Again Hazardous Algal Blooms (HABs): Why might this be happening? What can we do?

Norman Yan

Friends of the Muskoka Watershed

We are uniquely blessed with our lakes

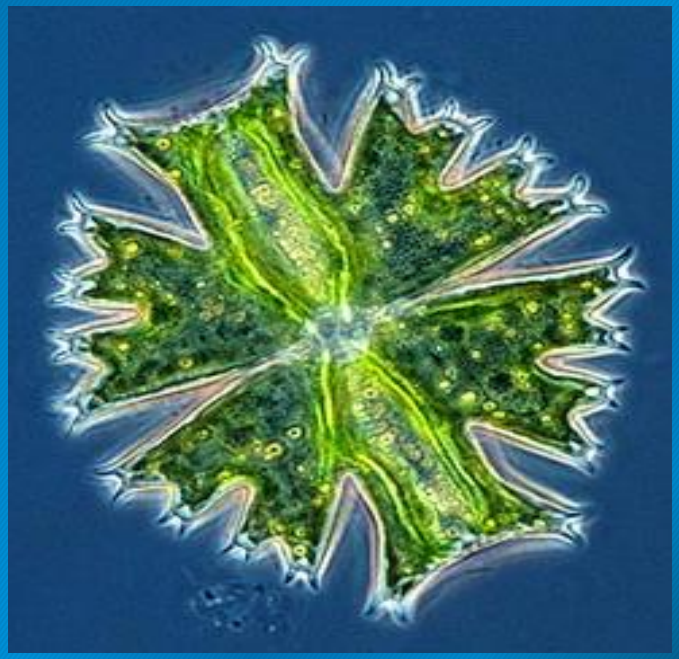
<Title>

There are 1000s of algal species, and we owe them our very existence

Wiki: microalgae

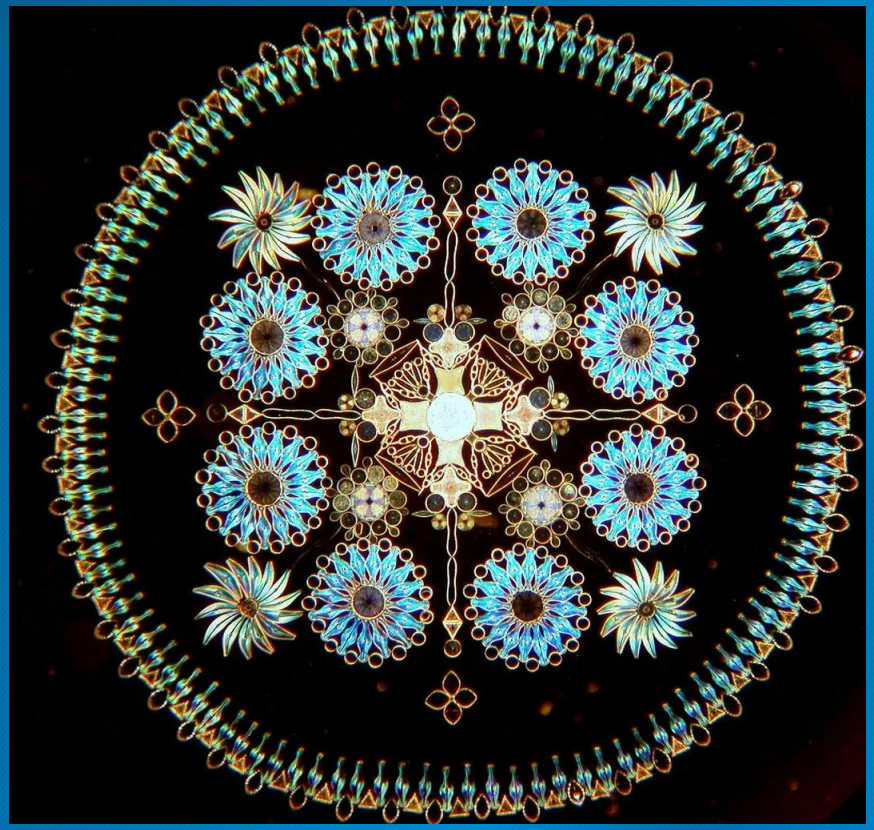
We need algae

- We'd stupefy, starve and suffocate without the gifts provided by algae



the desmid: Micrasterias

And many algae are beautiful



From Smithsonian magazine

But algal blooms have been a problem

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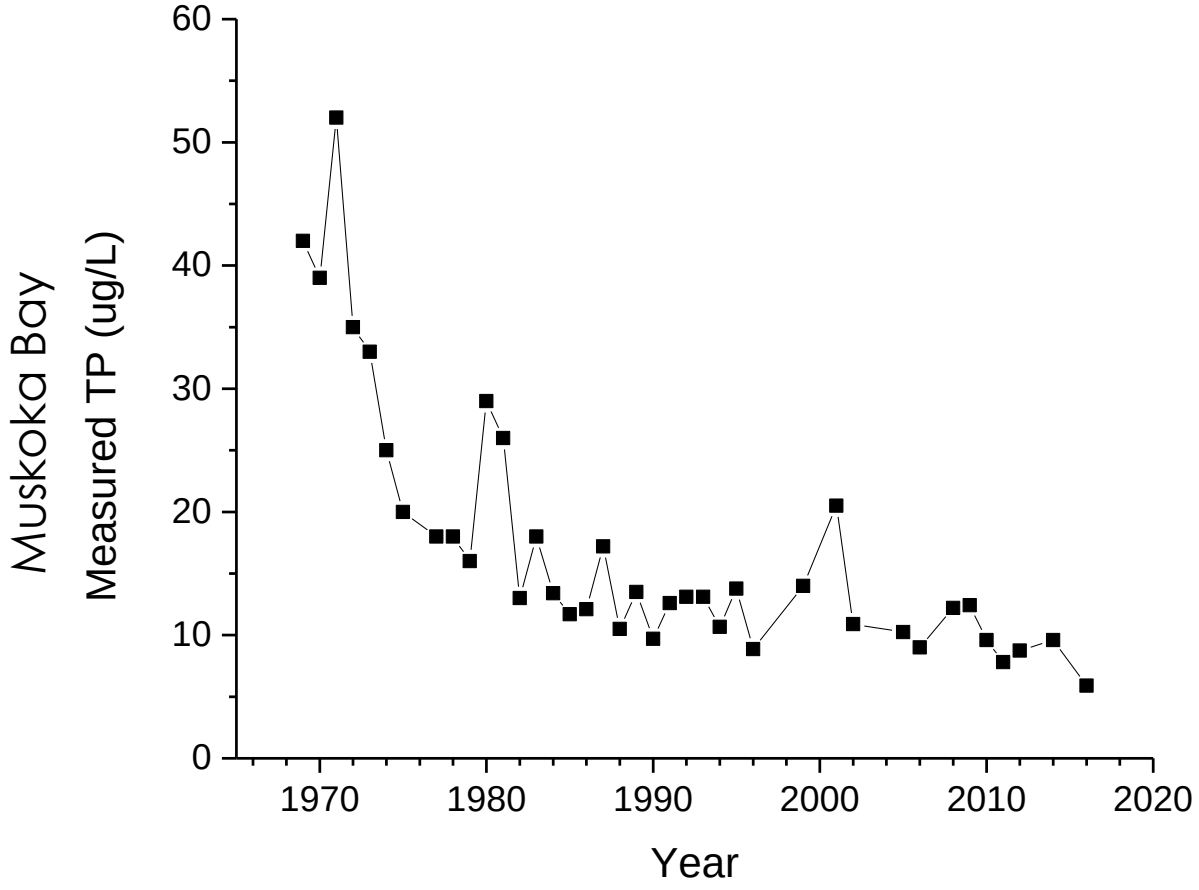
Image: Tom Archer, Encyc. Brit.

too much Phosphorus (P) was the main cause

Lake 226 in the Experimental Lakes Area

So we reduced P input to lakes globally: and TP levels in lakes fell (e.g. Muskoka Bay)



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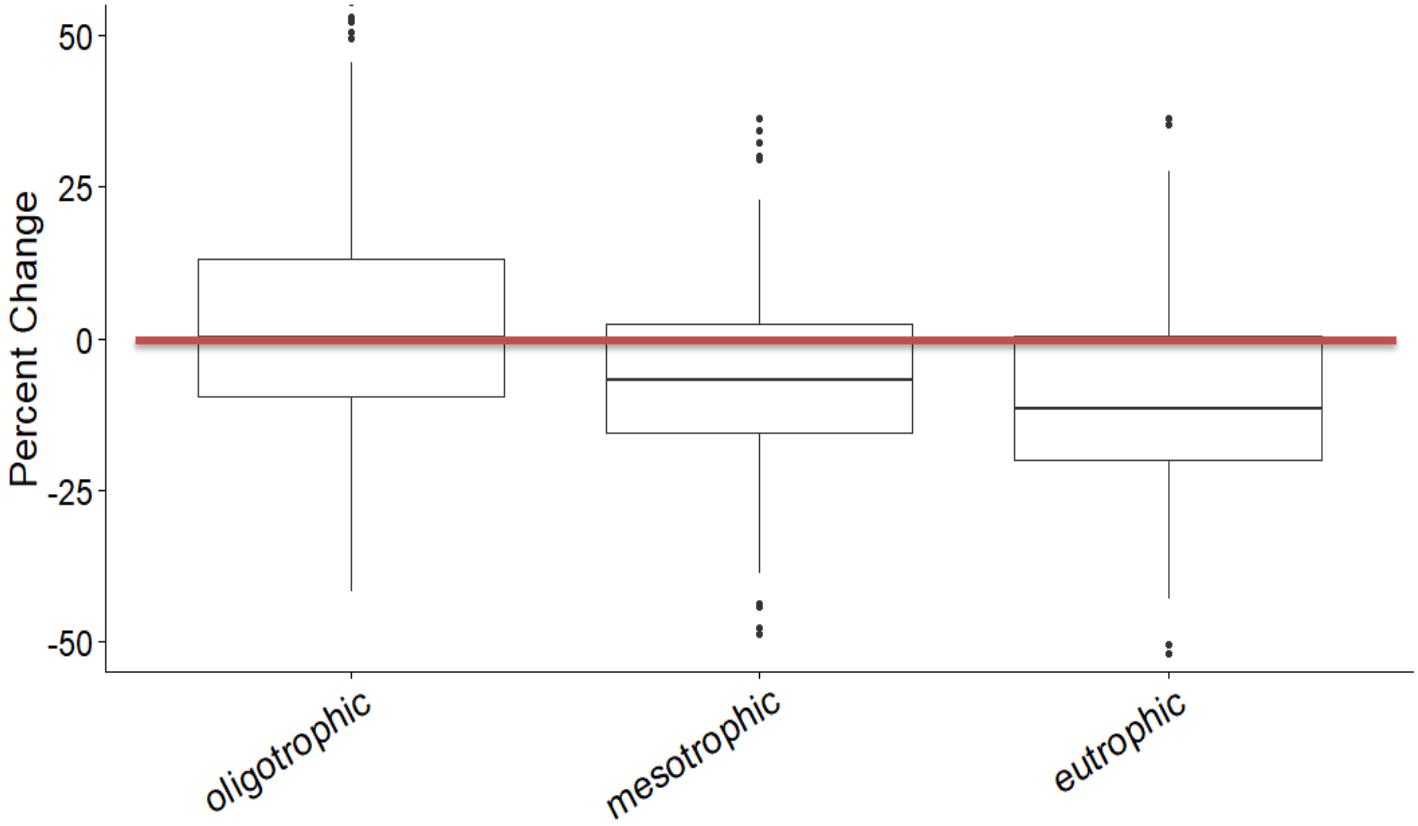
And in many other more TP-enriched lakes (% change in TP since 2005-2009)

(n = 636 lakes, Favot et al 2023*)



*Favot et al. 2023 Lake Reserv. Managm)

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And then this happened
in Dickson Lake, Algonquin Park in 2014*
a troubling mystery

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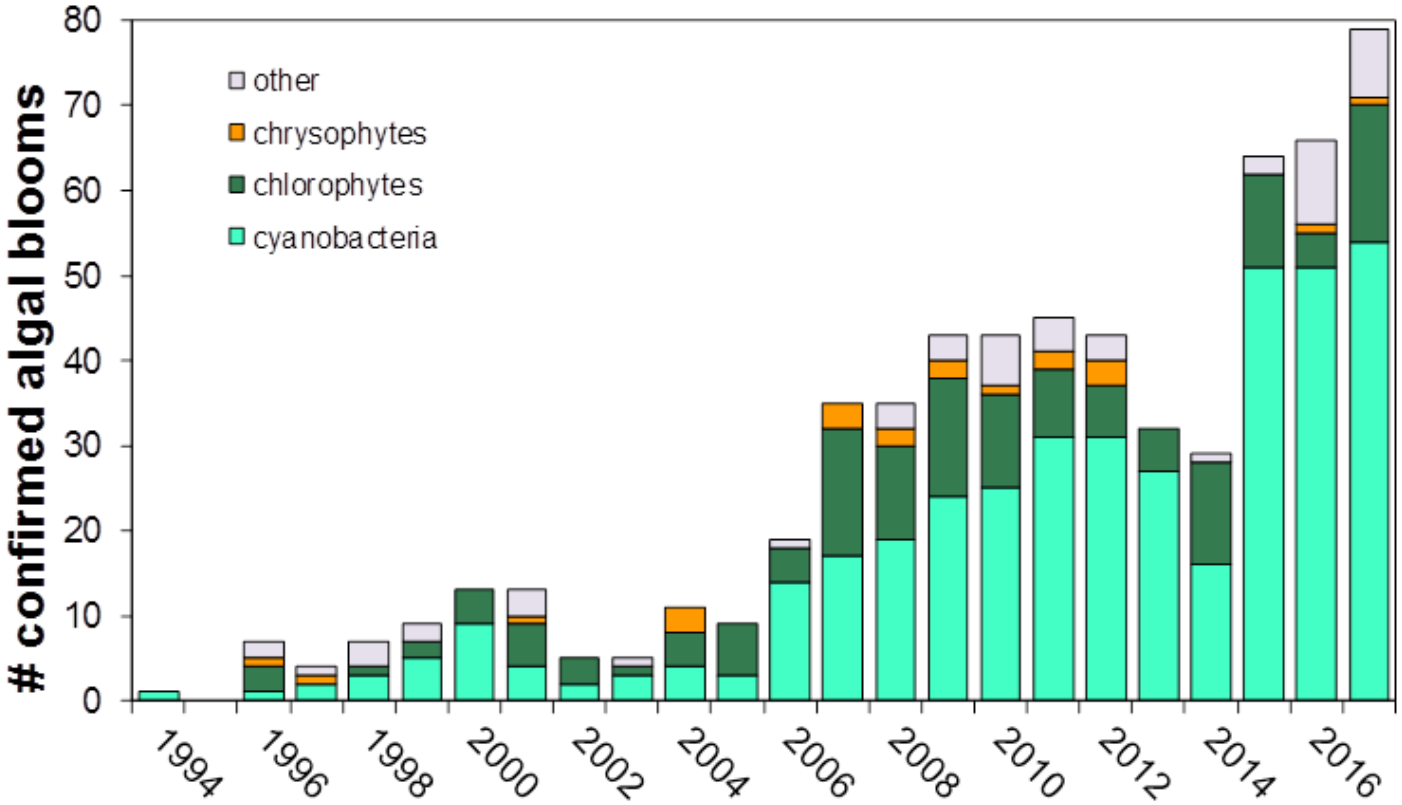
*Favot et al. 2019 J. Paleolim

Algal blooms are on the rise in Ontario



Source: Claire Holeton via A. Paterson, MECP
And Favot et al. 2023

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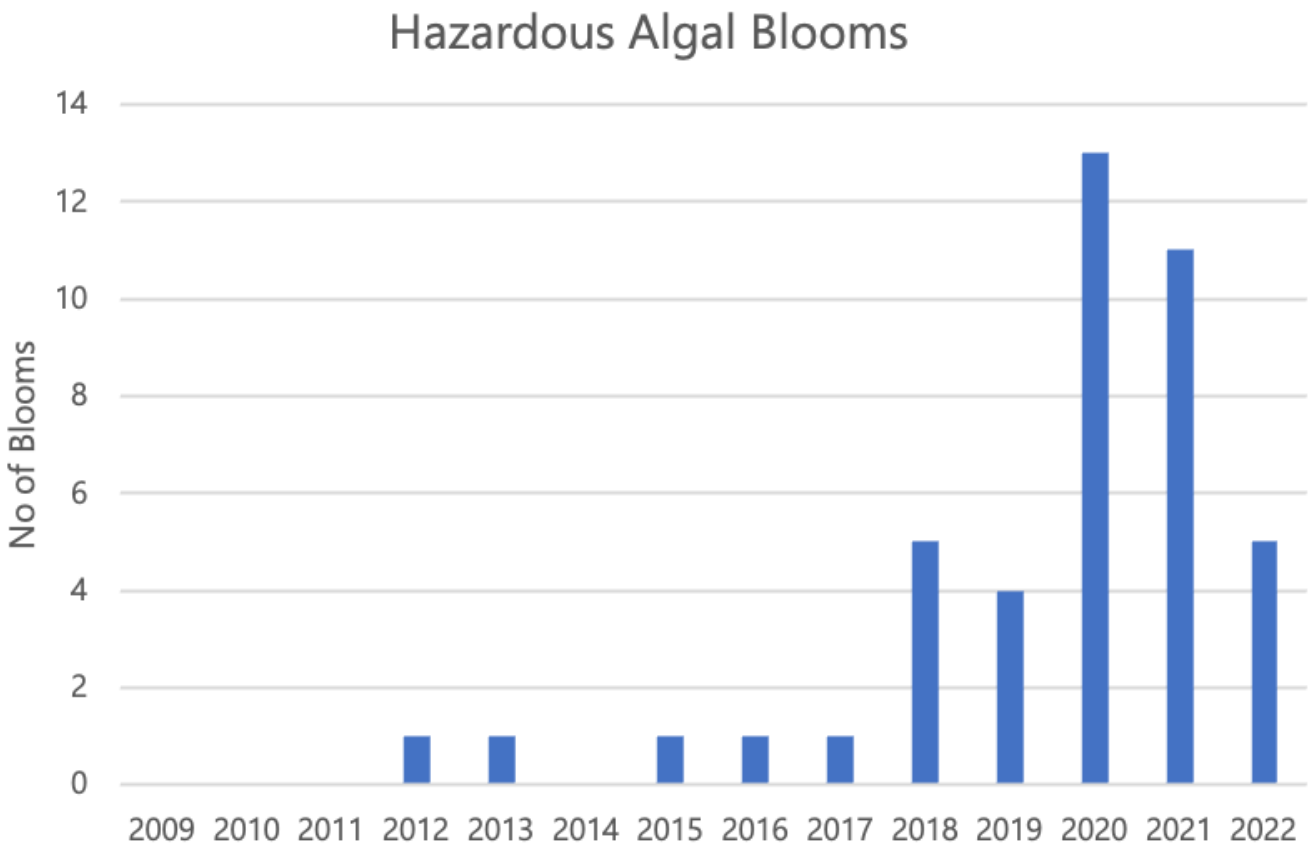
Recorded HAB advisories in Muskoka (SMDHU)



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?

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Algal Blooms are influenced by:

- Species habitat preferences: turbulence, chemistry, oxygen and temperature
- Algal growth rates linked to phosphorus supply
- Algal death rates linked to grazing by zooplankton

Consider a good lawn

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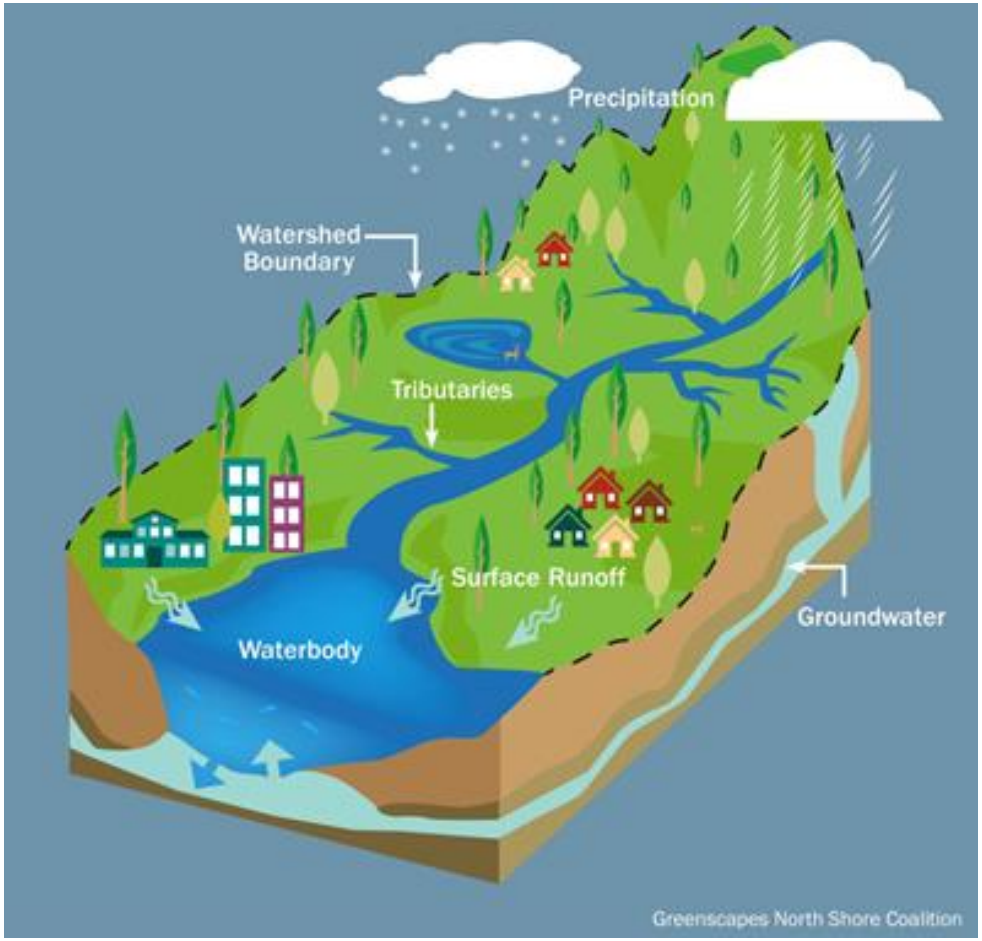
Where do lakes get their phosphorus?



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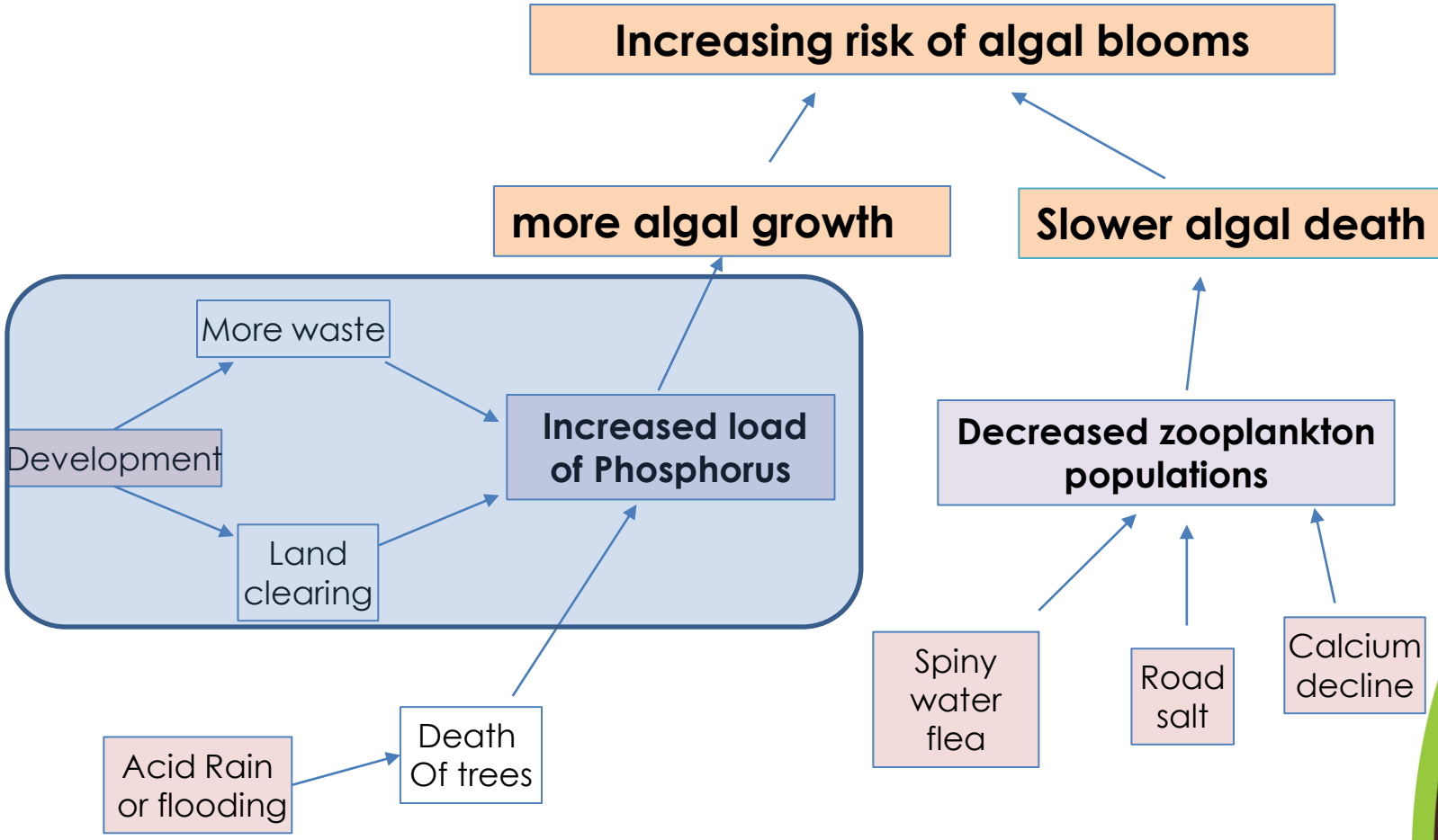
Images from Greenscapes North Shore Coalition

And zooplankton are the “mowers”

Image from Utah State U



Linking new threats other than climate change to algal blooms

The spiny water flea has spread rapidly

Images from SLELO PRISM

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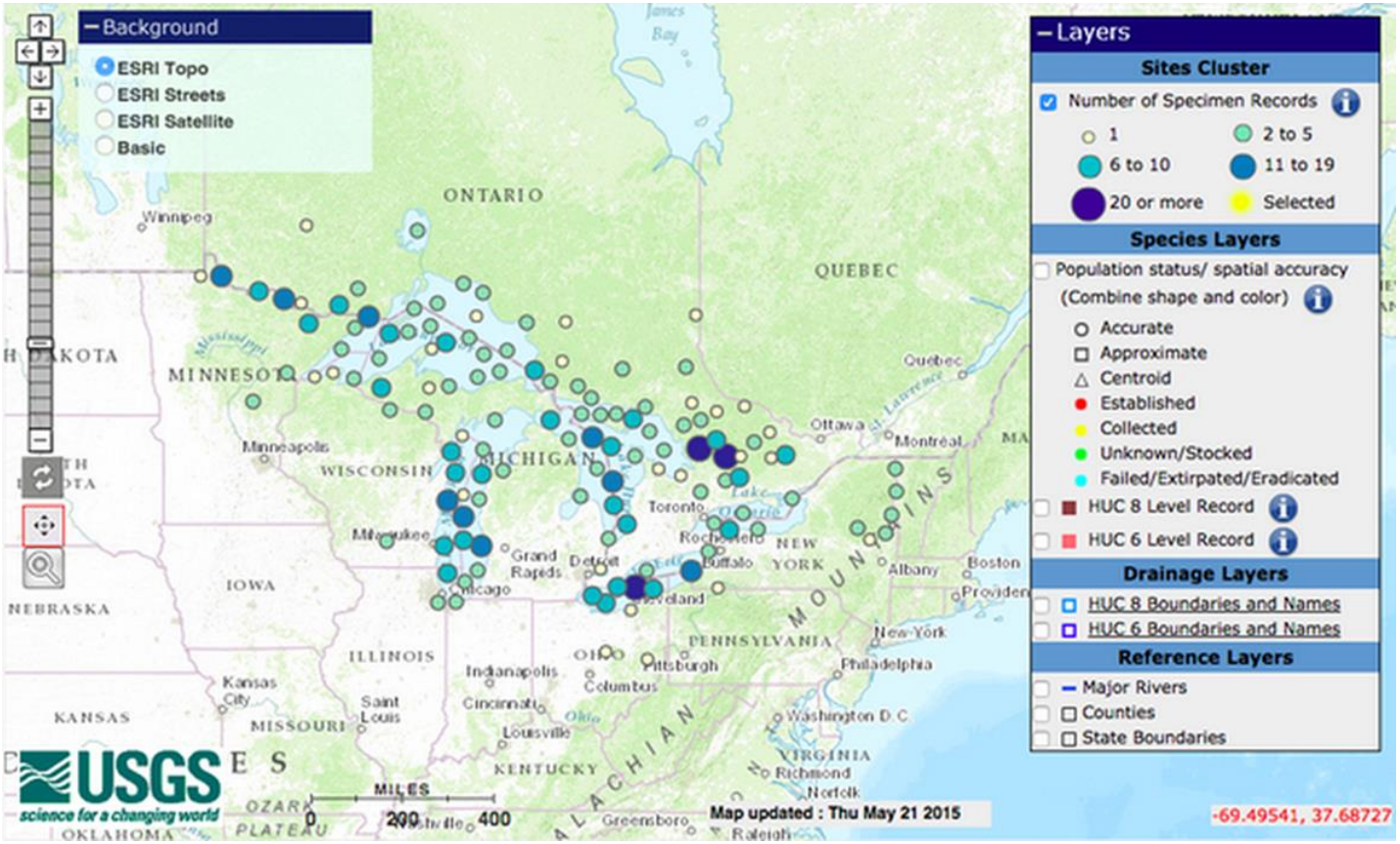
Bythotrephes in N. America in 2015



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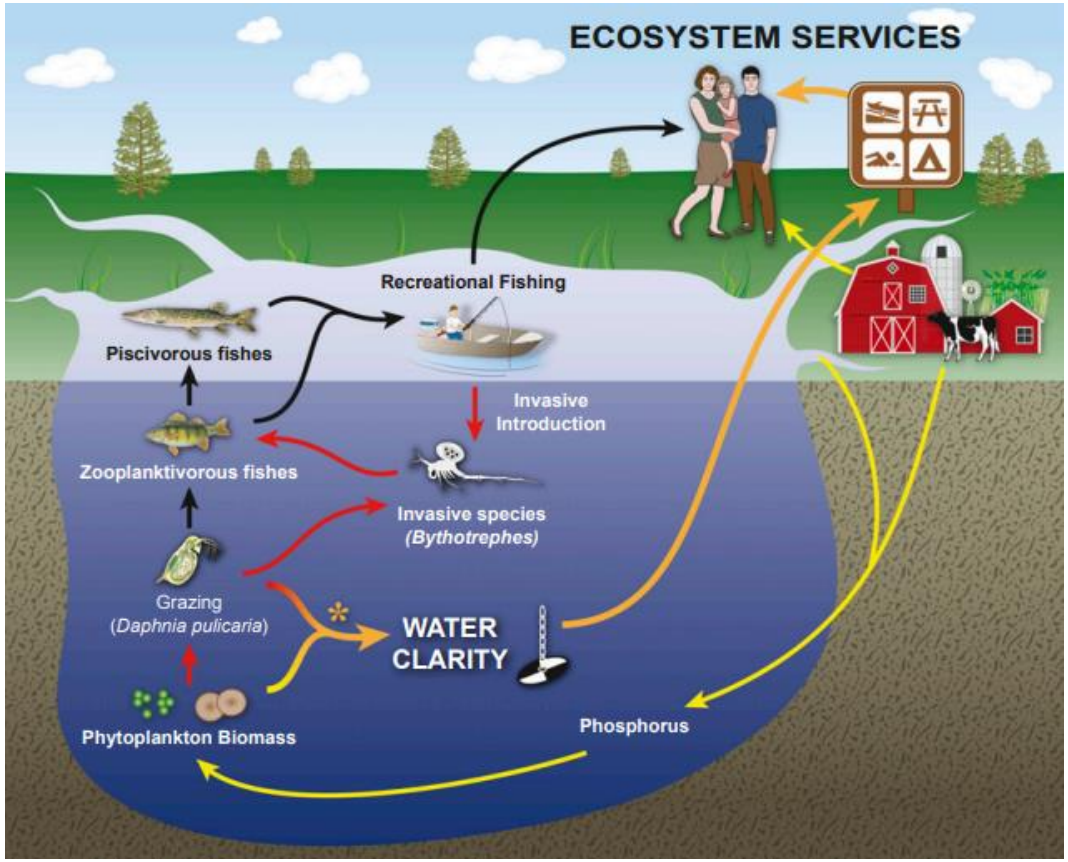
In Lake Mendota, WI, it would cost $140M to restore water clarity lost after *Bythotrephes* invaded*



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*Walsh et al 2015 PNAS

And then there is road salt

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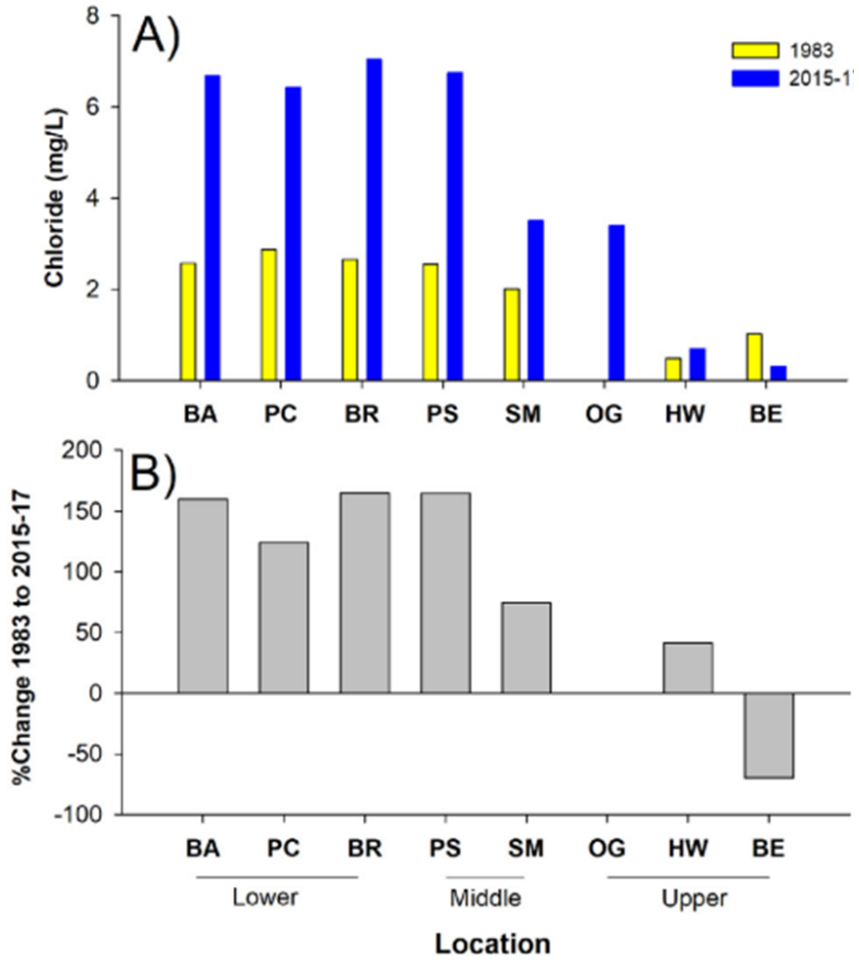
Chloride has risen in developed watersheds in Muskoka (Sorrichetti et al. 2022)



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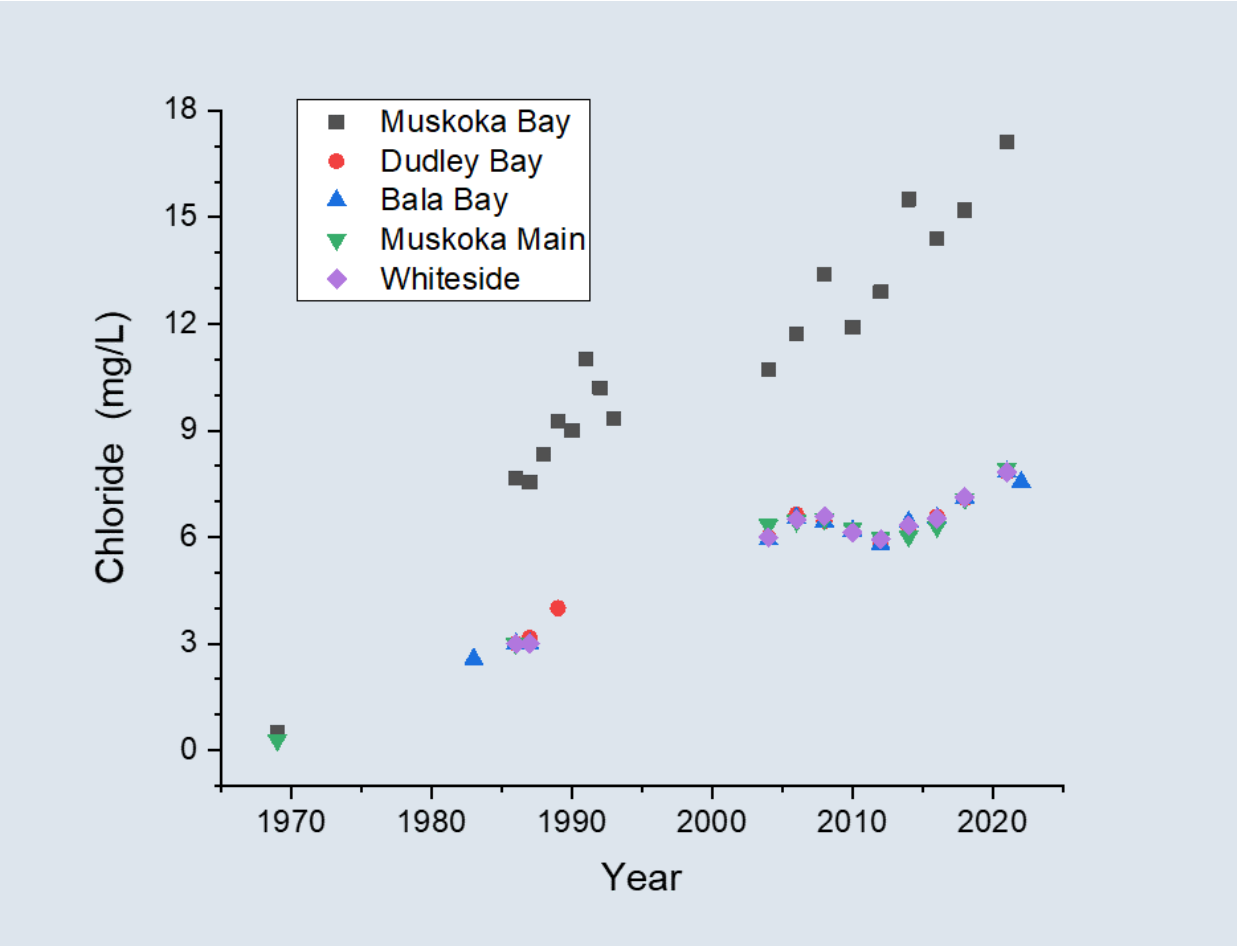
The trend is clear in Lake Muskoka



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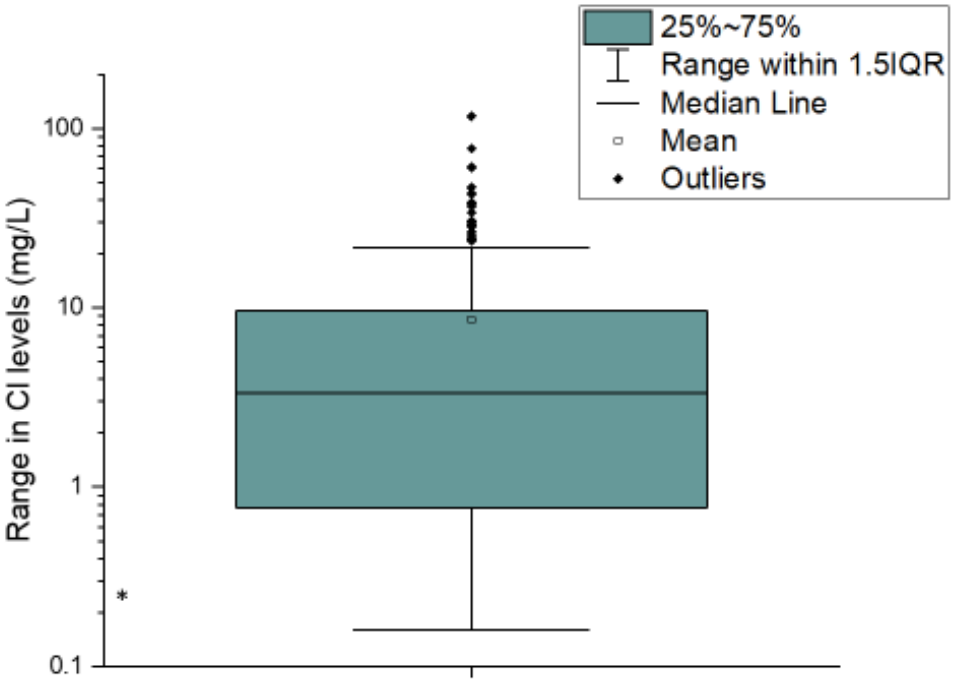
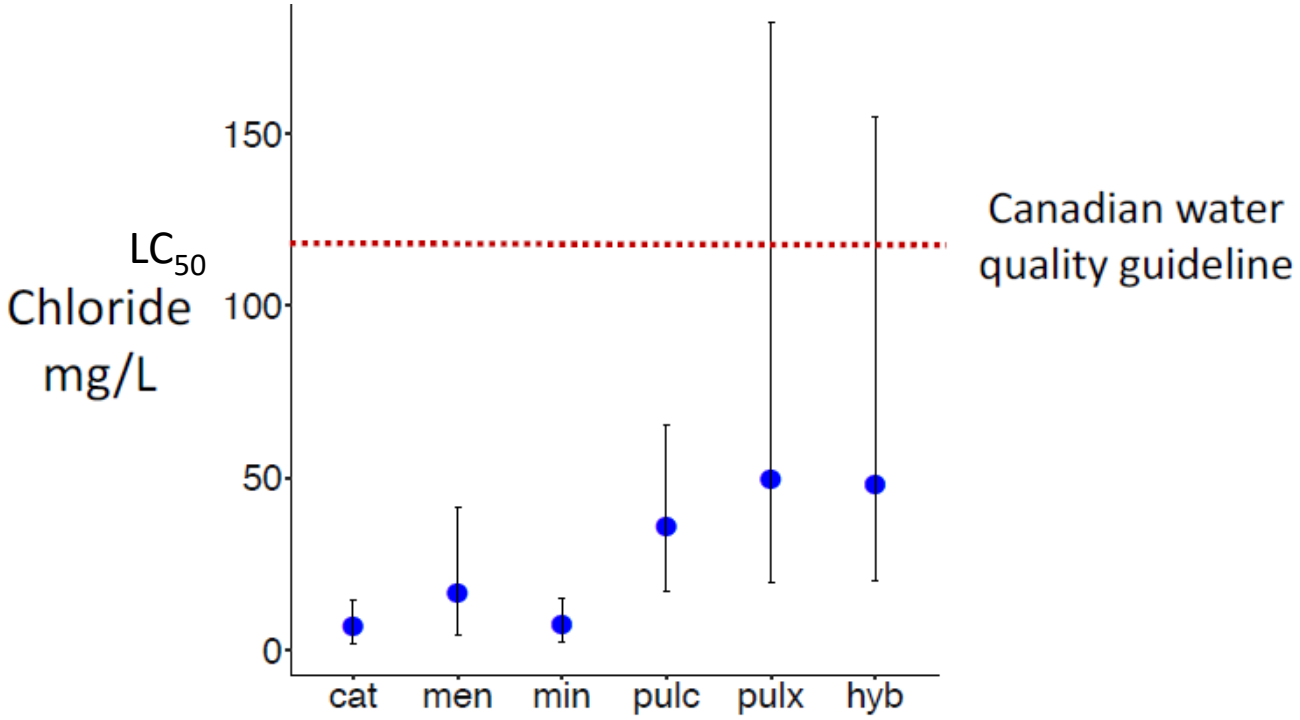
And there is now a 700 fold range in Chloride levels in Muskoka lakes, because of road salt with 25% of lakes above 10 mg/L*



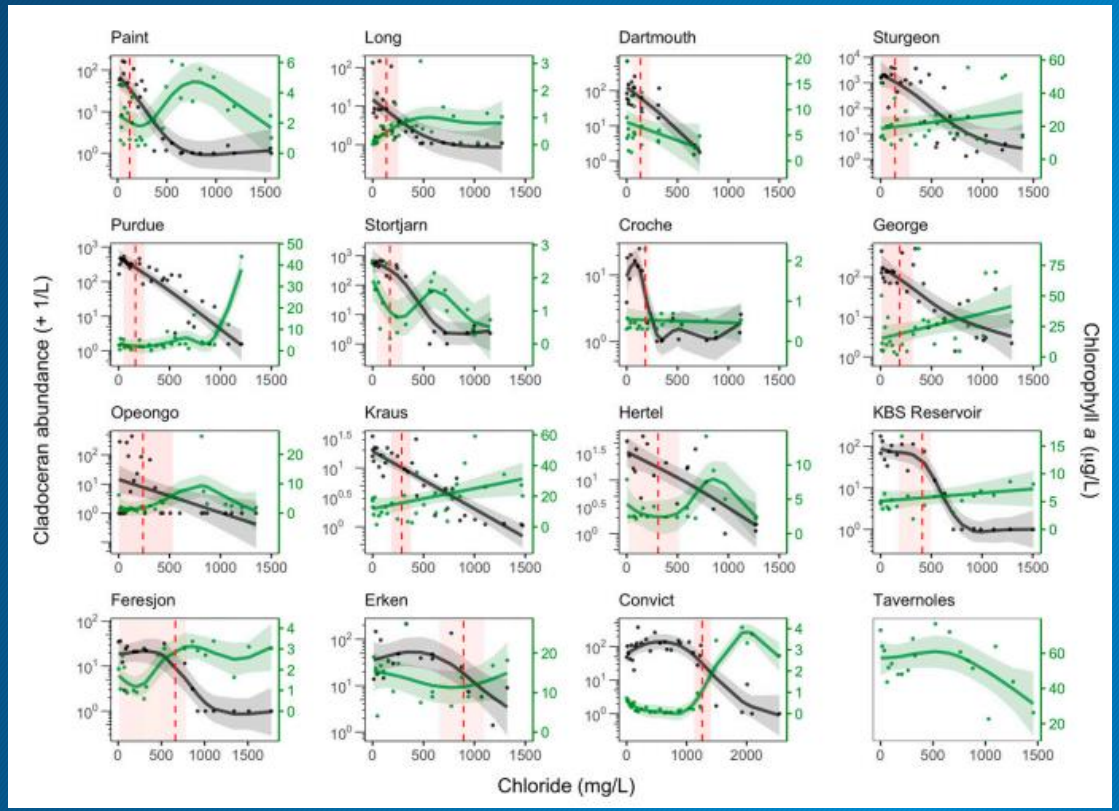
*data from the District of Muskoka's Water Quality Monitoring Program
Summarized in Yan 2020 10 Key questions about road salt

10-20 mg/L of Chloride is toxic to key water fleas (21 day LC_{50} in soft-water at high food)*



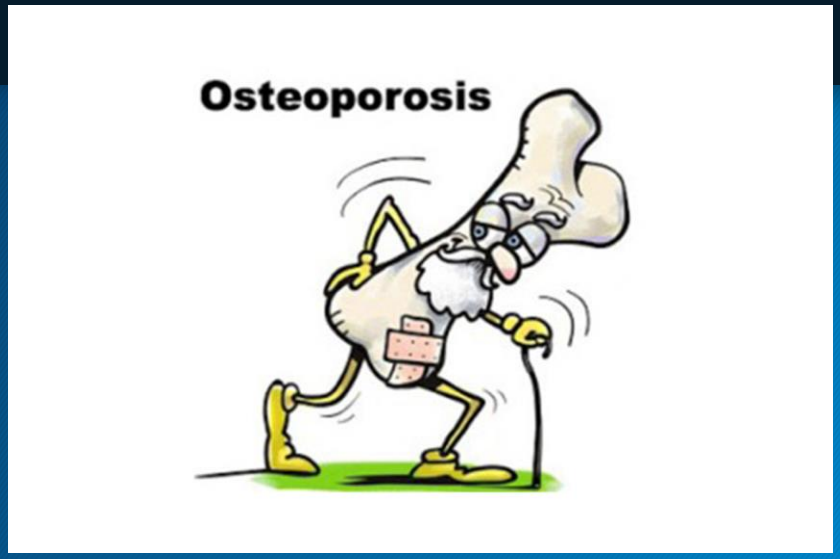
* Arnott et al ES&T 2020

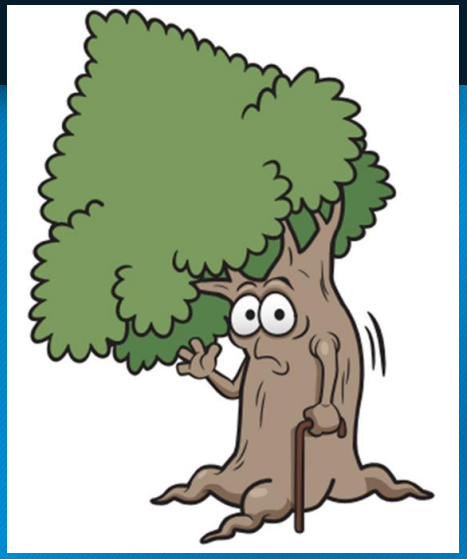
And algae number increased (the green line) when salt reduced zooplankton numbers (the black line).



Current water quality guidelines across North America and Europe do not protect lakes from salinization

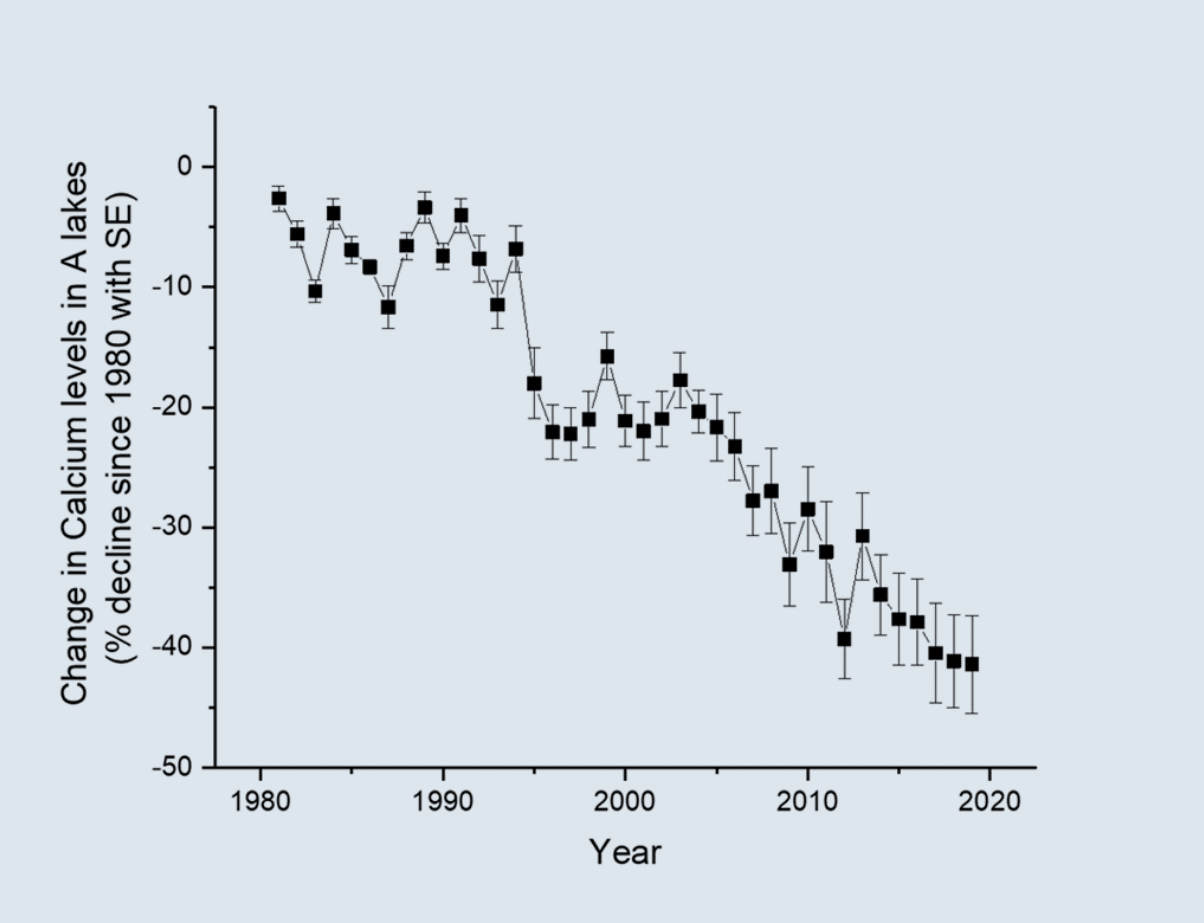
William D. Hintz[a,b,1,2], Shelley E. Arnott[c,1], Celia C. Symons[d], Danielle A. Greco[c], Alexandra McClymont[c], Jennifer A. Brentrup[e], Miguel Cañedo-Argüelles[f], Alison M. Derry[g], Amy L. Downing[h], Derek K. Gray[i], Stephanie J. Melles[j], Rick A. Relyea[k], James A. Rusak[c,l], Catherine L. Searle[m], Louis Astorg[g], Henry K. Baker[n], Beatrix E. Beisner[g], Kathryn L. Cottingham[e], Zeynep Ersoy[o], Carmen Espinosa[p], Jaclyn Franceschini[i], Angelina T. Giorgio[k], Norman Göbeler[q], Emily Hassal[r], Marie-Pier Hébert[g,s], Mercedes Huynh[t], Samuel Hylander[t], Kacie L. Jonasen[m], Andrea E. Kirkwood[r], Silke Langenheder[u], Ola Langvall[v], Hjalmar Laudon[w], Lovisa Lind[x], Maria Lundgren[y], Lorenzo Proia[z], Matthew S. Schuler[aa], Jonathan B. Shurin[n], Christopher F. Steiner[bb], Maren Striebel[cc], Simon Thibodeau[g], Pablo Urrutia-Cordero[u,dd], Lidia Vendrell-Puigmitja[z], and Gesa A. Weyhenmeyer[u]





And then there is Calcium (Ca) decline: "aquatic or terrestrial osteoporosis"

Calcium levels have fallen in Muskoka's lakes (graph is for Dorset's main study lakes)*



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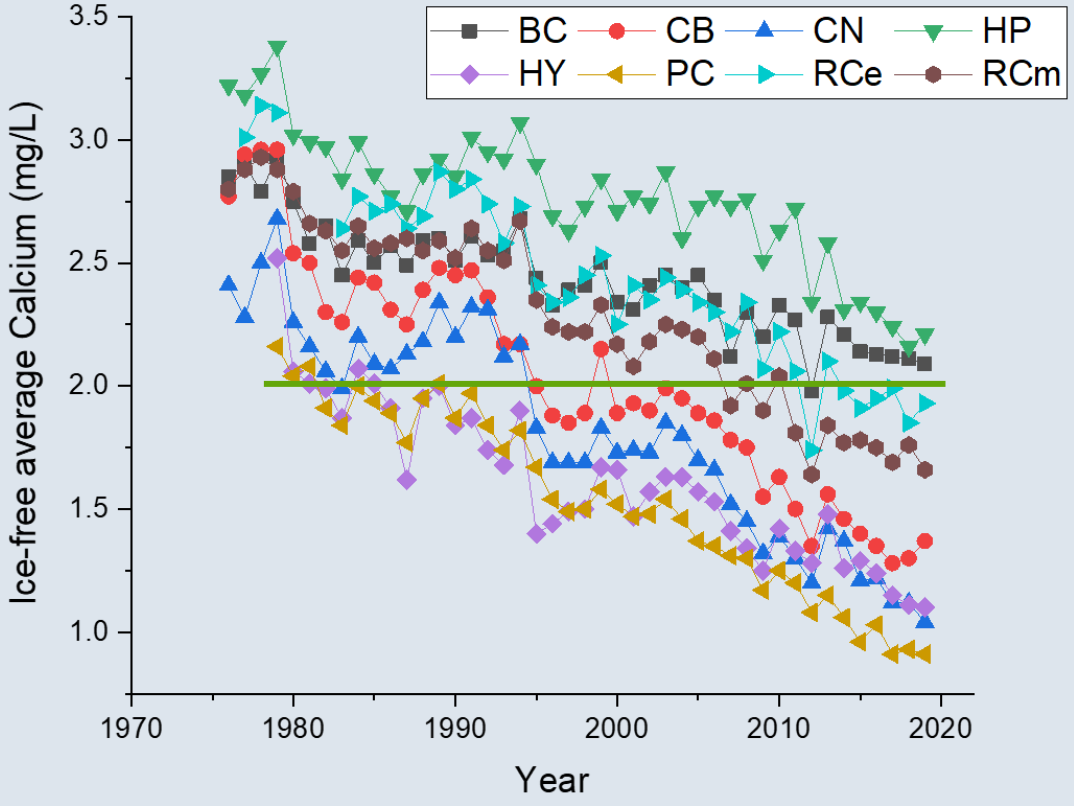
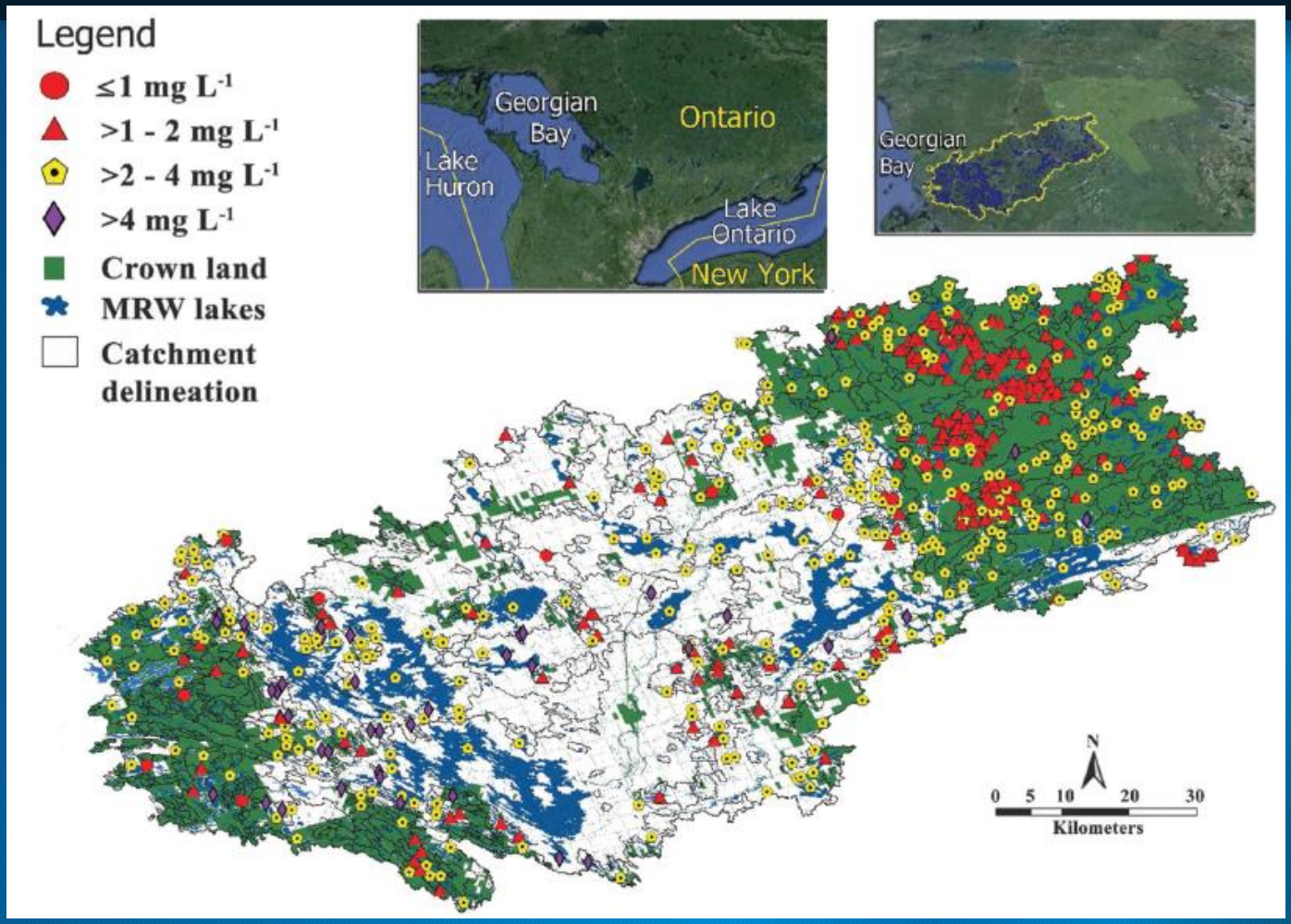
*From Paterson MECP DESC

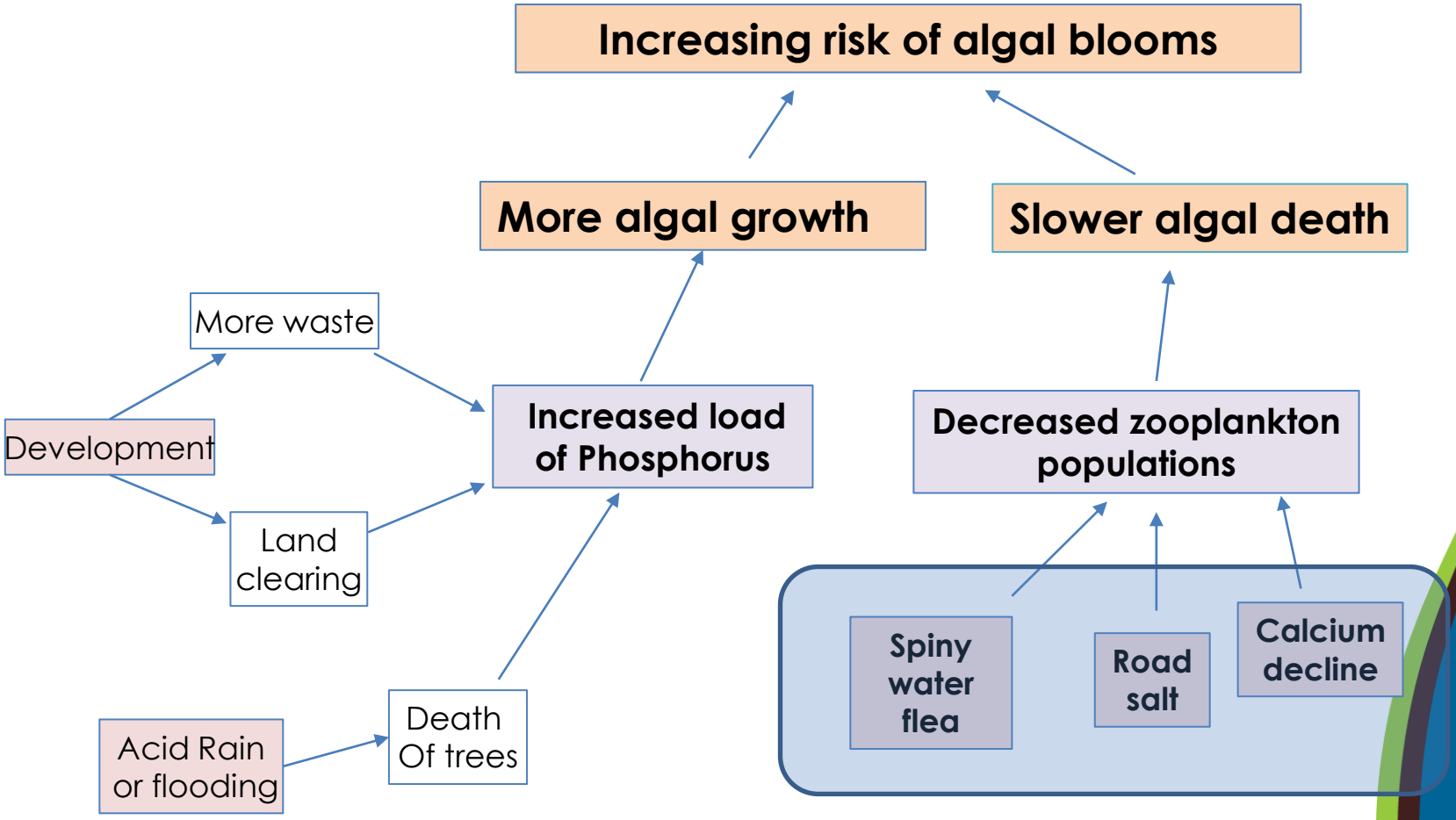
Ca levels < 2 mg/L are now common in the Dorset lakes



And lots of Muskoka lakes have Ca < 2 mg/L

Reid and Watmough 2018





Linking new threats other than climate change to algal blooms

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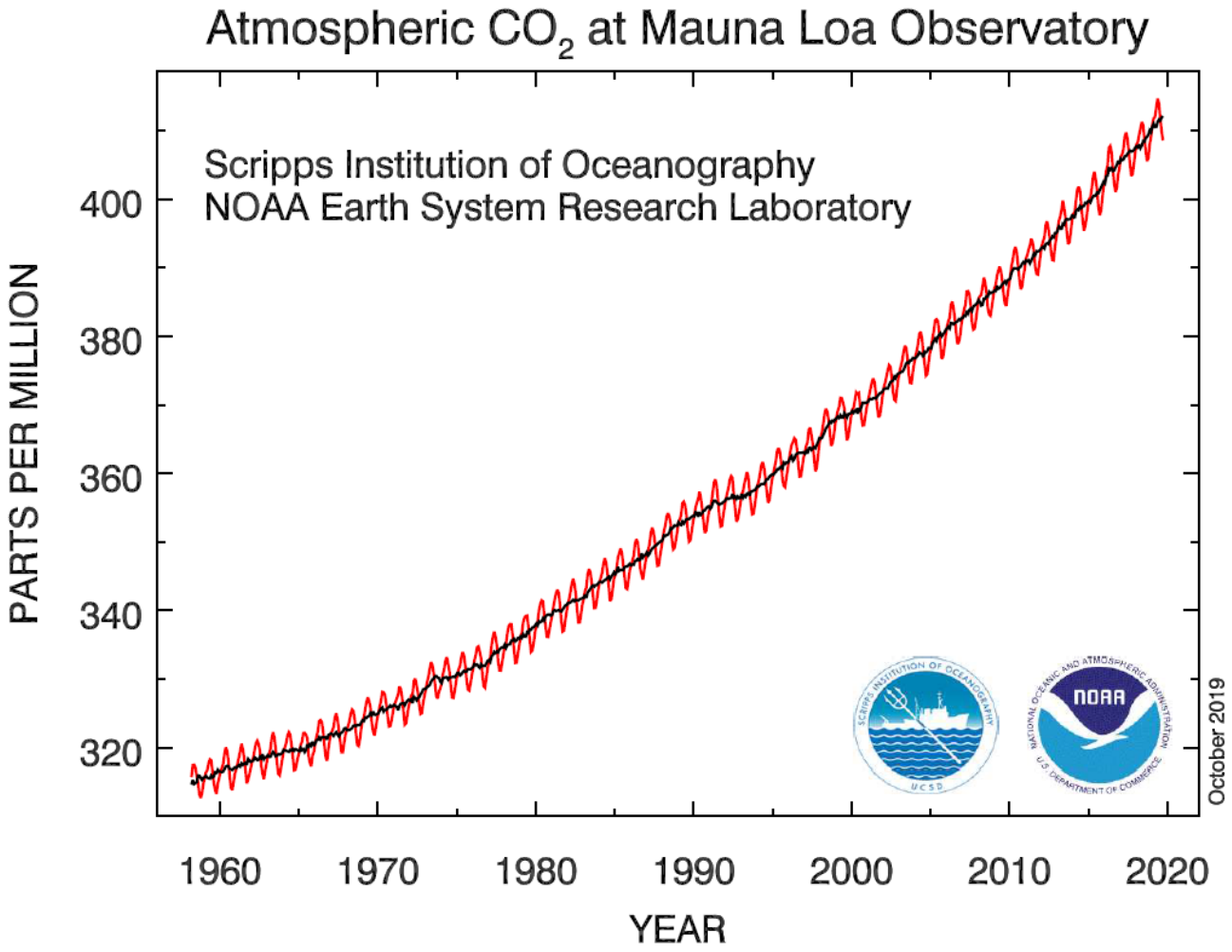
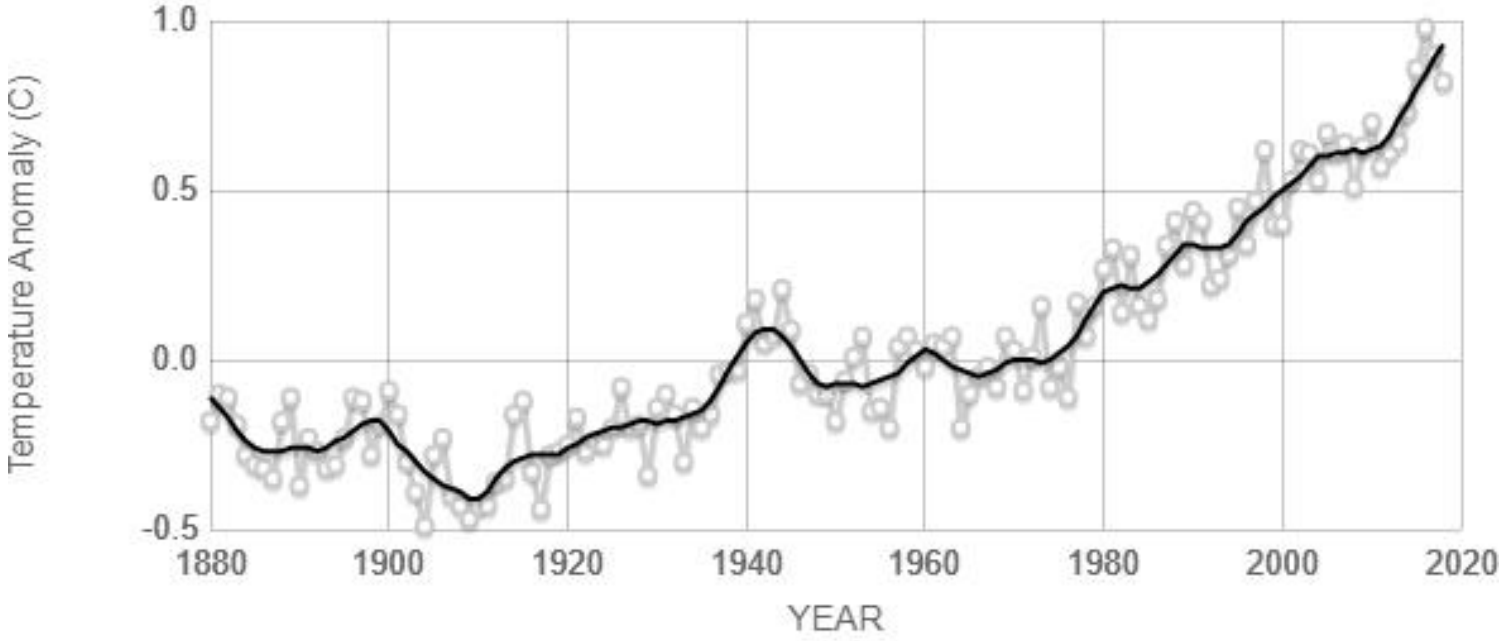
But atmospheric CO_2 levels are rising



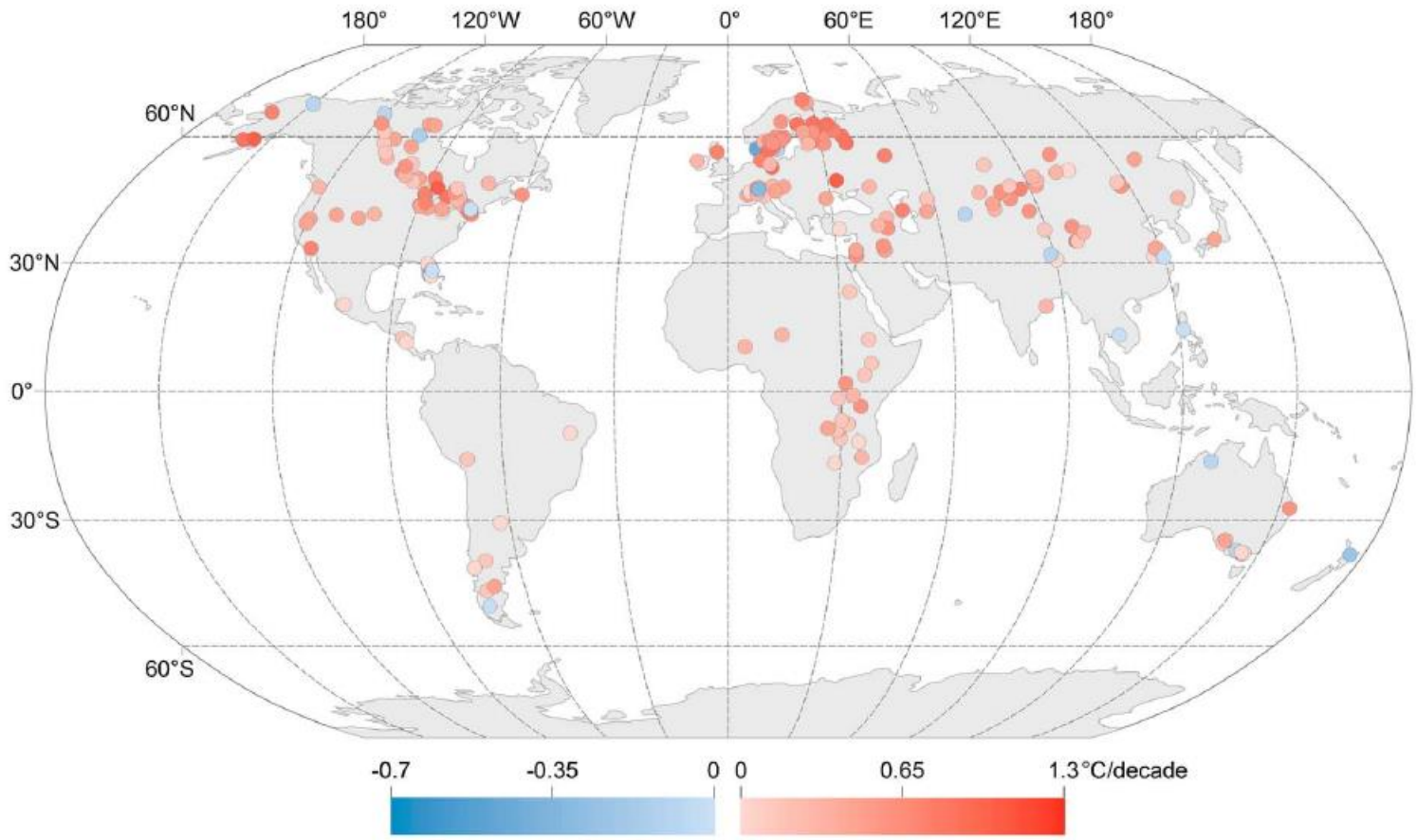
Raising global air temperatures*
(compared to 1950 to 1980 mean)



Source: climate.nasa.gov

*Source: climate.nasa.gov

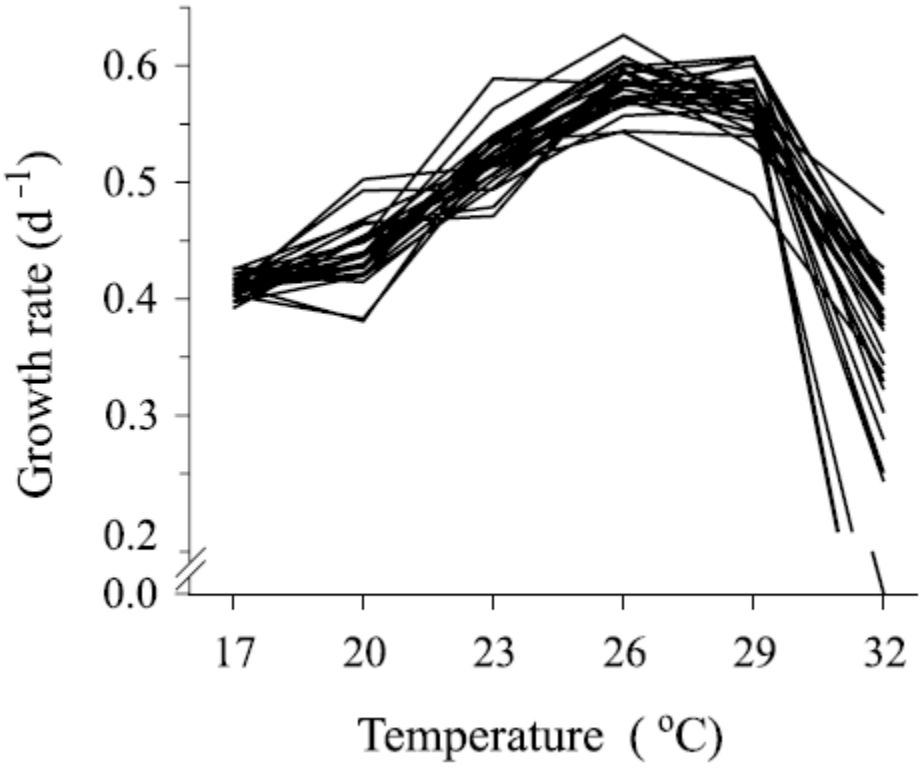
And lake surface waters are warming (from 1985 to 2009 in 240 lakes)



*O'Reilly, Sharma et al. 2015 Geophys. Res Lett.

Daphnia suffer in water >28 degrees

growth vs. temperature for *Daphnia magna**



*Lampert 2006 Pol. J. Ecol

Spring floods can be severe

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Image from Toronto.com

With more lake-effect snow there is more use of salt in Muskoka

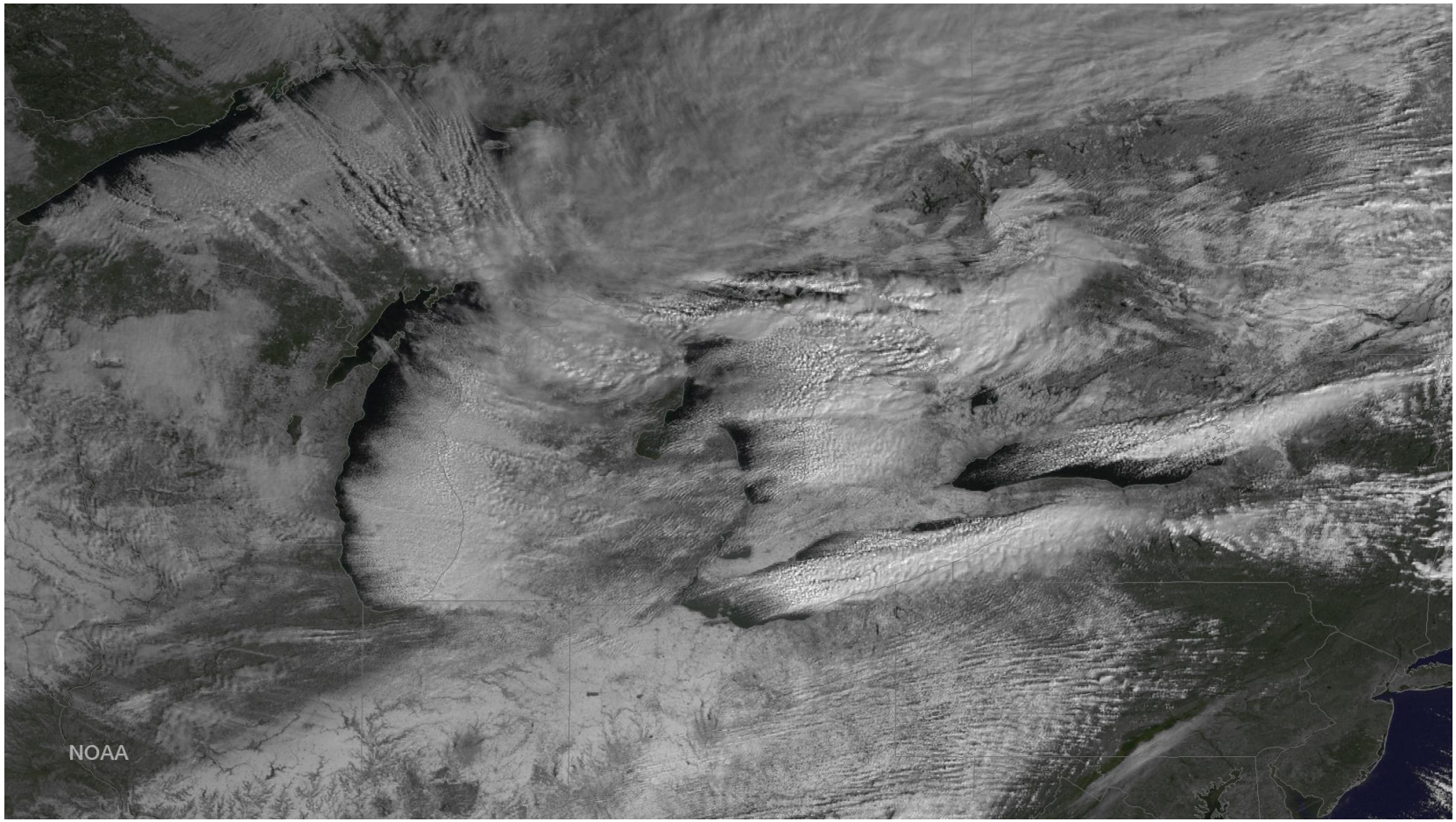
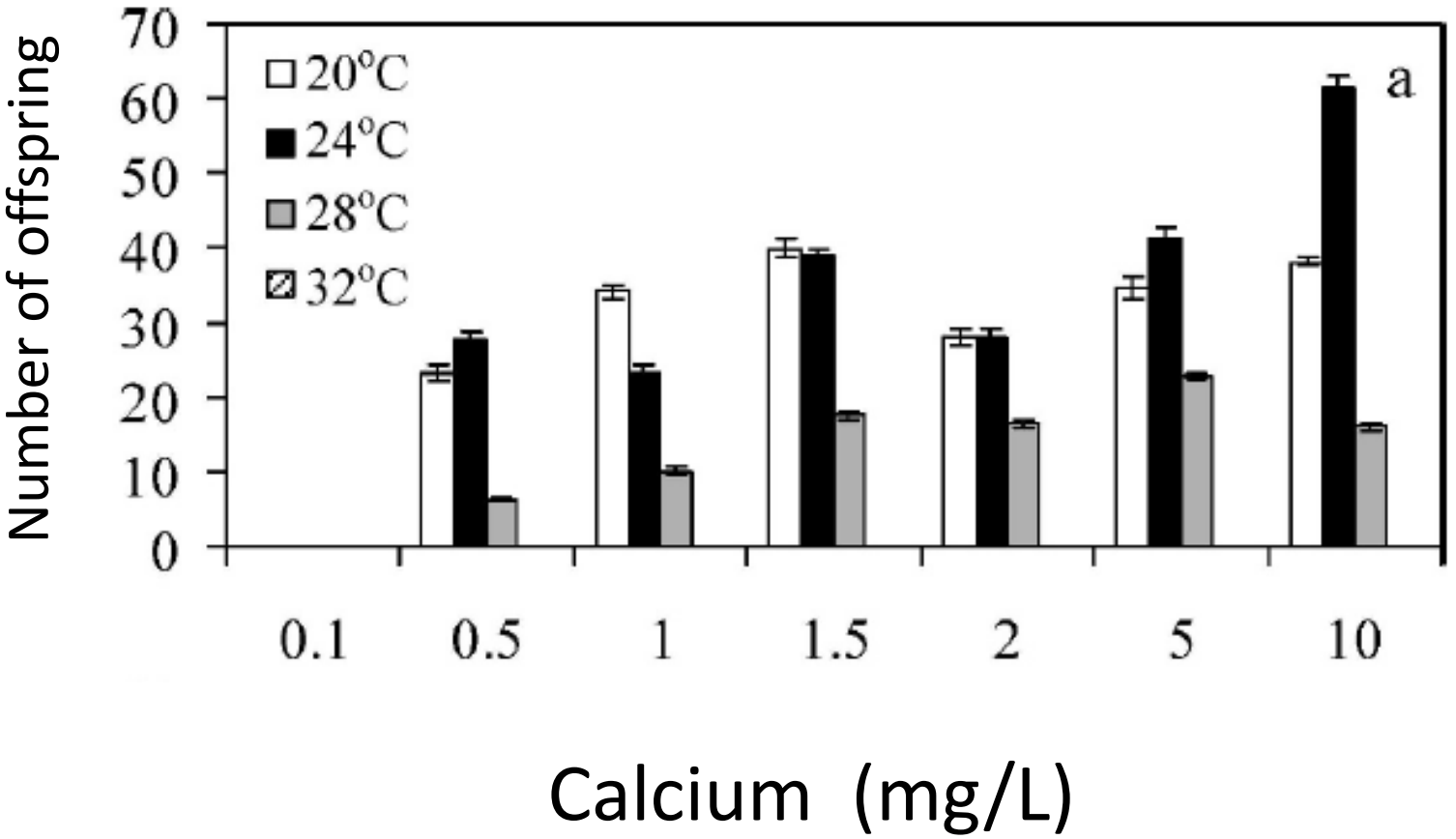


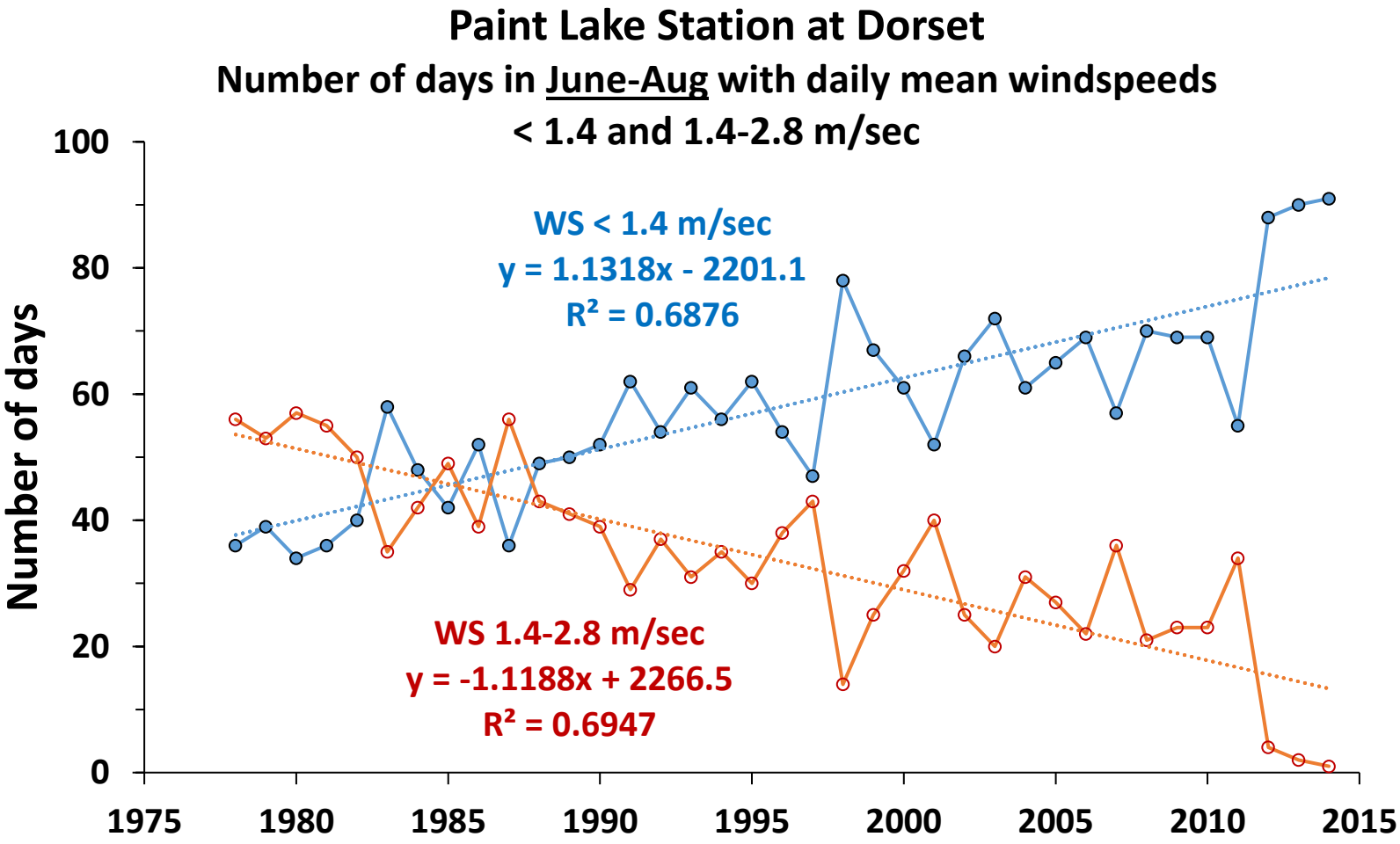
Image from NOAA

High temperatures interact with other stressors, e.g. increasing low Ca damage to *Daphnia**



*Ashforth and Yan 2008 Limnol. Oceanogr.

Summer wind speeds in Muskoka are falling*, favouring blue-greens



*From Yao MECP DESC and Molot York U

Can we imagine that new lake stressors coupled with climate change lead to novel algal blooms?

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Climate change is likely a threat multiplier for HABs

By damaging animal plankton, that eat algae via

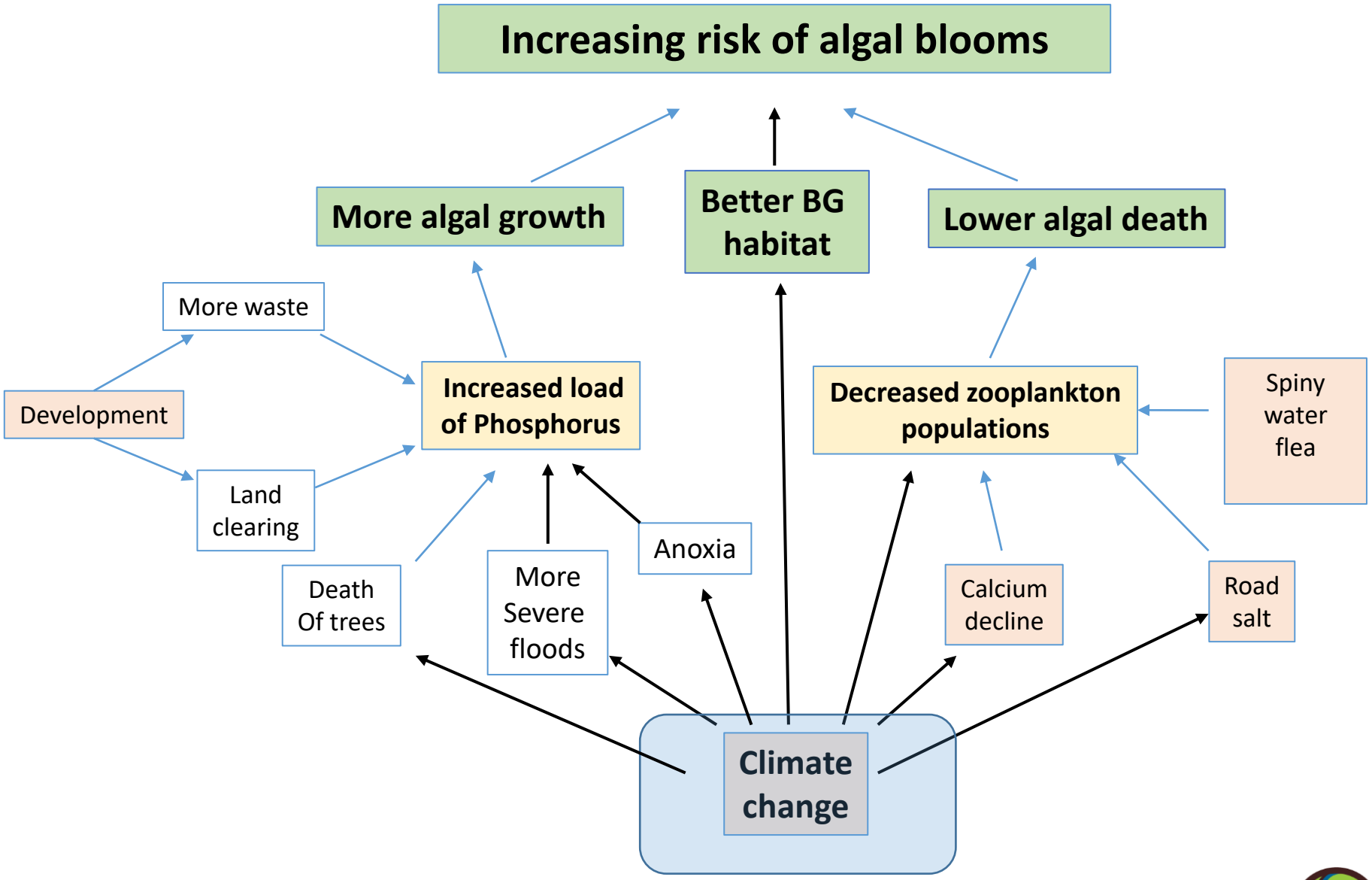
- more salt
- warmer water
- increasing damage from low calcium

Increasing nutrient supply

- more erosion via floods
- Lower bottom water oxygen in late summer releasing sediment P

Improving habitat for blue-green algae

- Warmer water
- Lower wind speeds
- Later fall turnover



Linking emerging threats and **Climate Change to algal blooms**

4: So what should we do

- Fix the problems we do understand
- Study those we don't yet understand to generate the knowledge of what to do

Fix the problems we understand

The problem	The solution
• Faulty septic systems	• Ensure we get them fixed
• Too much salt	• Reduce salt use
• Too many invaders	• Prevent new introductions
• Too little calcium	• Add it, e.g. FOTMW's ASHMuskoka project

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Study the problems we don't understand well enough to manage, e.g. HABs

Our current data aren't good enough
We need real-time, continuous lake monitoring in blue-green 'nursery areas'
to identify conditions that precede HABs

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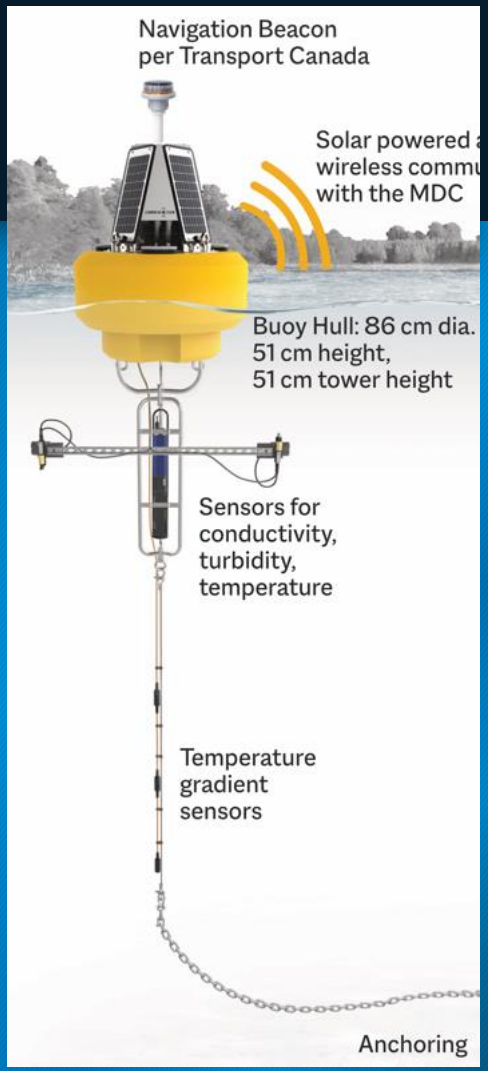
The research idea

- Place ~ 10 sensor strings for temp, O_2 & conductivity in lakes ranging in vulnerability to HABs, to determine..
- $Prob_{HAB}$= f(wind, day of fall mixing, surface temp, bottom O_2, lake depth, grazer density)
- Measure Ca, Cl, water flea density, TP, temperature & O_2 profiles, in sheltered bays, that can serve as good blue-green nurseries
- Cost - $170K in 2023 & 2024
- Real science costs real money



And to sample water fleas

The applied solution research idea

- Once the model to predict HABs is verified, and if bottom O_2 is the cause, then
- Install sensor strings in lakes deemed vulnerable, monitored by lake associations.
- And test potential solutions to maintain oxidizing sediments:
  - Nitrate additions
  - Sediment inactivation
  - lake mixers
  - Hypolimnetic aeration

Friends of the Muskoka Watershed

Science Driving Solutions

Our vision:

Healthy Muskoka watersheds forever

Our mission:

To foster the understanding, choices, actions and wise management needed to protect our freshwater ecosystems forever

Our approach:

Science Driving Solutions

FOTMW 5-year plan

- Involve the community in ash additions and assessing the threat of road salt
- Test if ash additions can increase carbon capture and reduce the severity of spring floods
- Identify the cause of HABs
- Identify novel toxic chemicals
- Build public will for action

How can you help?

- Follow us
- Volunteer
- Become a member
- **Make a donation**

- sandy@fotmw.org
- norman@fotmw.org

- Check us out at **fotmw.org**

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