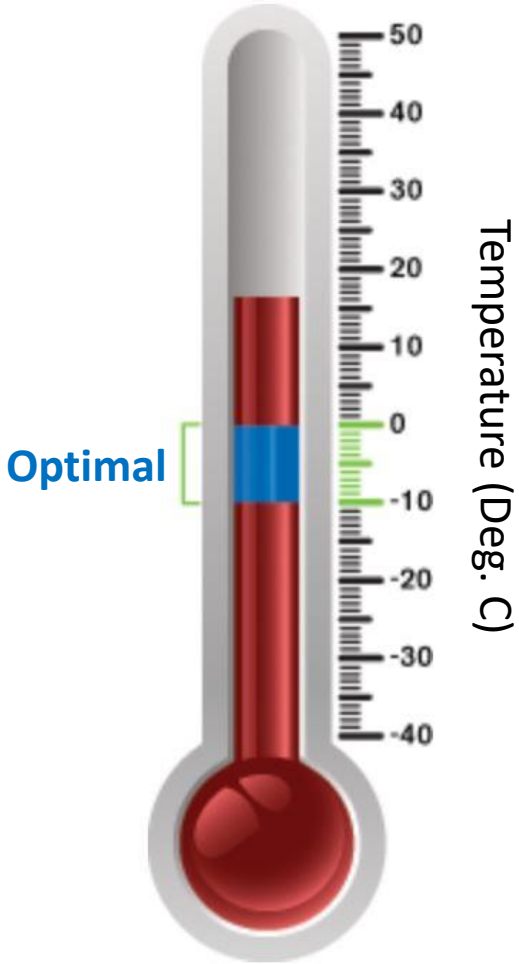
Chloride Trends in Ontario Surface Waters

S. Arnott[1], N. Benoit[2], M. Celis-Salgado[1], A. DeSellas[2], C. Holeton[2], T. Howell[2], C. Jones[2], G. Kaltenecker[2], M. Palmer[2], A. Paterson[2], J. Rusak[2], **R. Sorichetti[2]**, A. Todd[2], N. Yan[3], H. Yao[2]

Queens University[1], Ontario Ministry of the Environment, Conservation and Parks[2], York University[3]

Why the focus on chloride?

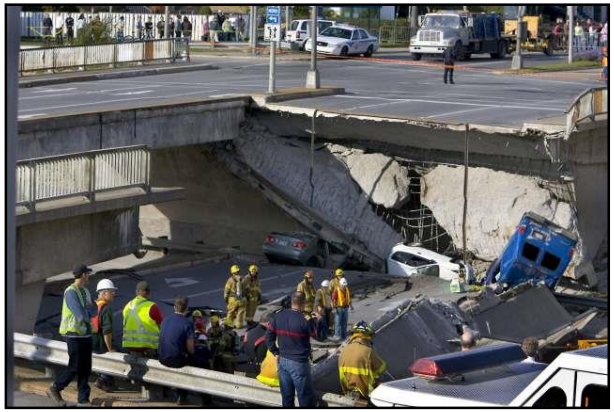
- Sources of chloride in surface waters
  - "De-icers" and water softeners
- Most common "de-icers" in N. America:
  - Na**Cl**, Mg**Cl**$_2$, Ca**Cl**$_2$, K**Cl** – $50/tonne
- Hygroscopic properties
  - Strongly attracts moisture from surroundings
  - Lowers brine solution freezing point
- Road salt alternatives
  - Sugar beat juice, pickle brine, cheese brine
  - 6 – 18 × higher cost



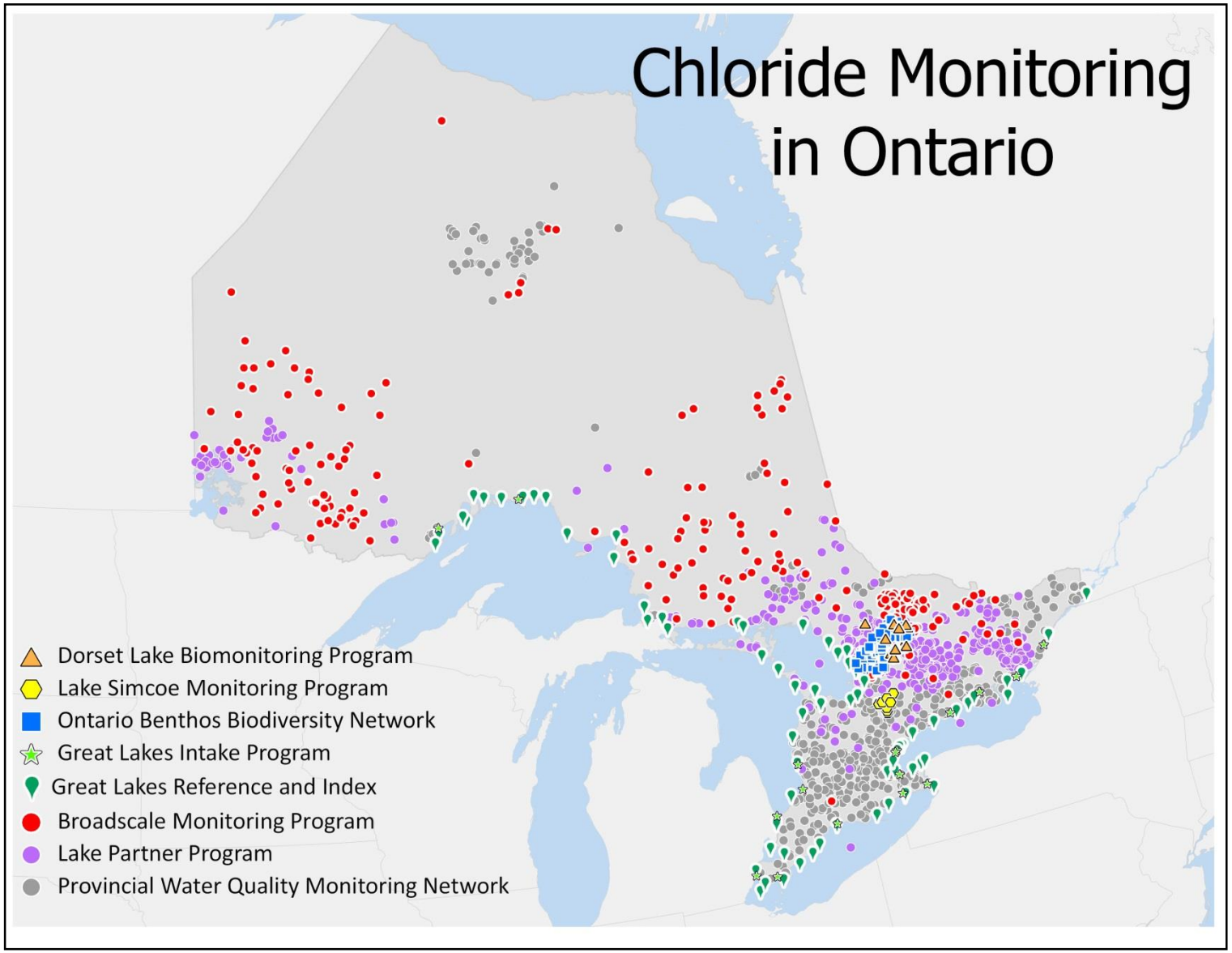
Ontario

Safety and economic implications

- Canada applies 5 to 9 million tonnes annually
- Transport Canada (per car, per year):
  $200 (1975) → $854 (2017)
- Roads, buildings, bridges: $680 to $5000/tonne
- Increased incidence of vehicle and animal encounters



Ontario

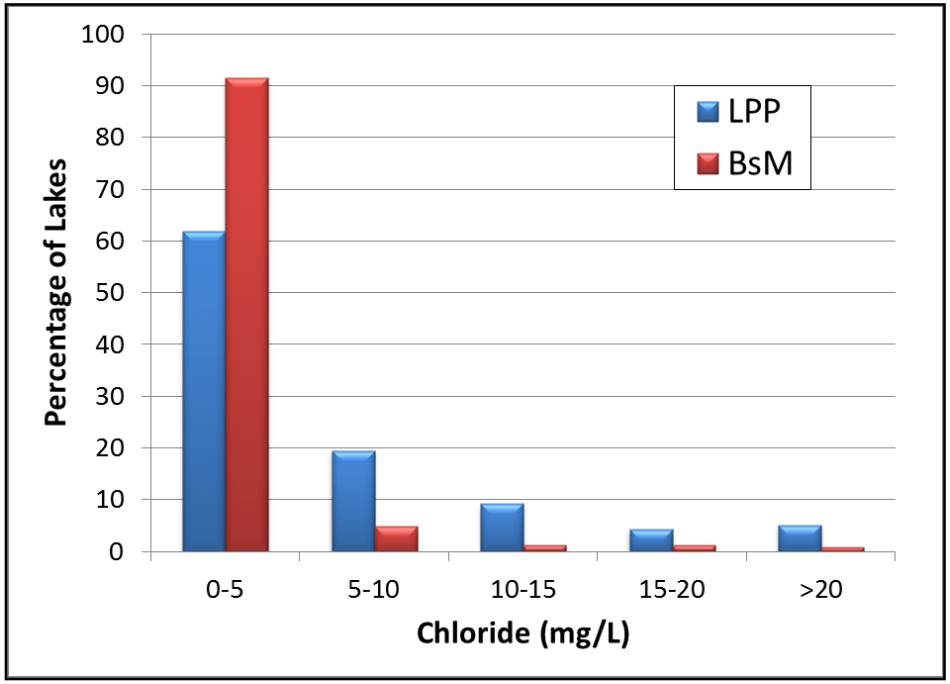


Ministry of the Environment, Conservation and Parks (MECP)

Ontario

Building a lake Cl database in Ontario

- Lake Partner Program (LPP) in 2015; Broadscale Monitoring program (BsM) in 2008
- Cl in 690 lakes across Ontario from 2013-2016

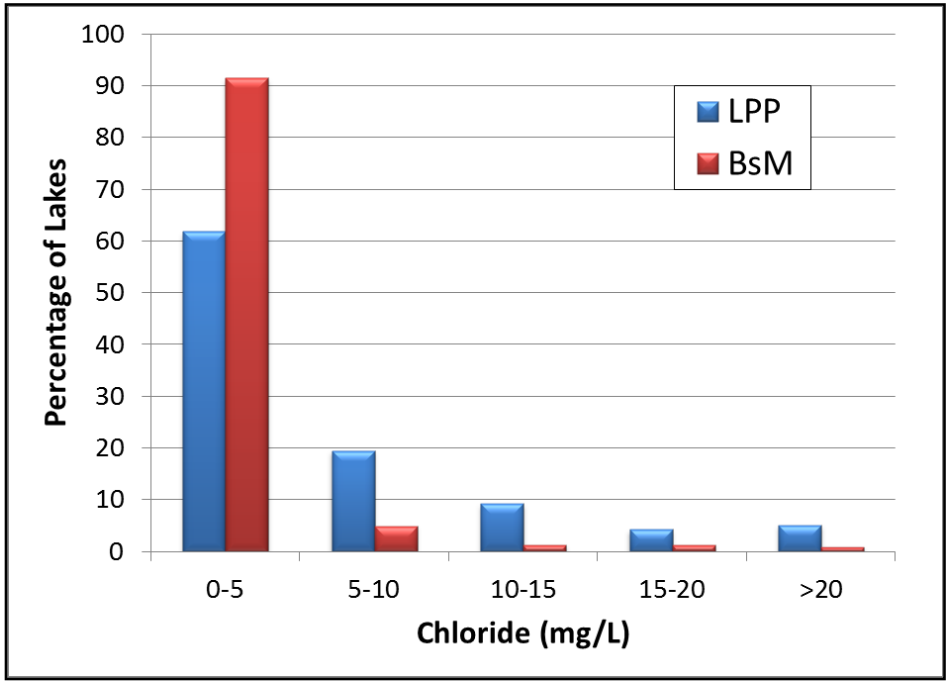


LPP (MECP Dorset); BsM (MNRF)

Ontario

Building a lake Cl database in Ontario

- 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 (Brown & Yan, 2015)



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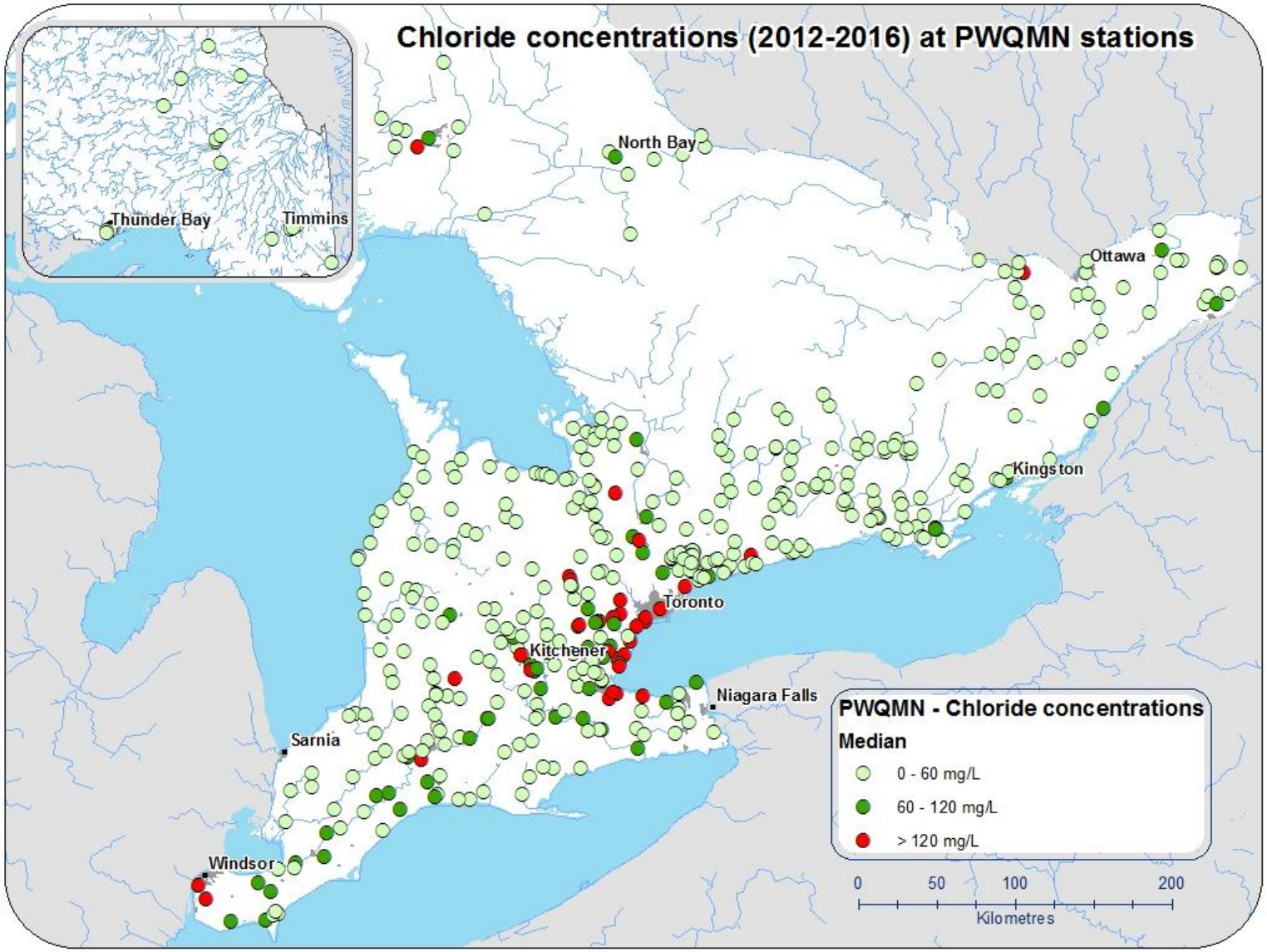
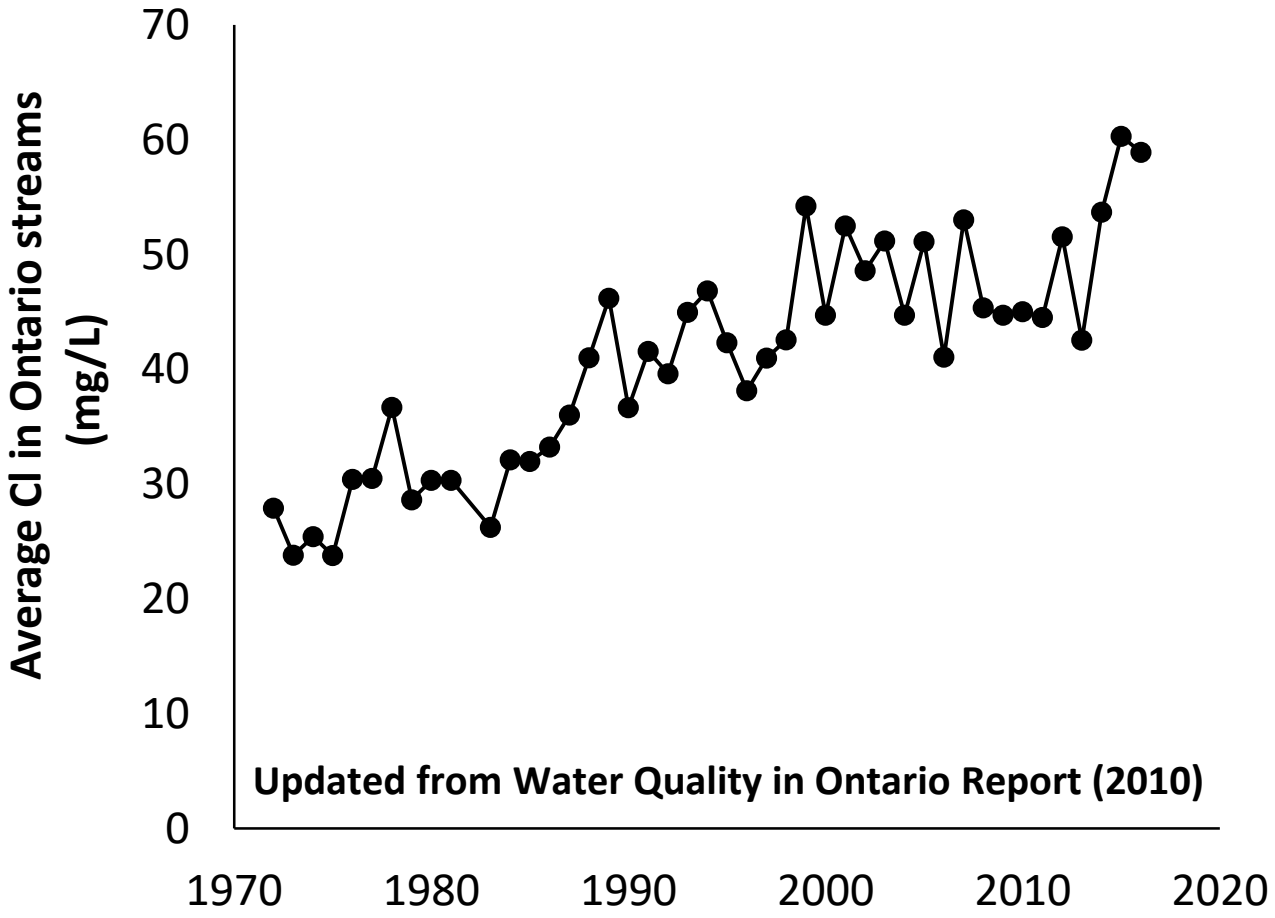


Provincial Water Quality Monitoring Network (PWQMN)

Ontario

Increased stream Cl concentrations since 1970's



Provincial Water Quality Monitoring Network (PWQMN)

Todd & Kaltenecker (2012) – *Environmental Pollution*

Ontario

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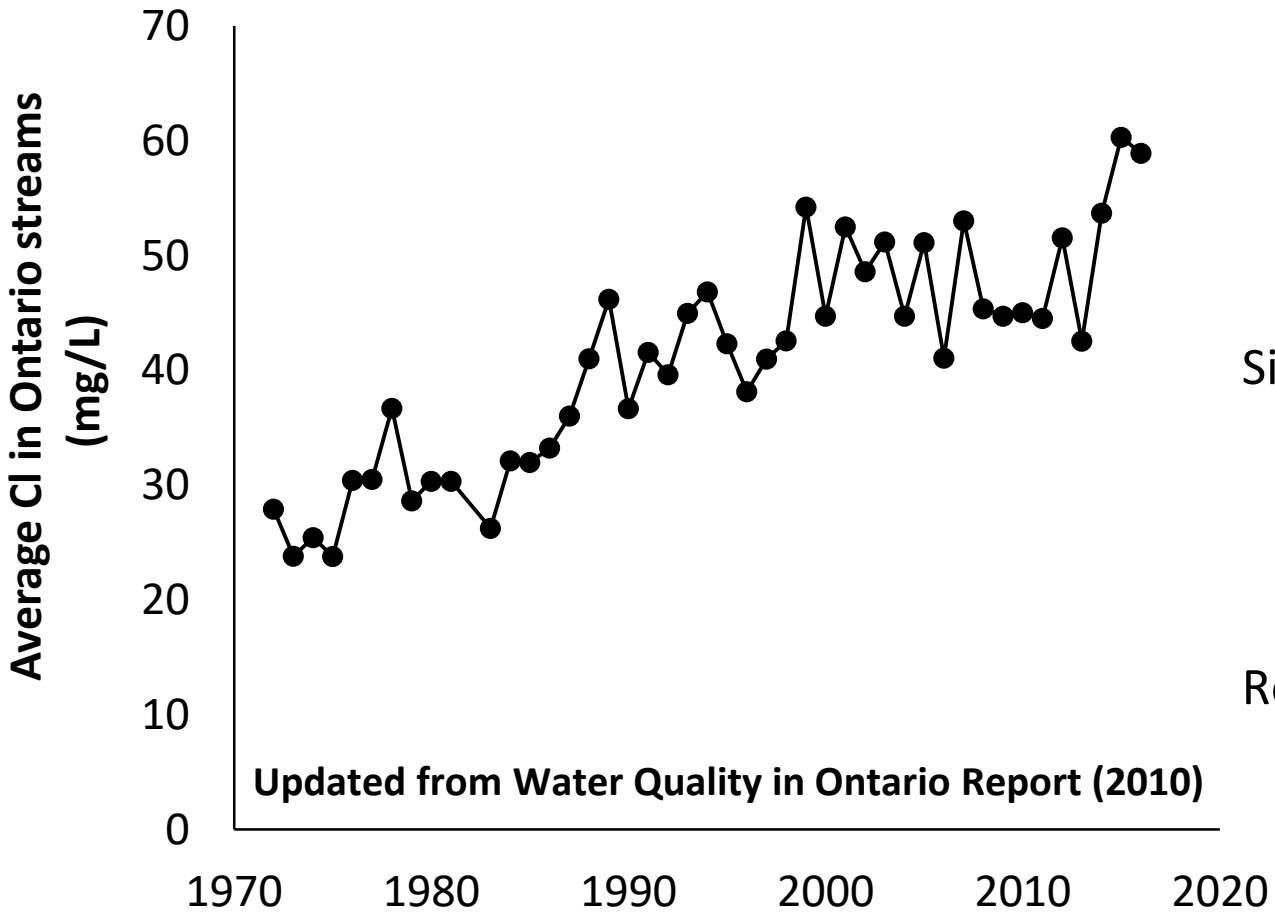


Significant increases in concentrations observed at majority of long-term stream monitoring sites in southern Ontario

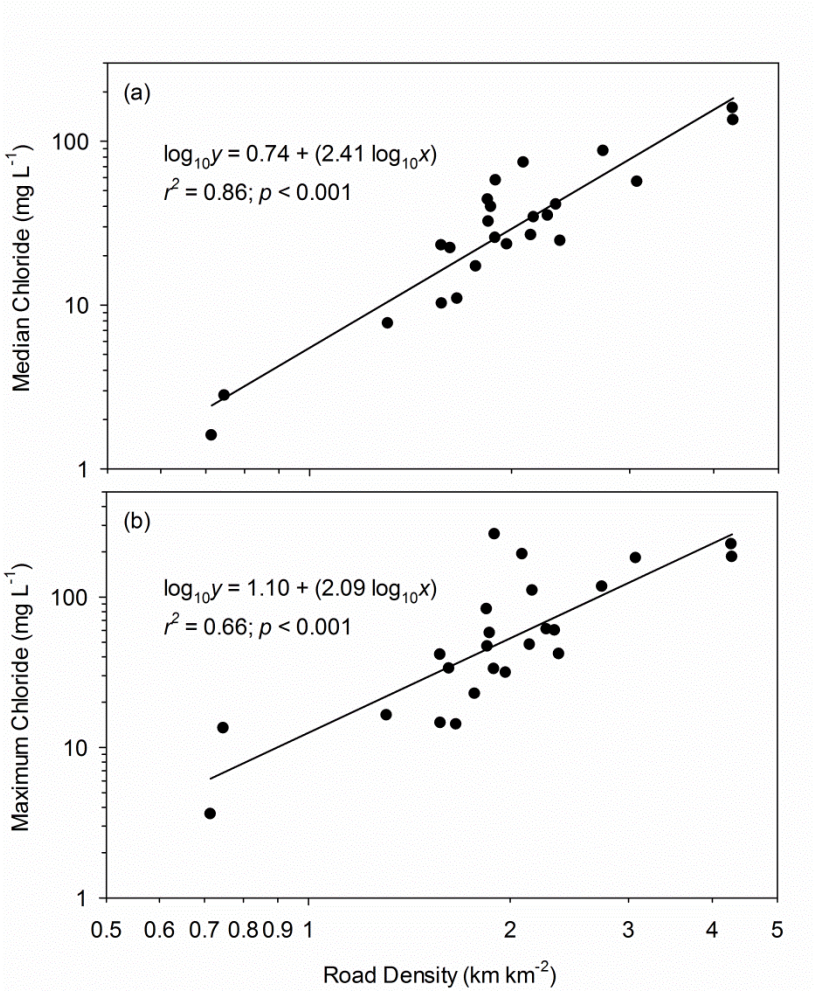
Results suggest long-term road salt use is contributing to gradual increase in chloride concentrations in at risk mussel habitats

Provincial Water Quality Monitoring Network (PWQMN)

Todd & Kaltenecker (2012) – *Environmental Pollution*

Ontario

Stream chloride concentration significantly correlated to road density



High population density leads to high road density

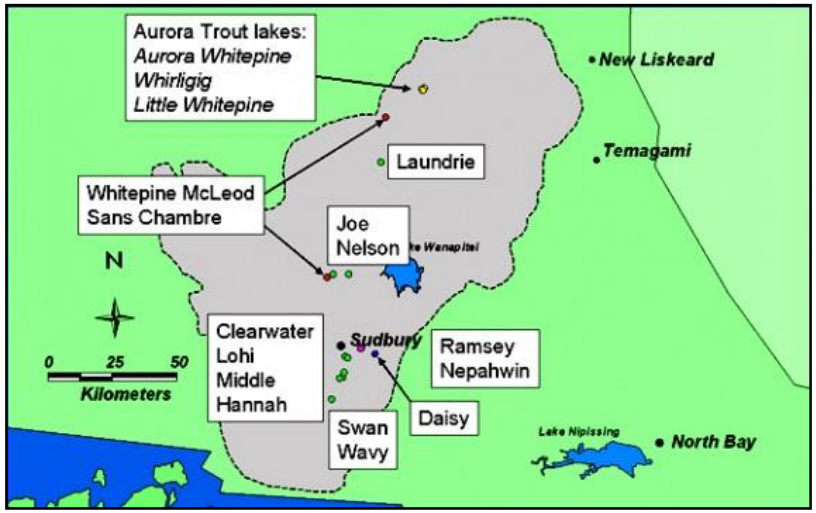
Median and **maximum** chloride concentrations positively and significantly correlated to road density

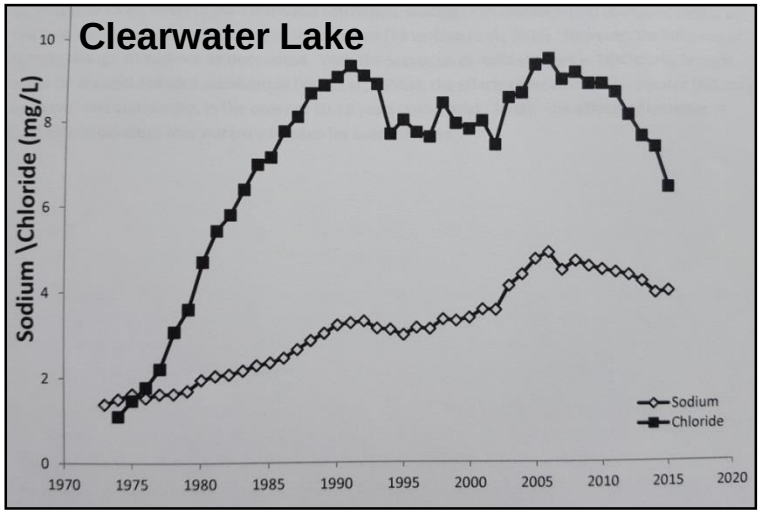
Todd & Kaltenecker (2012) – *Environmental Pollution*

Ontario

Sudbury long-term lake monitoring

- Average Cl in lakes increasing and plateau well below sensitive species guideline (ECCC, 2001)



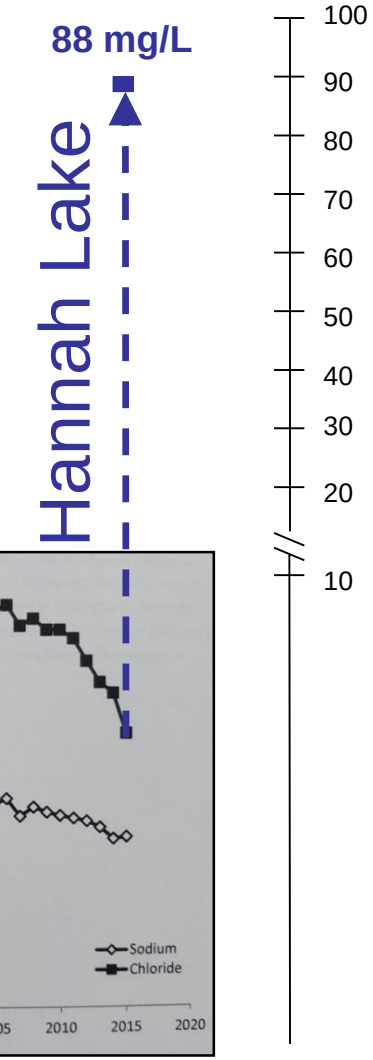


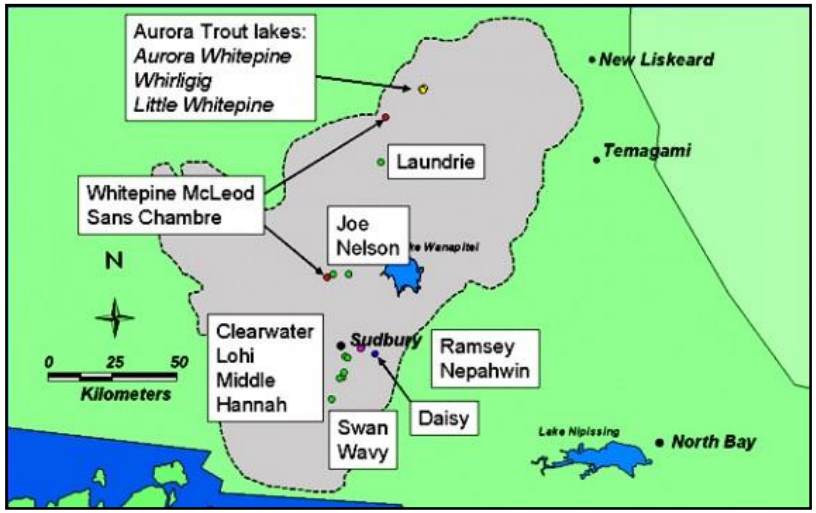
MECP Long-Term Lake Monitoring

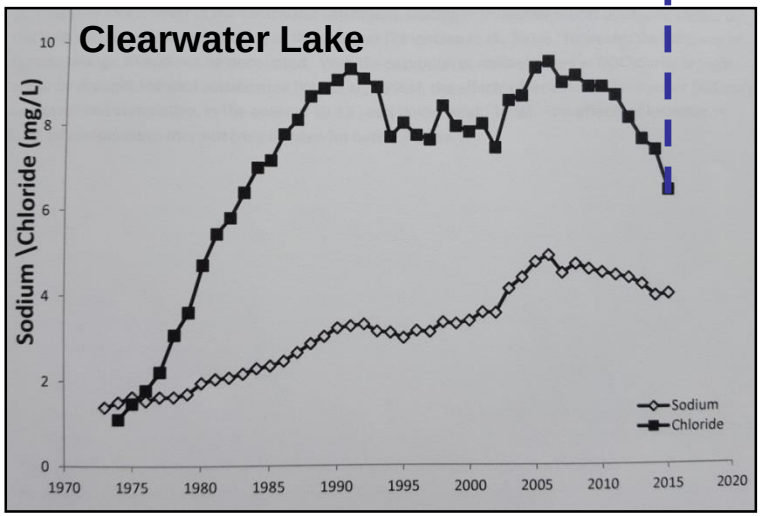
Ontario

Sudbury long-term lake monitoring

- Average Cl in lakes increasing and plateau well below sensitive species guideline (ECCC, 2001)
- Some urban lakes show higher increases (e.g., Hannah Lake)
- Separating ecological effects from post-acidification recovery trajectories is difficult and ongoing



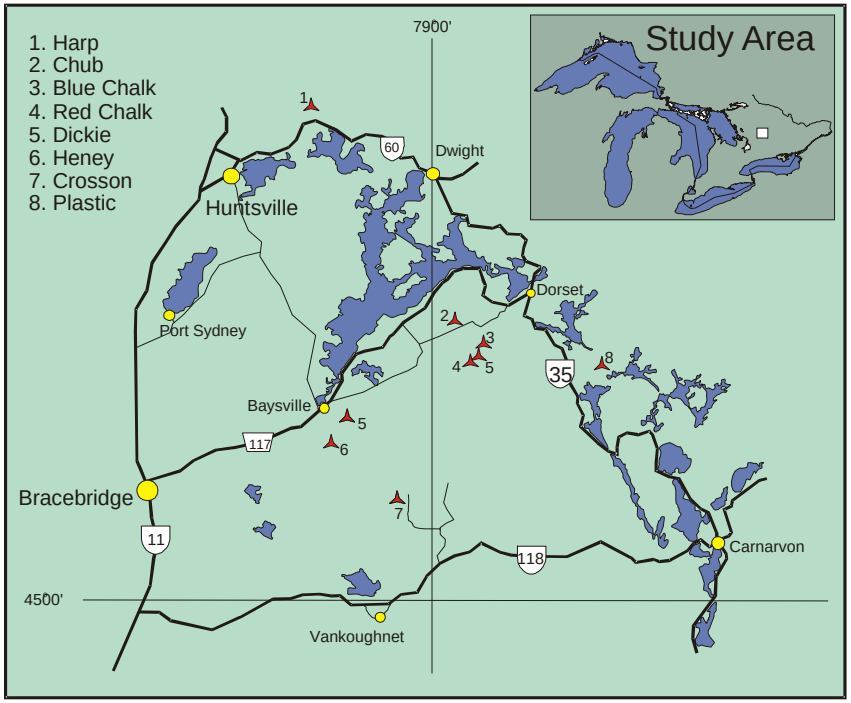


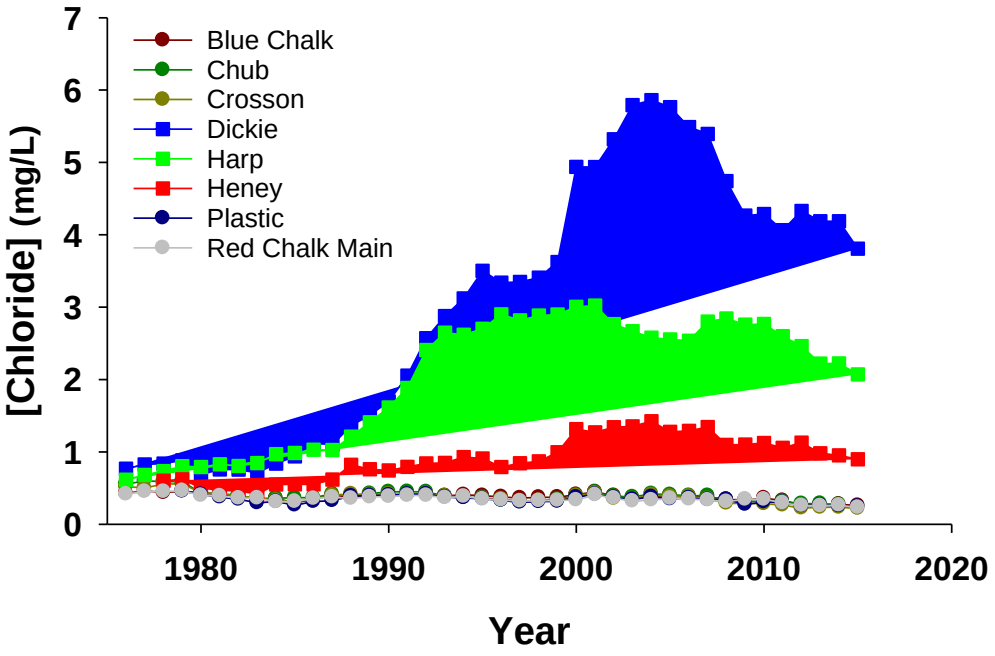


MECP Long-Term Lake Monitoring

Ontario

Long-term changes in the Dorset “A” lakes



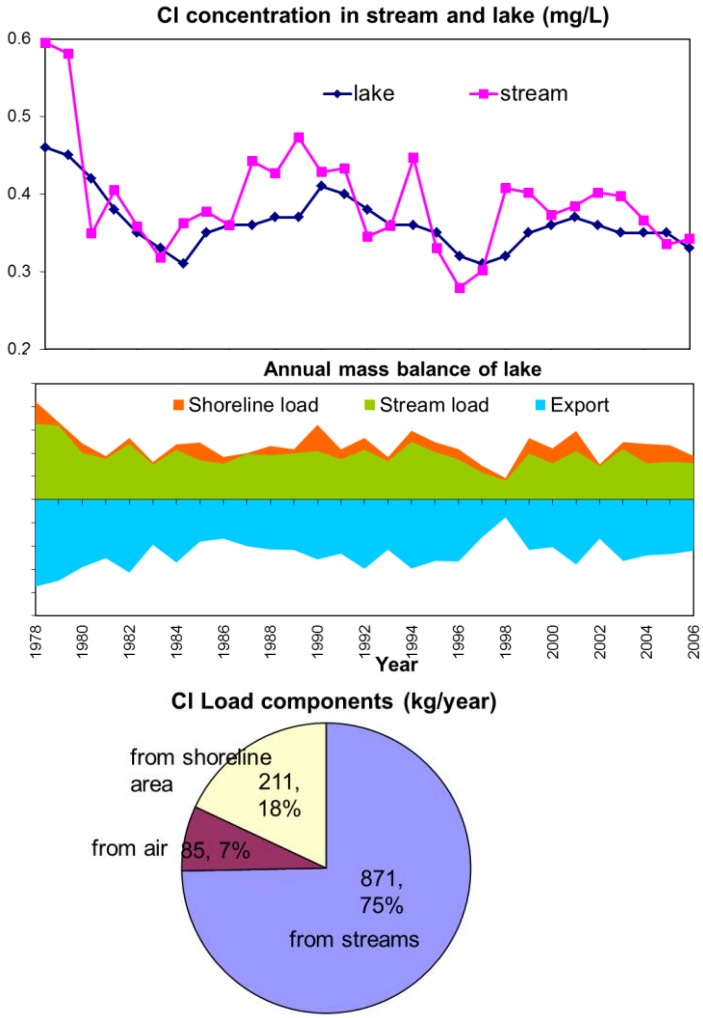


MECP (Dorset) Long-Term “A” Lakes Monitoring

Ontario

Comparing loads with differing land use

Red Chalk: **Pristine**: Cl declined slightly; loading decreased; load mainly from streams



Ontario

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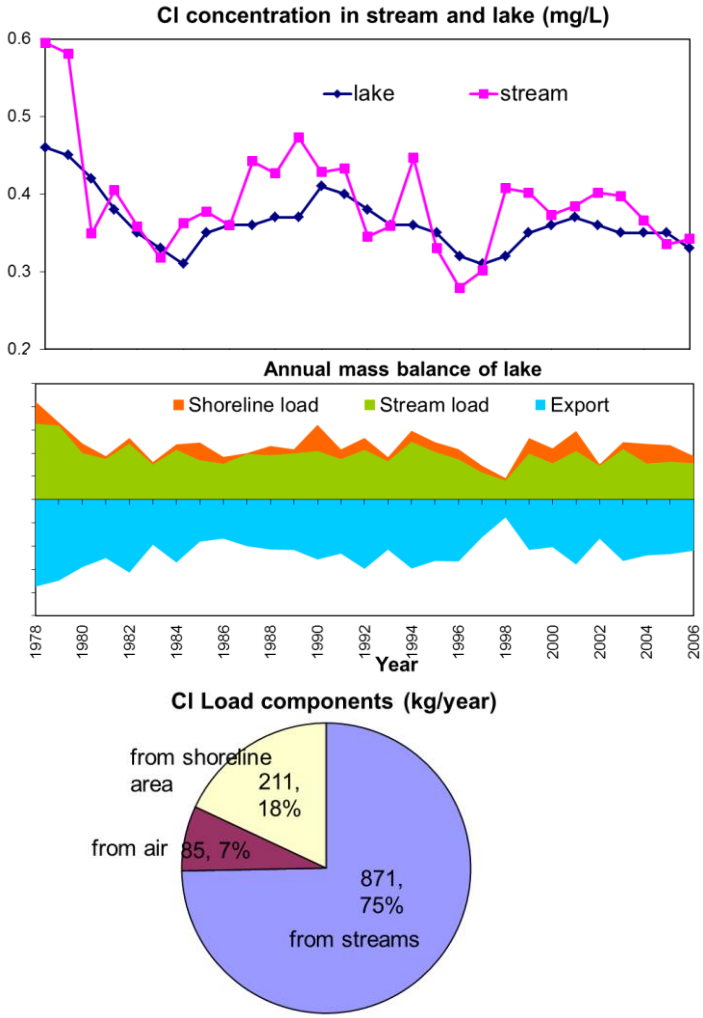
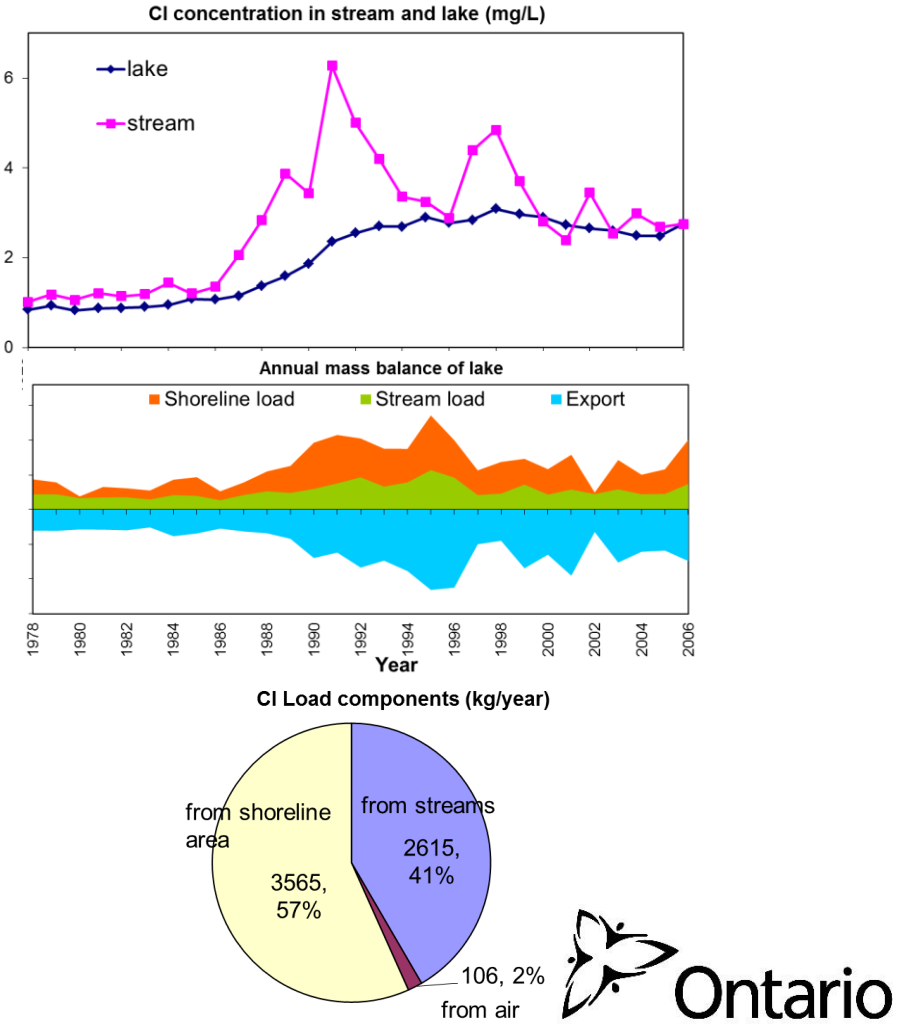
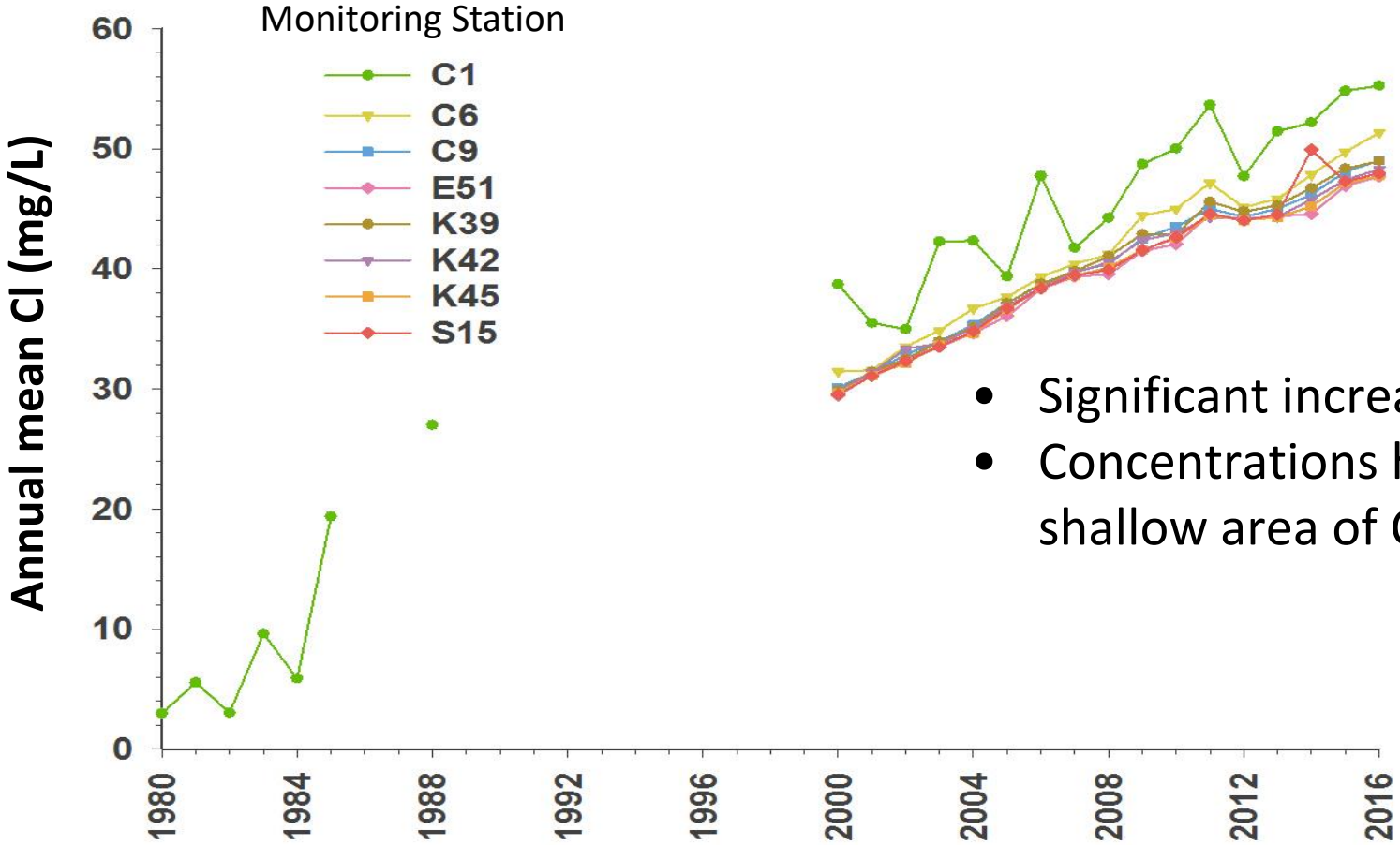


Harp: **Impacted (cottages, roads)**: Cl increased significantly; loading increased; load mainly from shoreline area (salts applied)



Ontario

Strong increasing trend in Lake Simcoe 1980 to 2016



- Significant increasing trend
- Concentrations highest in shallow area of Cook's Bay (C1)

Lake Simcoe Monitoring (MECP)

More information in Minister's Annual Report on Lake Simcoe, 2016

Ontario

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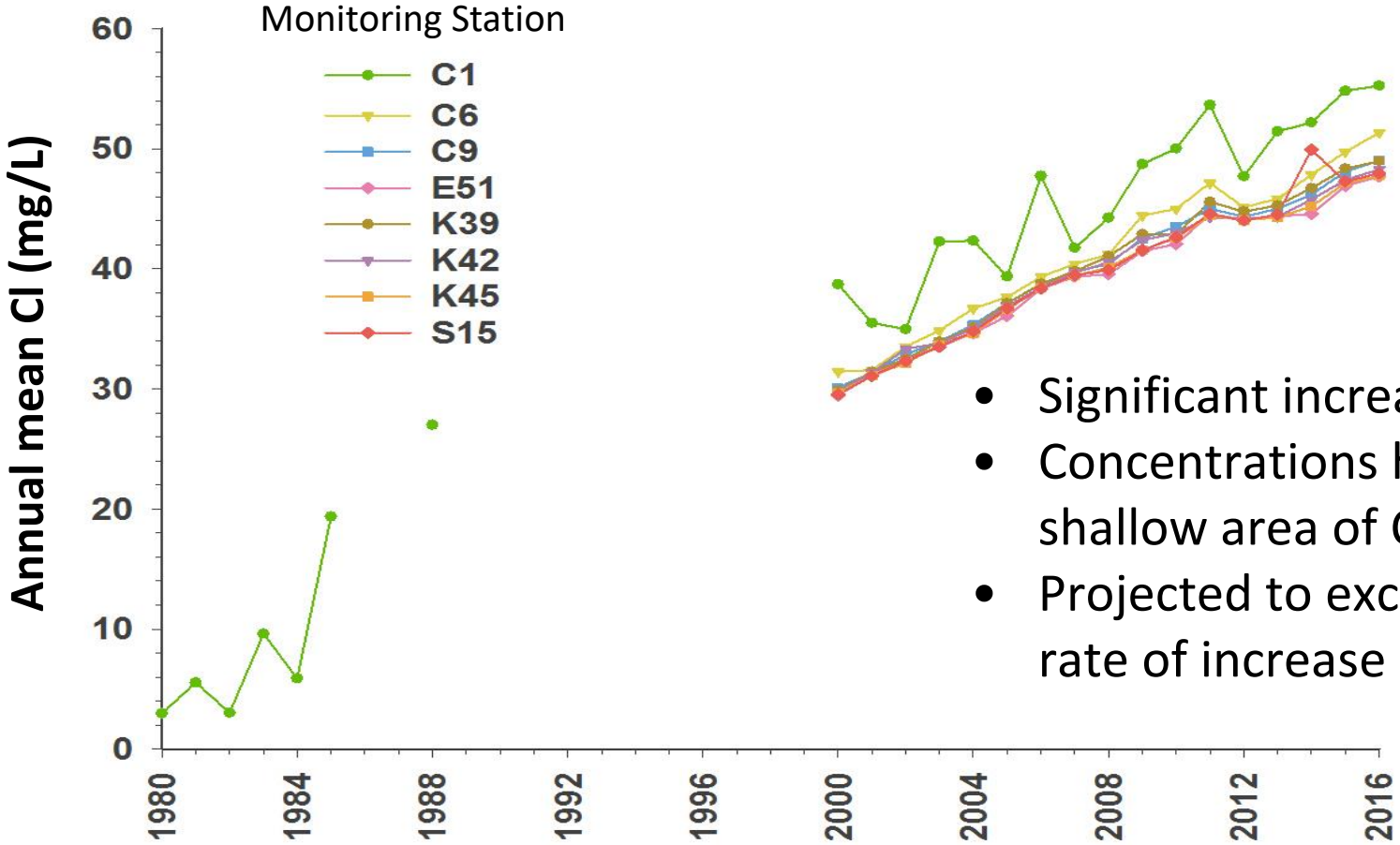

- Significant increasing trend
- Concentrations highest in shallow area of Cook's Bay (C1)
- Projected to exceed CWQG if rate of increase continues

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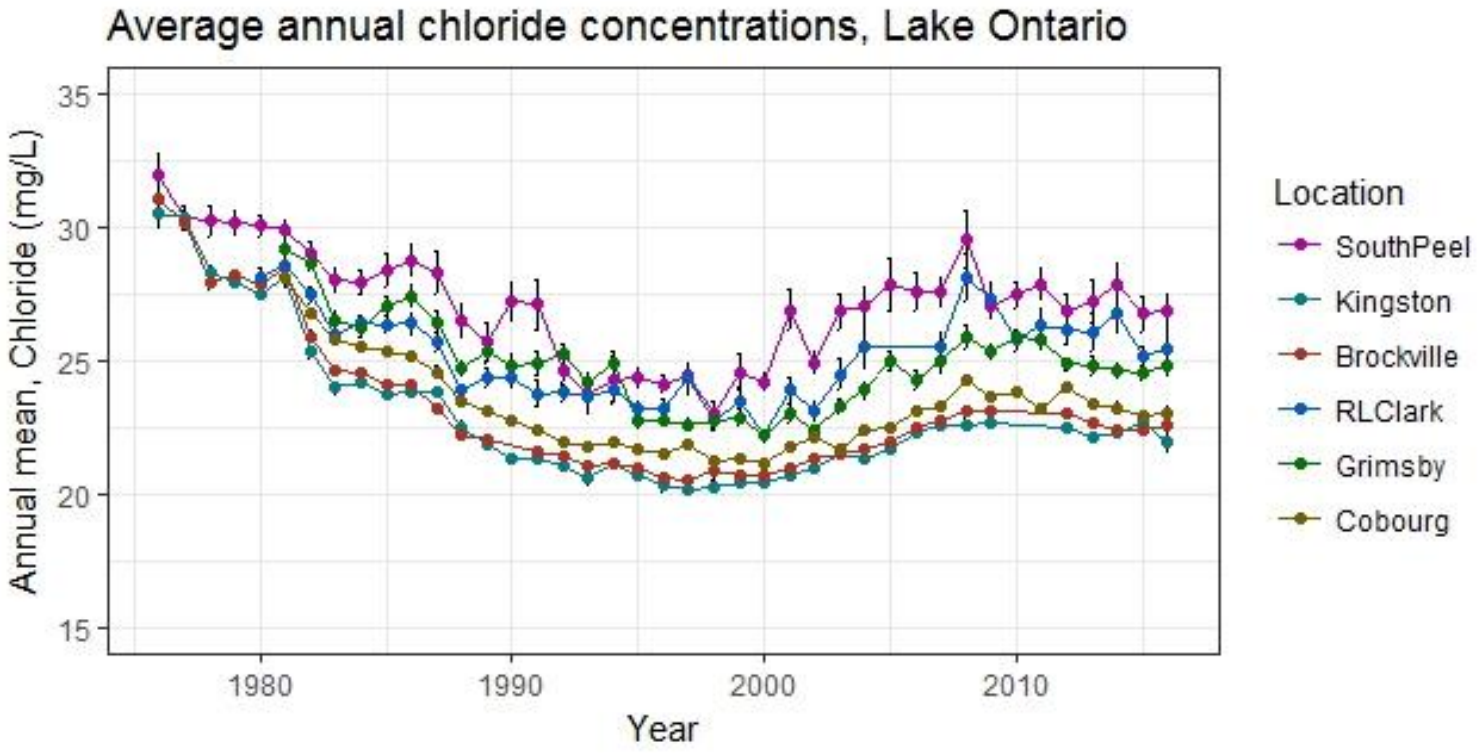
Ontario

Great Lakes nearshore monitoring trends

- Highest concentrations and strongest increasing trend in Lake Ontario since mid-1990's



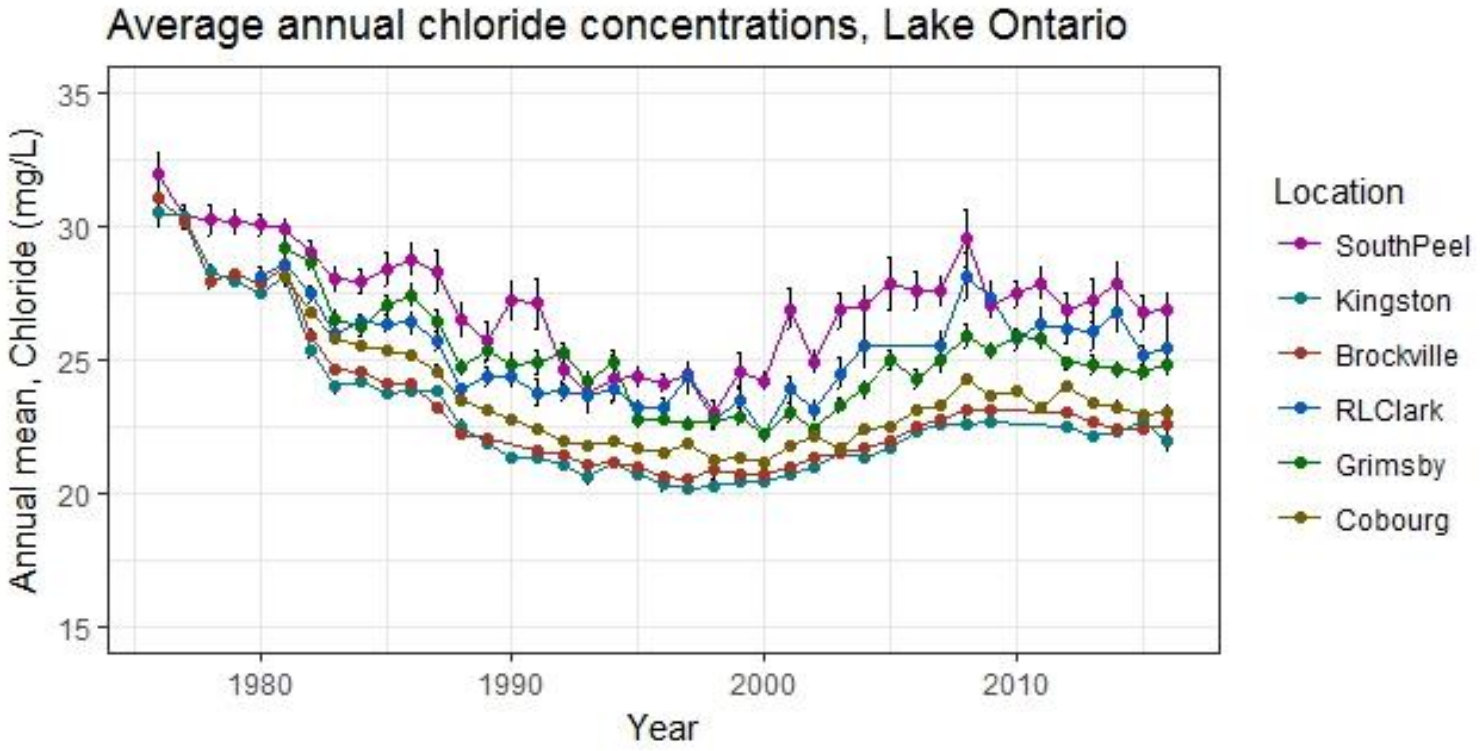
Great Lakes Intake Program (MECP)

Trends to 2009 analysed in Winter et al. 2012 JGLR

Ontario

Great Lakes nearshore monitoring trends

- Highest concentrations and strongest increasing trend in Lake Ontario since mid-1990's
- Increasing trend annual average Cl in locations proximal to urban watersheds since mid-1990s



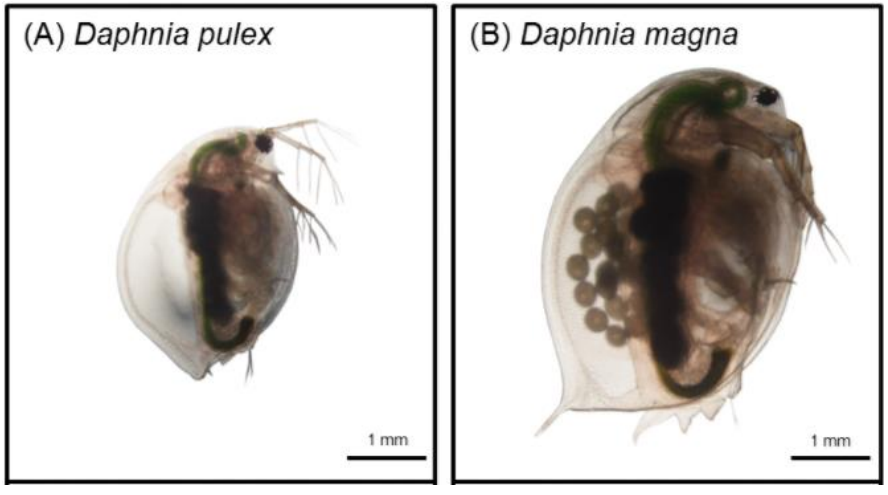
Great Lakes Intake Program (MECP)

Trends to 2009 analysed in Winter et al. 2012 JGLR

Ontario

Ecotoxicology to test effects of road salt in soft water lakes

Our approach (Celis-Salgado 2010)	Standard Method
Regional species (Muskoka)	Standard species
Soft water lake species	Hard water pond and lake species
Very soft medium	Moderately to very hard media
21d survival bioassay and reproduction	24-96 h survival



Ontario

Summary

- MECP has long-term lake and stream Cl datasets across the province
- Trends show Cl in Ontario impacted lakes and streams are increasing compared to reference systems
- Greatest increases are in areas of high population and road density
- Concentrations in many lakes and streams are below CWQG (120 mg/L)

Ontario

Summary

- MECP has long-term lake and stream Cl datasets across the province
- Trends show Cl in Ontario impacted lakes and streams are increasing compared to reference systems
- Greatest increases are in areas of high population and road density
- Concentrations in many lakes and streams are below CWQG (120 mg/L)
- Concentrations in southern Ontario streams and Lake Simcoe are increasing and may exceed CWQG at current rate of increase
- Ecotoxicity of Cl on aquatic organisms is under investigation – evidence suggests regional differences in species-specific tolerance

Ontario

Acknowledgements

Environmental Monitoring and Reporting Branch (MECP)

Dorset Environmental Sciences Centre (MECP)

Provincial Water Quality Monitoring Network (MECP)

OBBN Biocriteria Study (Muskoka)

Lake Simcoe Monitoring Program (MECP)

Lake Partner Program (MECP)

Algae Group (MECP)

Laboratory Services Branch (MECP)

Broadscale Monitoring Program (MNRF)

Queens University

FLAMES Laboratory

York University

Ontario Conservation Authorities

Water Treatment Plant Operators

G. Arabian November 23rd 2018