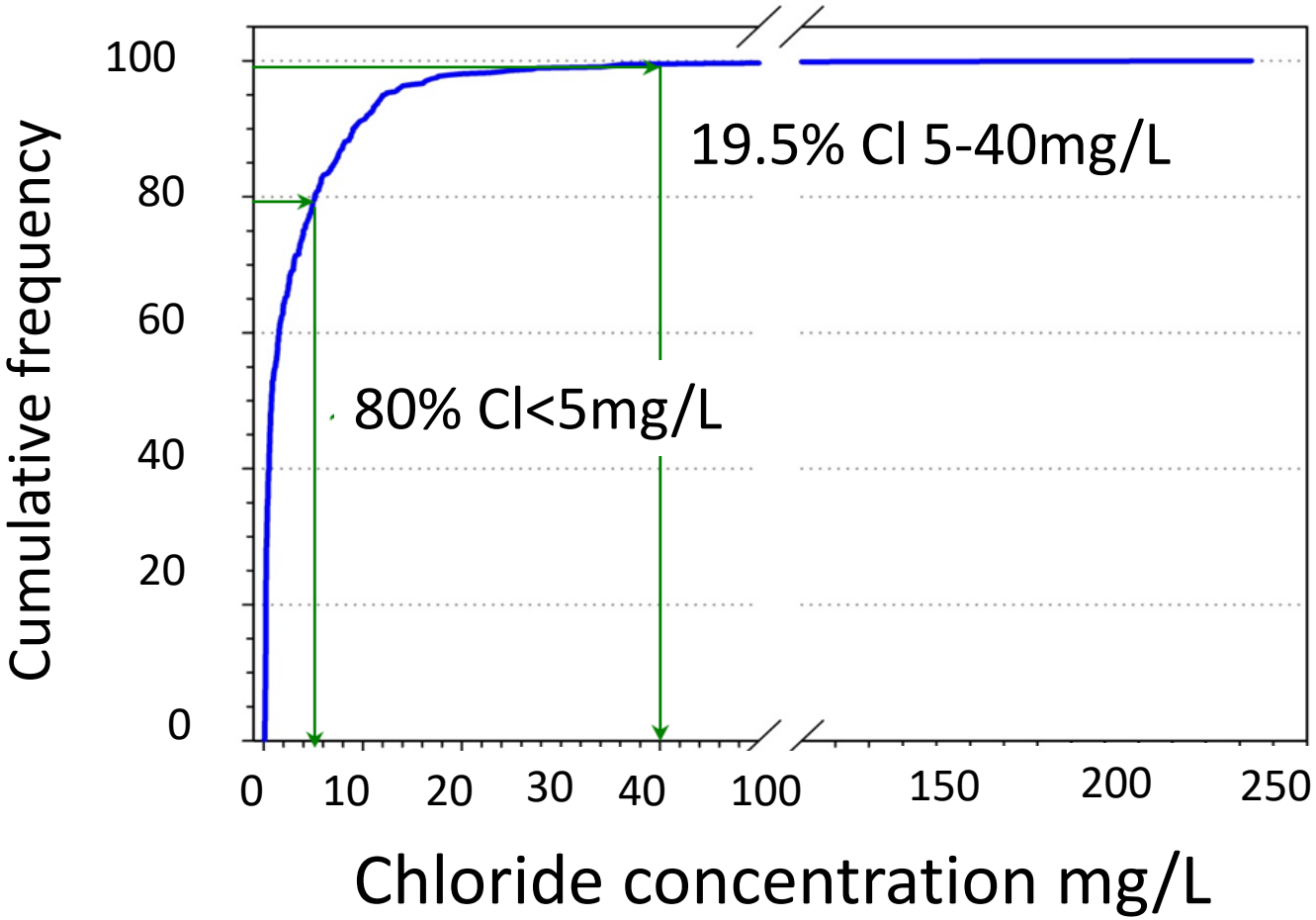
Chloride in Ontario's recreational lakes





Broadscale Monitoring Program
Lake Partner Program

Frequency distribution of chloride



Is aquatic life threatened?

Canadian water quality guidelines for the protection of aquatic life









Chronic exposure: 120 mg Cl^-/L

Acute exposure: 640 mg Cl^-/L

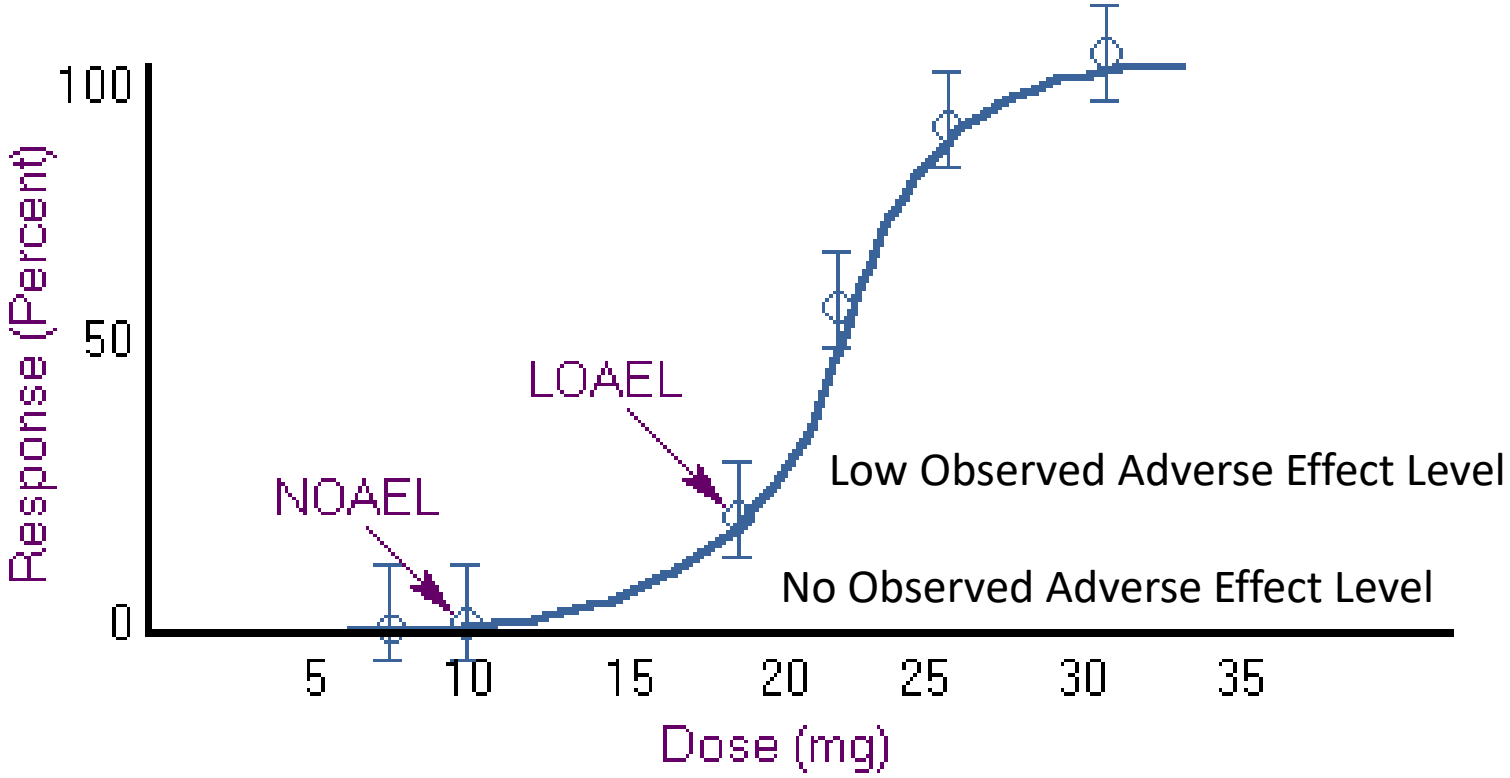
Guidelines may not be adequate

- Lab experiments
  - 6 *Daphnia* species
  - 10 iso-female lines from different lakes
- Mesocosm experiments on zooplankton communities
  - Paint Lake, Muskoka
  - Long Lake, Queen's University Biological Station
- Global salt experiment
- Historical changes in community composition
  - Jevins Lake, Muskoka

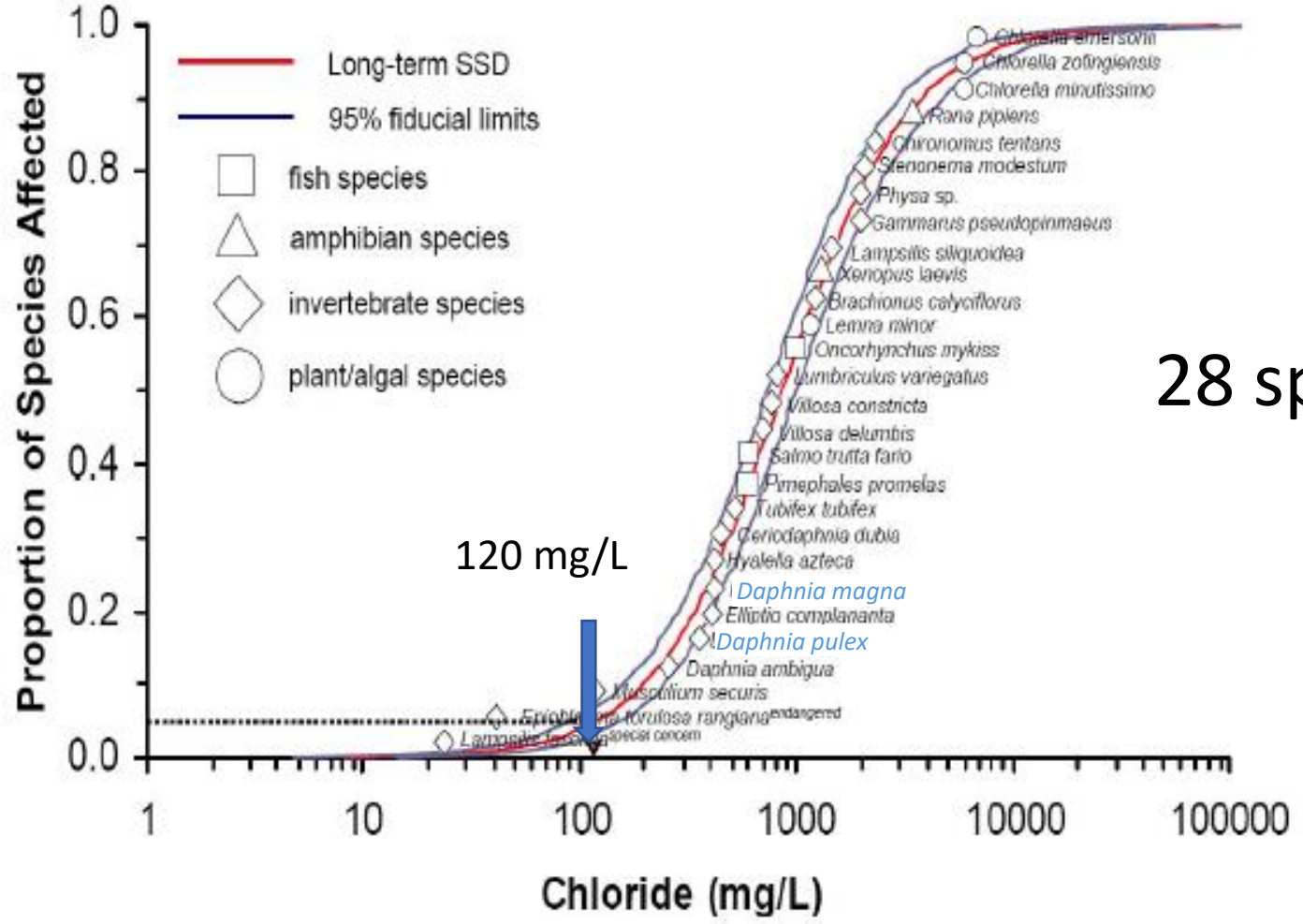
How are water quality guidelines determined?

Laboratory test on individual species

Survival
Reproduction



Water quality guidelines based on species sensitivity distribution



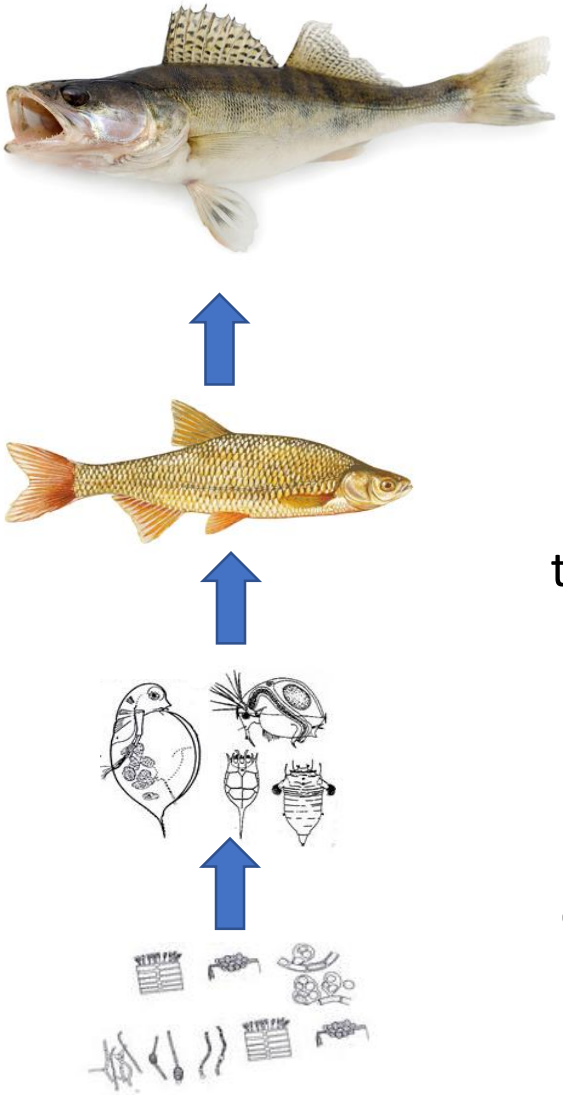
28 species

Why question the guidelines?

- Species tested
  - *Daphnia magna* - not in Boreal Shield Lakes
  - *Daphnia pulex* - mostly a pond species

- Water hardness
  - 40-180 mg/L of hardness as $CaCO_3$ for softest media (Elphick et al.2010)
  - Shield Lakes are 10-13 mg/L hardness as $CaCO_3$

Zooplankton



Are food for higher trophic levels like fish

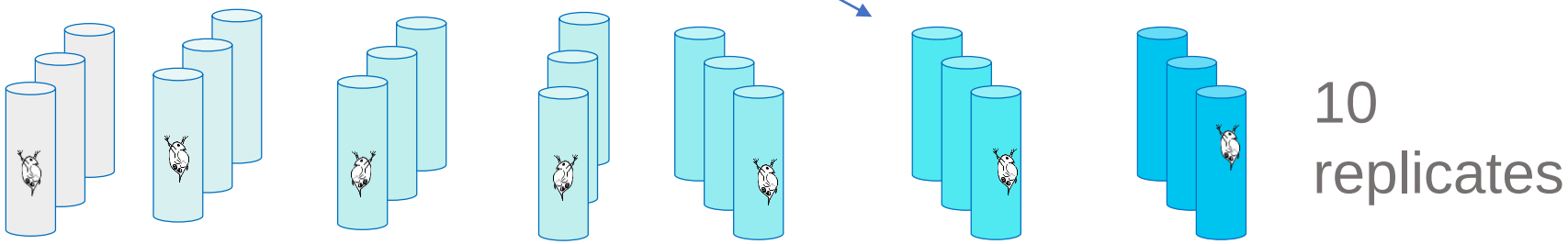
Control the amount of algae in lakes through grazing

21 day, soft water lab tests

Soft water media, FLAMES

6 species

High food concentration



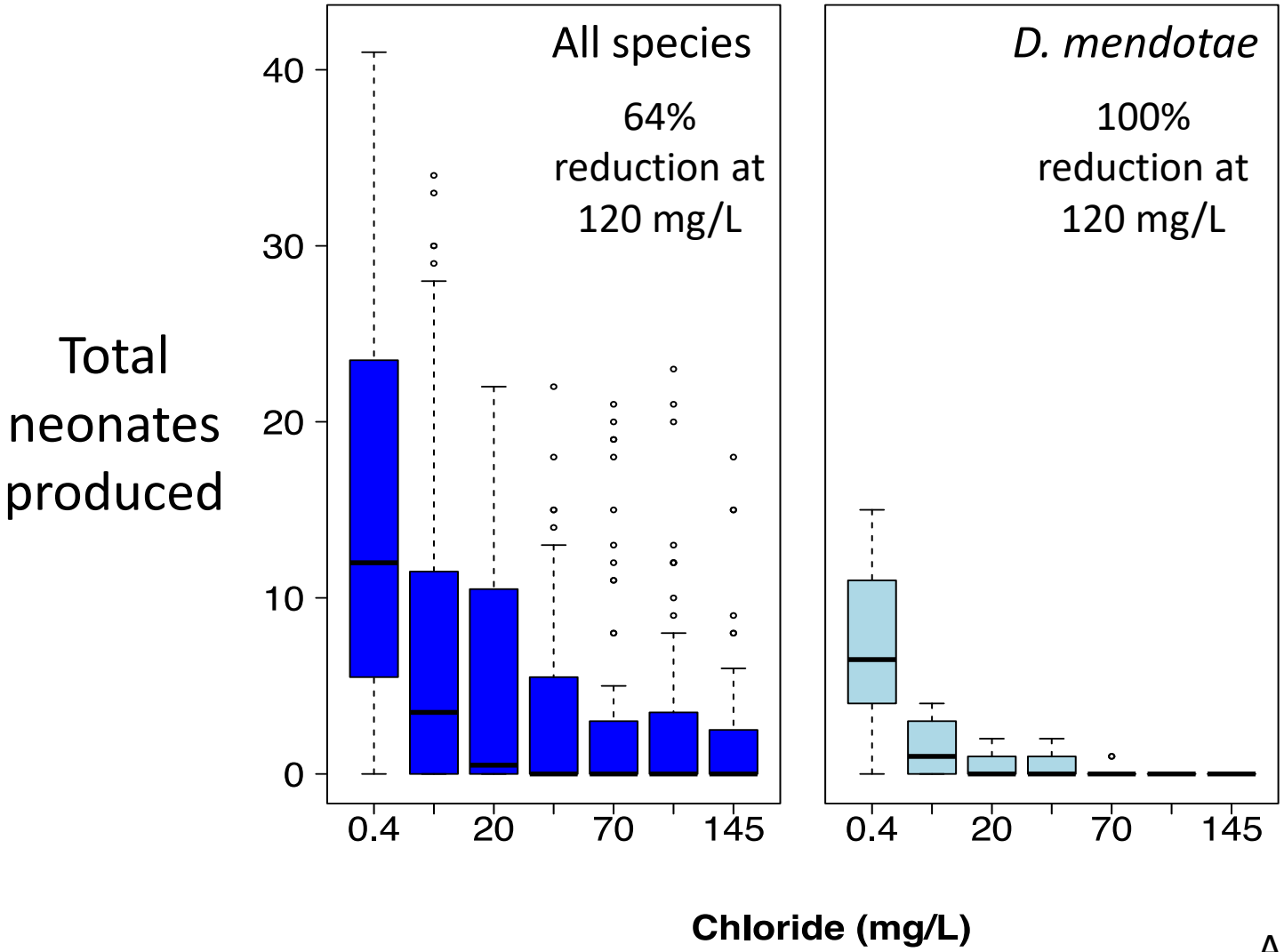
10 replicates

0.4 5 20 45 70 100 145 mg Cl/L

Daily survival
Offspring production

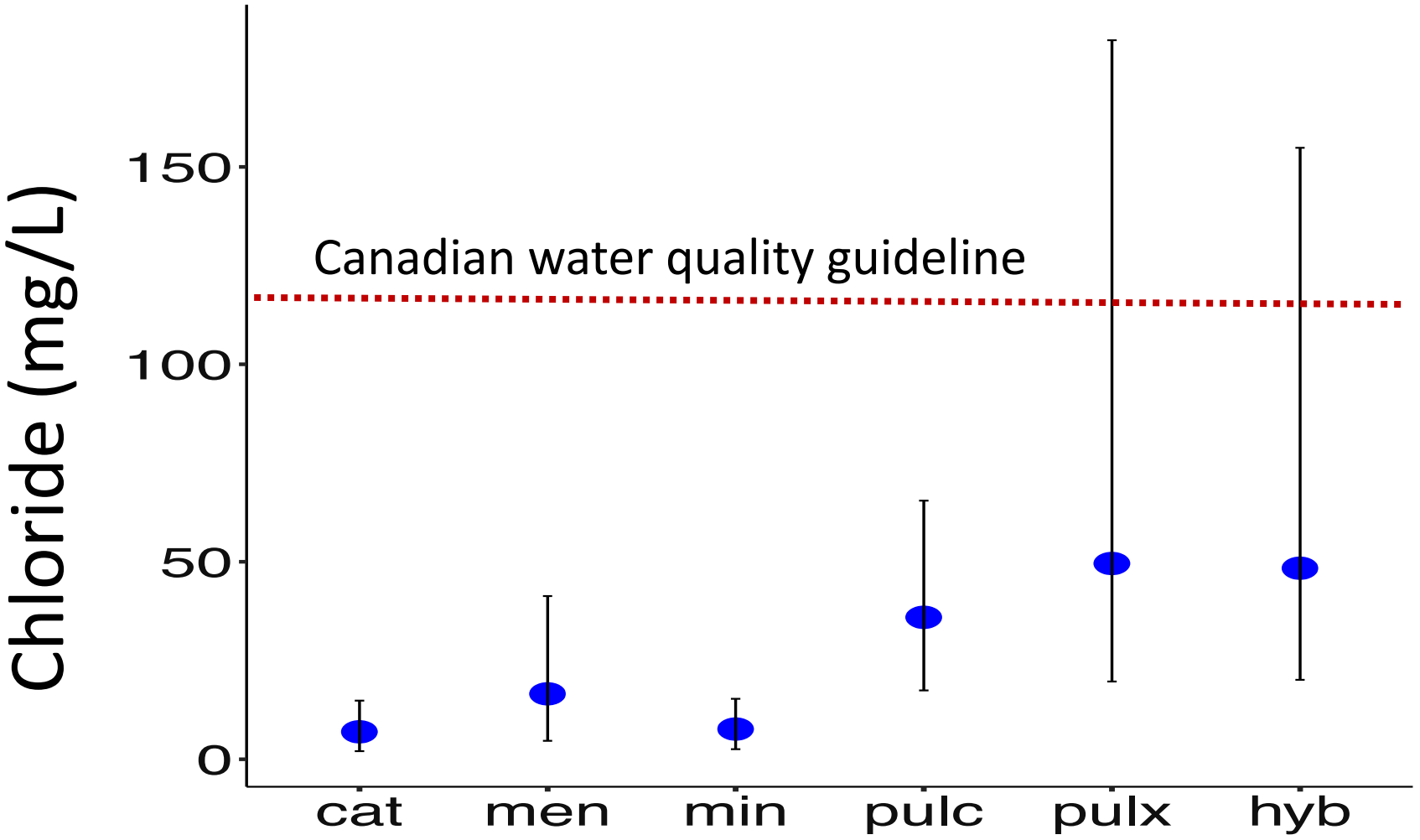
Martha Celis-Salgado

Increasing Cl reduced reproduction



Arnott et al. submitted

21-day LC50 for six *Daphnia* species



Celis-Salgado et al. in prep

21-day LC50 for 10 populations of *Daphnia pulicaria*

Celis-Salgado et al. in prep

Summary & Conclusion

- Laboratory experiments conducted in soft water, using multiple *Daphnia* species and clone lines
  - Reduced reproduction
  - Reduced survival

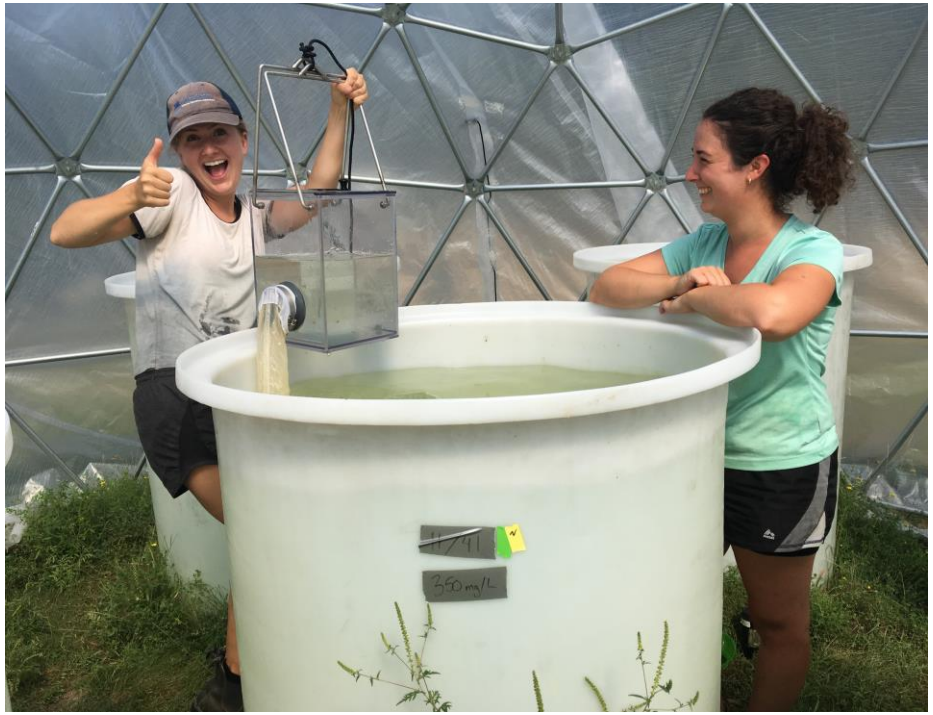
Current water quality guidelines may not provide adequate protection of Shield lake aquatic life

But….

- Lab-reared cultures
- Laboratory ≠ lake conditions
- Simple environmental context
- No species interactions

Field mesocosm experiments

Danielle Greco, MSc student



Alex McClymont, MSc student

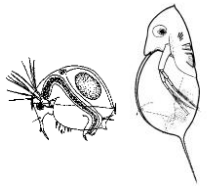
- 30 mesocosms along a gradient from ambient to 1500 mg Cl^{-1}/L
- High frequency of low Cl^{-1}
- Zooplankton response after 6 weeks

Study lakes

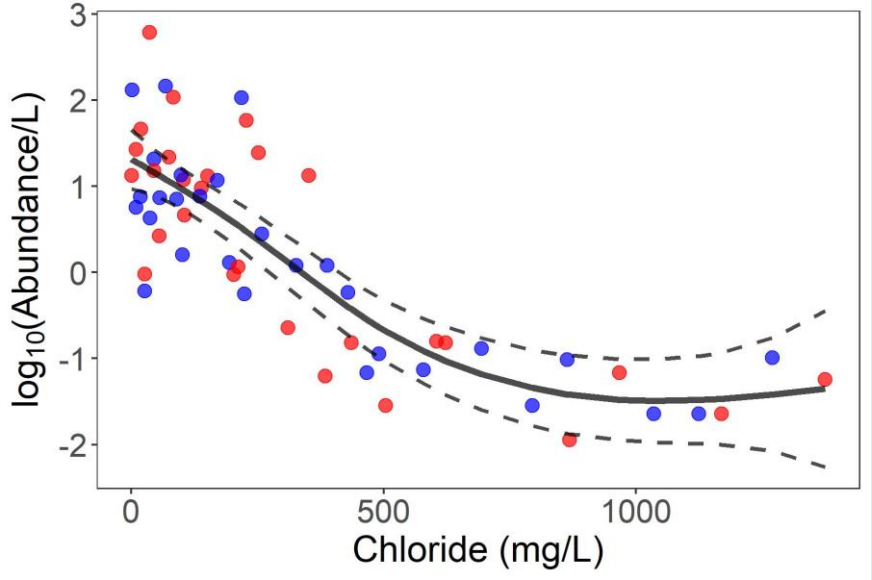
Long Lake, southern Ontario

Paint Lake, south-central Ontario

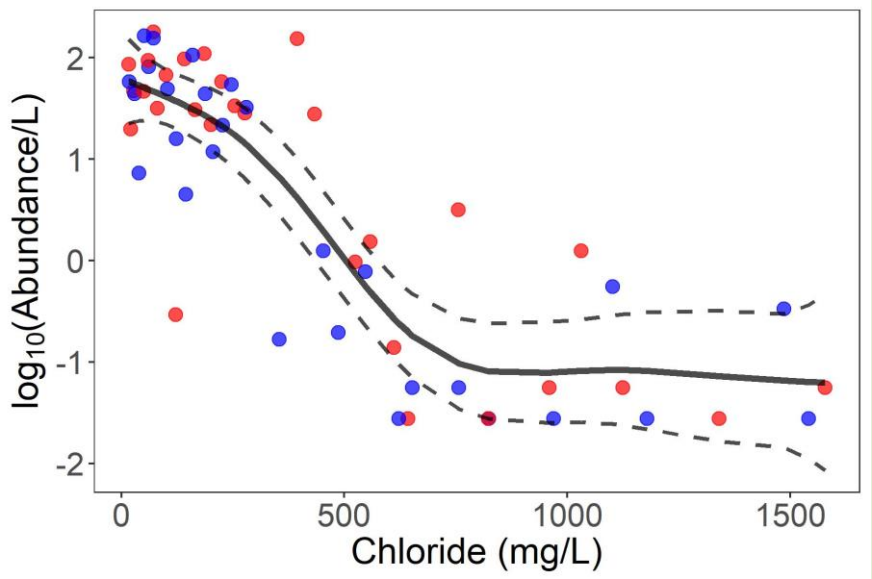
Cladoceran abundance



Long Lake



Paint Lake



Reduction at water quality guidelines

120 mg/L	62%	

120 mg/L	48%	

Global Salt Experiment

- 16 sites
- 4 countries; Canada, USA, Spain, Sweden

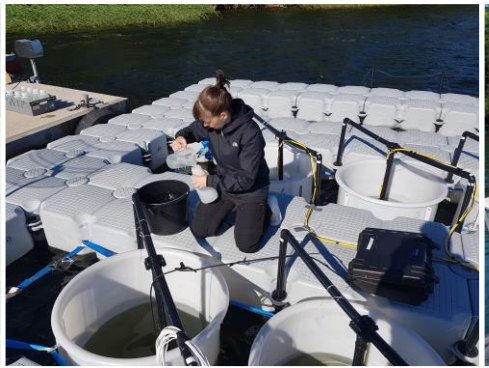






Coordinated experiments

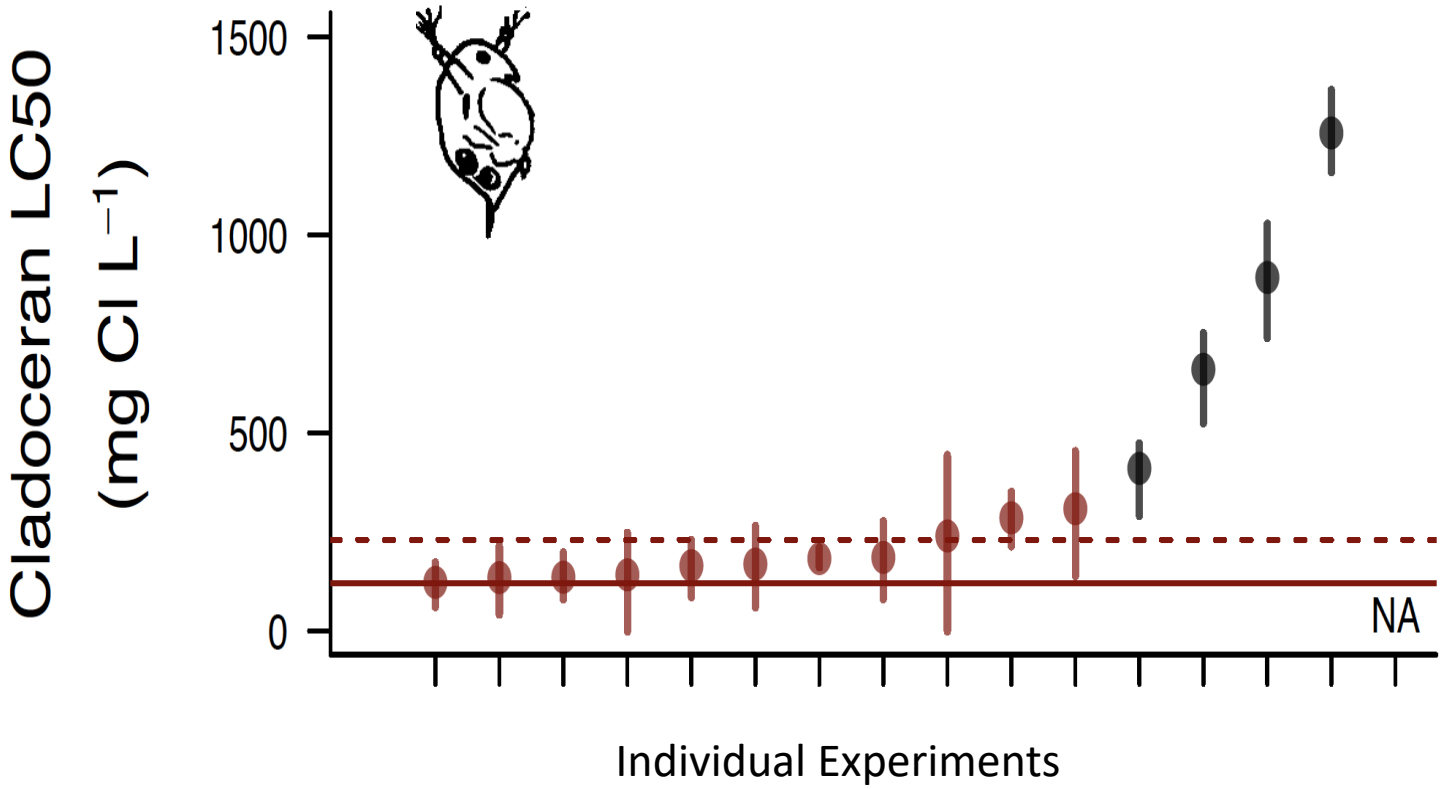
- Same experimental design and treatment gradient
  - 20-30 outdoor mesocosms
  - Chloride gradient from ambient to 1500 mg/L
- Same sampling protocol
  - 6 week experiment
  - Zooplankton, water chemistry
- Analyzed combined data

Workshop to combine results

Elbow Lake, Queen's University Biological Station

Zooplankton at most sites are sensitive

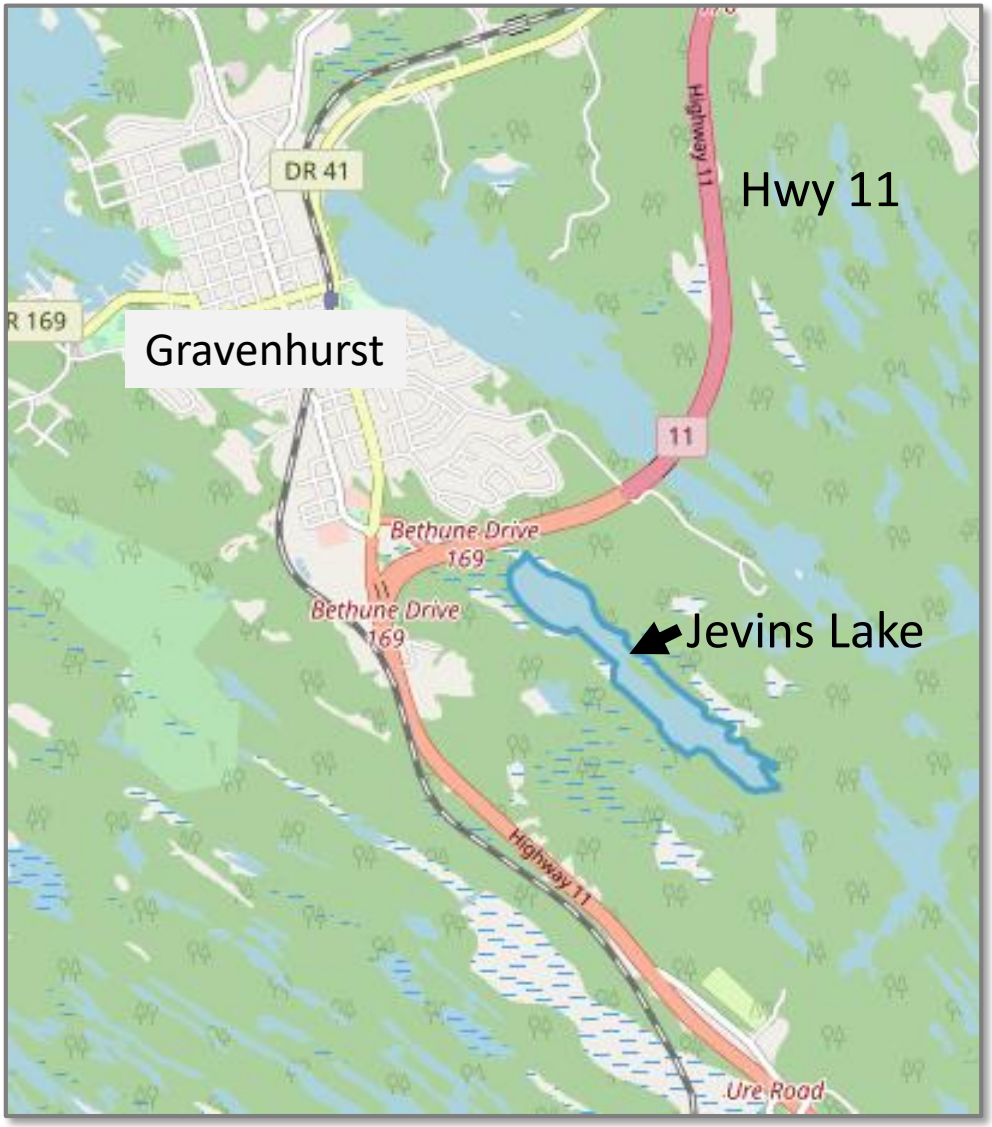


Conclusion

- Some variation in sensitivity among sites
- Cladocerans at most sites are vulnerable, even at current water quality guidelines

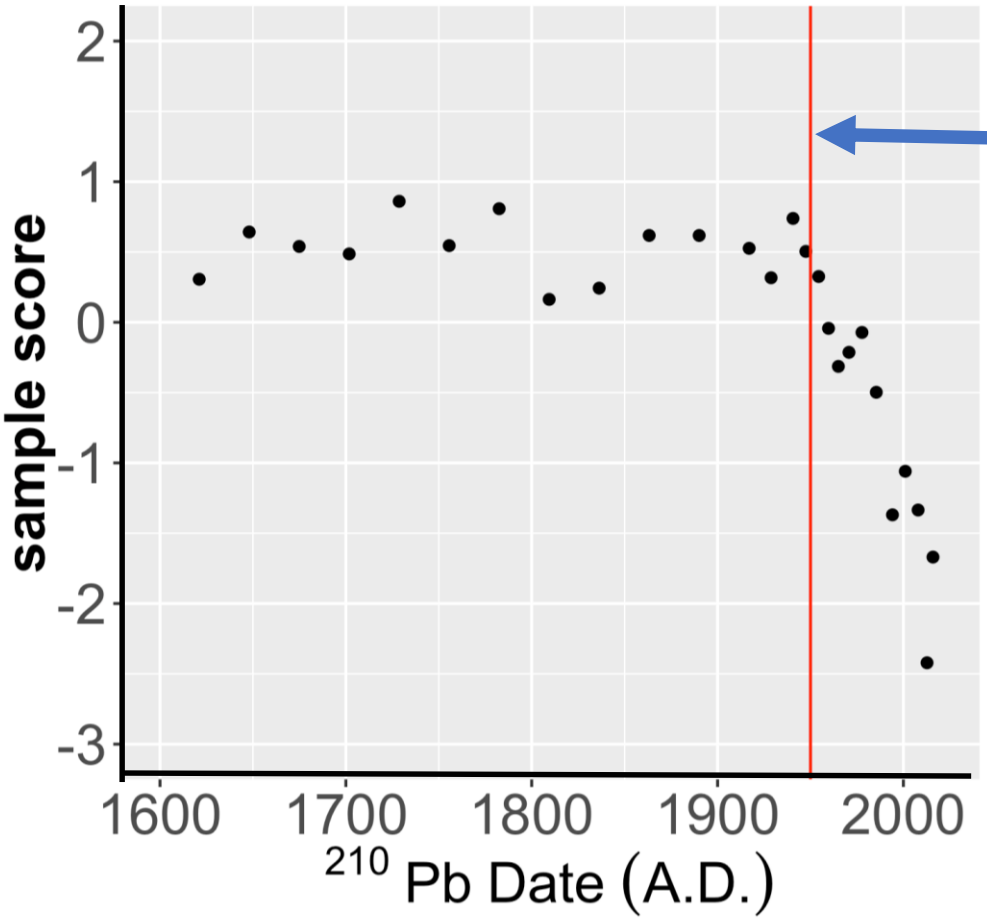
- BUT – is there evidence of declines in lakes?

Community change in Jevins Lake



Cladoceran community change in Jevins Lake

PCA Axis 1



Winter road salt application begins

Robin Valleau, unpublished data

Conclusion

- Current water quality guidelines do not protect zooplankton in all lakes
  - Laboratory experiments with multiple *Daphnia* species and populations
  - Field experiments in multiple lakes
  - Historical reconstruction of cladoceran communities

What can we do?

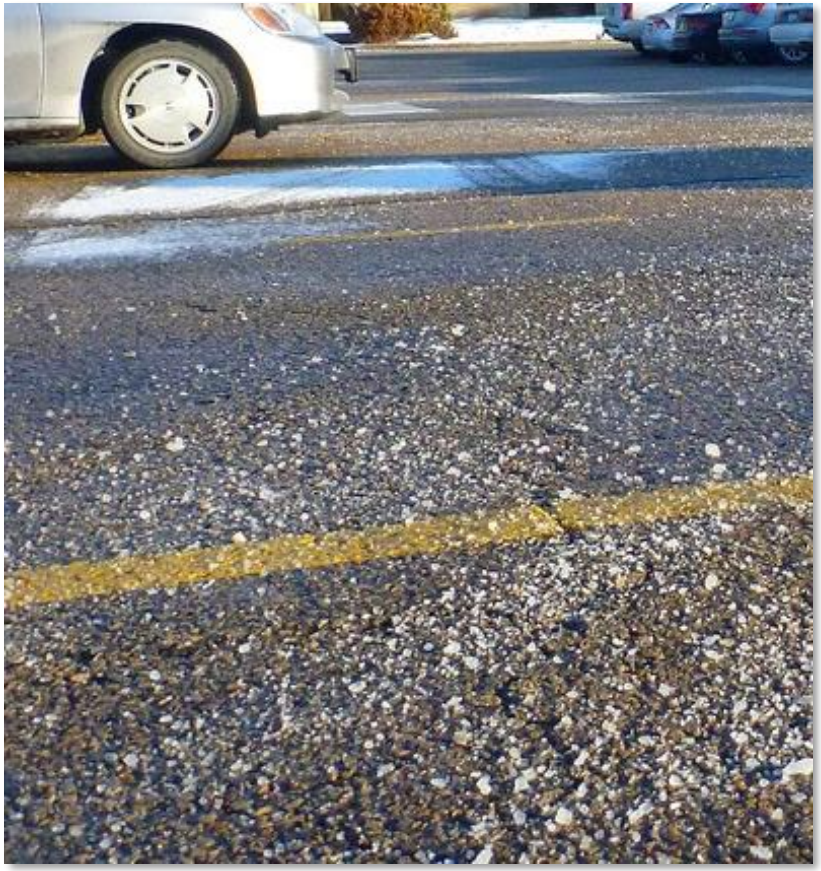
95% salt storage under roof and on impermeable pad – goal is 100%

94% salt trucks have ground speed electronic controllers

67% using pre-wetting or pre-treated salts
58% of vehicles equipped for pre-wetting

ECCC Report

Better management of private lots



- Only use salt when temperature > -10°C
- Ensure proper drainage of water
- Remove as much snow as possible for more effective de-icing
- Apply 1.5-3.5 kg/ha depending on temperature
- Smart about Salt training

Be safe, but use less salt

- Shovel snow
- Don’t overapply salt
- Pre-treat
- Apply brine
- Wear boots with traction
- Winter tires
- Drive cautiously

Acknowledgments

Field & Lab Assistants

Hayley Richardson

Brooke Rathie

Sara Baker

Nathaniel Wong

Queen's University

Best-in-Science

NSERC CRSNG

GLEON global lake ecological observatory network

DORSET ENVIRONMENTAL SCIENCE CENTRE

QUEEN'S UNIVERSITY BIOLOGICAL STATION

ciee icéé canadian institute of ecology and evolution institut canadien d'écologie et d'évolution