The Historical Reconstruction of Energy Pathways and Contaminant Accumulation in Lake Trout Between Two Contrasting Great Lakes: Superior and Michigan

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[3] - Water Enforcement & Compliance Assurance Branch EPA

[4] - University of Wisconsin - Madison Aquatic Sciences Center

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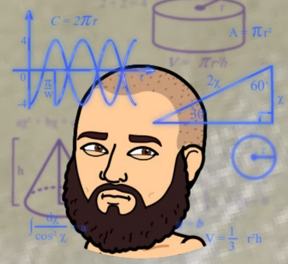

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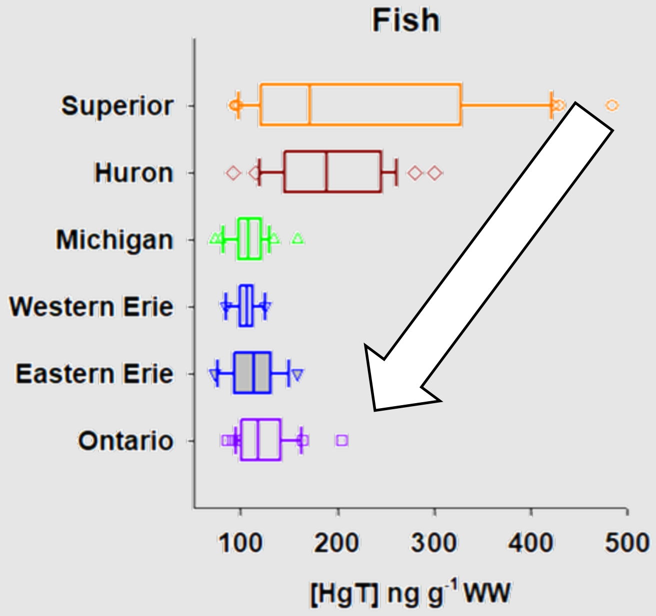
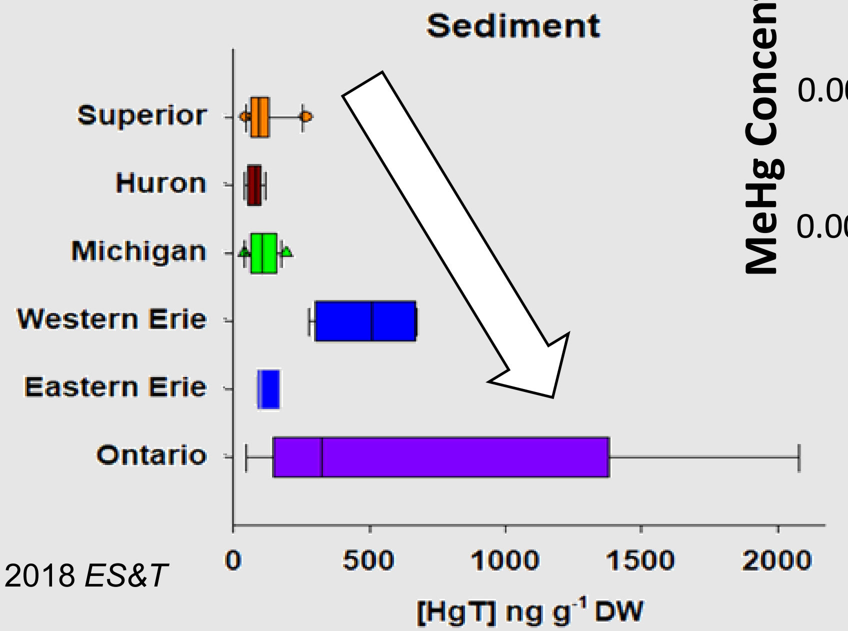
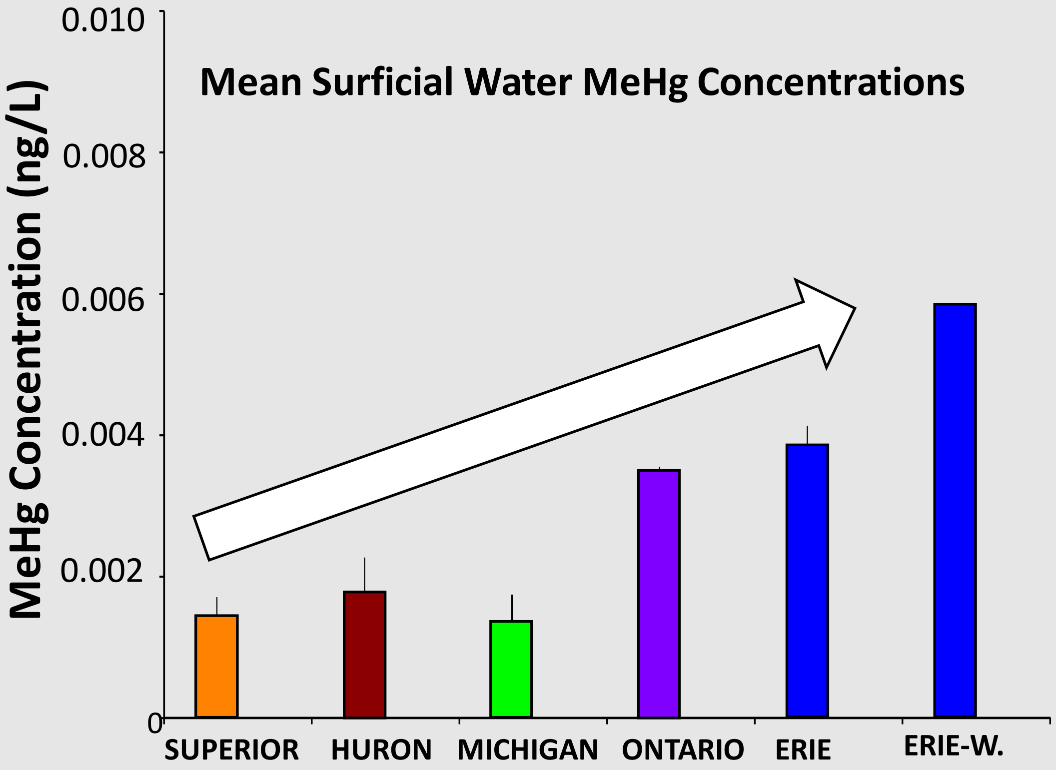
Comparing [Hg] between GLs

- Key finding:
    - Trends in fish [HgT] are opposite to sediment [iHg] and water [MeHg] concentrations.
    - 1) due to differing fish growth rates[1].







1. Zhou, 2018 *ES&T*

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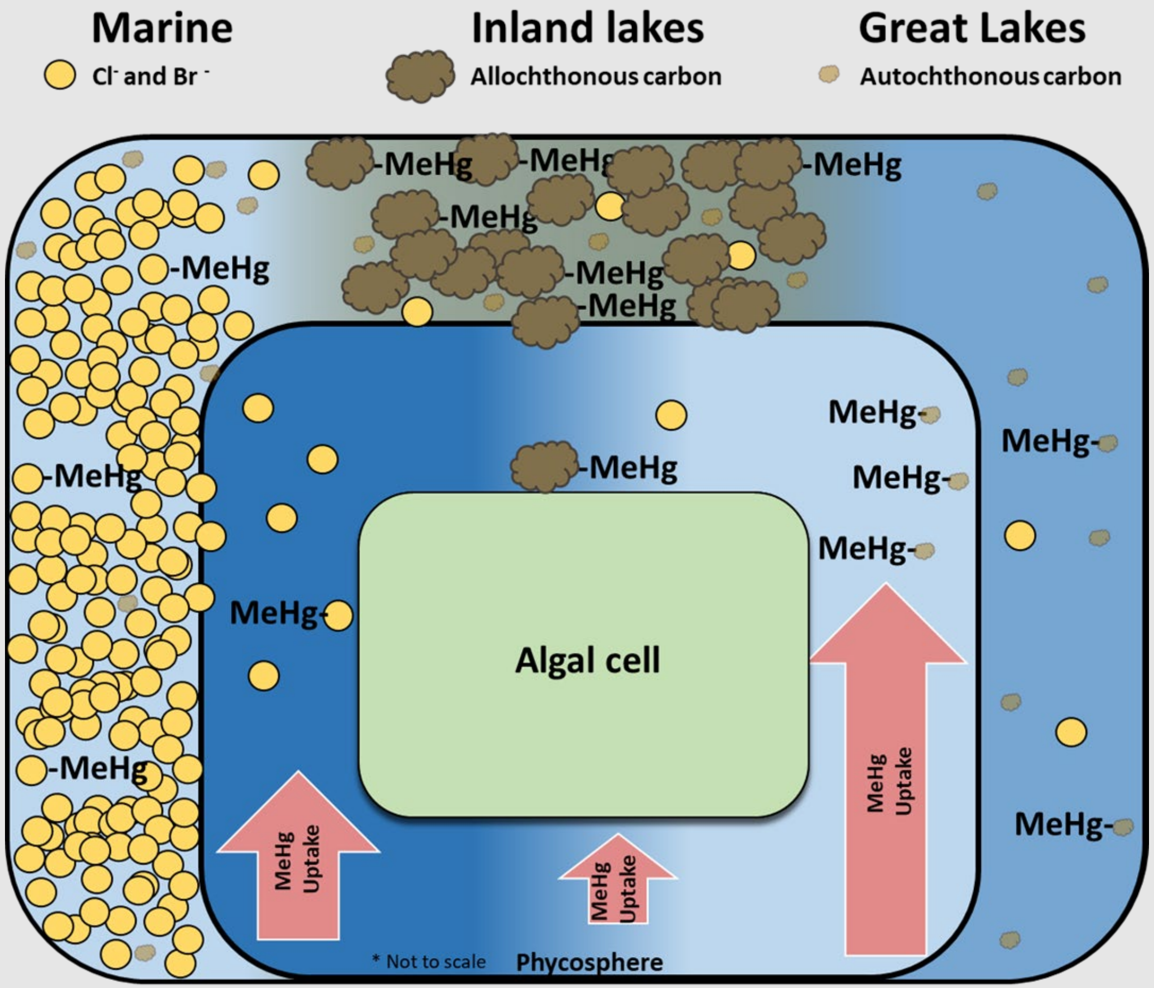
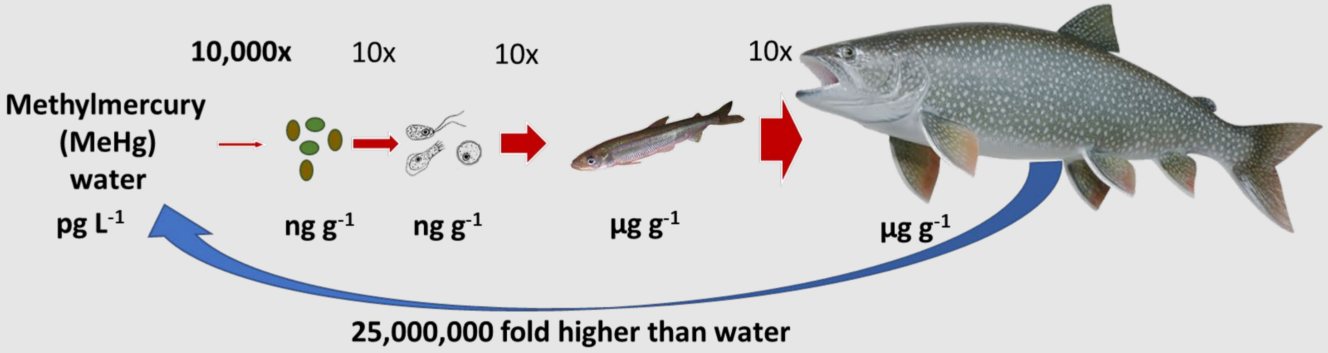
Methylmercury enters the food web

- Bioaccumulation:
  - Processes where biological incorporation begins in lower order taxon



Methylmercury enters the food web

- Bioaccumulation:
  - Processes where biological incorporation begins in lower order taxon
- Biomagnification:
  - chemicals that are <u>increased</u> in concentration up the food web



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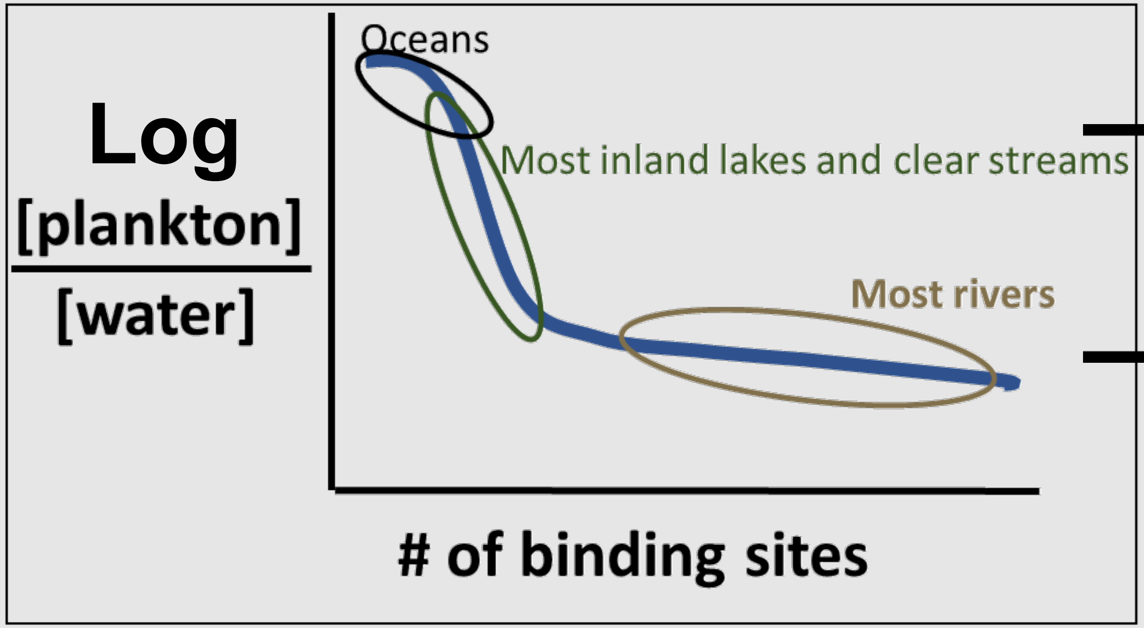

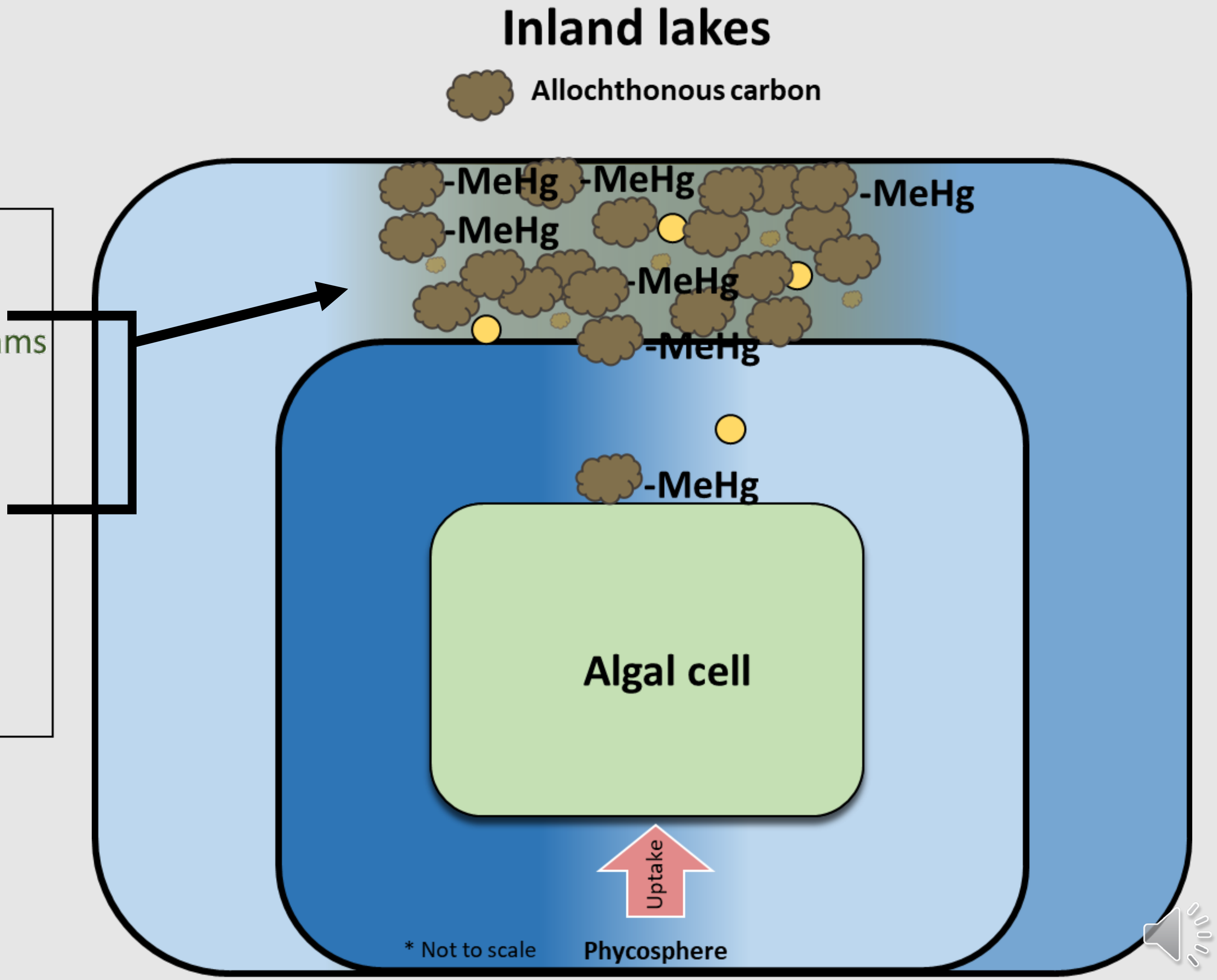

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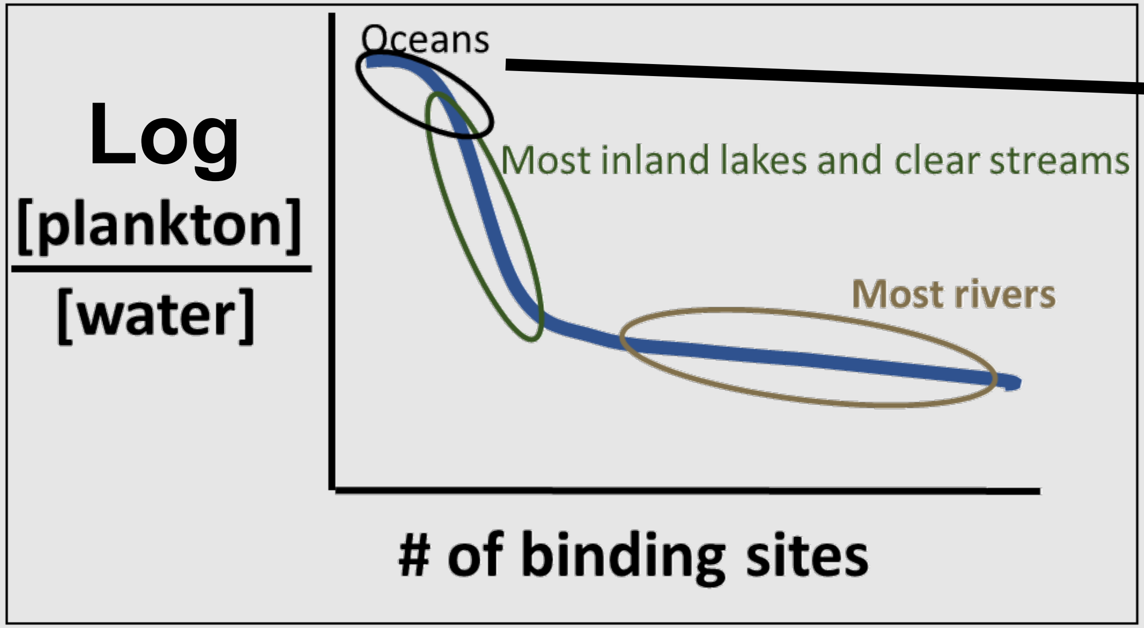

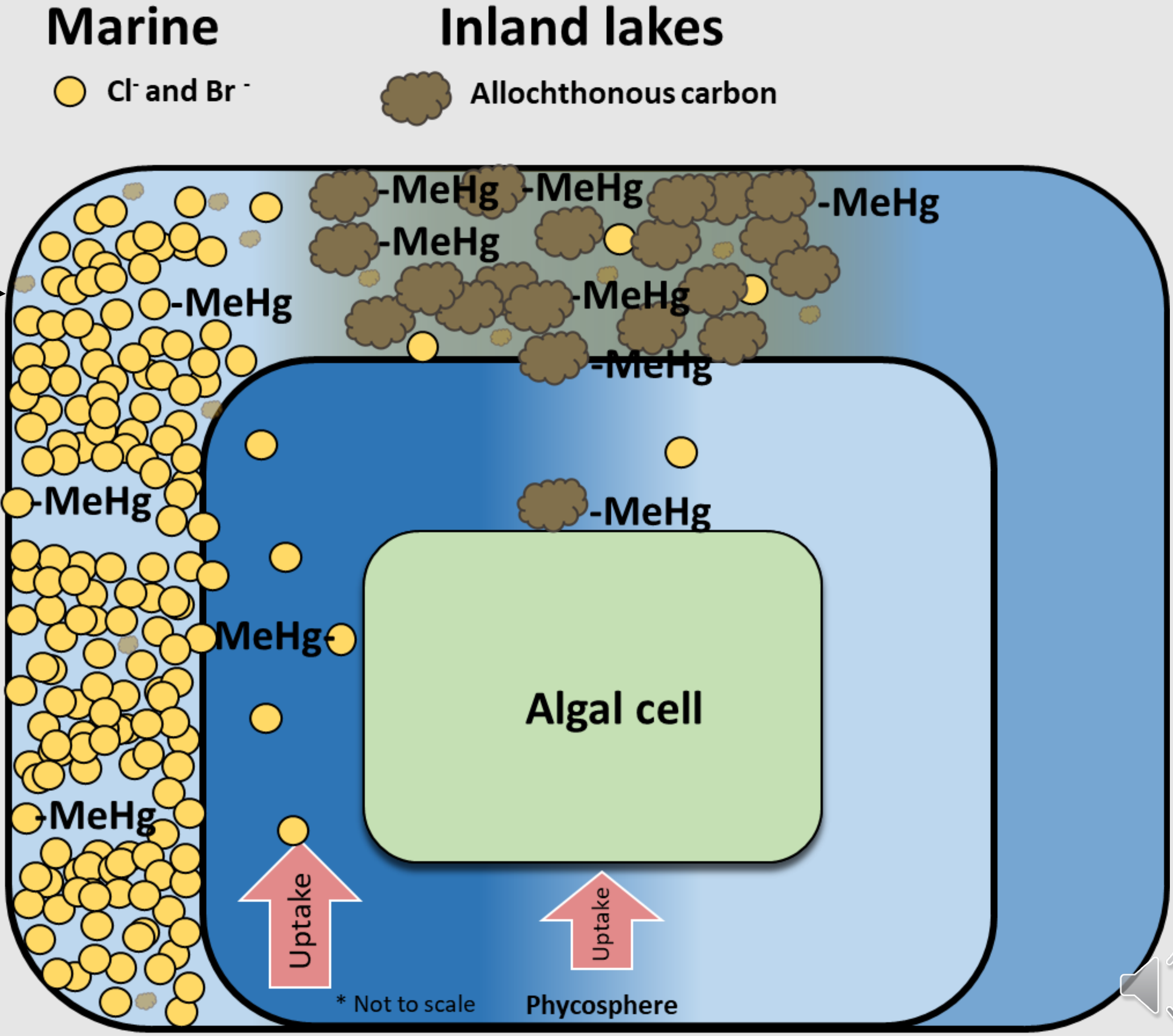

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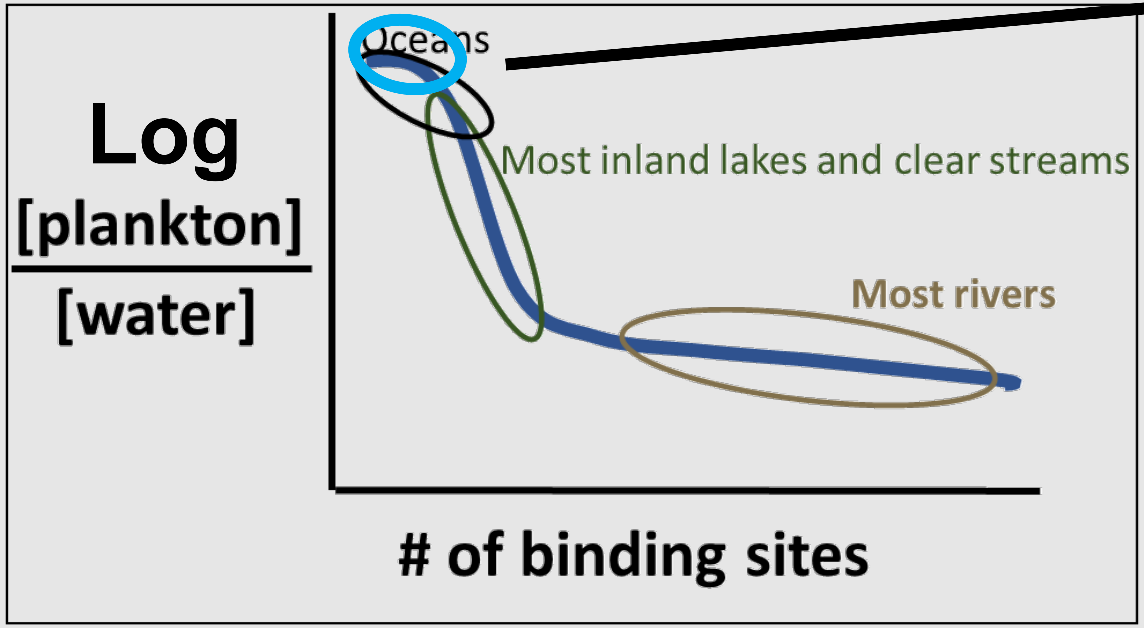

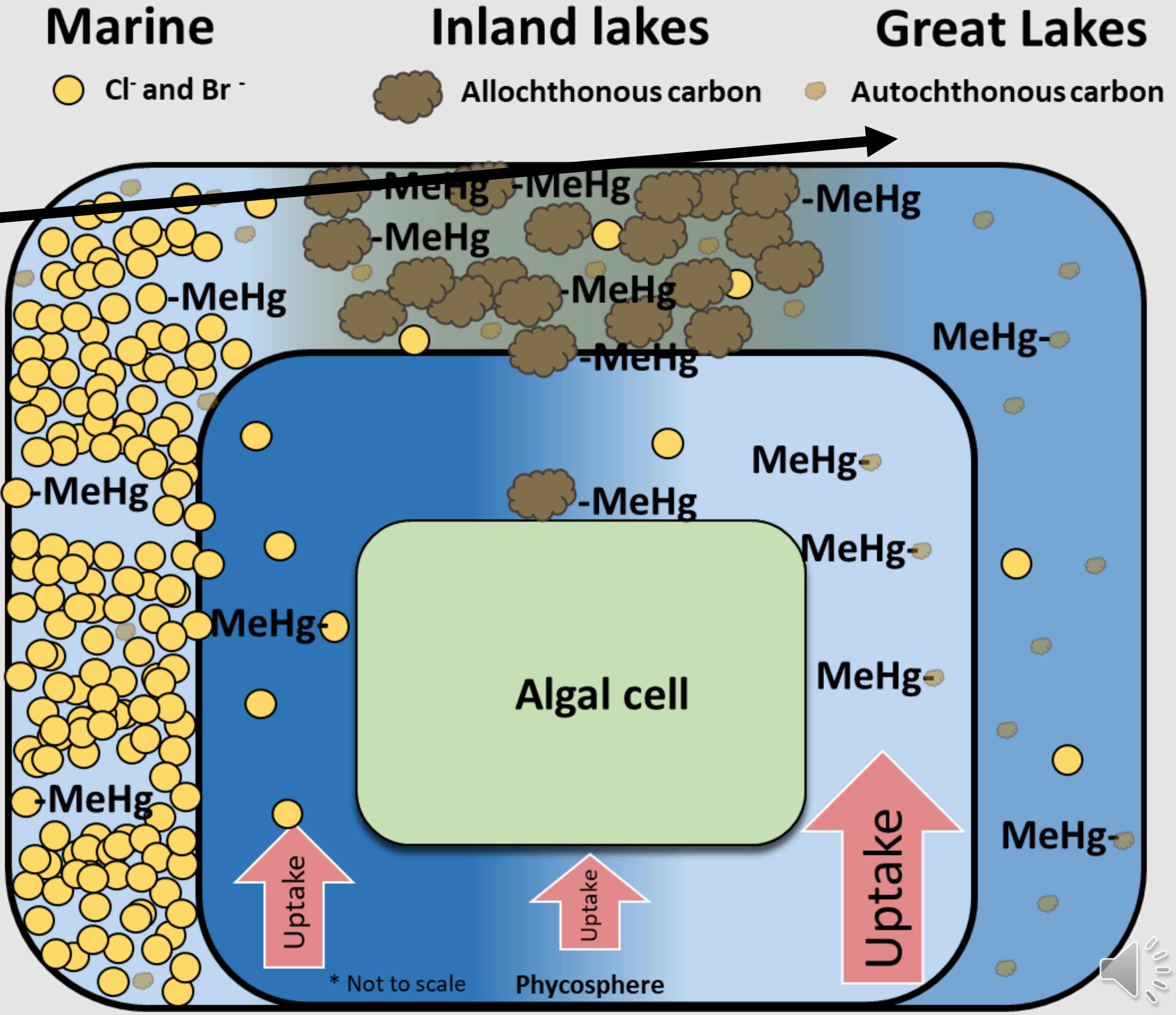

Why it matters

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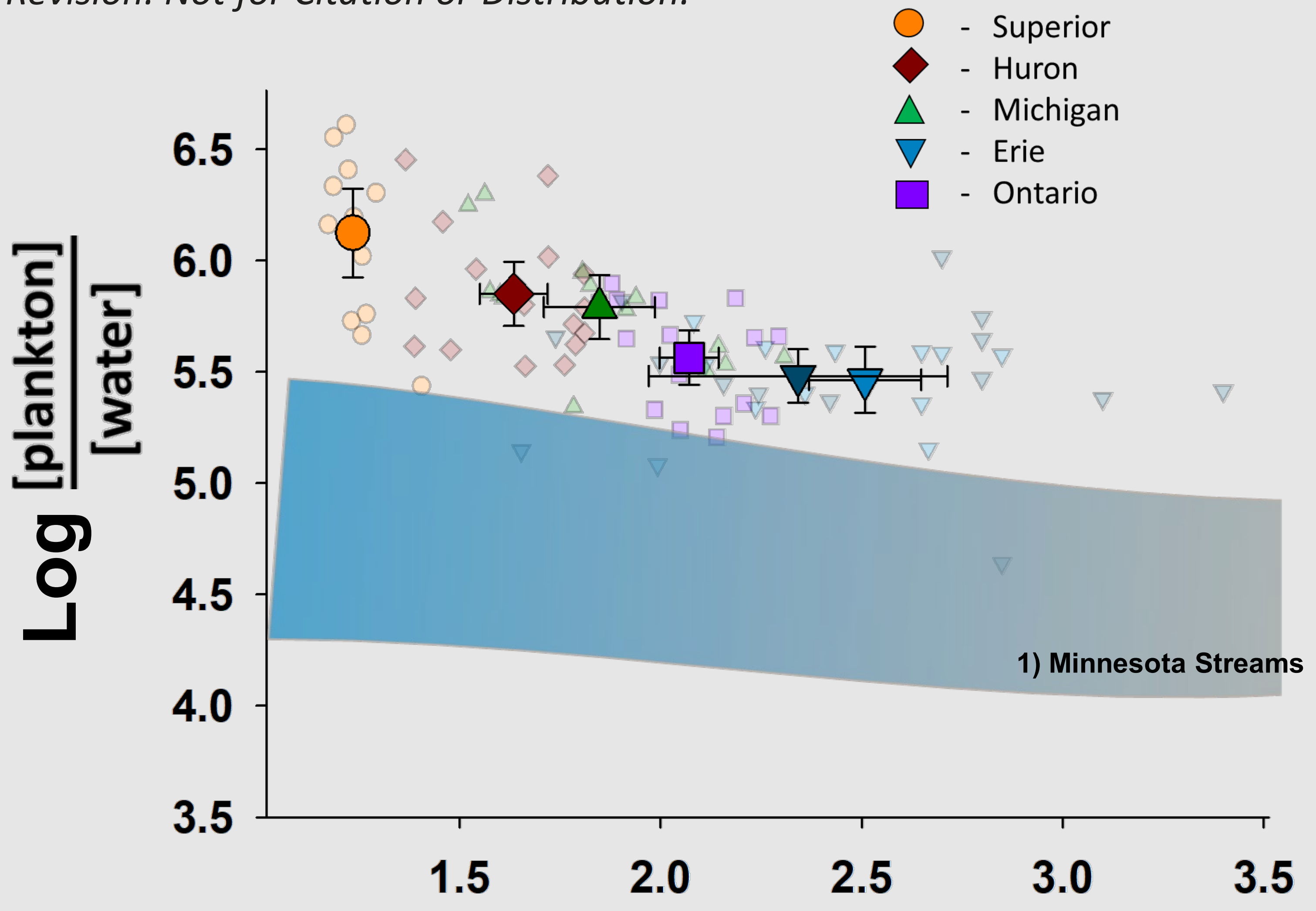

# of binding sites = [DOC] dissolved organic carbon

1) Tsui and Finlay, 2011
2) Schartup *et. al.*, 2015

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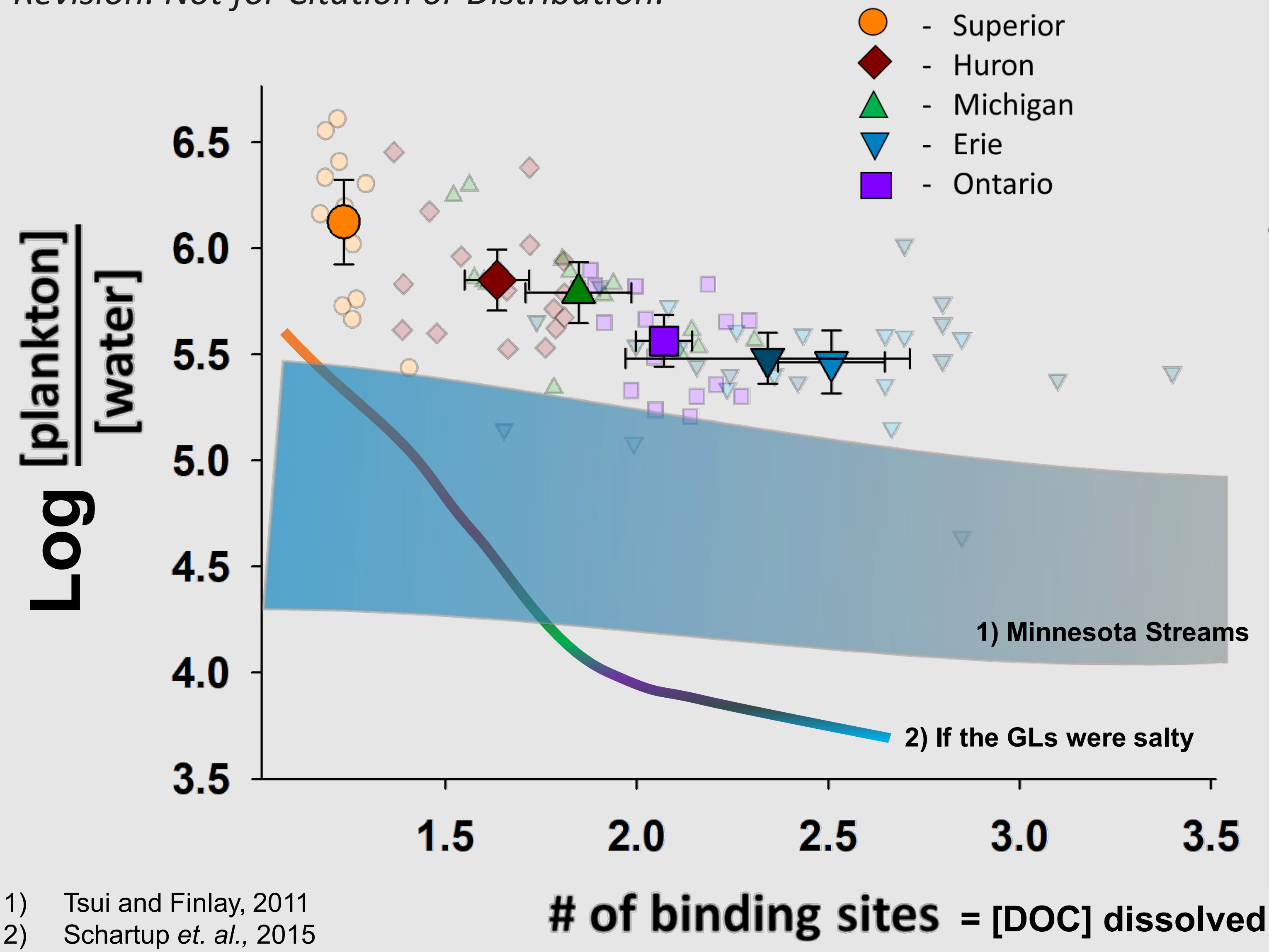

= [DOC] dissolved organic carbon

- Particle matter **sorbs** just like phytoplankton **bioaccumulates**
  - LS > LM = LH > LO = LE
- Fish burden is immediately **enhanced** for some contaminants

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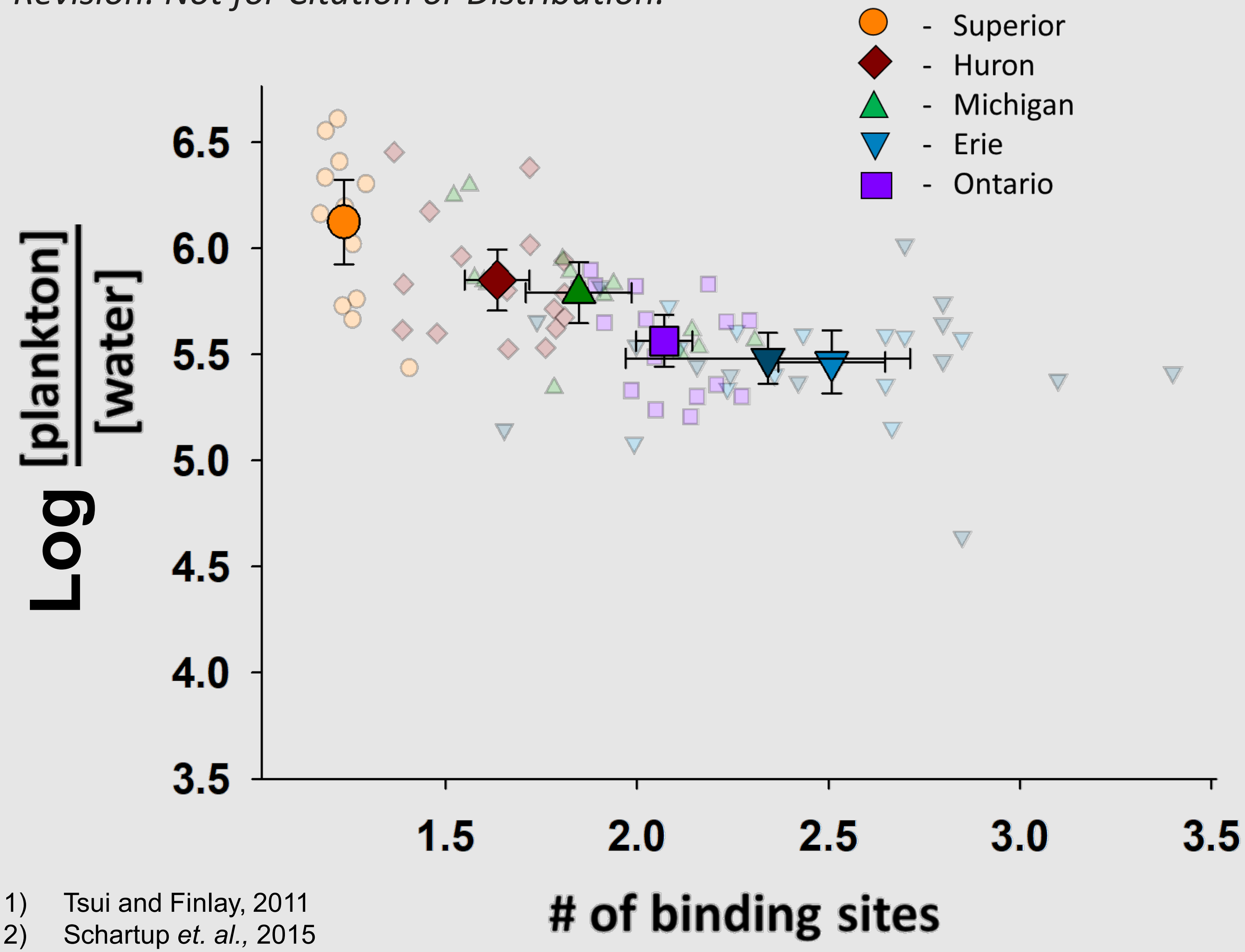

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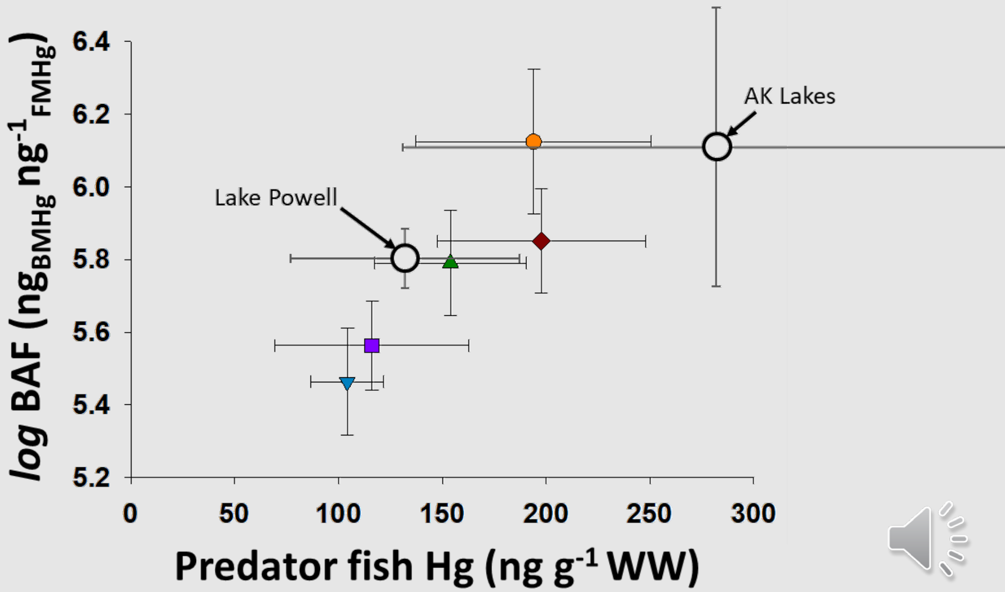

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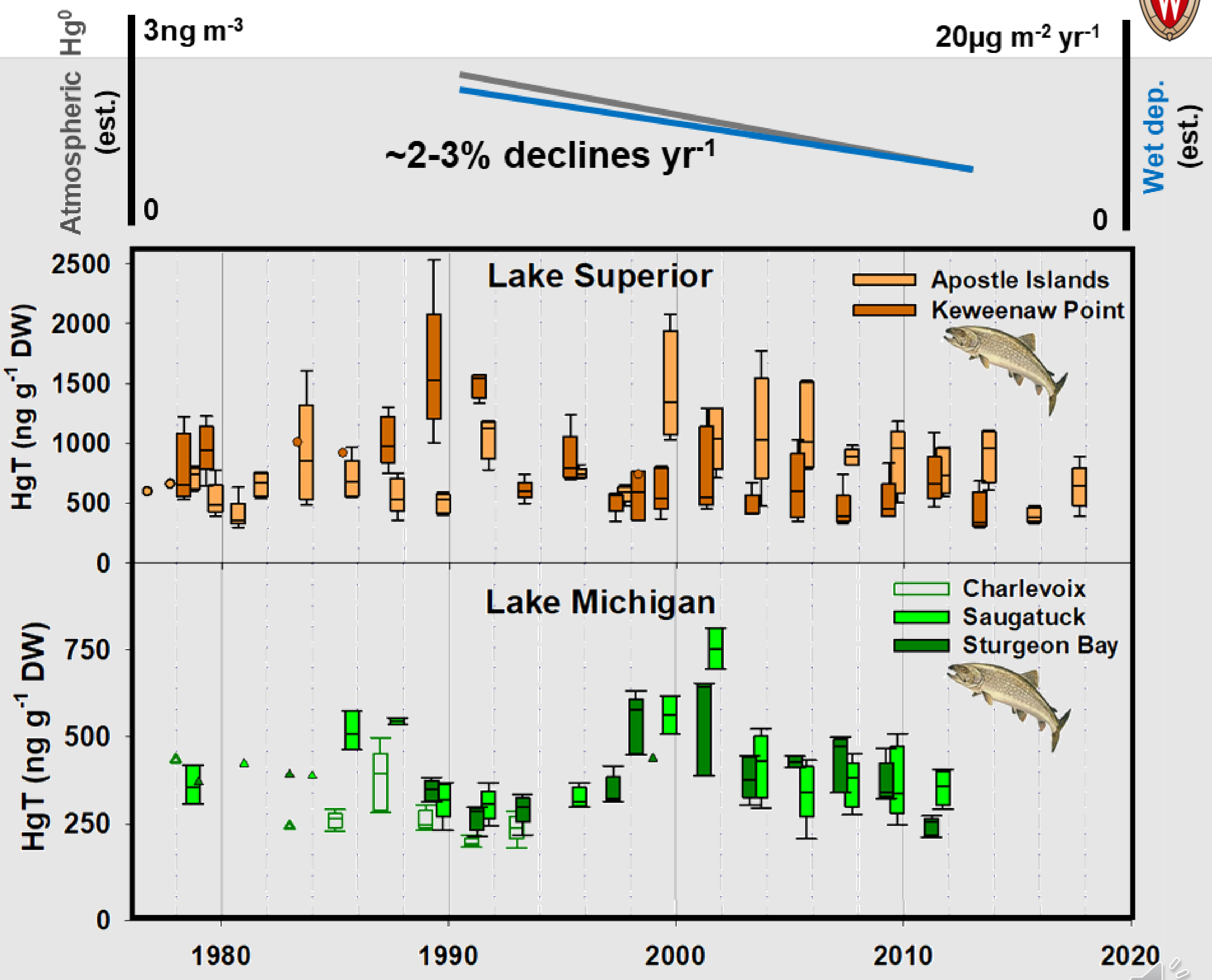
What drives variability?

- **Mercury inputs**
- **Physical**
  - Ice cover, water levels, temperature shifts and influence on biology
- **Bottom-up influence**
  - Primary producer
  - Diet shifts (2nd)
- **Top-down influence**
  - Polymorphism
  - Growth rate (2nd)

Zhang, et al. PNAS 2016



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What drives variability?

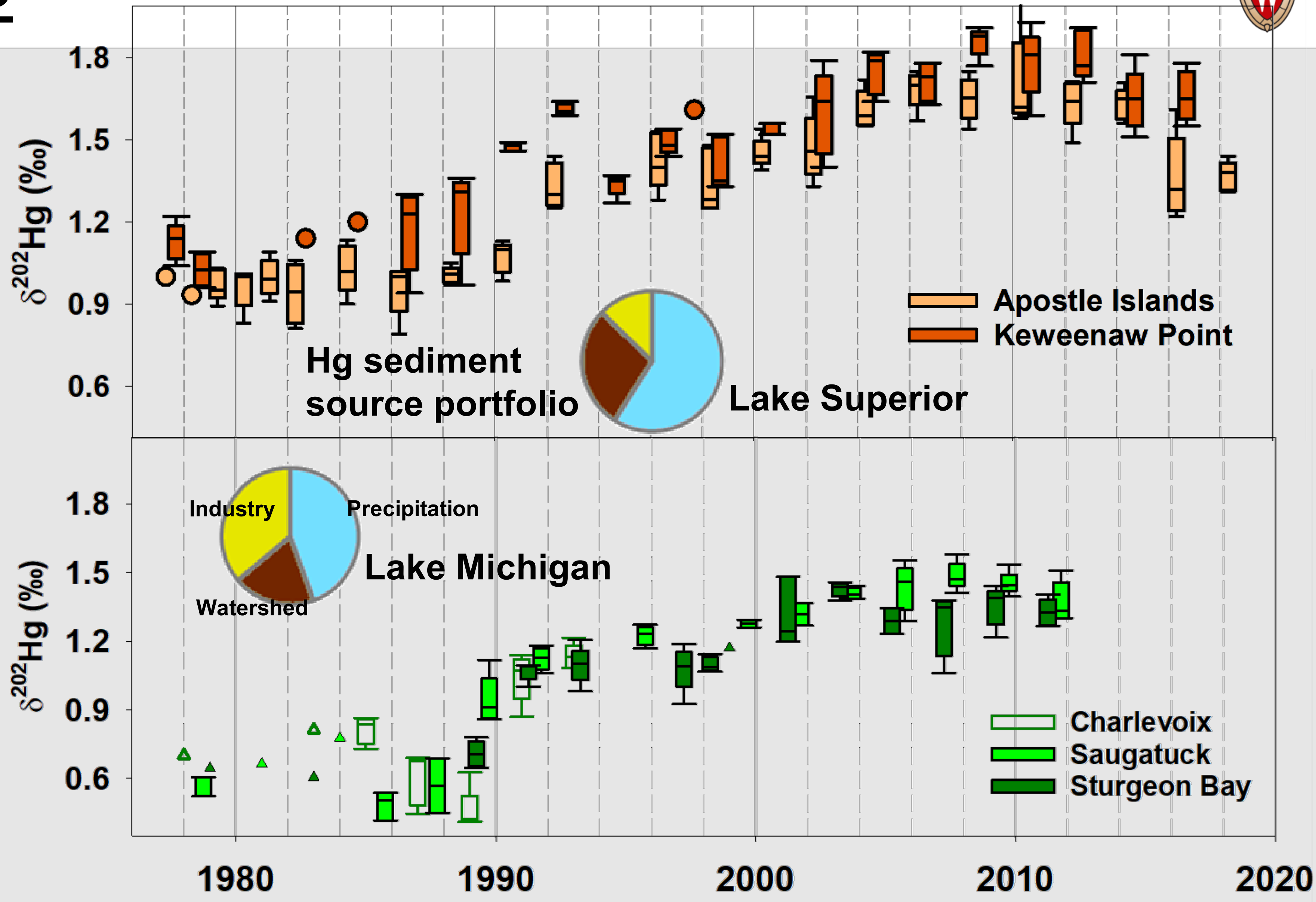
Lepak, et al. ES&T Letters 2015

- **Mercury inputs**

  Sources

  - Lake-lake coherence in δ^{202}Hg - response (and source)

  - Increasing ~0.6 per mille, away from point/local source contamination



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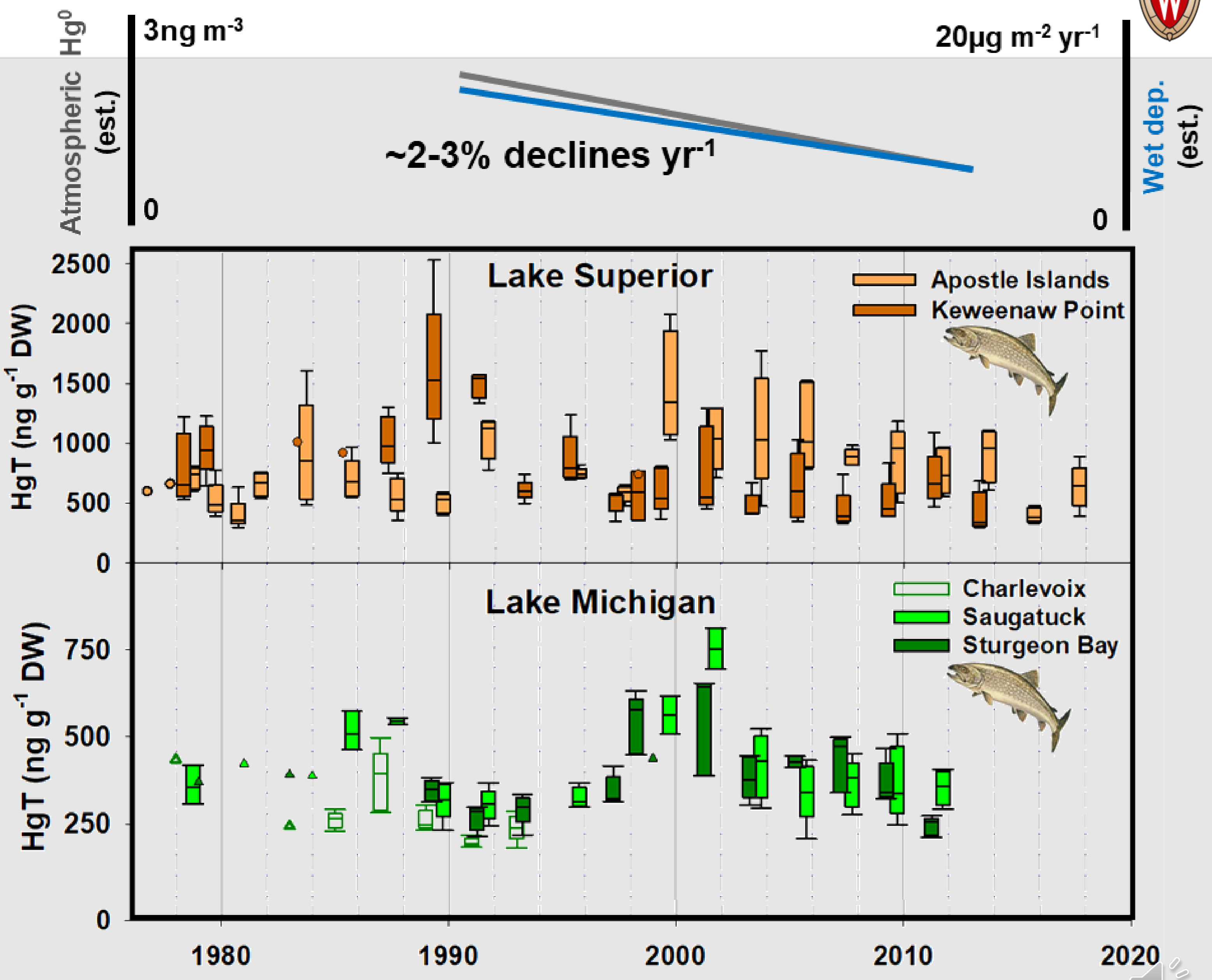

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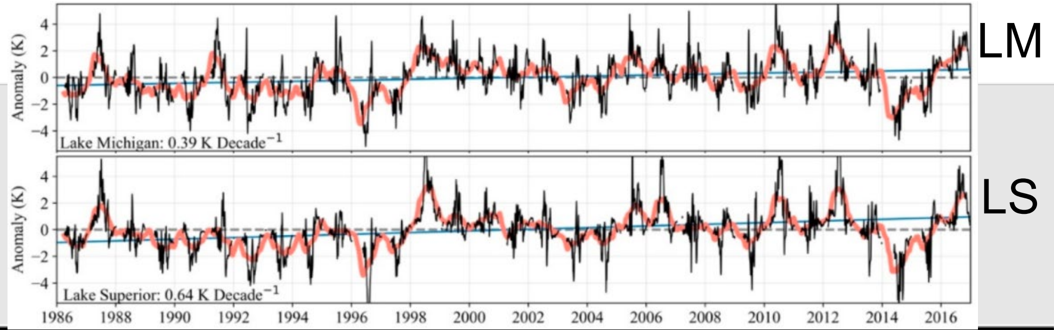
What drives variability?

White, et al. Remote Sensing 2018.

Temperature anomaly



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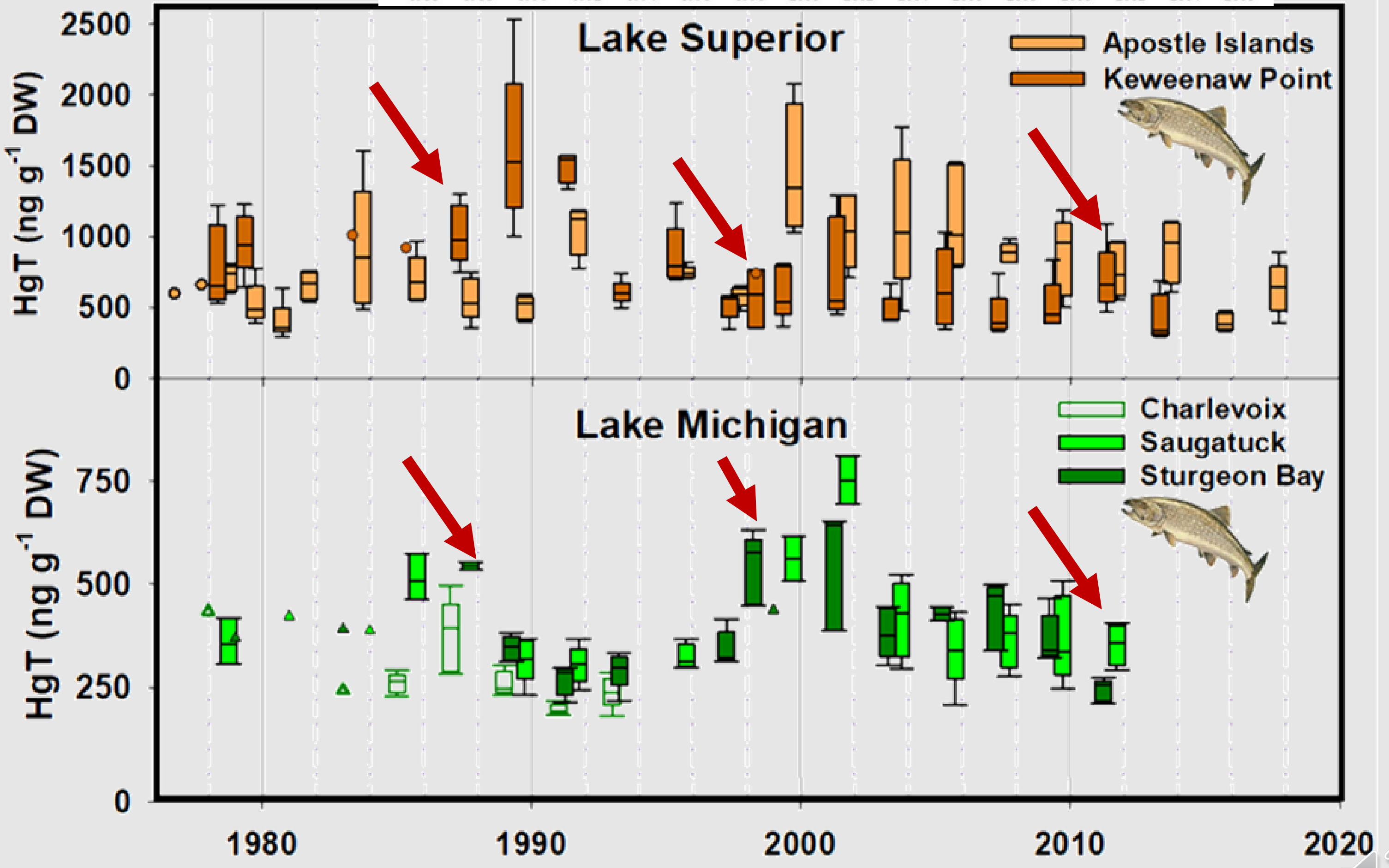

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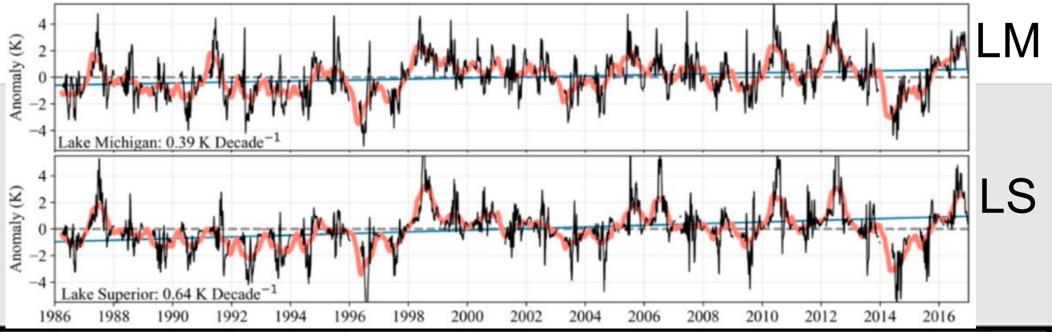

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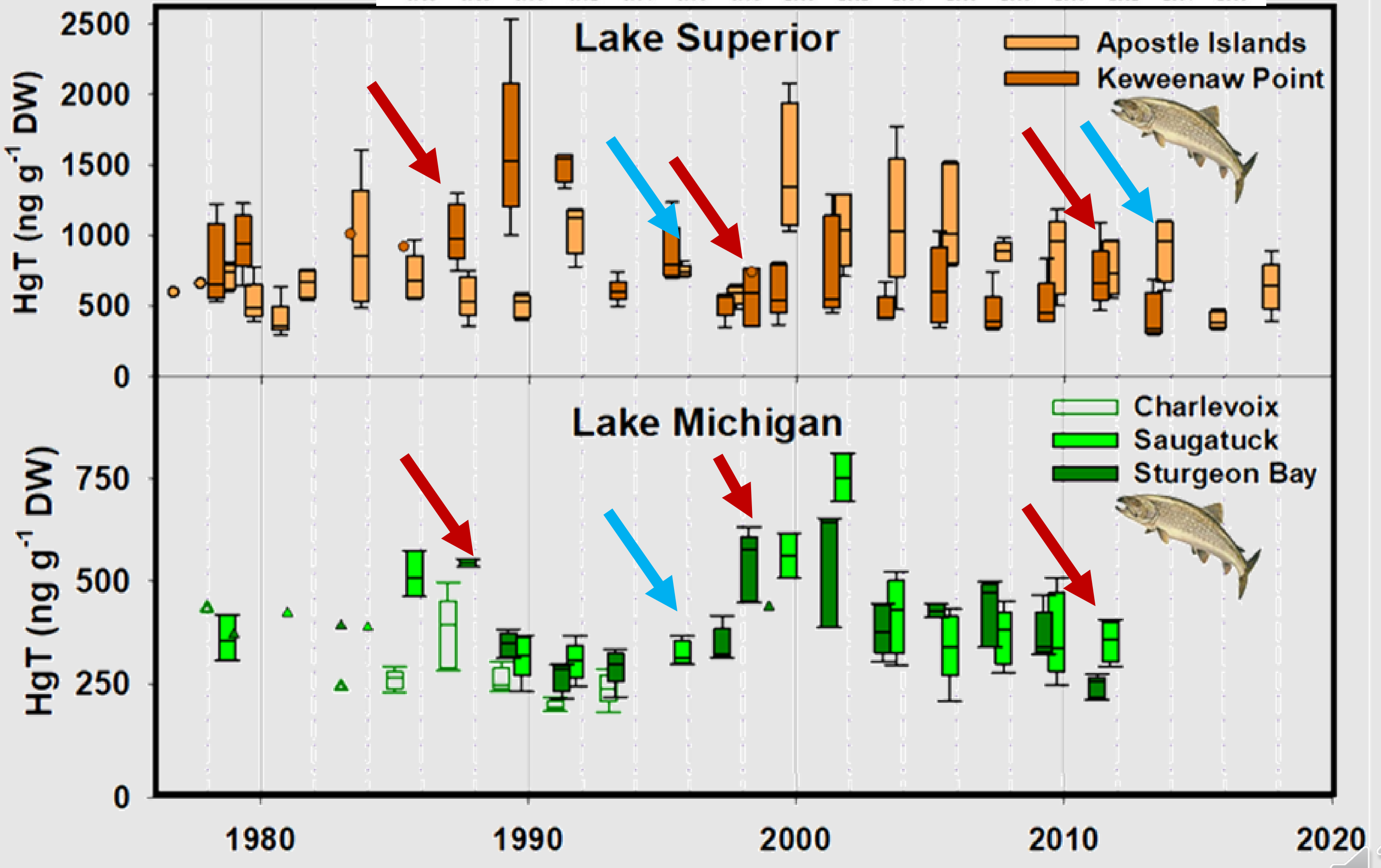

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Mason et al. Climatic Change 2016.

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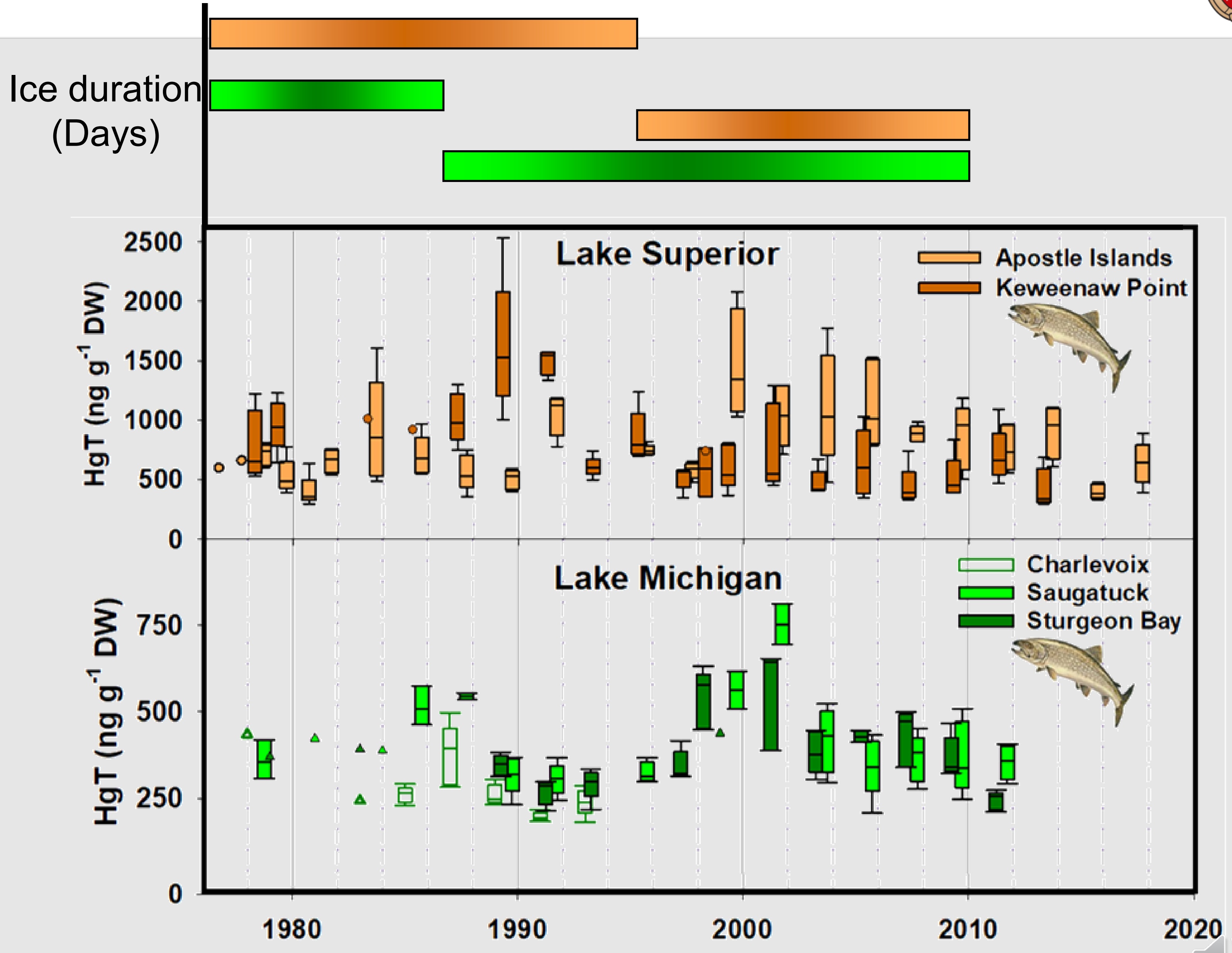

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What drives variability?

Scofield, et al. Limnology and Oceanography 2020.

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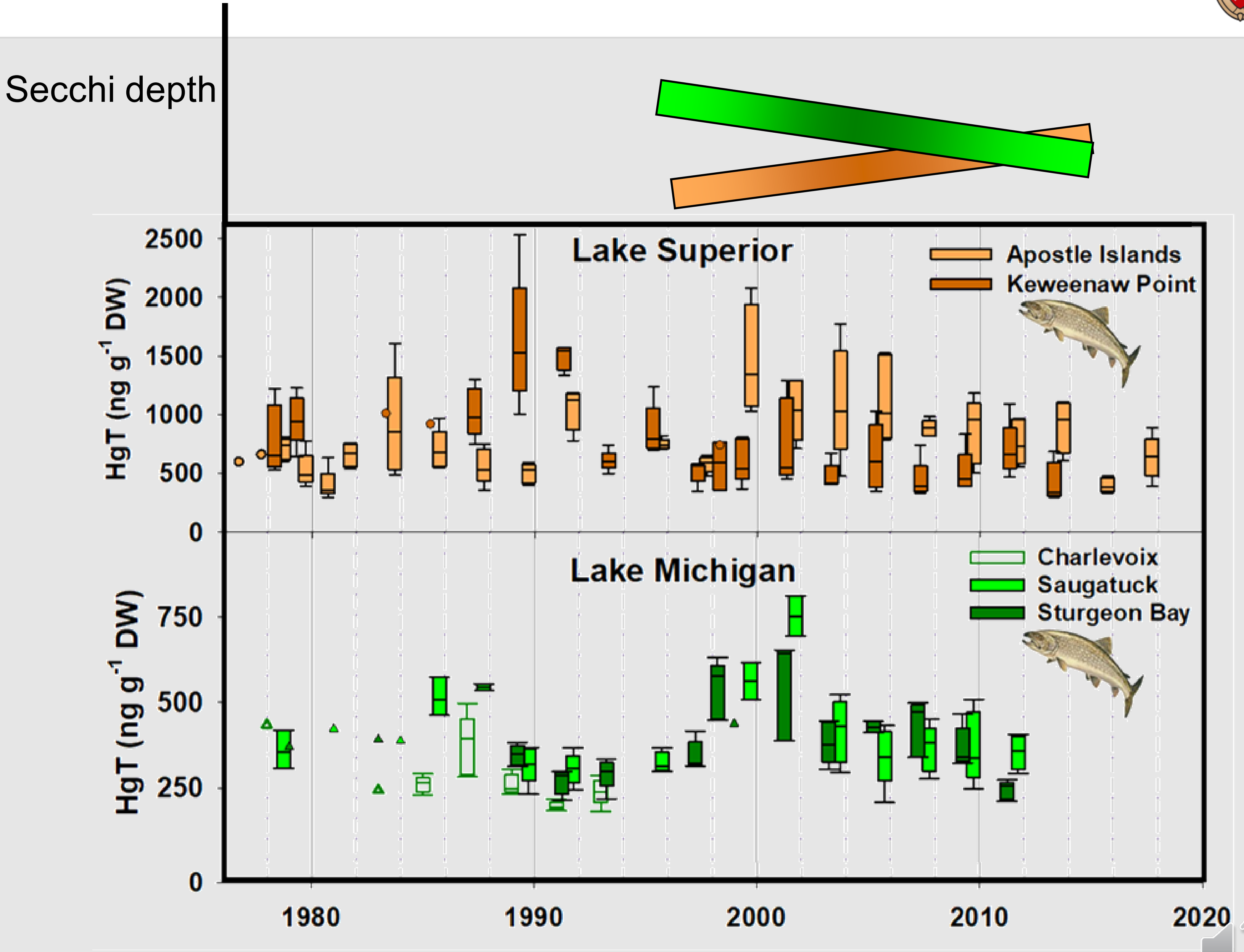

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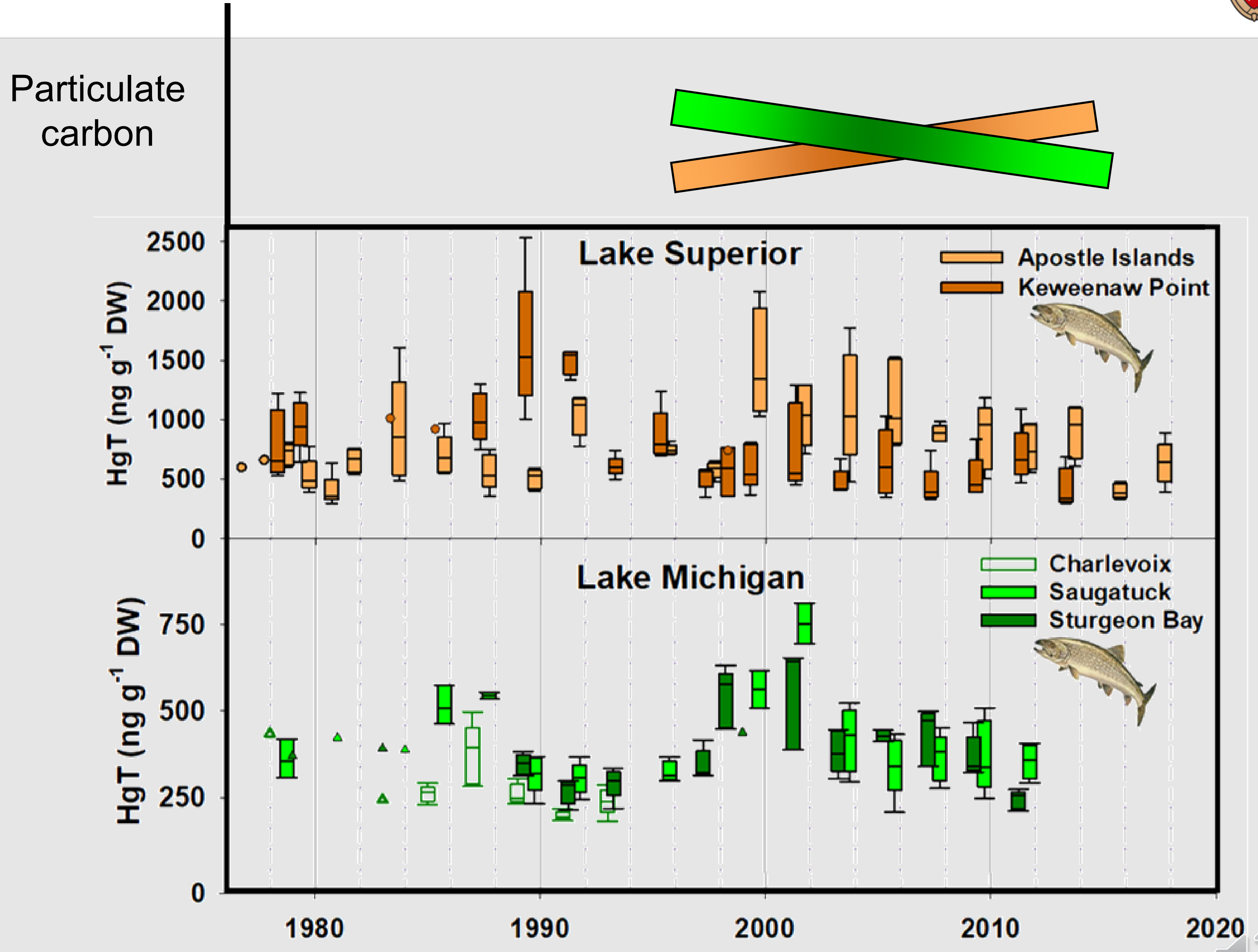

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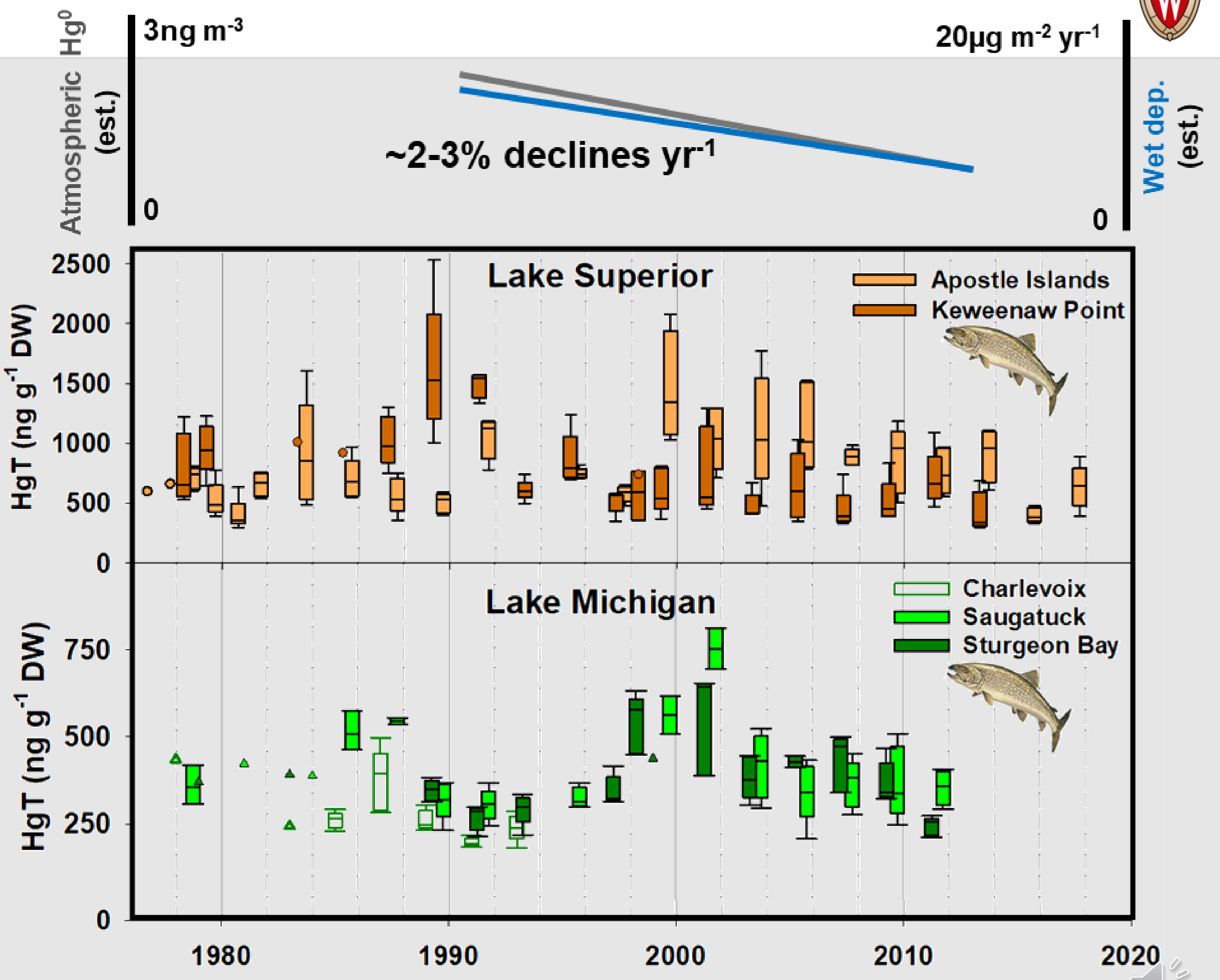

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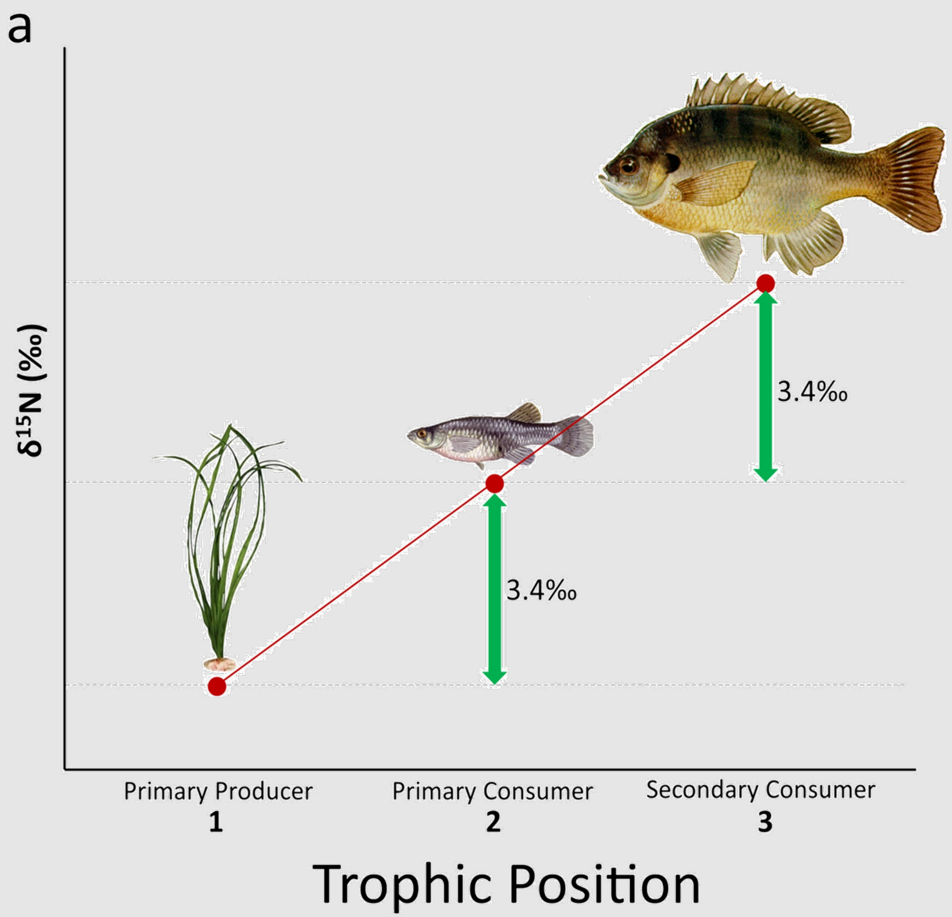
C and N bulk stable isotopes ratios



- Nitrogen isotopes increase up the food chain (carbon isotopes remain comparatively conserved)
  - $\delta^{15}N$ can signal relative trophic position
- Together, delineate energy sources and pathways for this sampling design
- Bulk atoms are sourced from many complicating factors, reducing precision

Bowes and Thorp. Ecosphere 2015.

C and N bulk stable isotopes ratios

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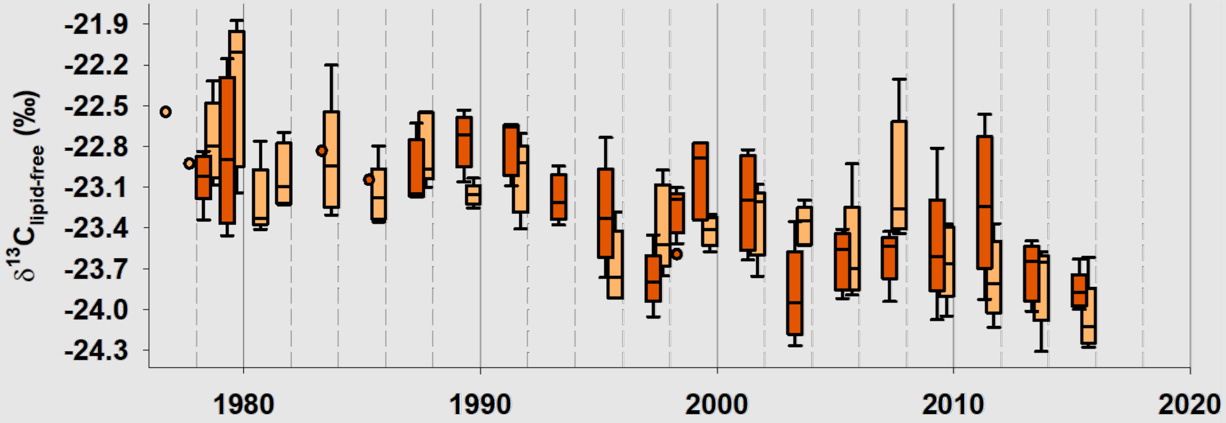
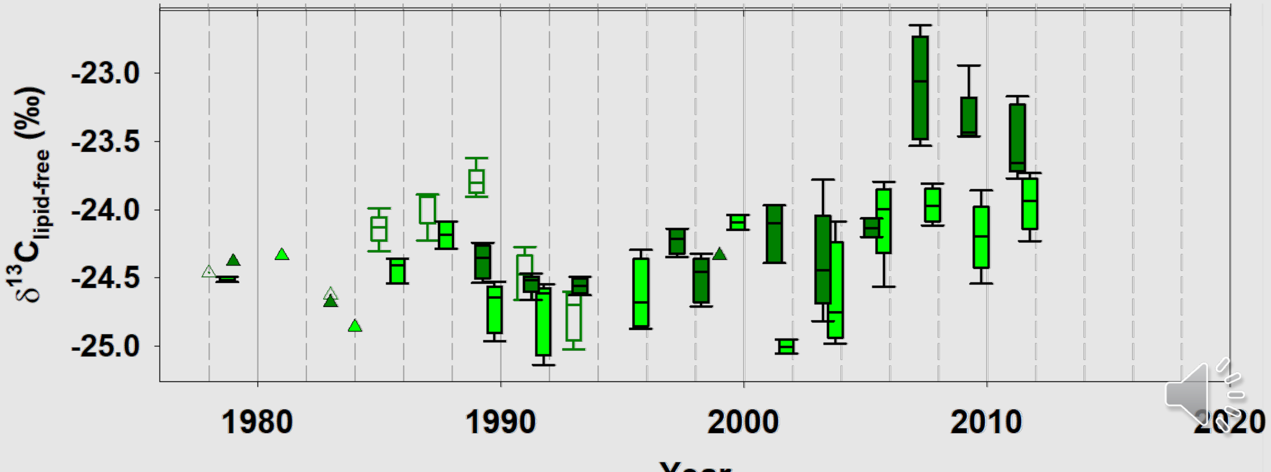
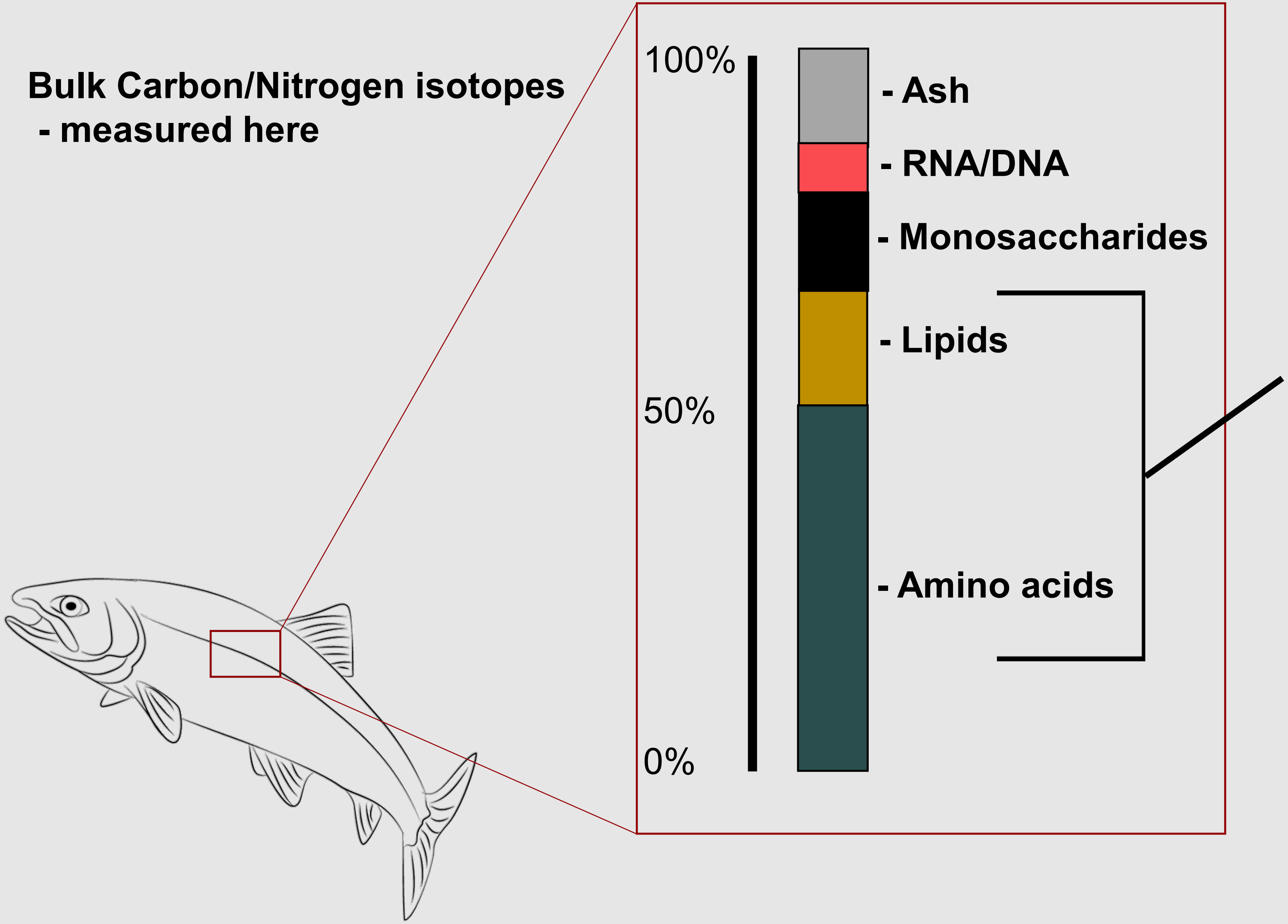




Stable isotopes ratios of select compounds

Bulk Carbon/Nitrogen isotopes
- measured here



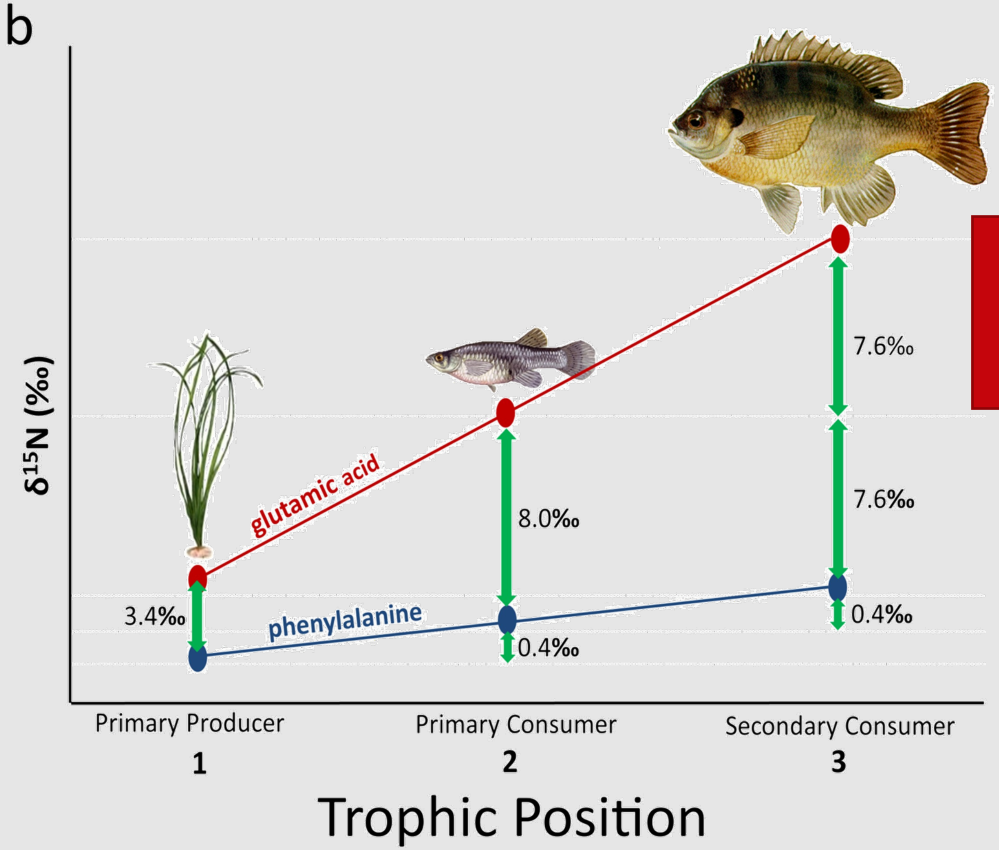
<u>Essential</u>

-produced by primary organisms

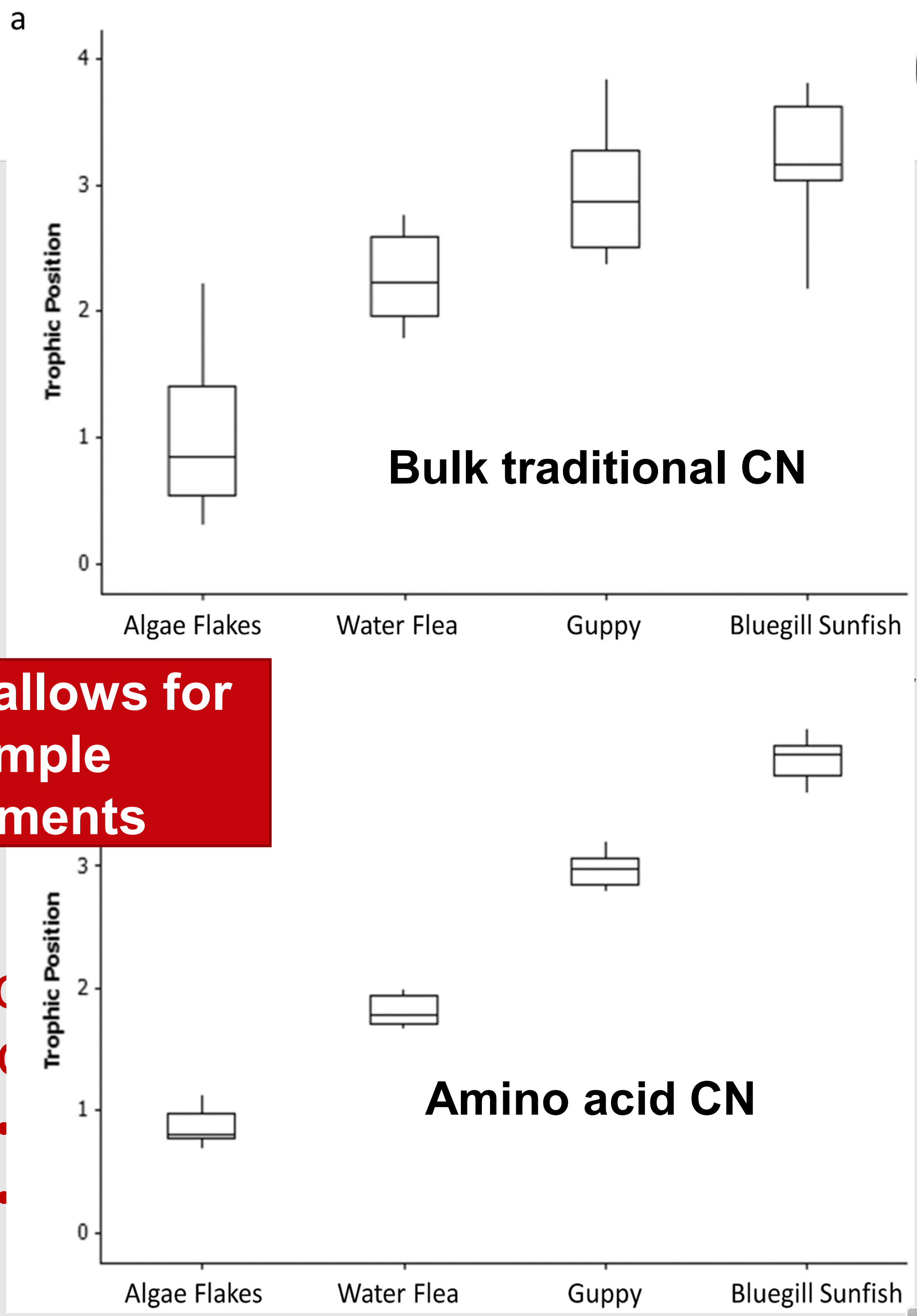
<u>Non-essential</u>

-synthesized by the organism

CN stable isotopes ratios in extracted amino acids



- Two



> Precision allows for less sample measurements

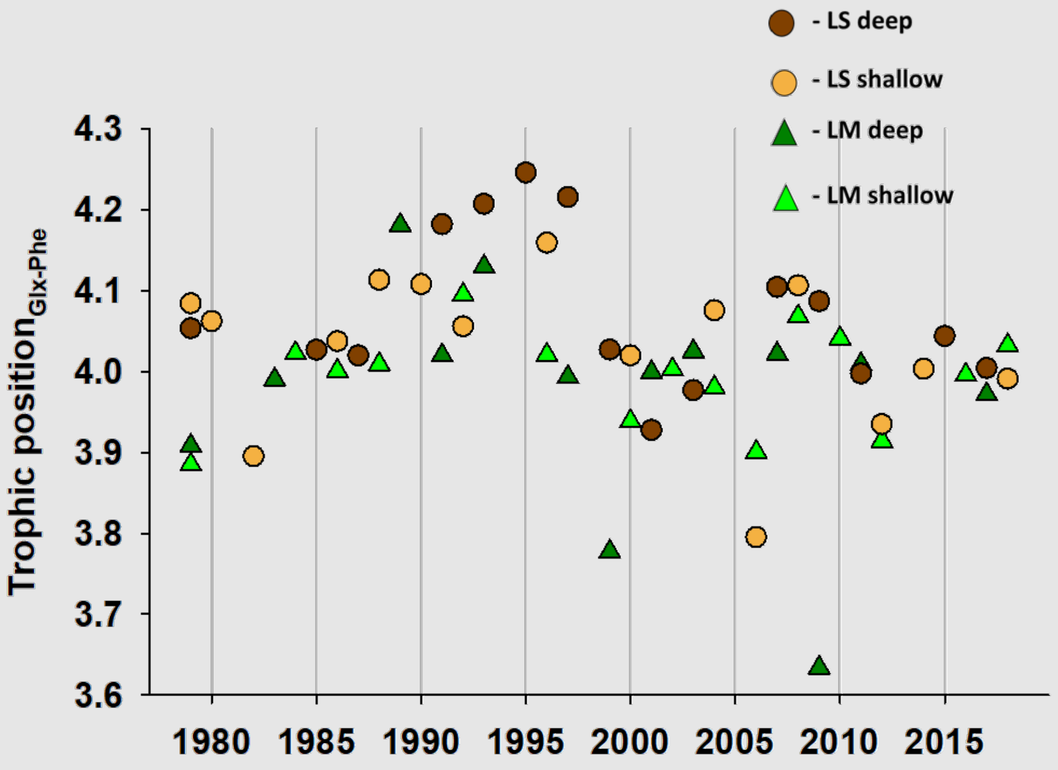
ey

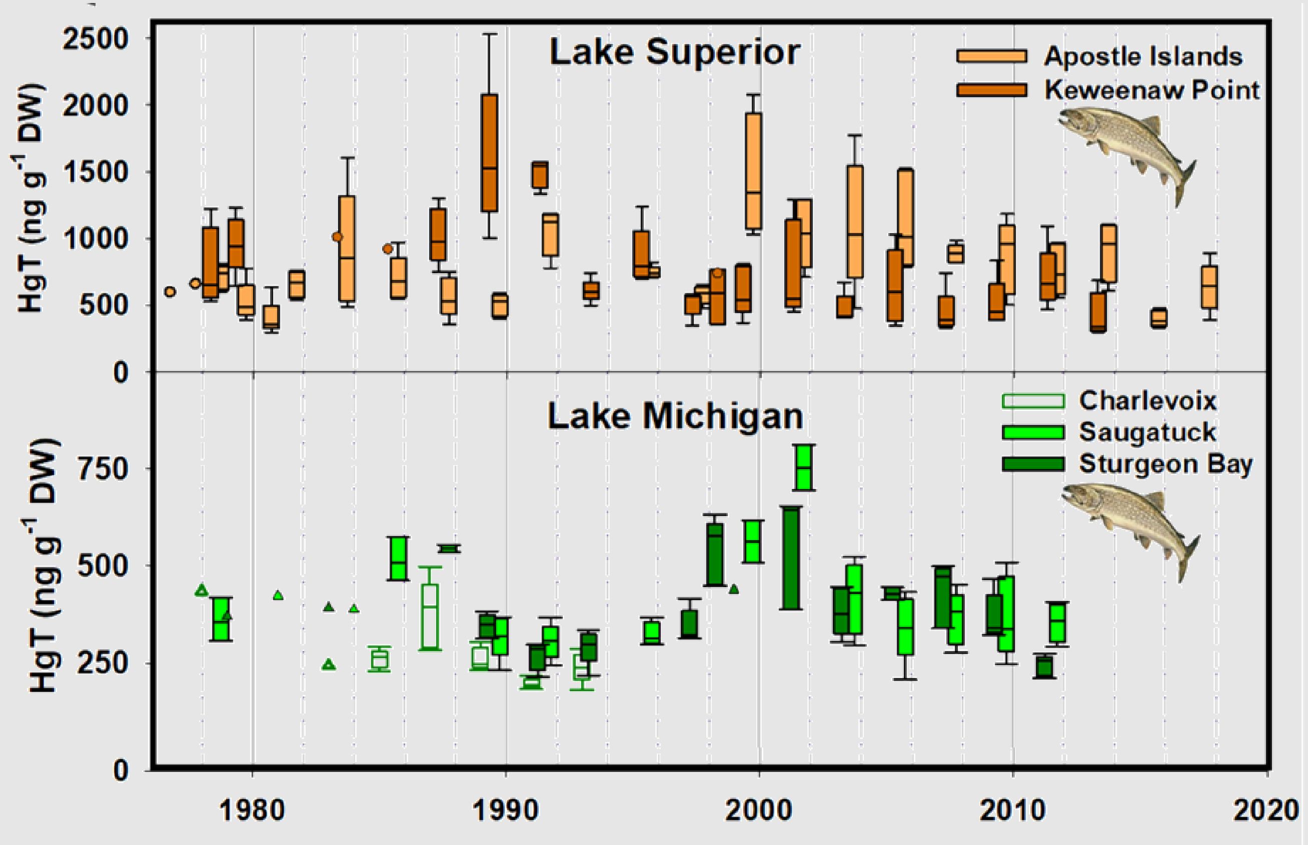
- No
bi

Bowes and Thorp. Ecosphere 2015.

Amino acids - one take away

- Surprising similarity between Lakes Superior and Michigan
  - TP consistent <u>after</u> QM in LM





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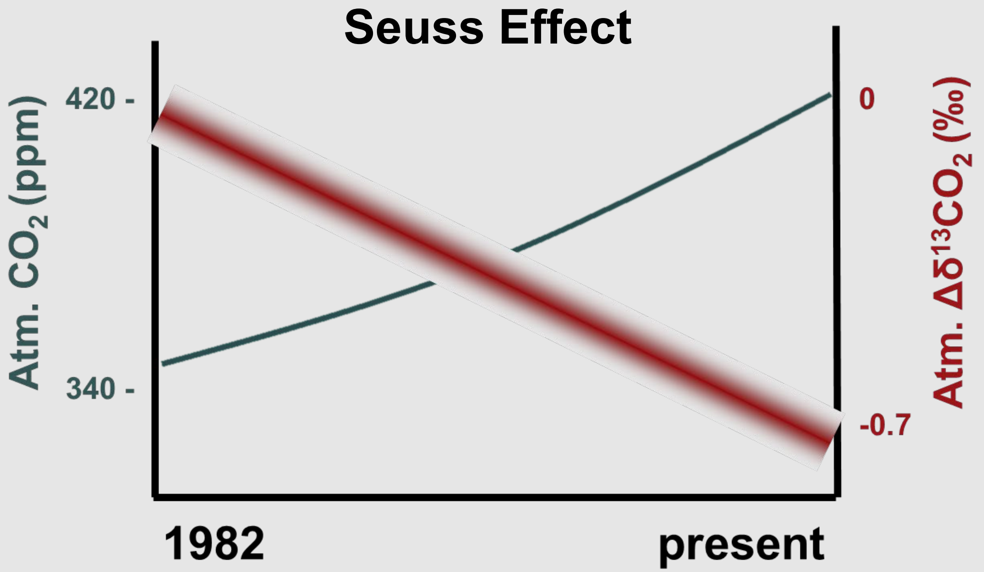
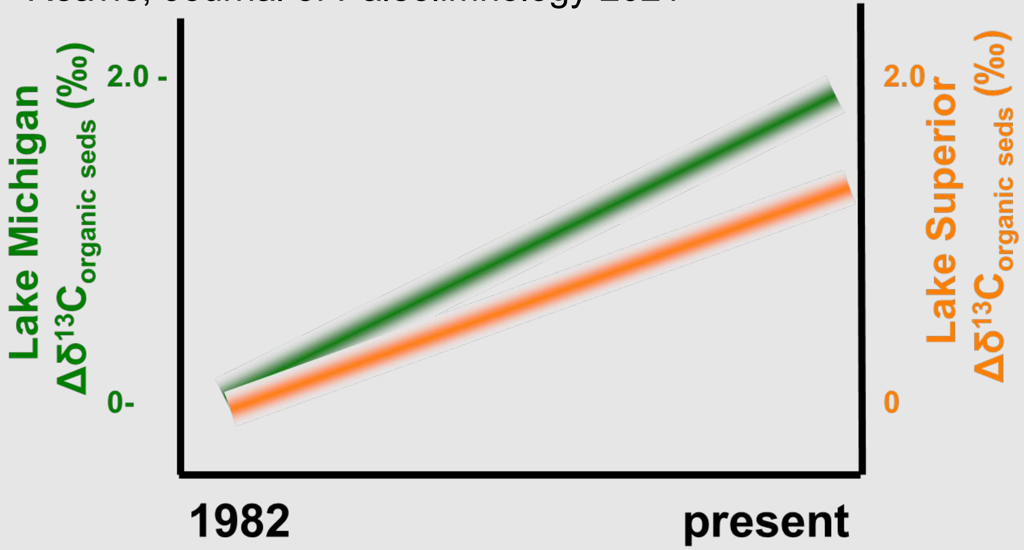
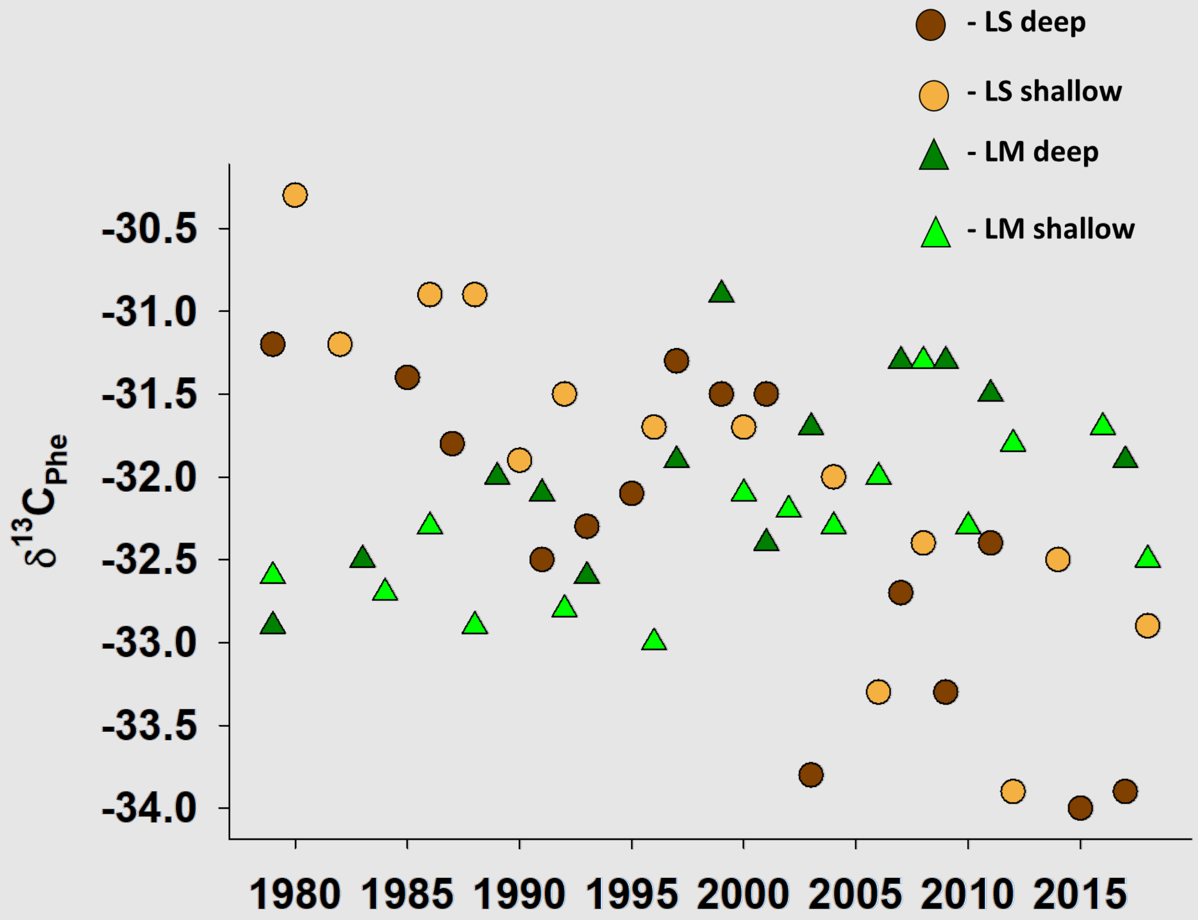
Basal - item CN sources

Keeling, Science 1979



Reavie, Journal of Paleolimnology 2021





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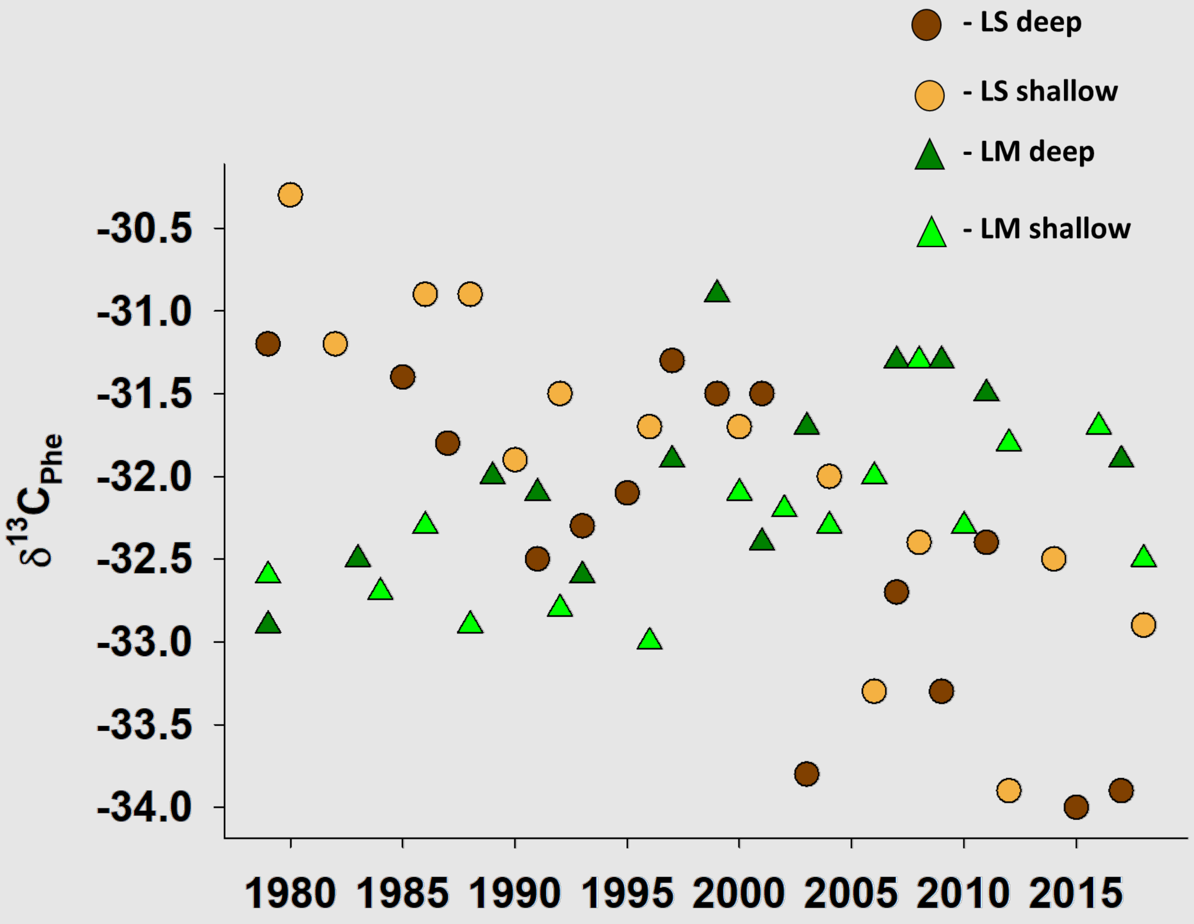
Basal - item CN sources

- Surprising differences in values

  Lake Superior (-) Lake Michigan (+)

  - Carbon - traces physical lake or planktonic phenomena or habitat movement?



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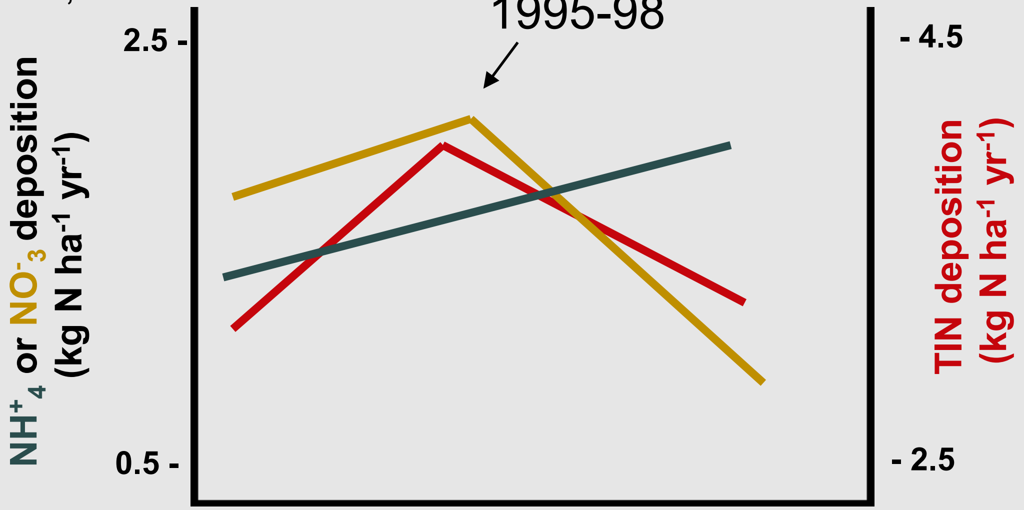
Du, PNAS 2016



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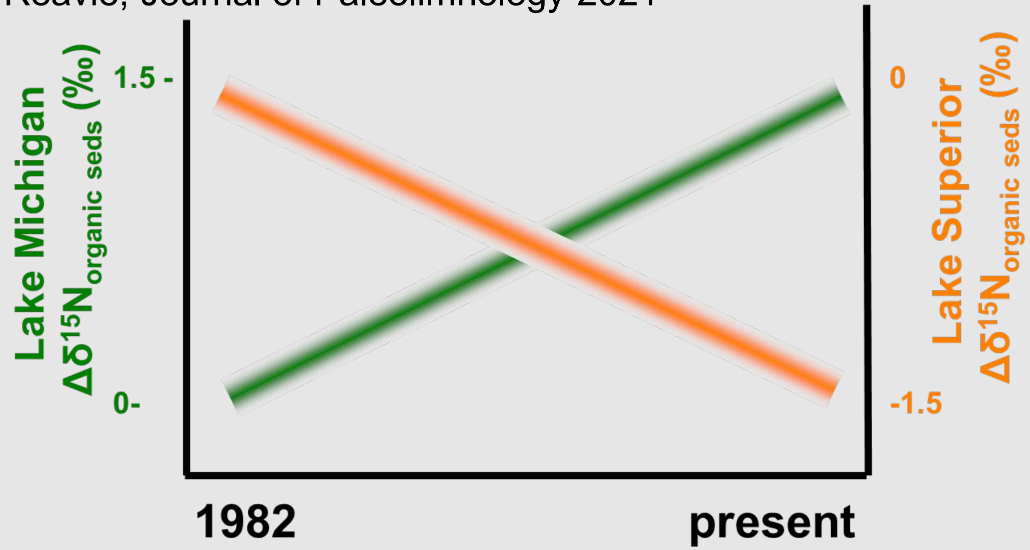

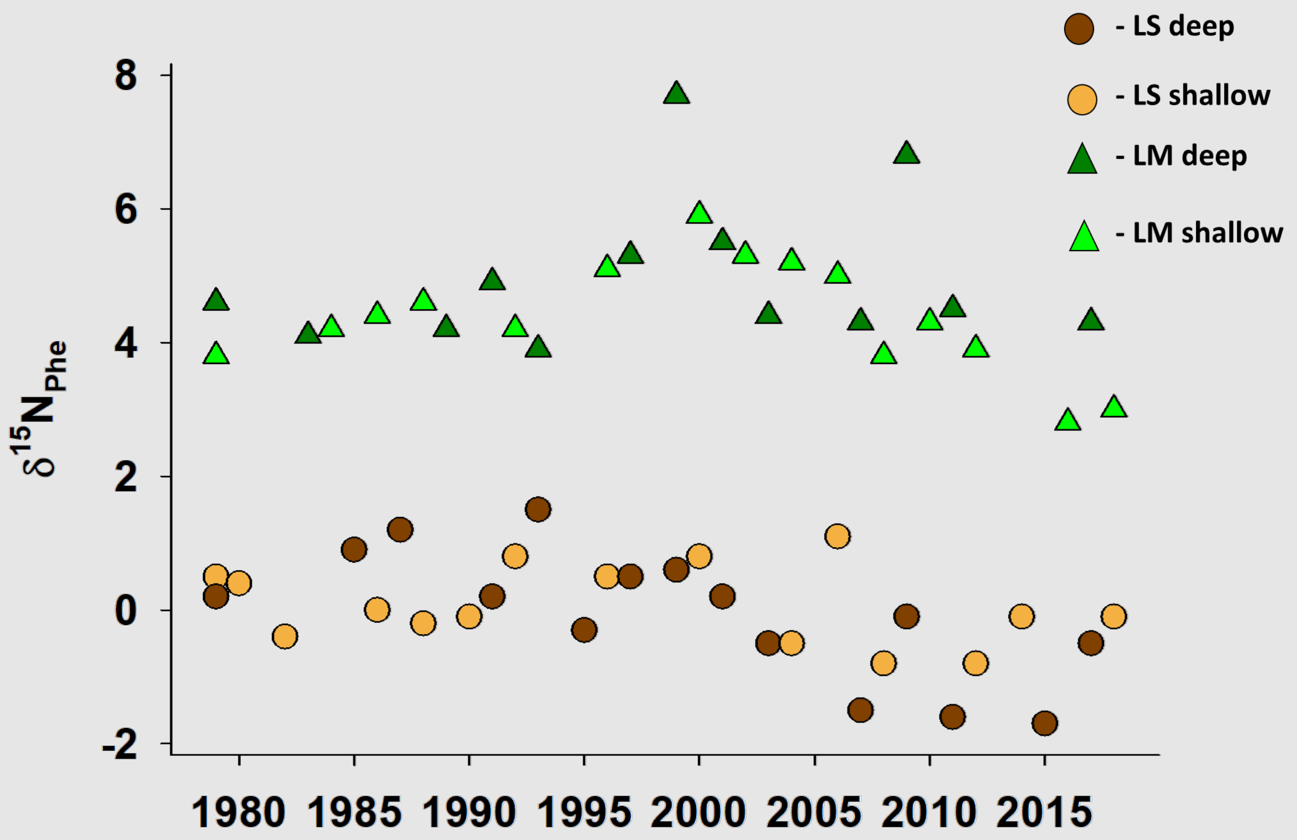

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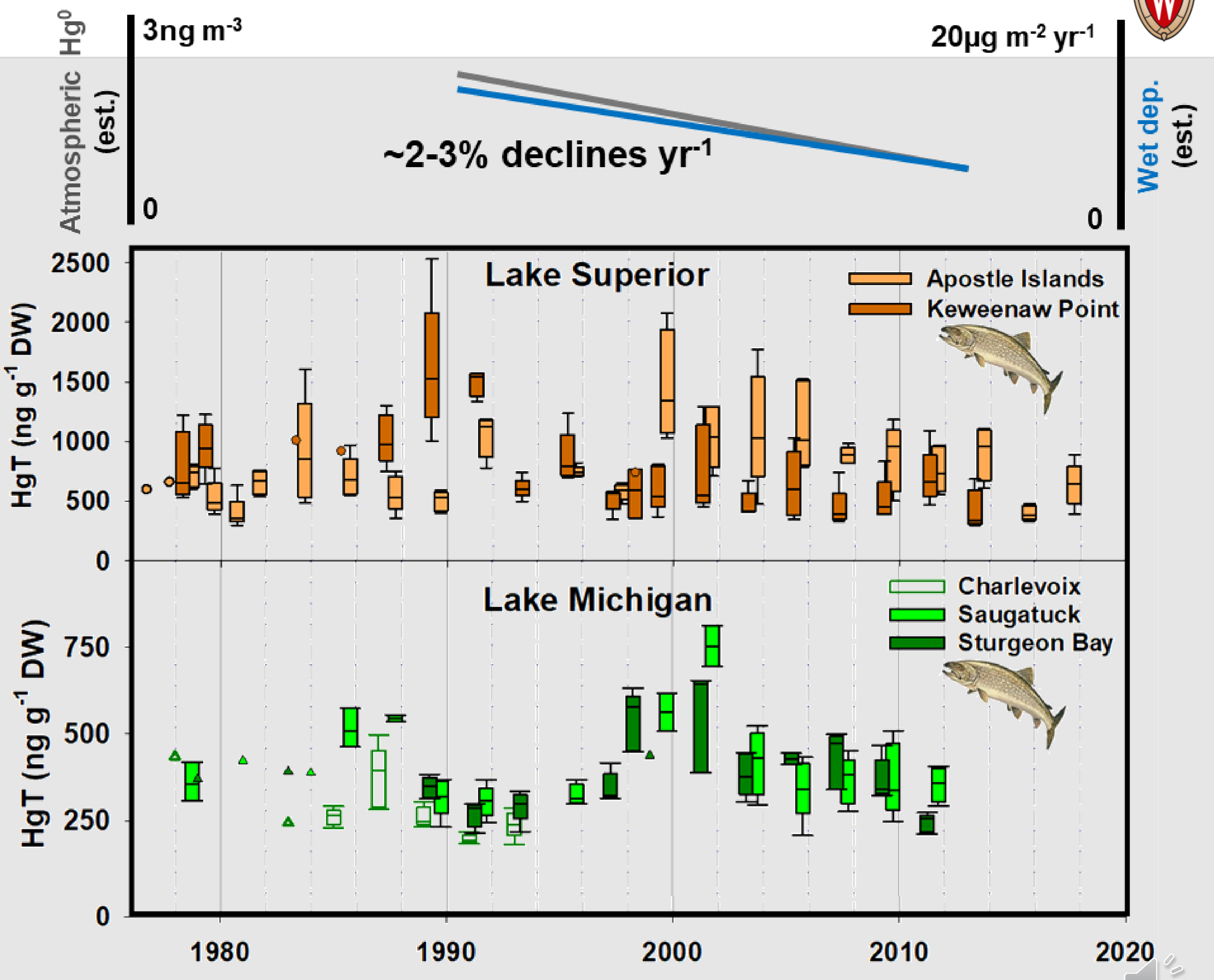

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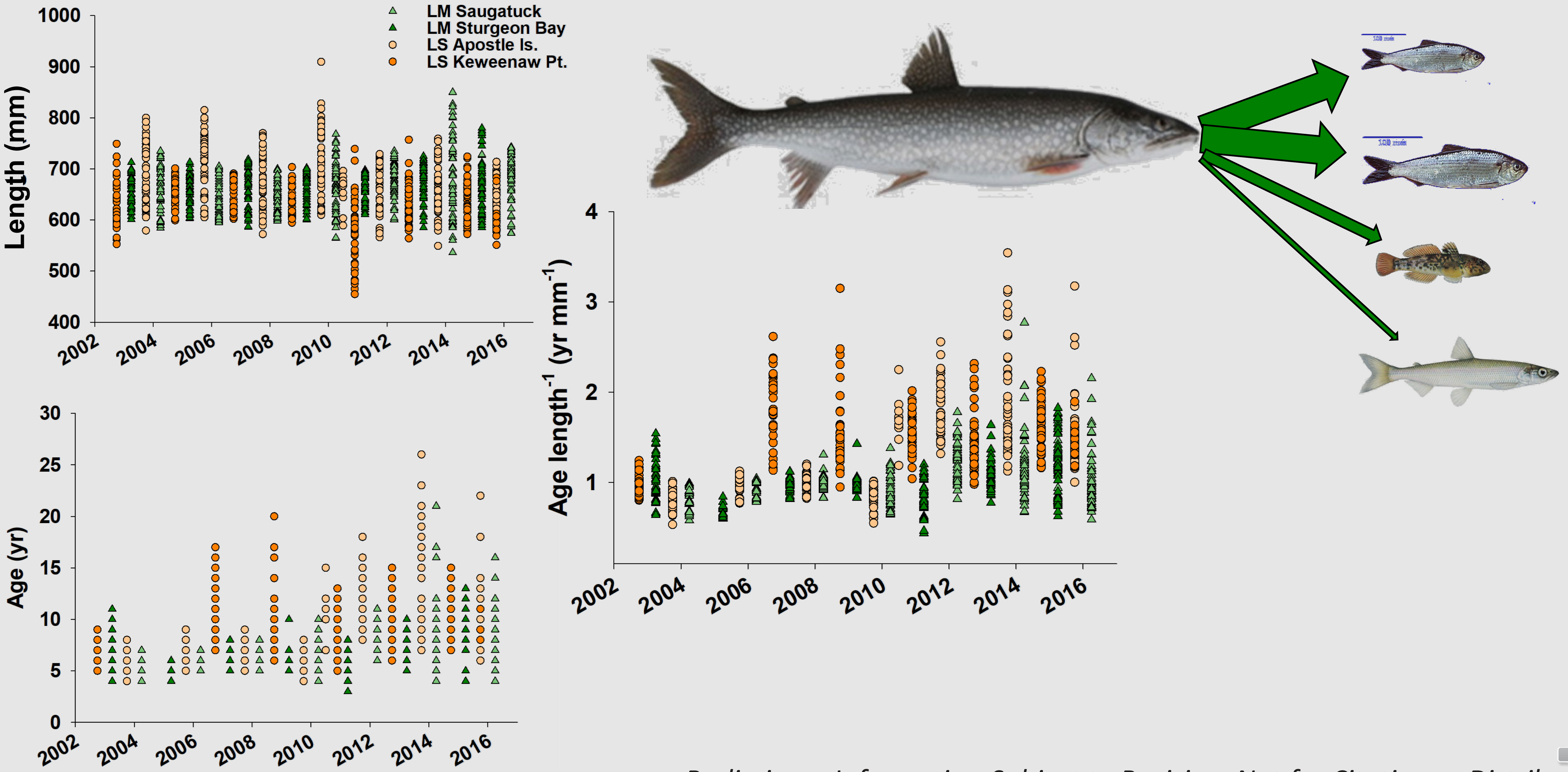
Growth and diet



Murphy et al Journal of Great Lakes Research, 2018

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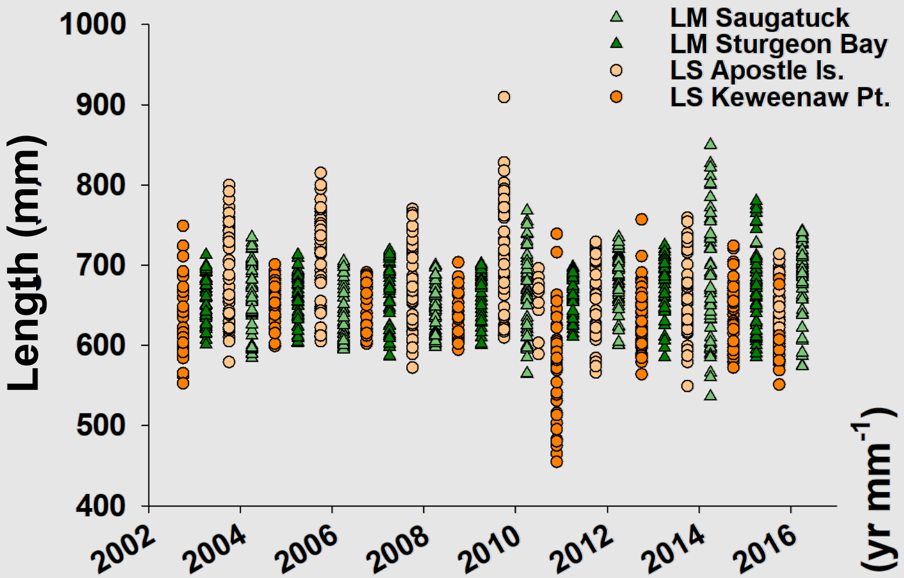

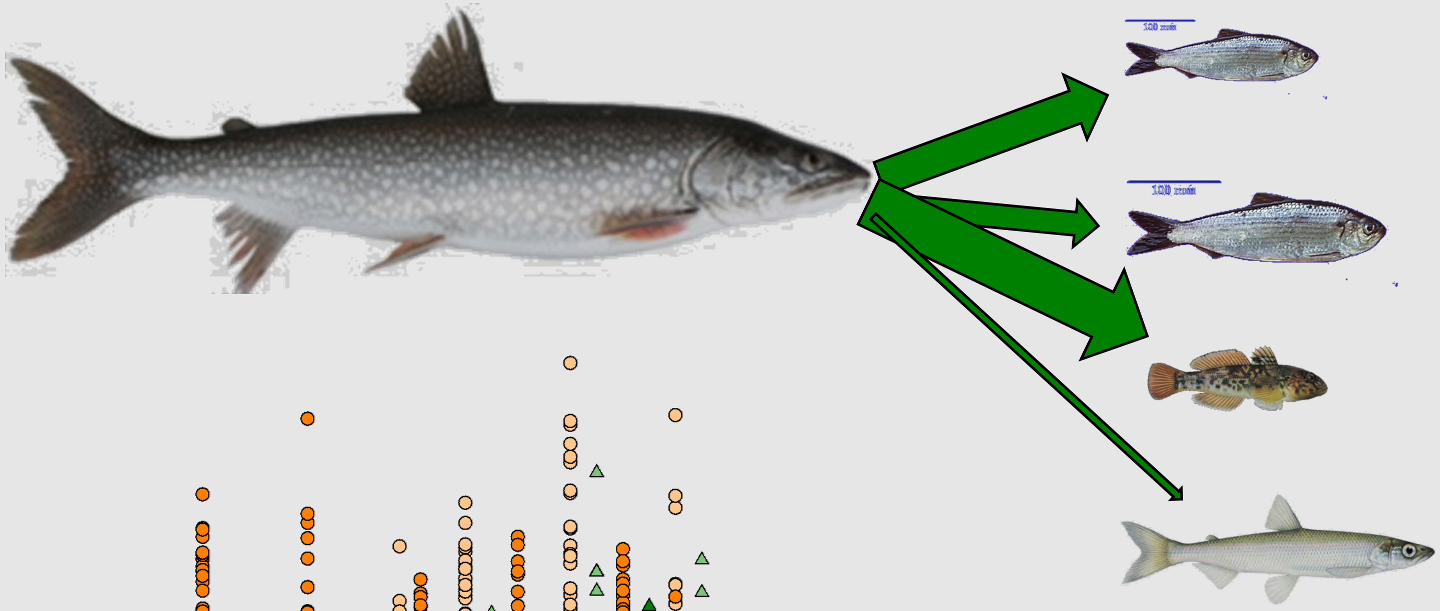

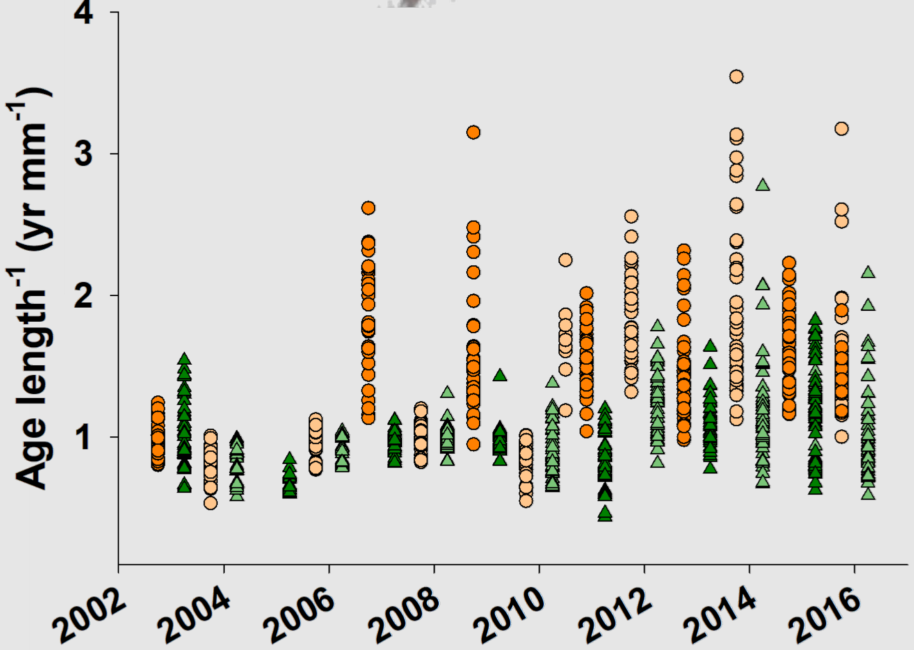

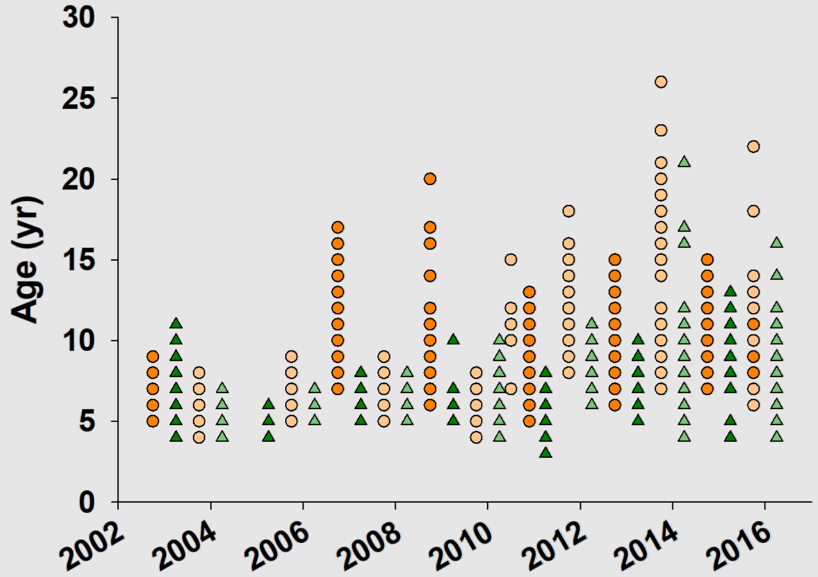

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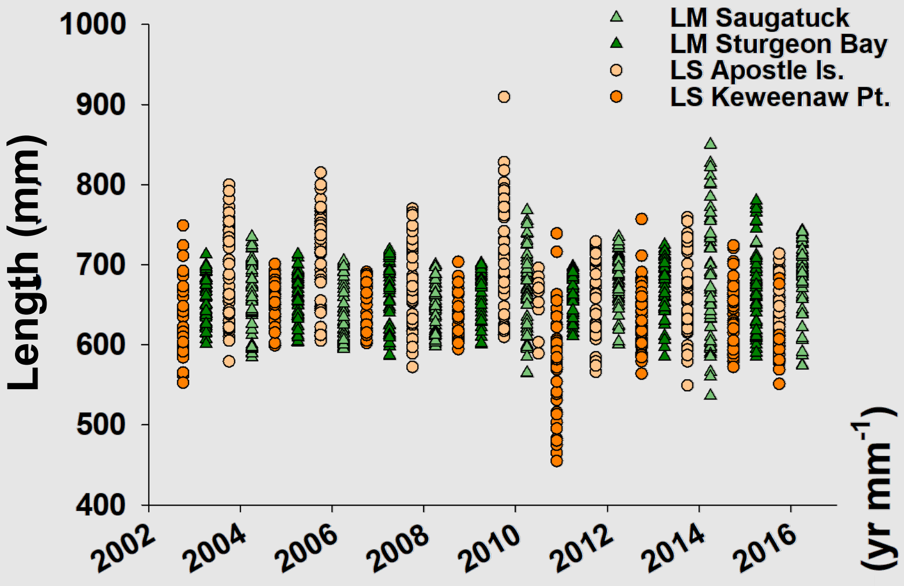

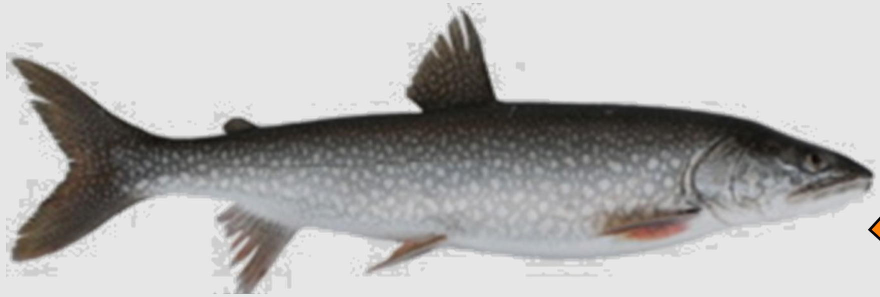

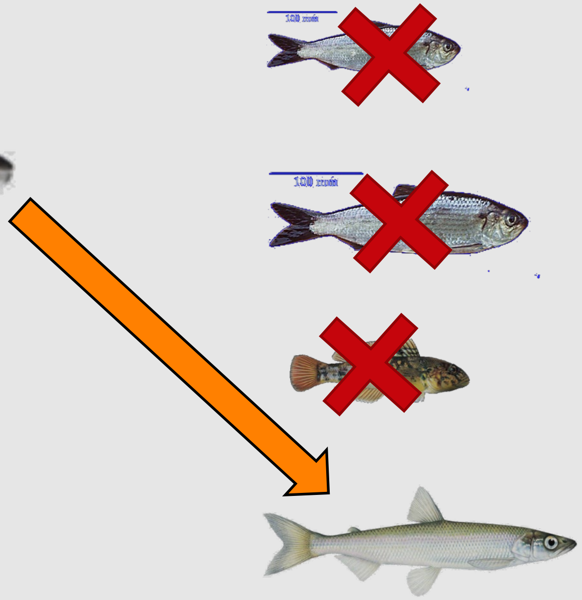

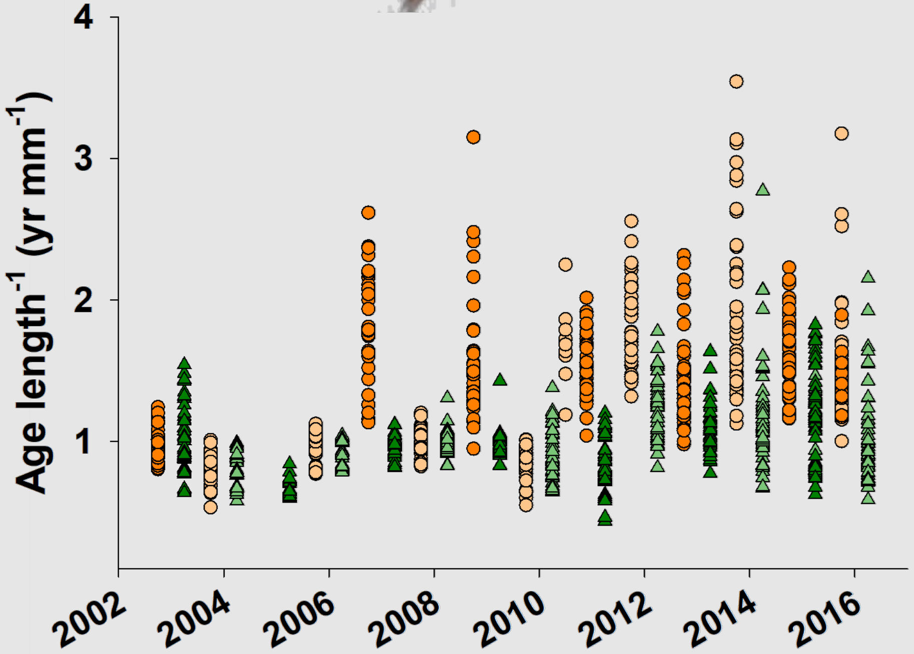

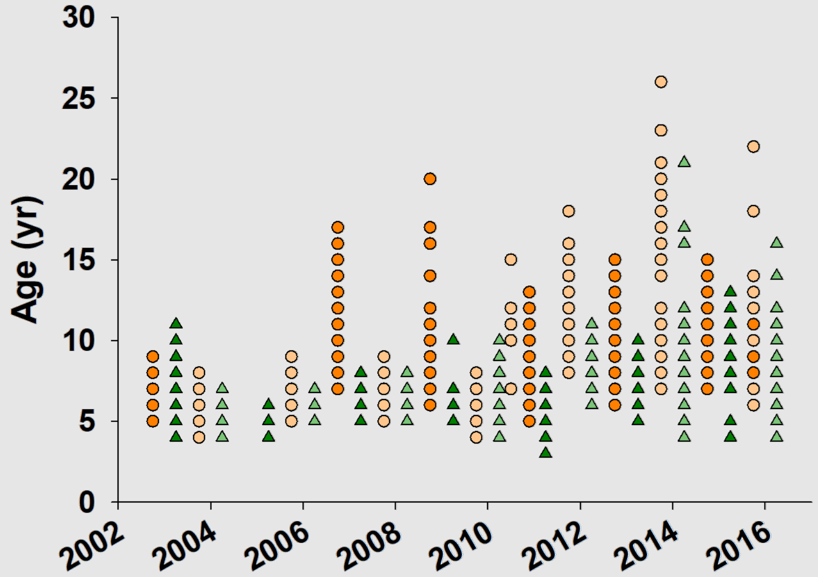

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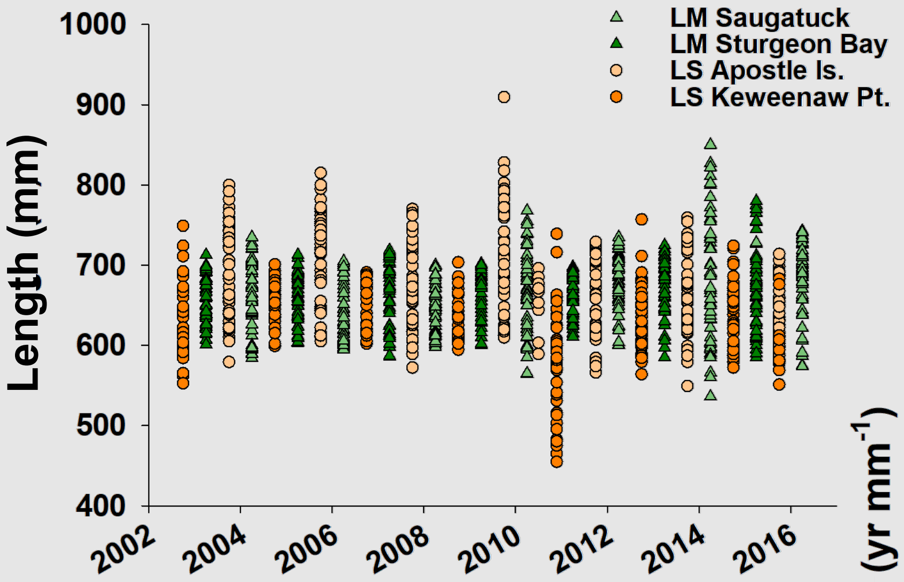
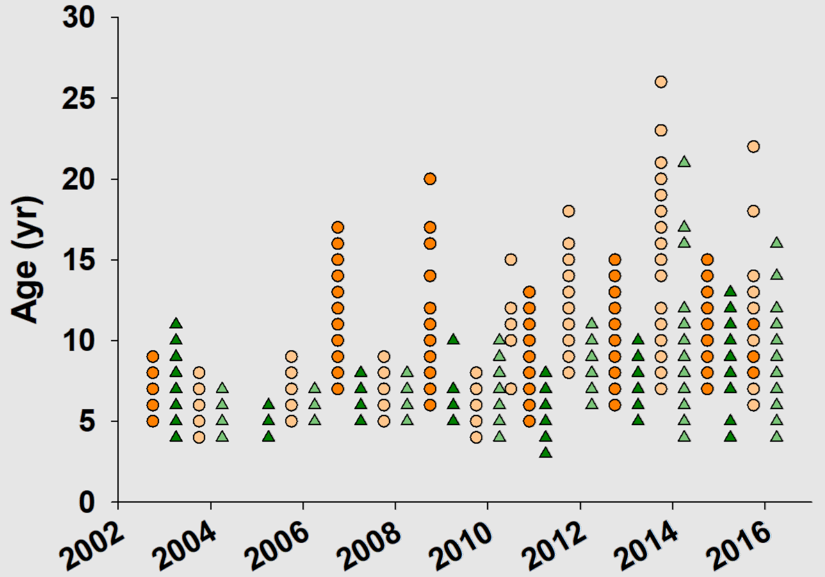
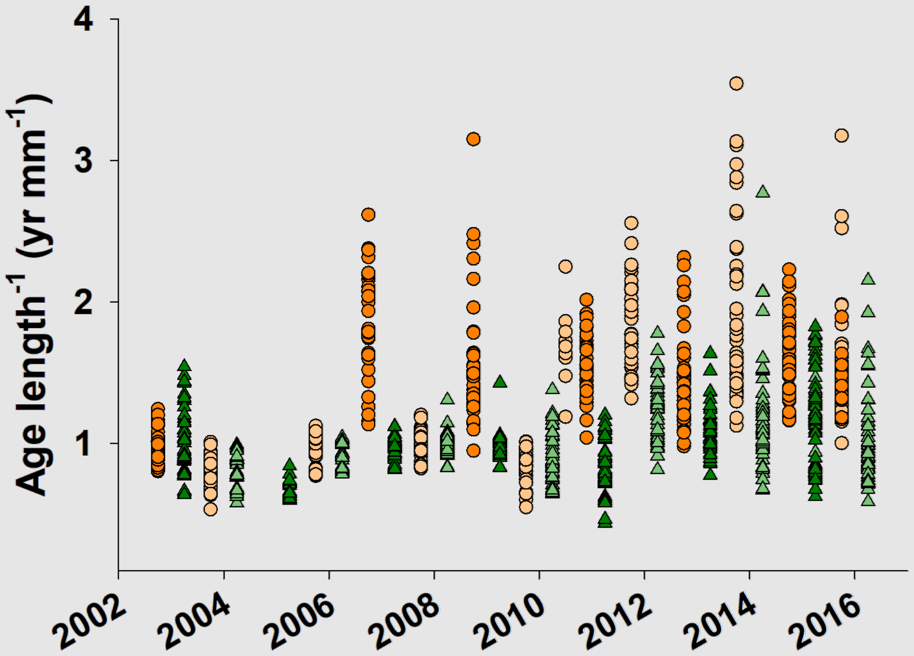






In Lake Superior

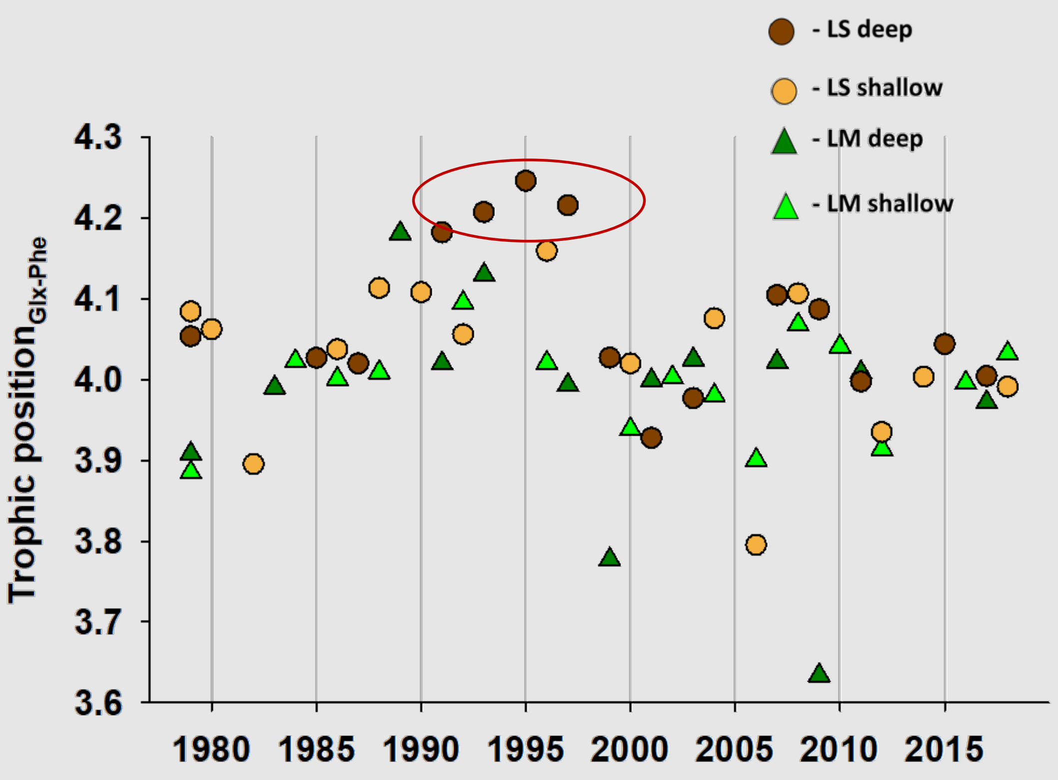
Murphy et al Journal of Great Lakes Research, 2018

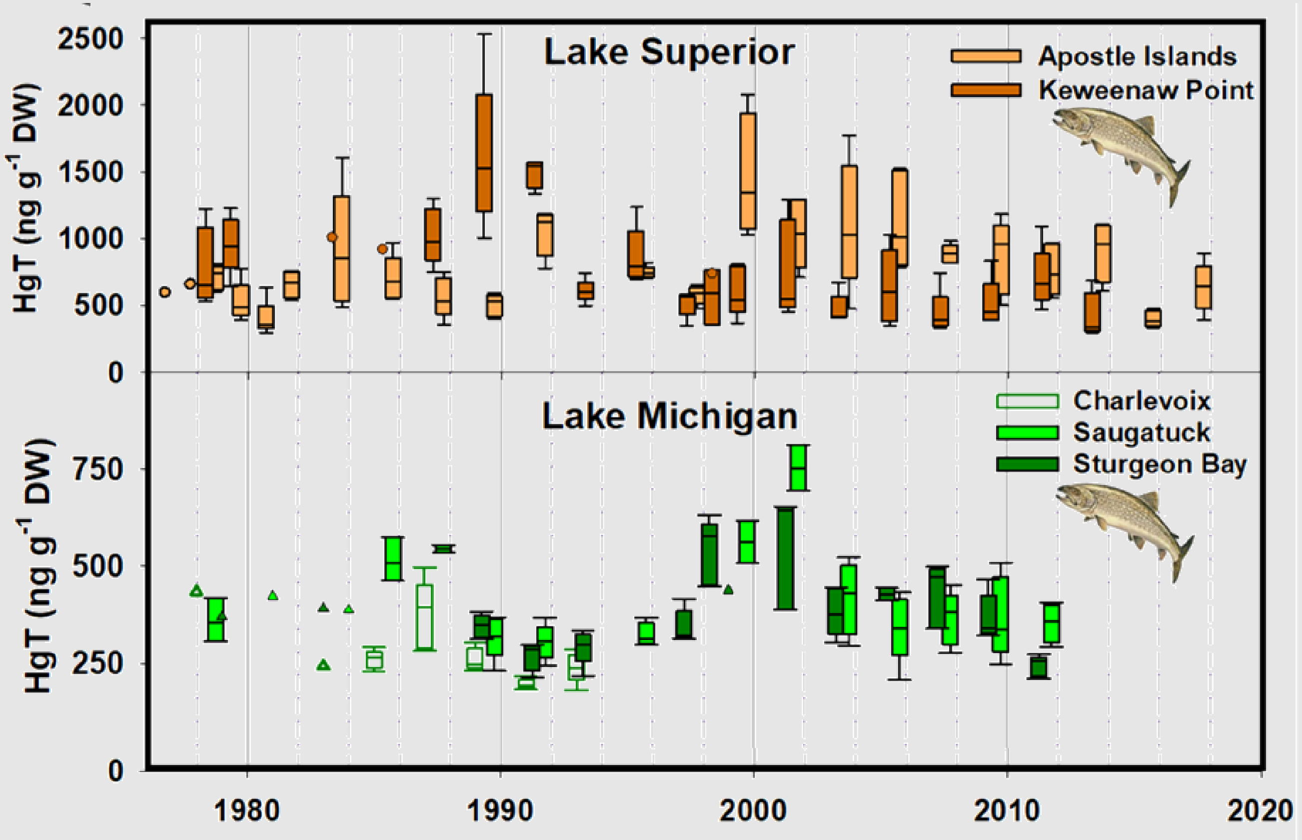
Preliminary Information-Subject to Revision. Not for Citation or Distribution.

Amino acids - one take away

Strongest evidence of siscowet - $Tp_{phe\text{-}glx} = 4.21 \pm 0.03$ and C:N = 12.0 ± 3.0 - HgT = 930 ± 310 ng g^{-1} n = 4

Ave. following - $Tp_{phe\text{-}glx} = 4.04 \pm 0.08$ and C:N = 7.8 ± 0.8 - HgT = 670 ± 160 ng g^{-1} n = 9





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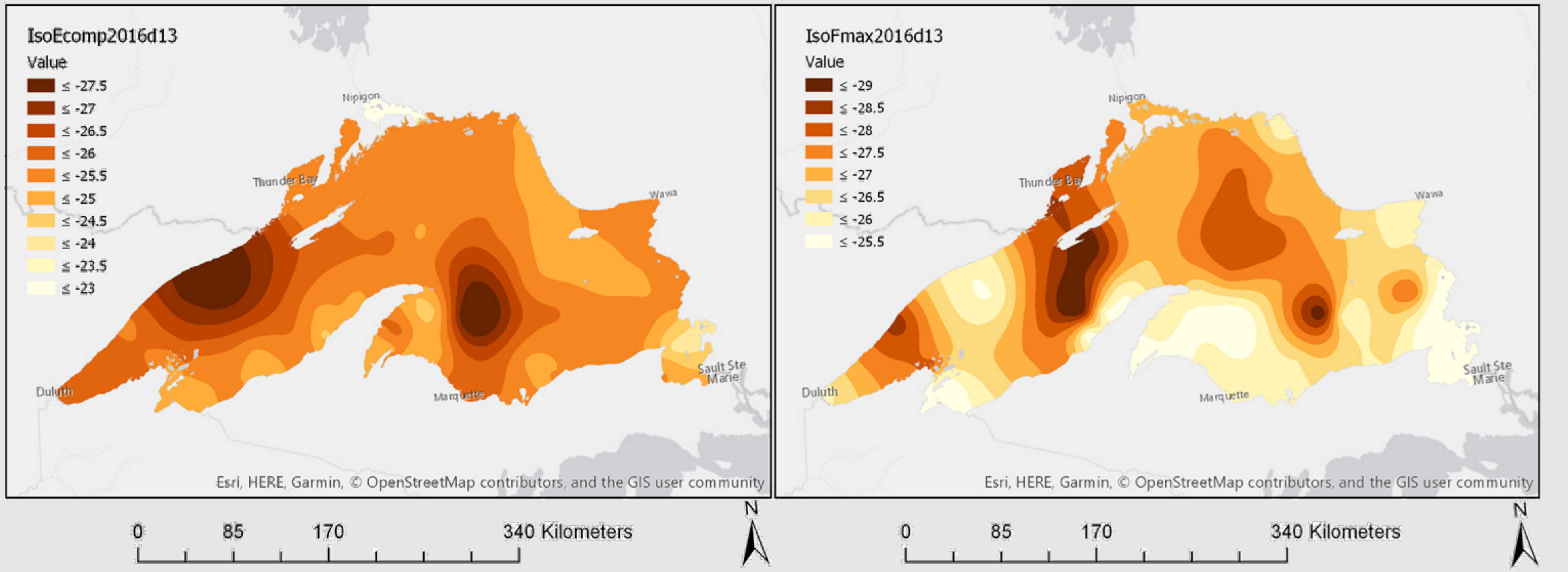
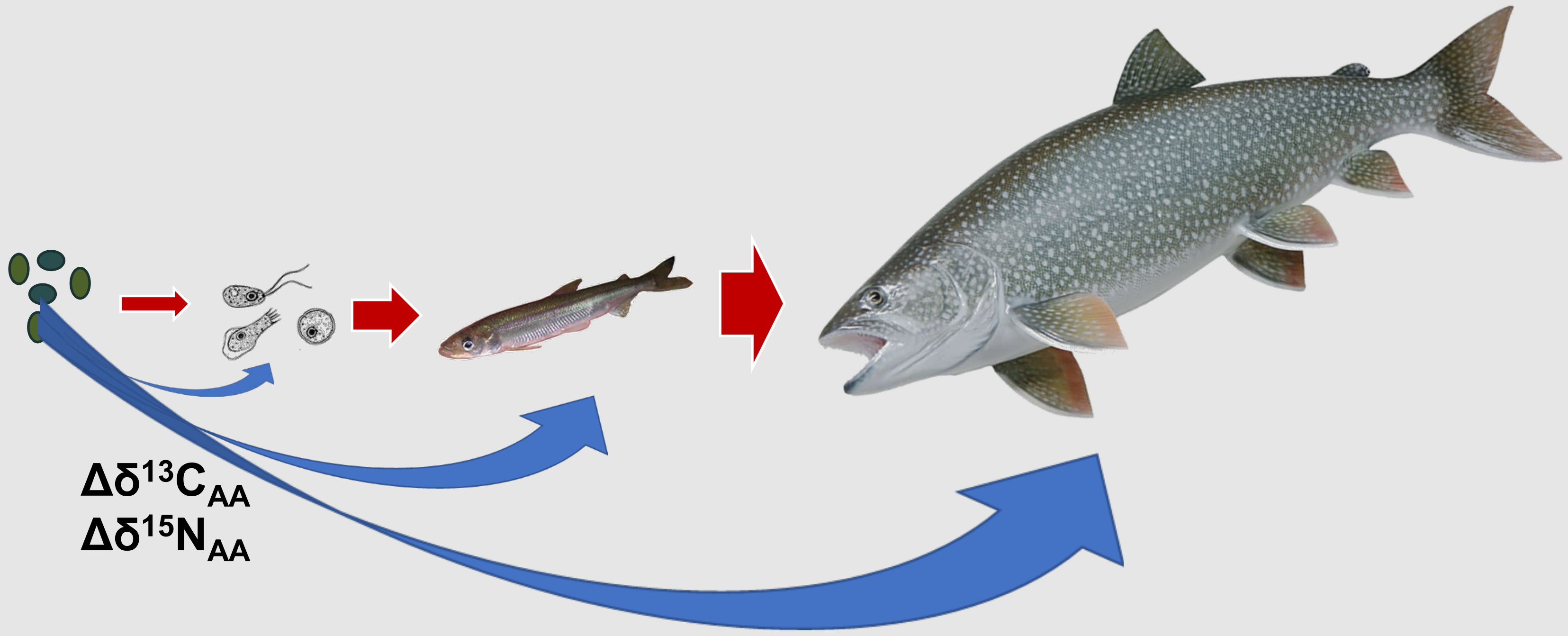
Next steps -

- Construct spatial and vertical isoscapes - in bulk, they exist.



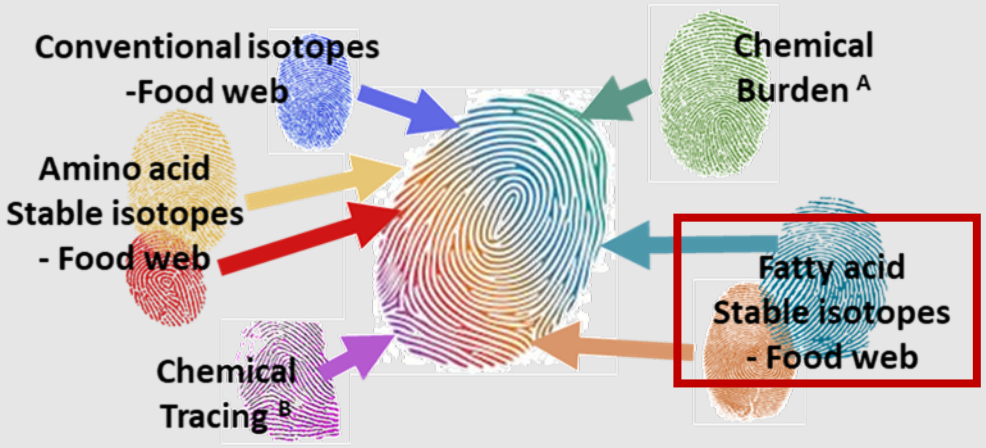
Next steps -

- Construct spatial and vertical isoscapes - in bulk, they exist.
- Understand isotope discrimination between basal items and receptor(s)



Next steps -

- Construct spatial and vertical isoscapes - in bulk, they exist.
- Understand isotope discrimination between basal items and receptor(s)
- Including other axes of inference (incl. individual LKT)



Thank you's

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  - Analysis and interpretations
- Joel Hoffman & EPA GLTED
- USGS Mercury Research Team
- Great Lakes National Program Office
- Great Lakes Fish Monitoring and Surveillance program
- UW Madison Aquatic Sciences and UW Sea Grant

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