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

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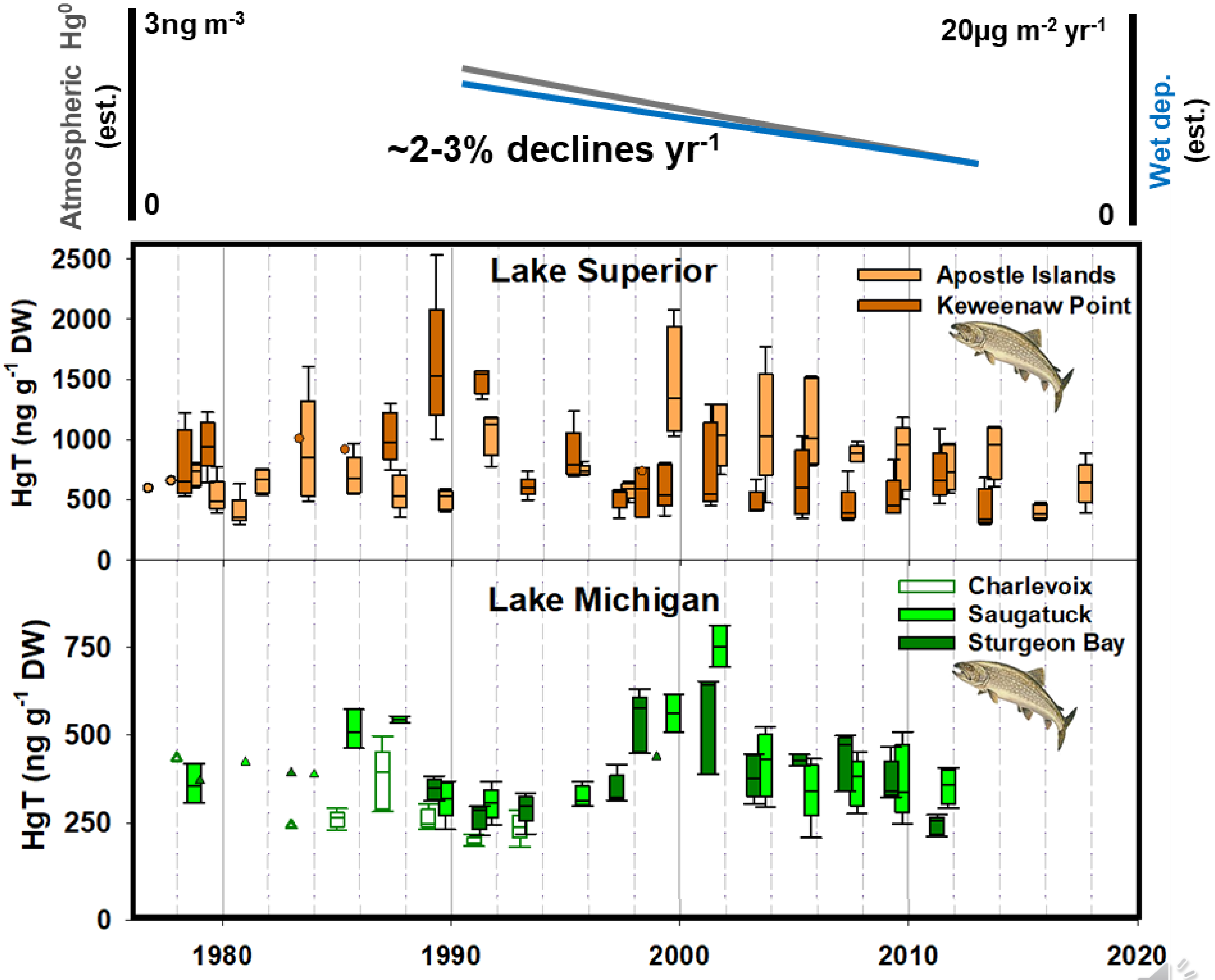
[2] - USGS Mercury Research Laboratory
[3] - Water Enforcement & Compliance Assurance Branch EPA
[4] - University of Wisconsin - Madison Aquatic Sciences Center

What drives mercury concentration 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, Yanxu, et al. "Observed decrease in atmospheric mercury explained by global decline in anthropogenic emissions." Proceedings of the National Academy of Sciences 113.3 (2016): 526-531.



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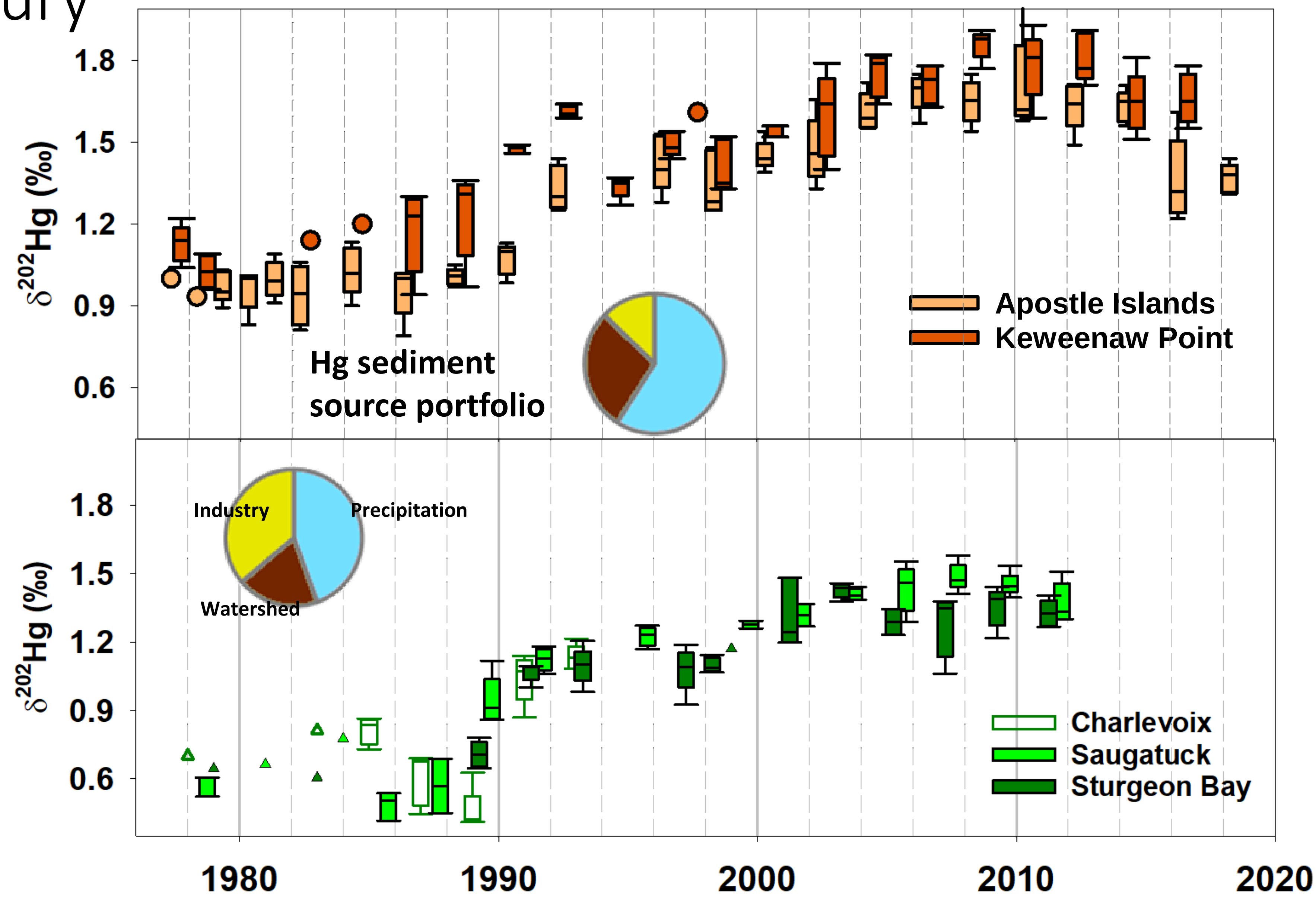
What drives mercury concentration variability?

- **Mercury inputs**

  Sources

  - Lake-lake coherence in $\delta^{202}Hg$
  - Increased ~0.6 per mille

Lepak, Ryan F., et al. "Use of stable isotope signatures to determine mercury sources in the Great Lakes." Environmental Science & Technology Letters 2.12 (2015): 335-341.



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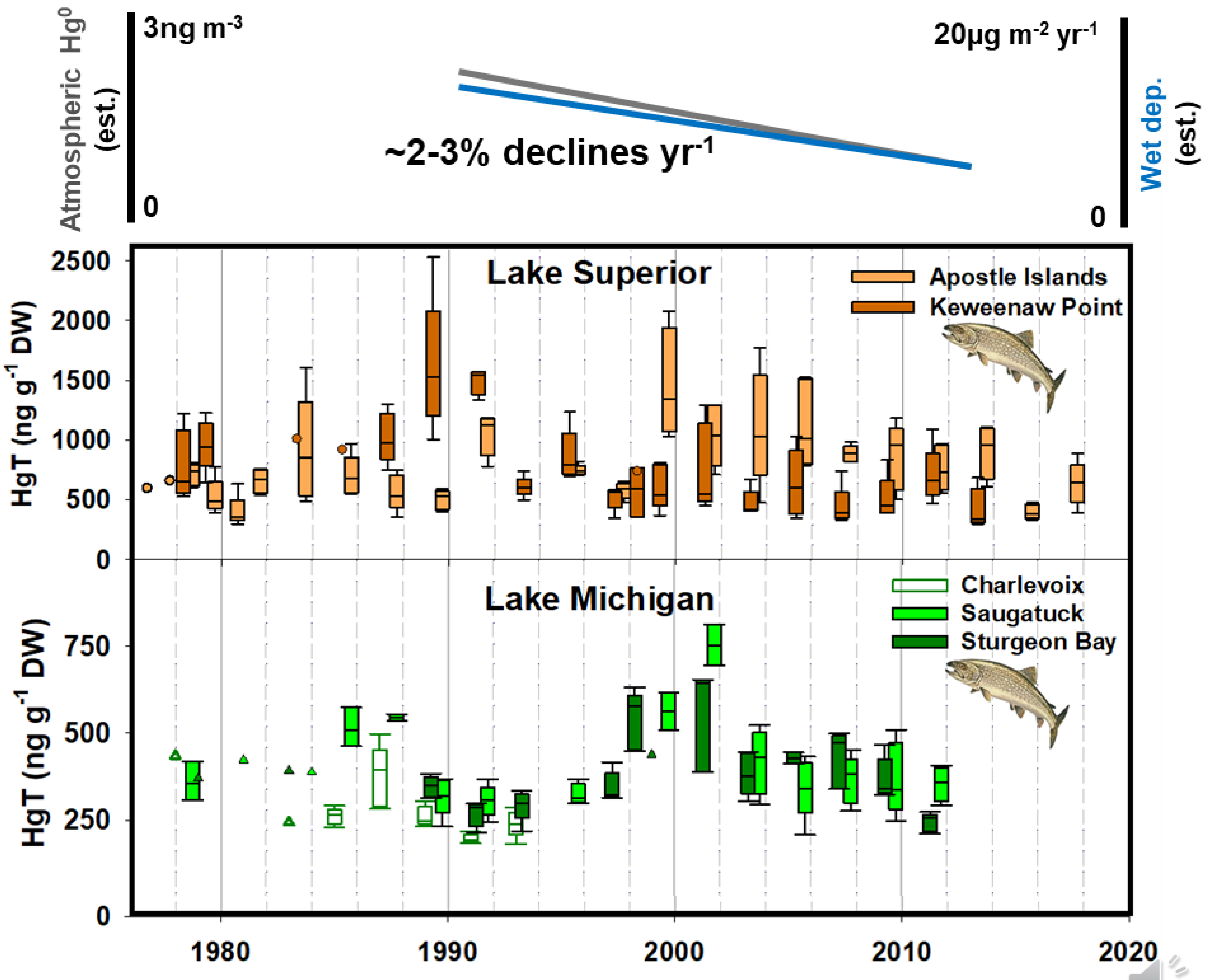

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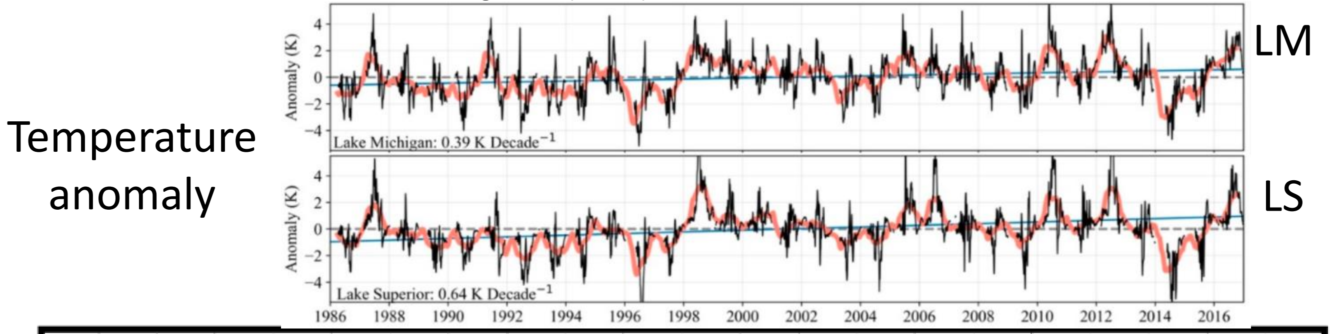

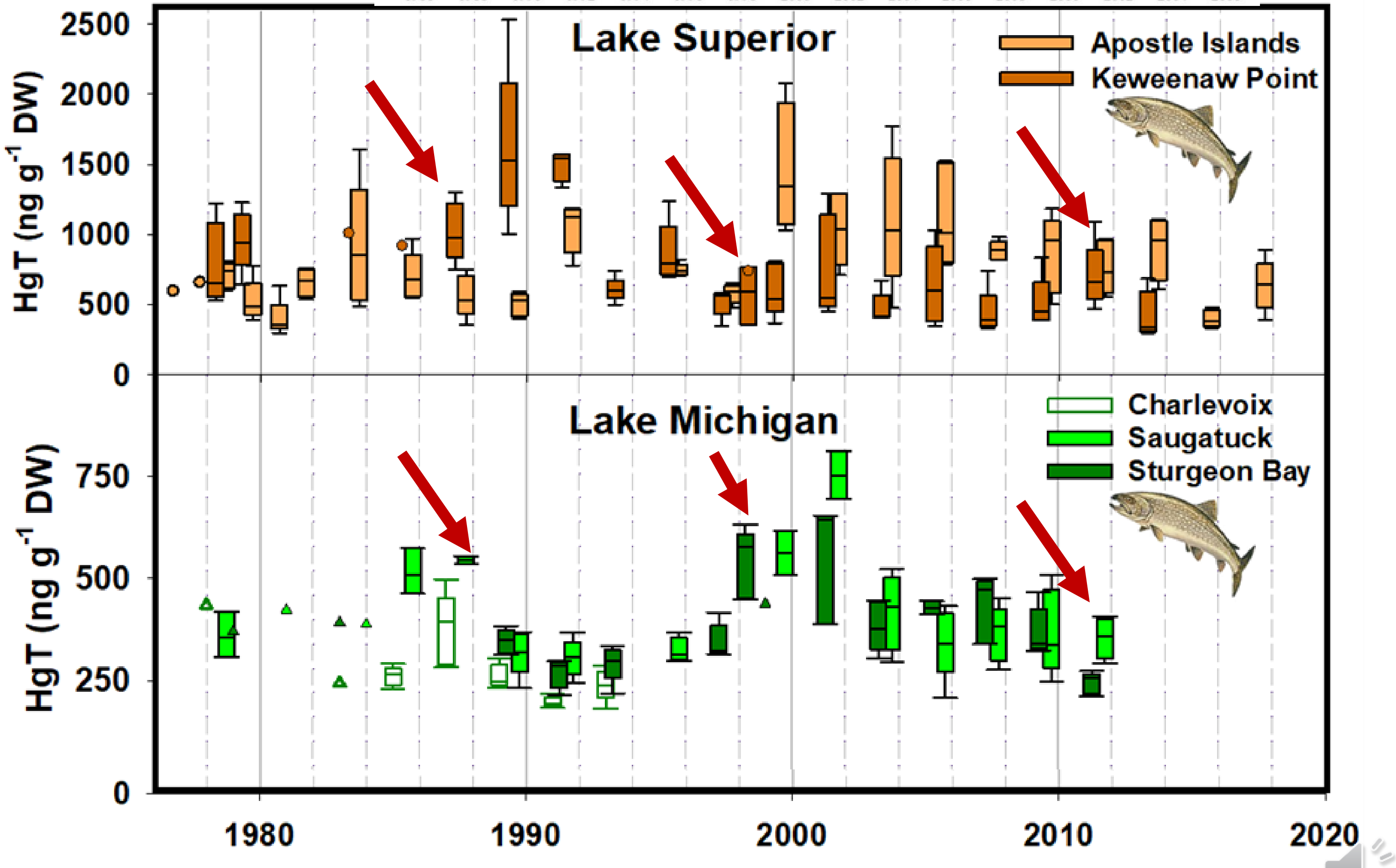

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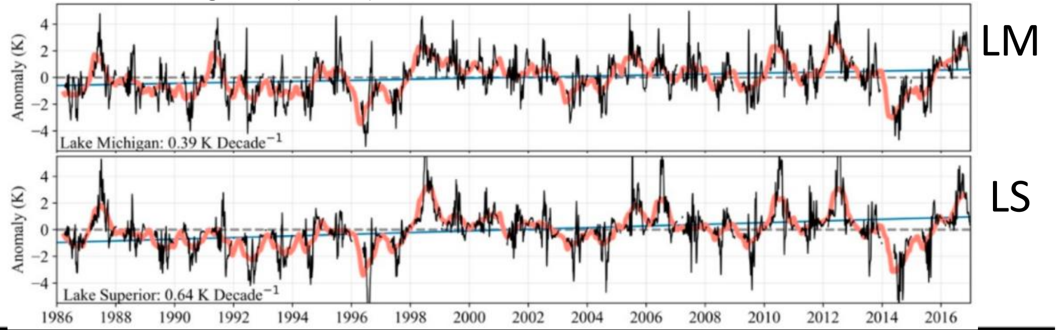
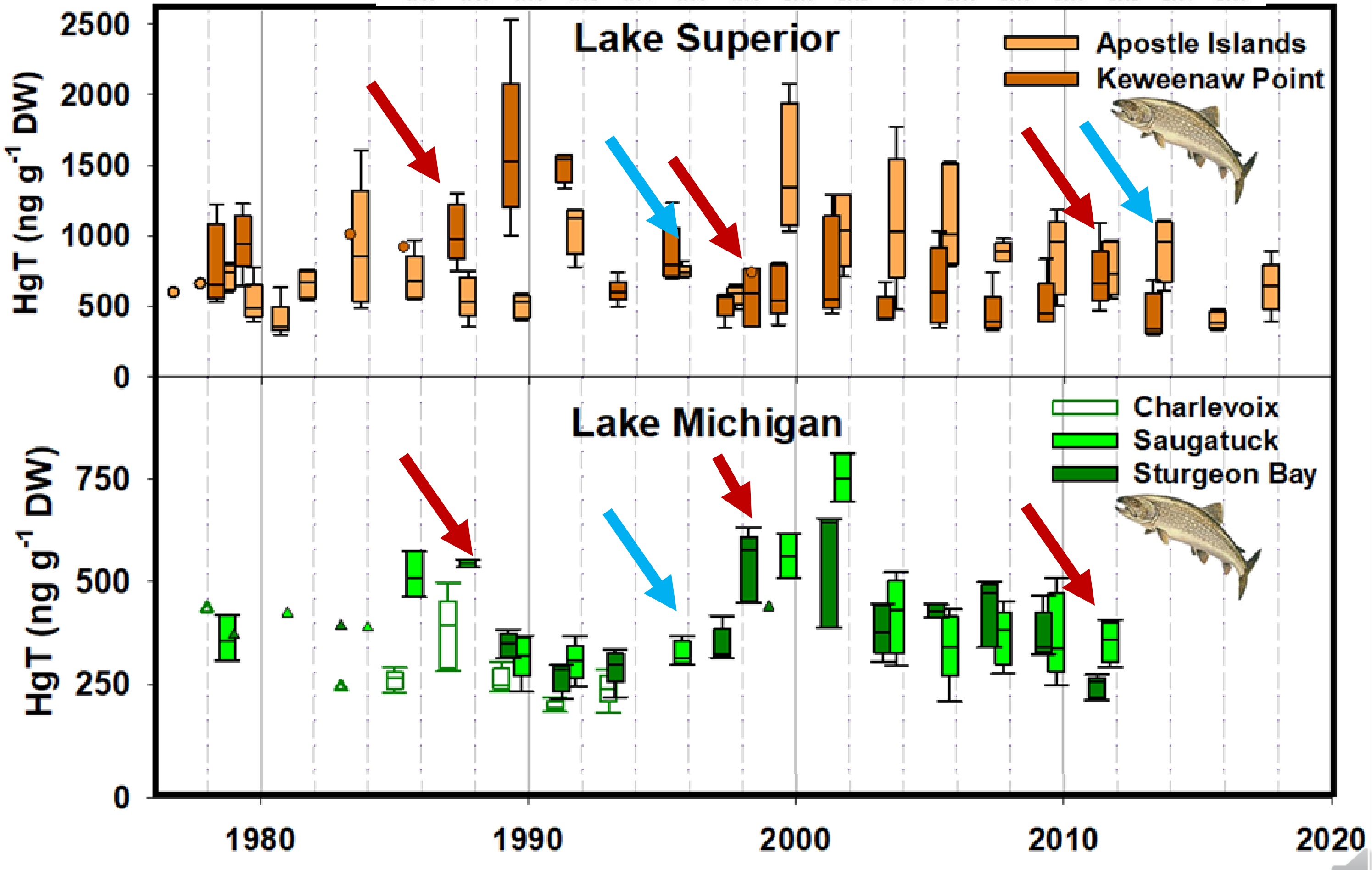
Temperature anomaly





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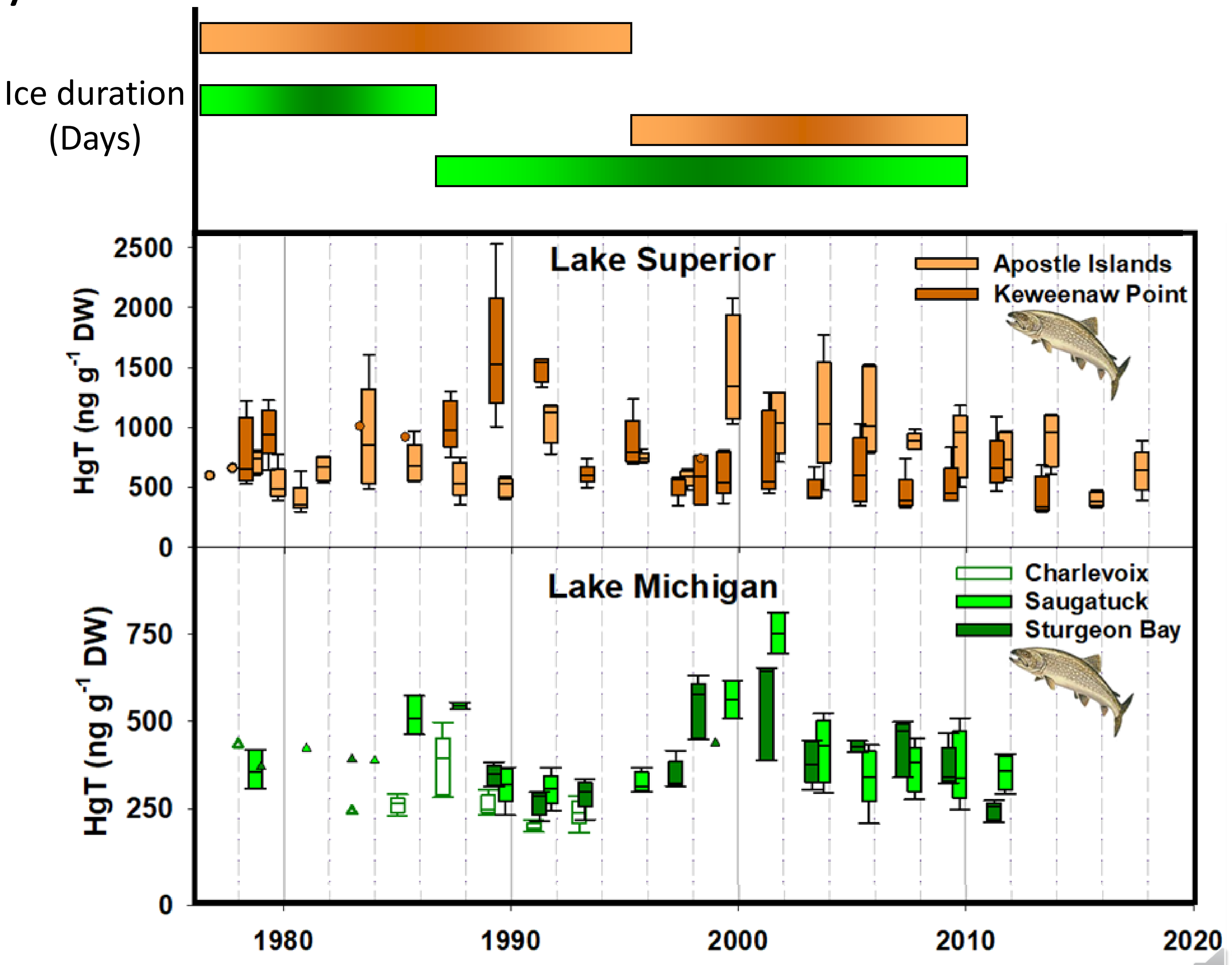
Mason, Lacey A., et al. "Fine-scale spatial variation in ice cover and surface temperature trends across the surface of the Laurentian Great Lakes." Climatic Change 138.1-2 (2016): 71-83.



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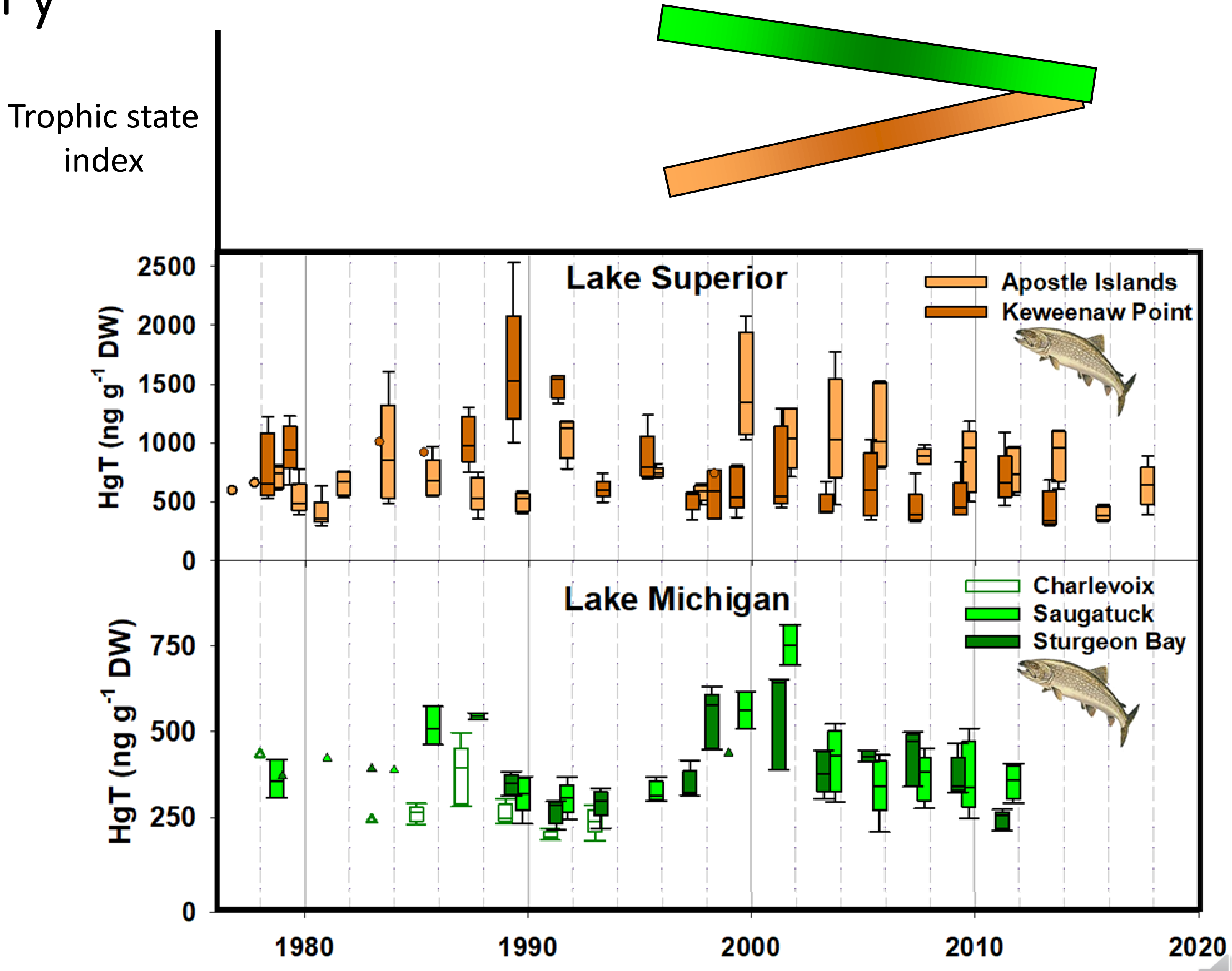
Scofield, Anne E., et al. "Deep chlorophyll maxima across a trophic state gradient: A case study in the Laurentian Great Lakes." Limnology and Oceanography (2020).



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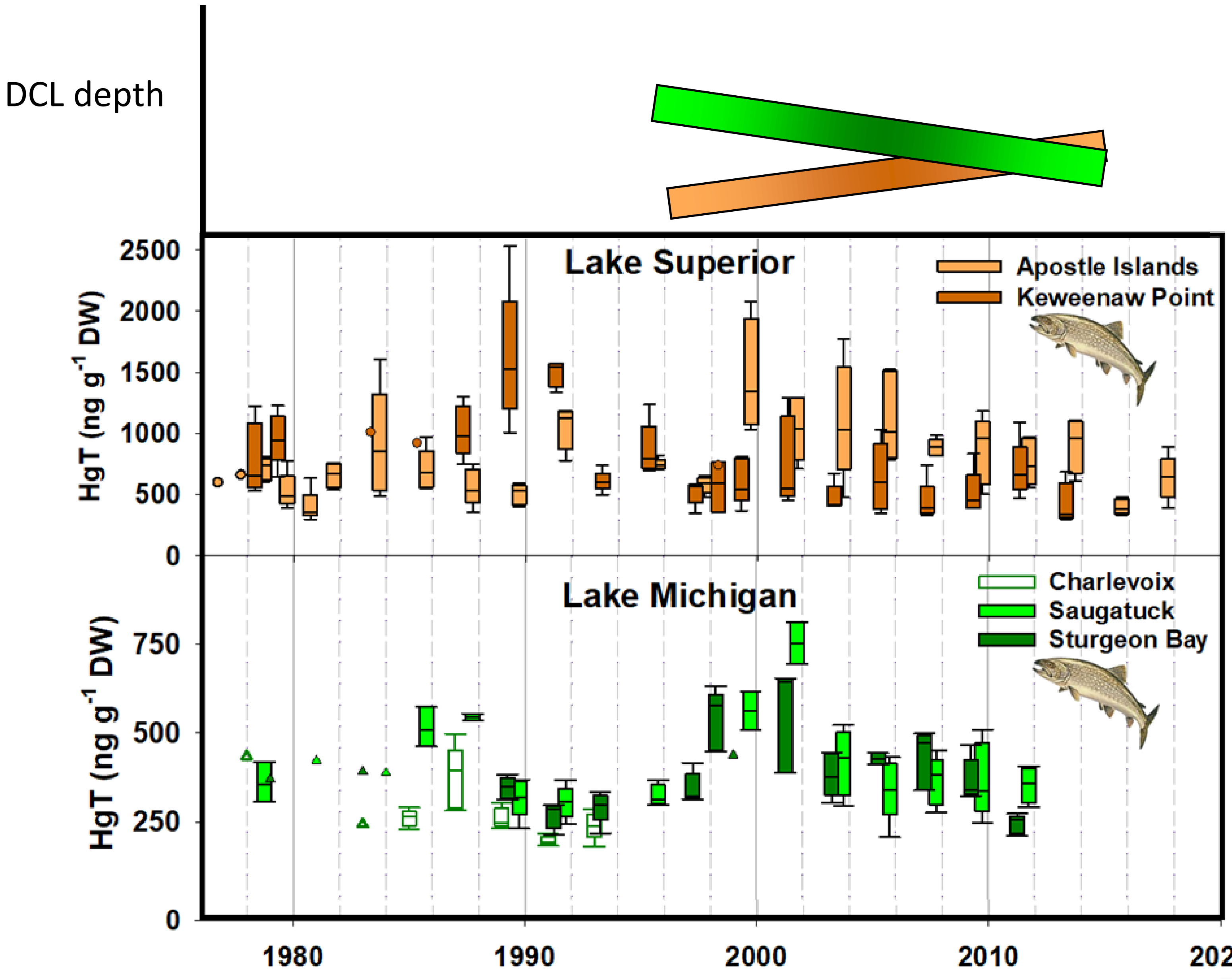

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What drives mercury concentration variability?

Scofield, Anne E., et al. "Deep chlorophyll maxima across a trophic state gradient: A case study in the Laurentian Great Lakes." Limnology and Oceanography (2020).

- **Mercury inputs**
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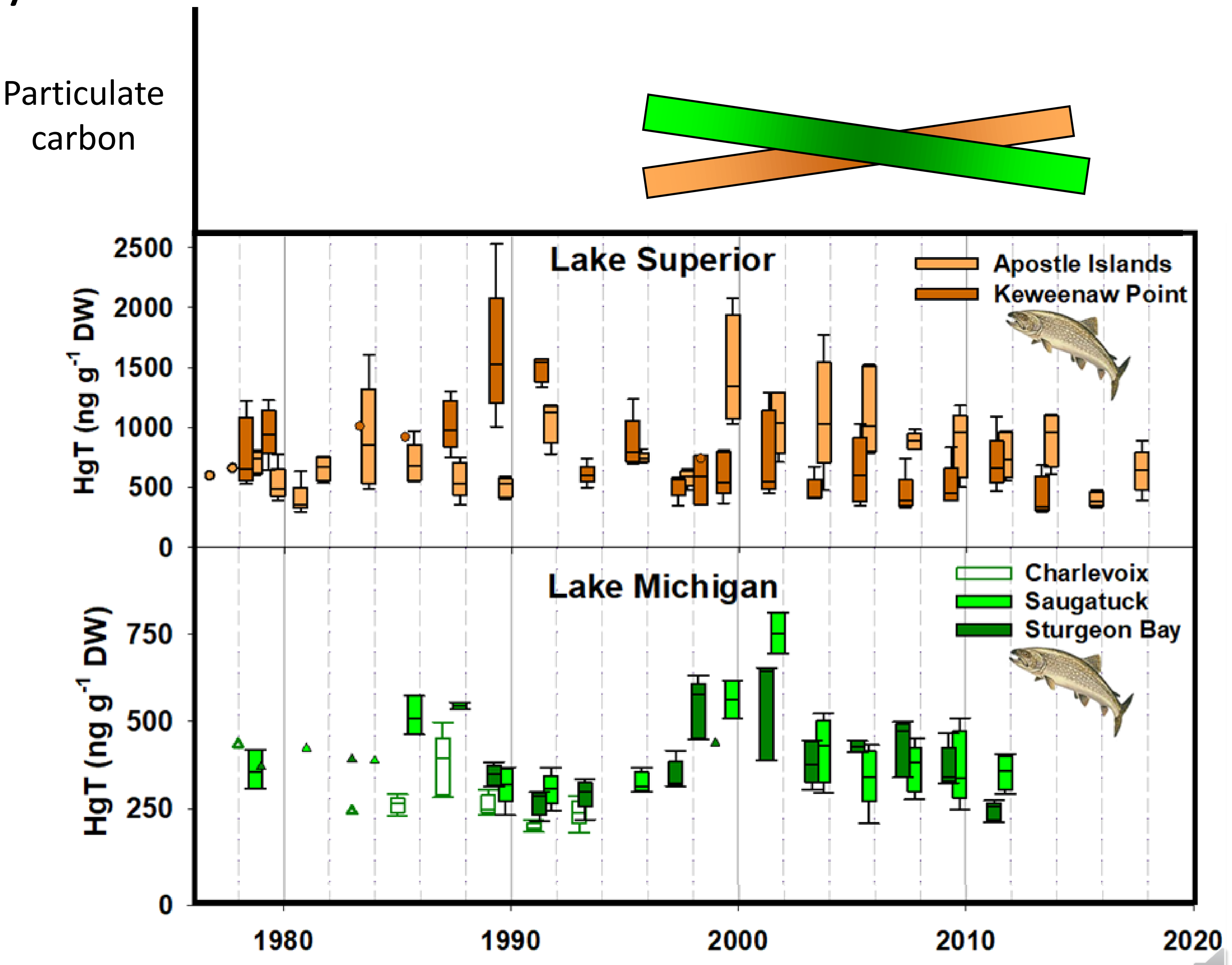

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What drives mercury concentration variability?

- Mercury inputs
- Physical
  - Ice cover, water levels, temperature shifts and influence on biology
- **Bottom-up influence**
  - Basal producer
  - Diet shifts (2nd)
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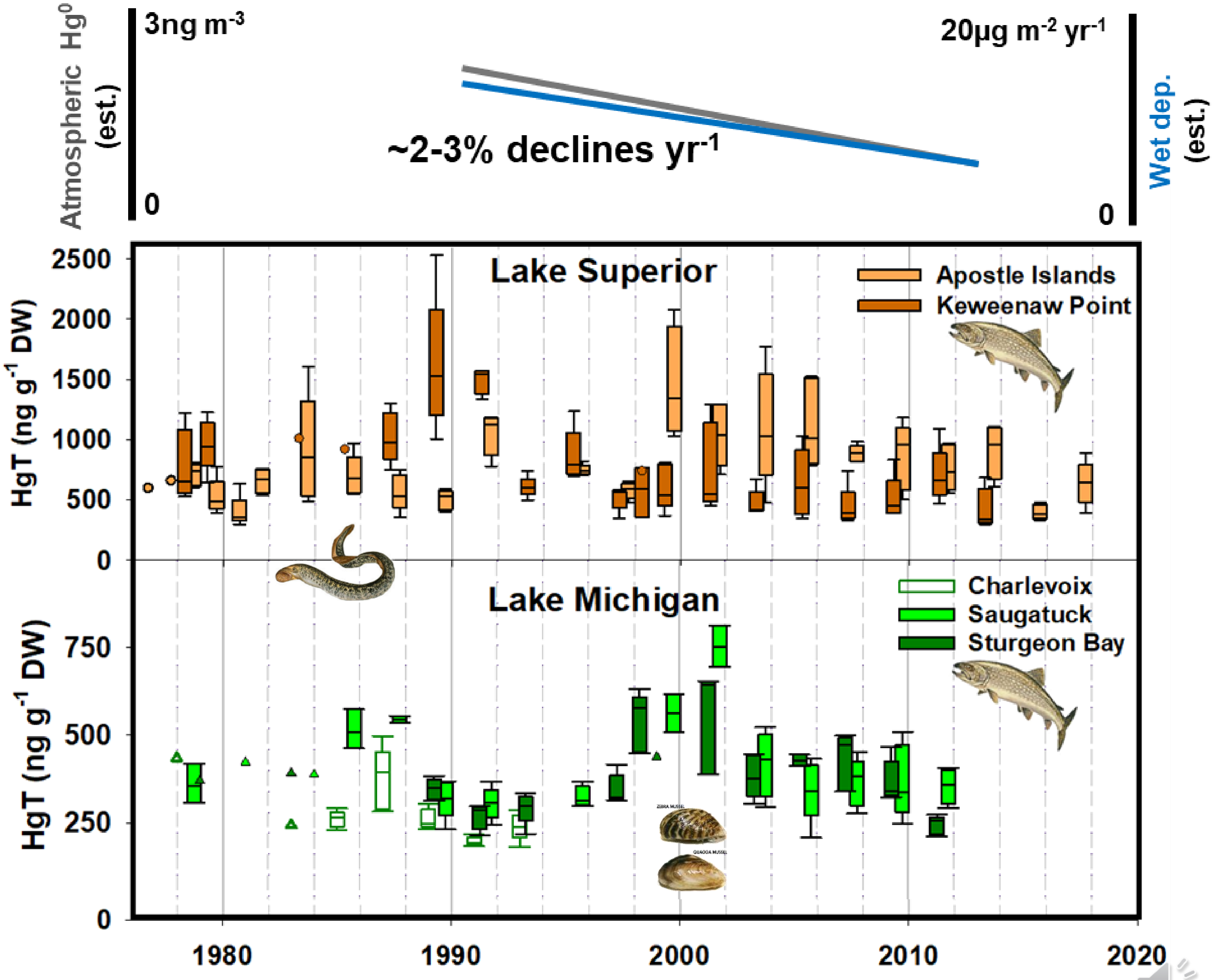
Zhang, Yanxu, et al. "Observed decrease in atmospheric mercury explained by global decline in anthropogenic emissions." Proceedings of the National Academy of Sciences 113.3 (2016): 526-531.



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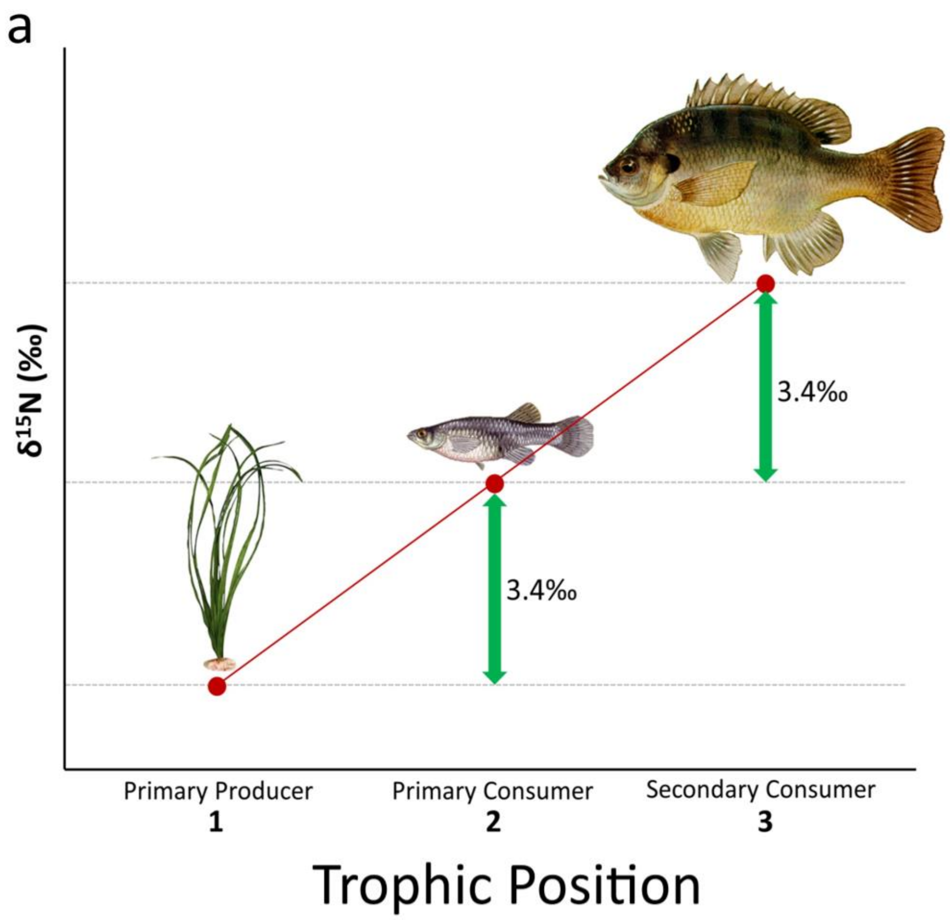
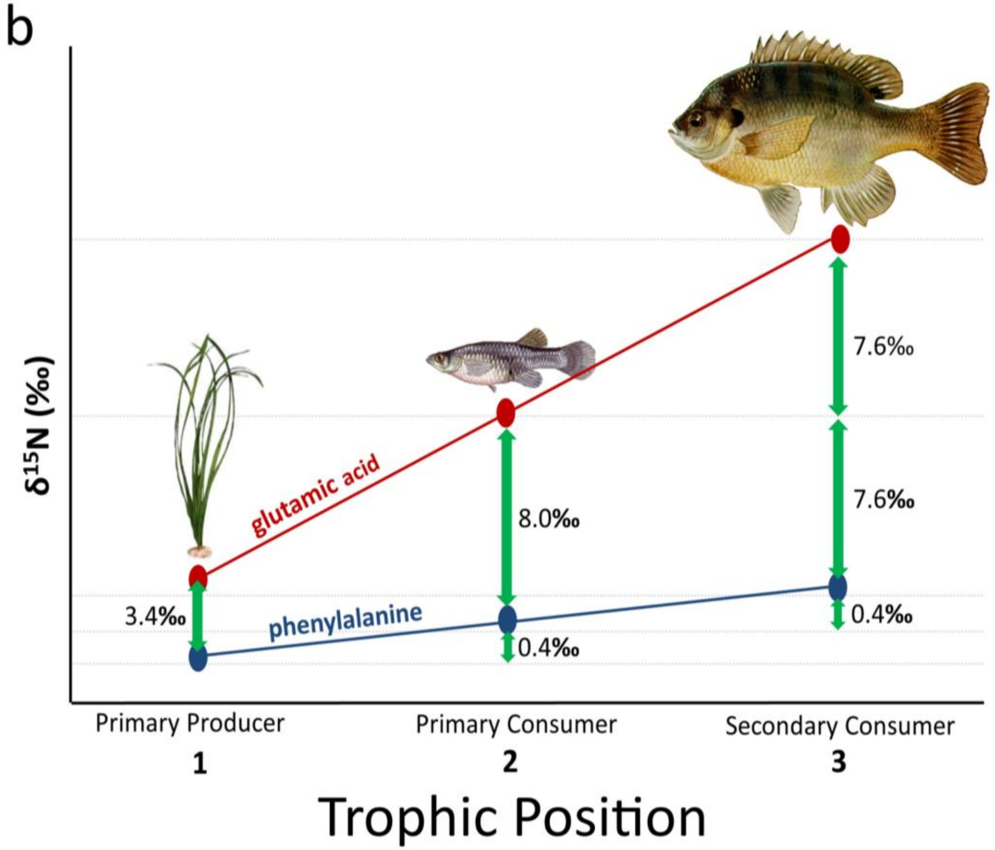
C and N bulk stable isotopes ratios



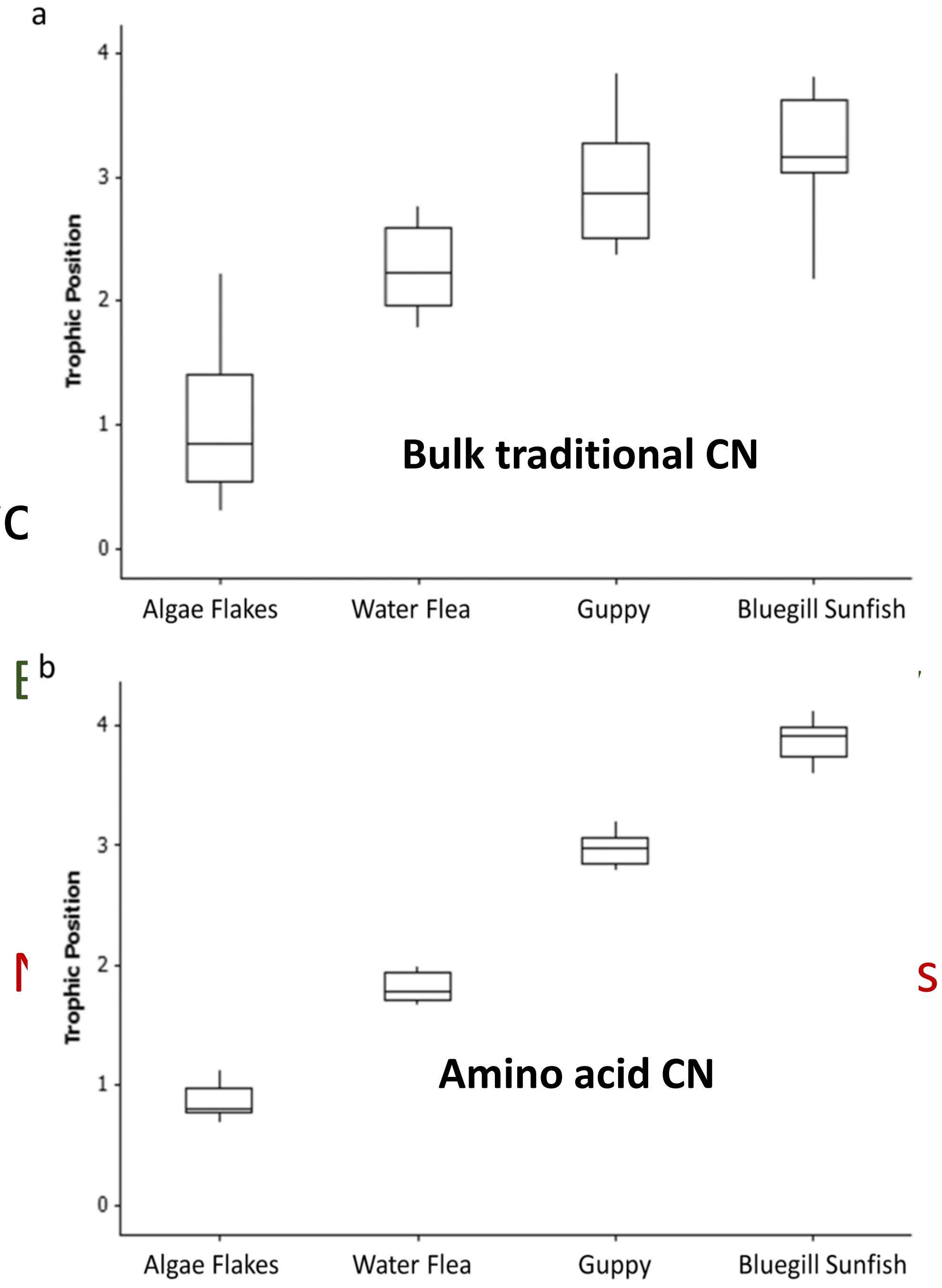
- Nitrogen isotopes increase up the food chain (carbon isotopes remain comparatively steady)
  - Estimates trophic position
- Together, delineate energy sources and pathways for this sampling design
- Bulk atoms are sourced from many complicating factors, reducing precision

Bowes, Rachel Elizabeth, and James H. Thorp. "Consequences of employing amino acid vs. bulk-tissue, stable isotope analysis: a laboratory trophic position experiment." Ecosphere 6.1 (2015): 1-12.

CN stable isotopes ratios in extracted amino acids



- Twc
  - E
  - N sized



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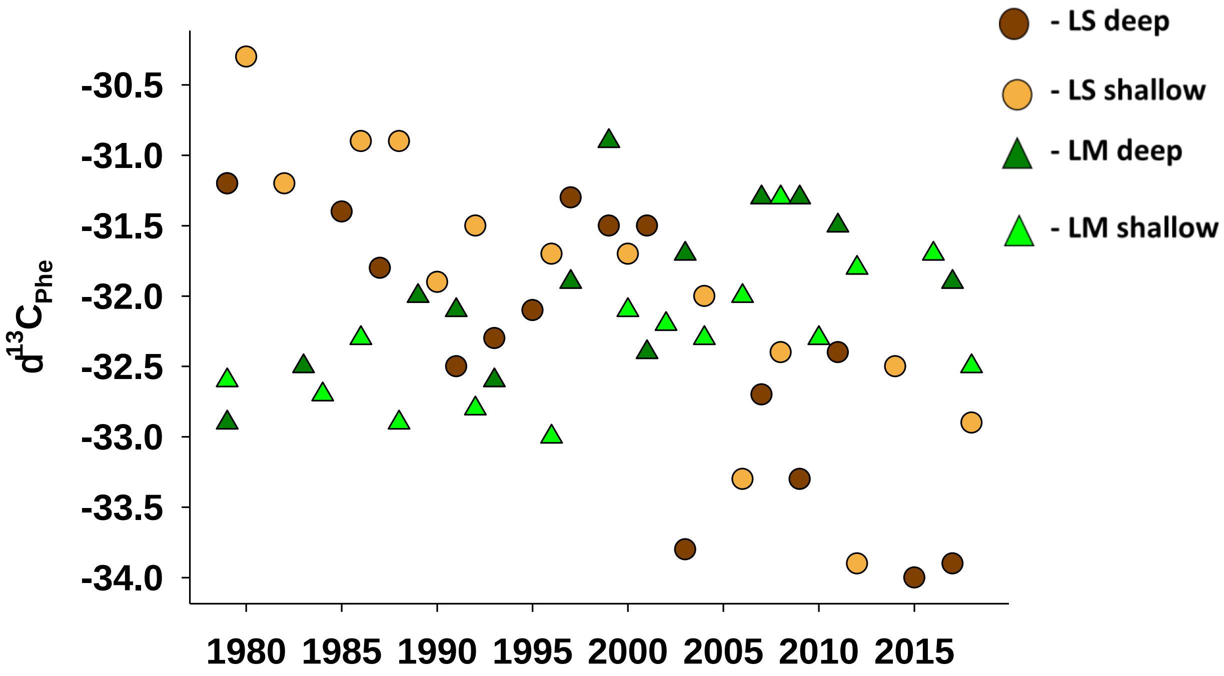
<u>Basal</u> - item CN sources

- Surprising differences in values

  <u>Lake Superior (-) Lake Michigan (+)</u>

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



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Basal - item CN sources

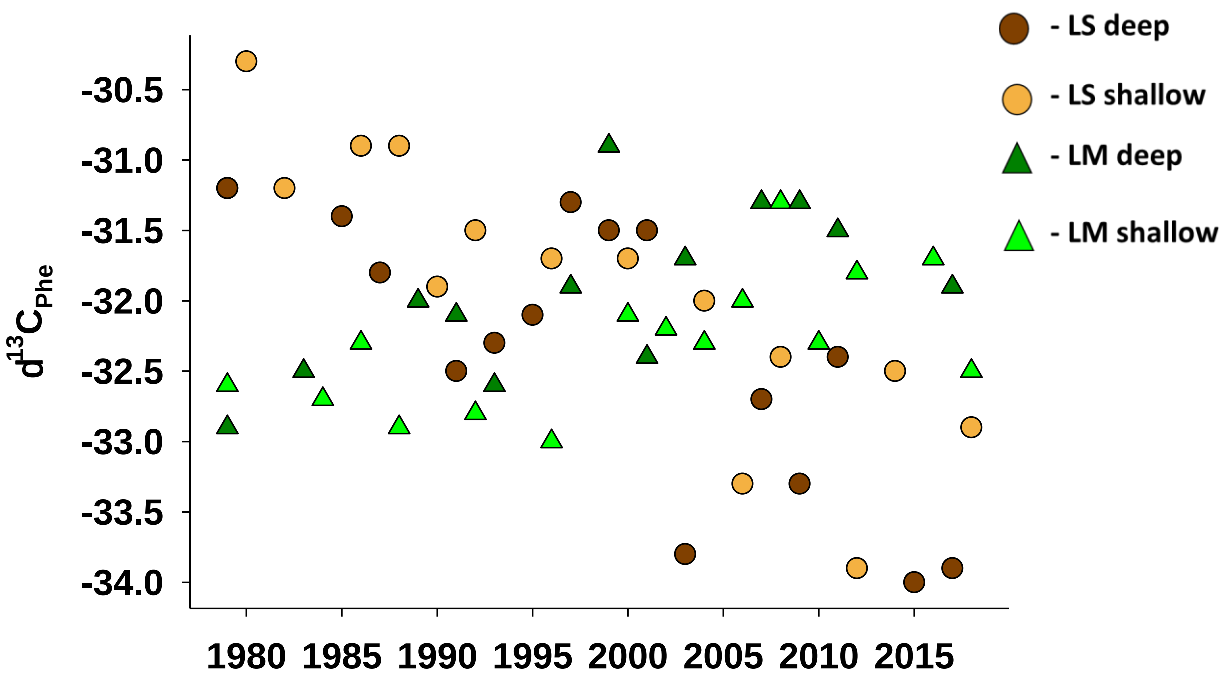
- Surprising differences in values

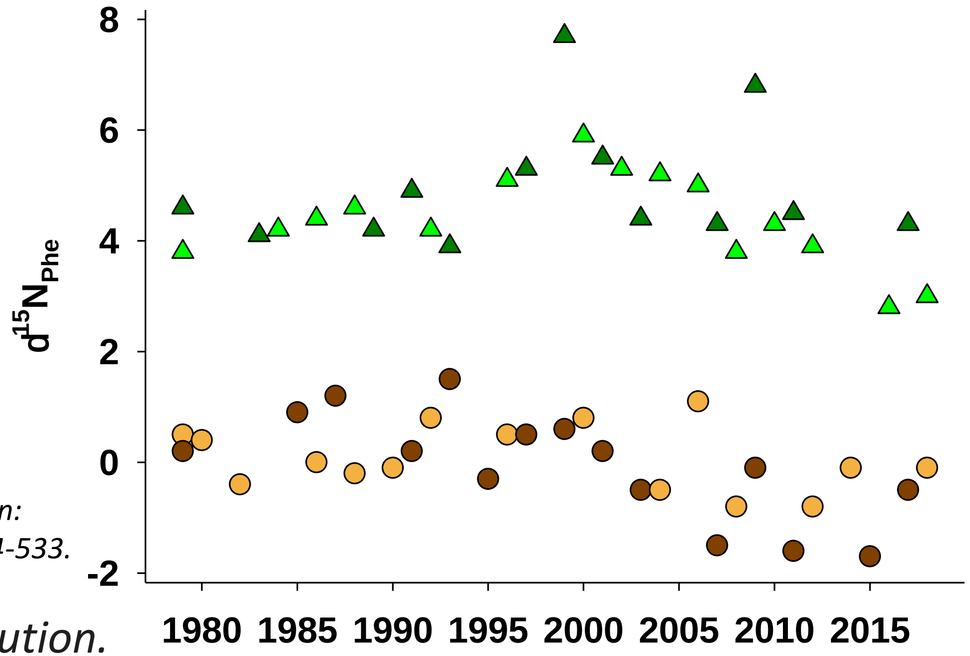
  Lake Superior (-) Lake Michigan (+)

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

  Both lakes

  - Nitrogen - coherence suggests shared response, likely related to loading.
    - 1970- present reduction in point source N, Haber Bosch generally near zero N values[1]
    - ~2000 atmospheric NO_x declines[1]





[1]Hobbs, William O., et al. "Nitrogen deposition to lakes in national parks of the western Great Lakes region: Isotopic signatures, watershed retention, and algal shifts." Global Biogeochemical Cycles 30.3 (2016): 514-533.

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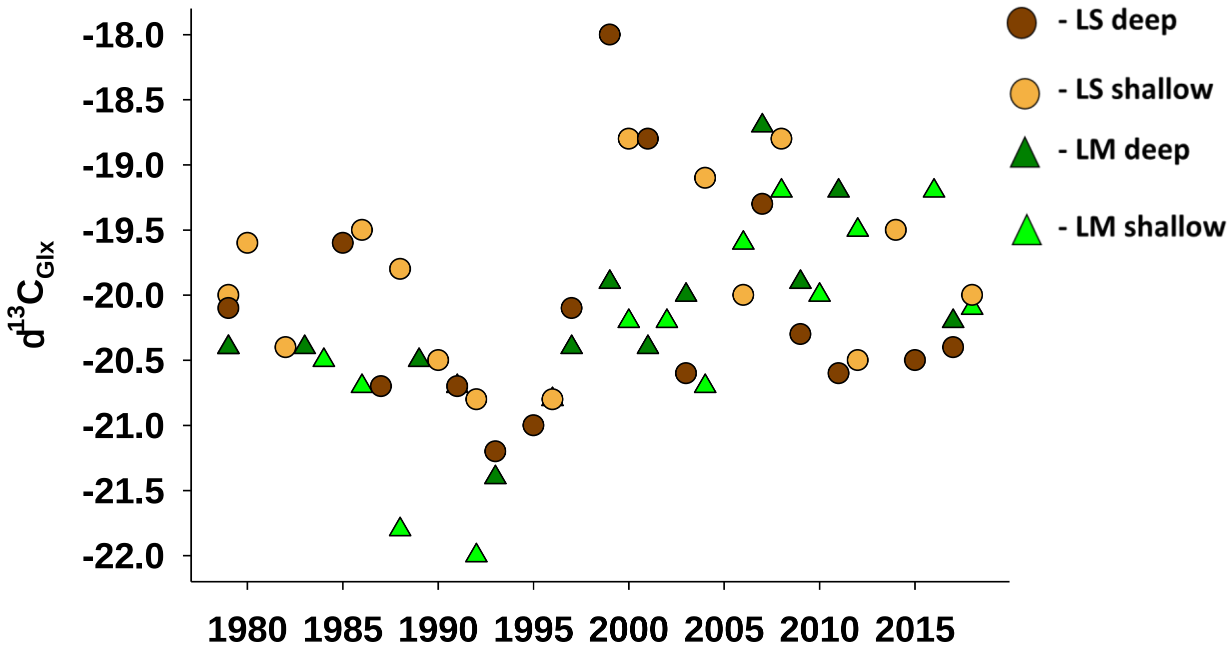
<u>LKT</u> - induced response

<u>Lake Superior & Lake Michigan = noise?</u>

- Carbon - traces the fish modifications on carbon (metabolic or dietary) over the imprinted basal trend (LM+, LS-)



LKT - induced response

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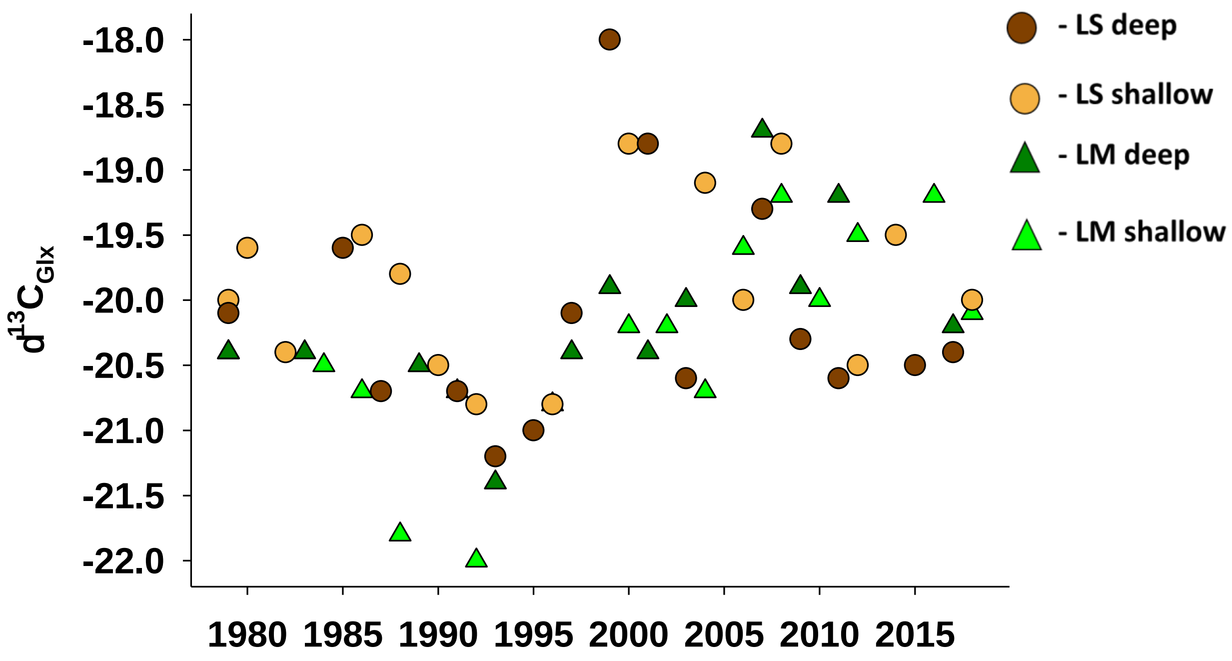
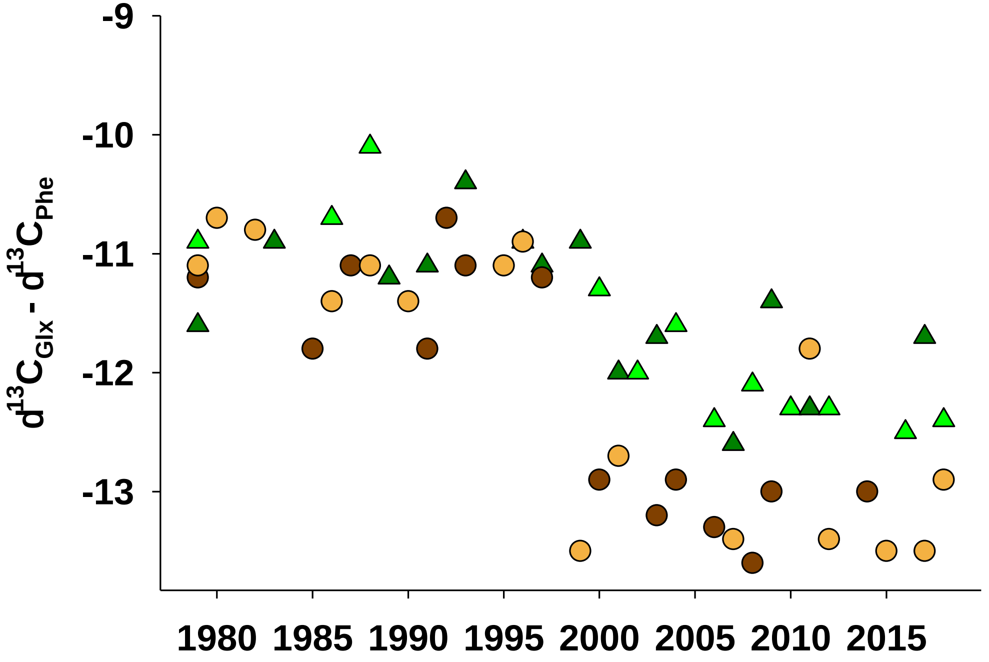
- **Account for baseline - imprecise**





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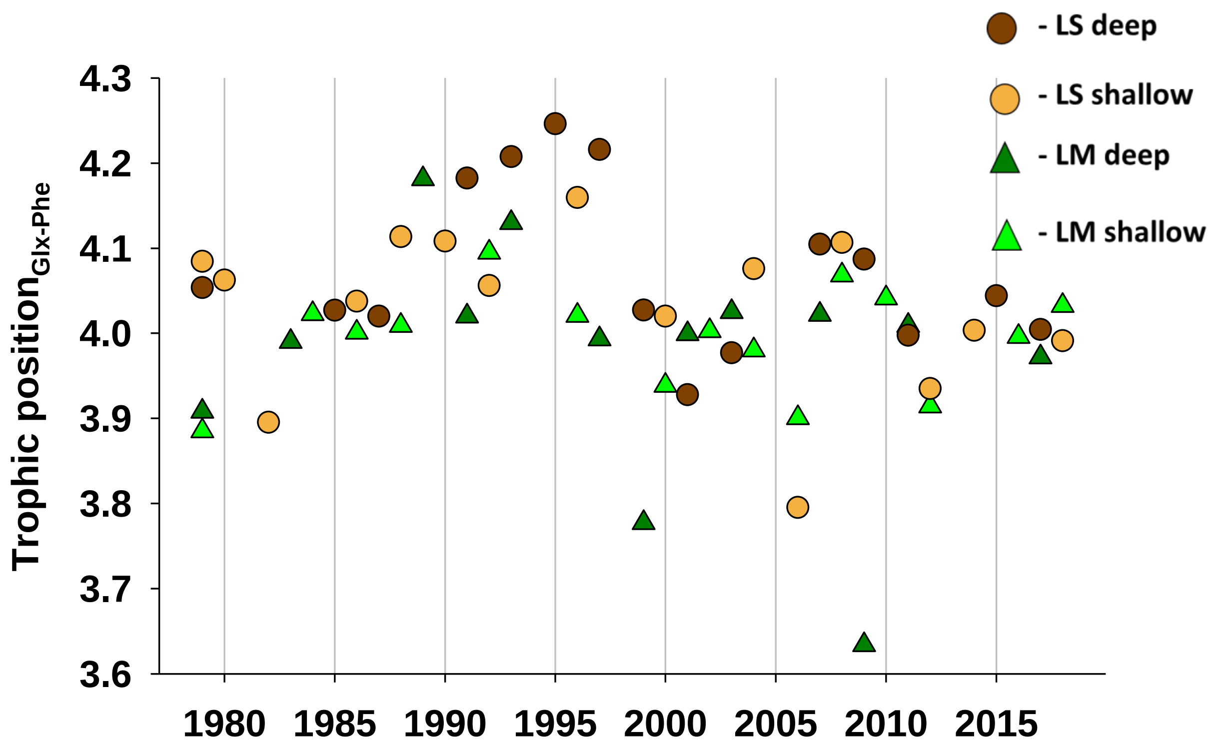
LKT - induced response

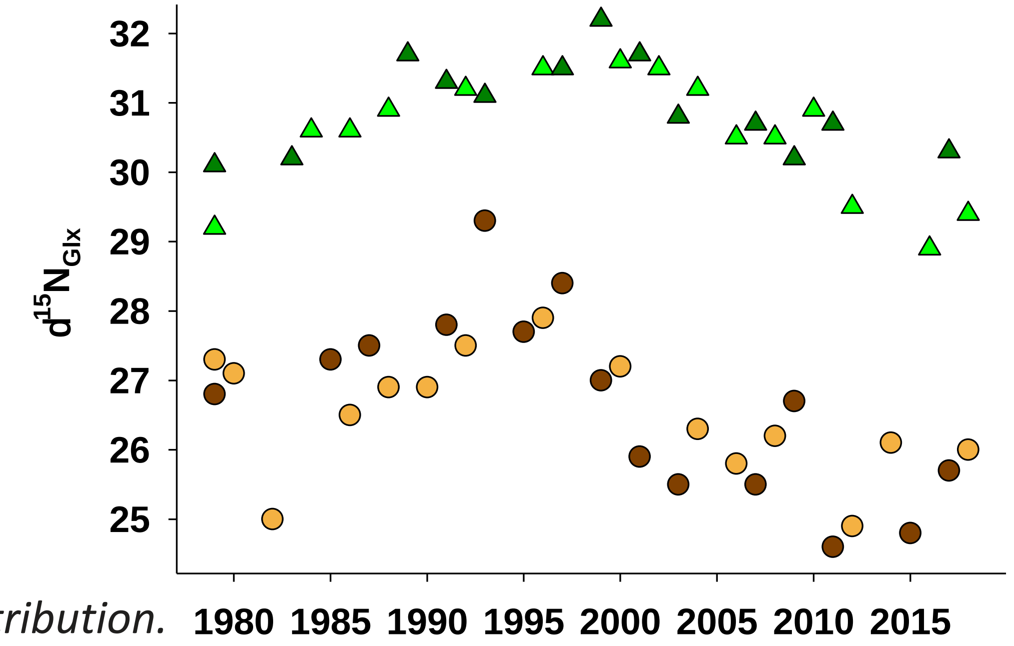
Lake Superior & Lake Michigan = noise?

- Carbon - traces the fish modifications on carbon (metabolic or dietary) over the imprinted basal trend (LM+, LS-)

Both lakes

- Nitrogen - coherence reaffirms previous findings
  - No differing trophic modifications exist
  - **Trophic position comparable - not responsible**





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LKT - induced response

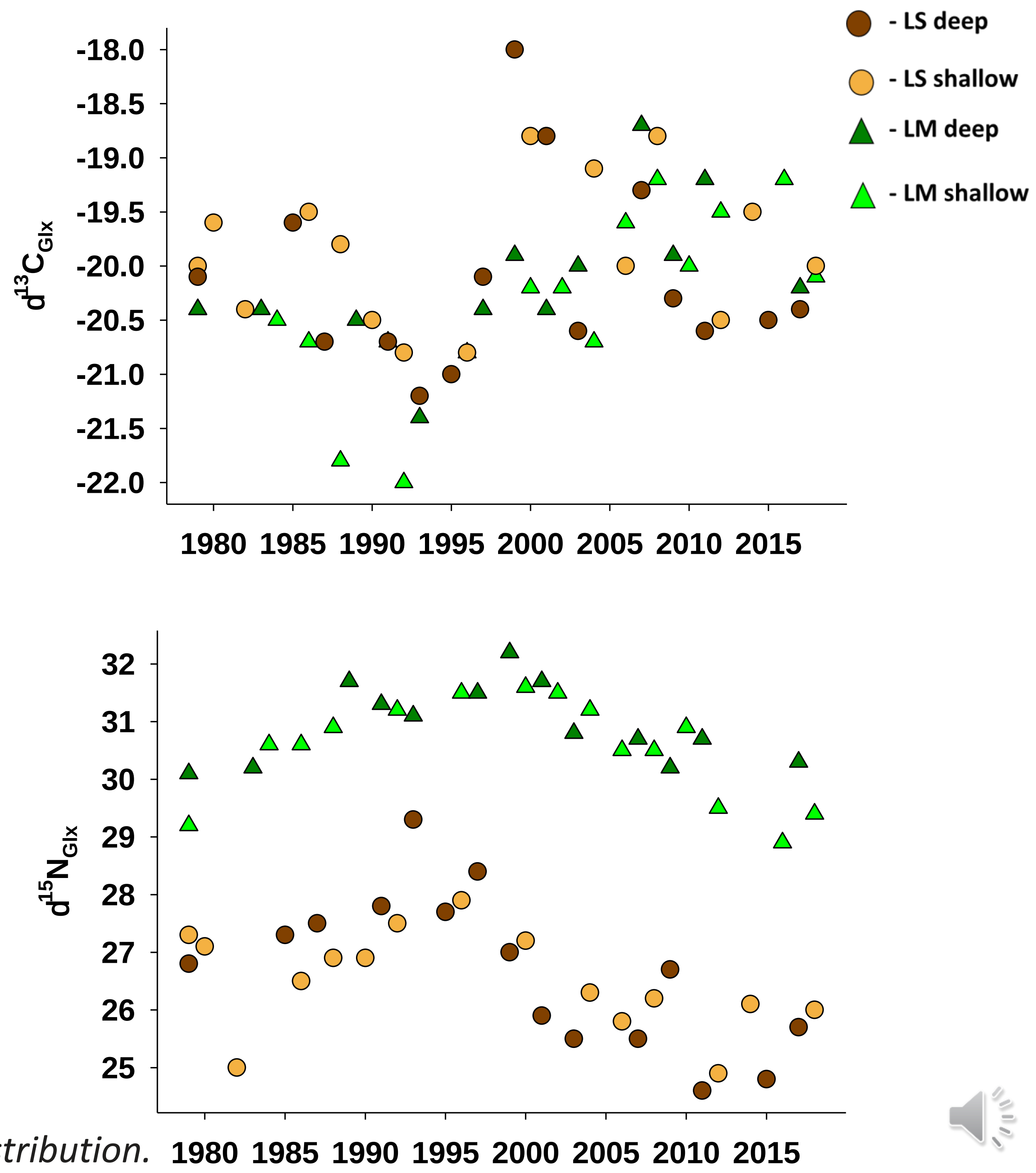
Lake Superior & Lake Michigan = noise?

- Carbon - traces the fish modifications on carbon (metabolic or dietary) over the imprinted basal trend (LM+, LS-)

- **Not obviously linked to morphotype**

Both lakes

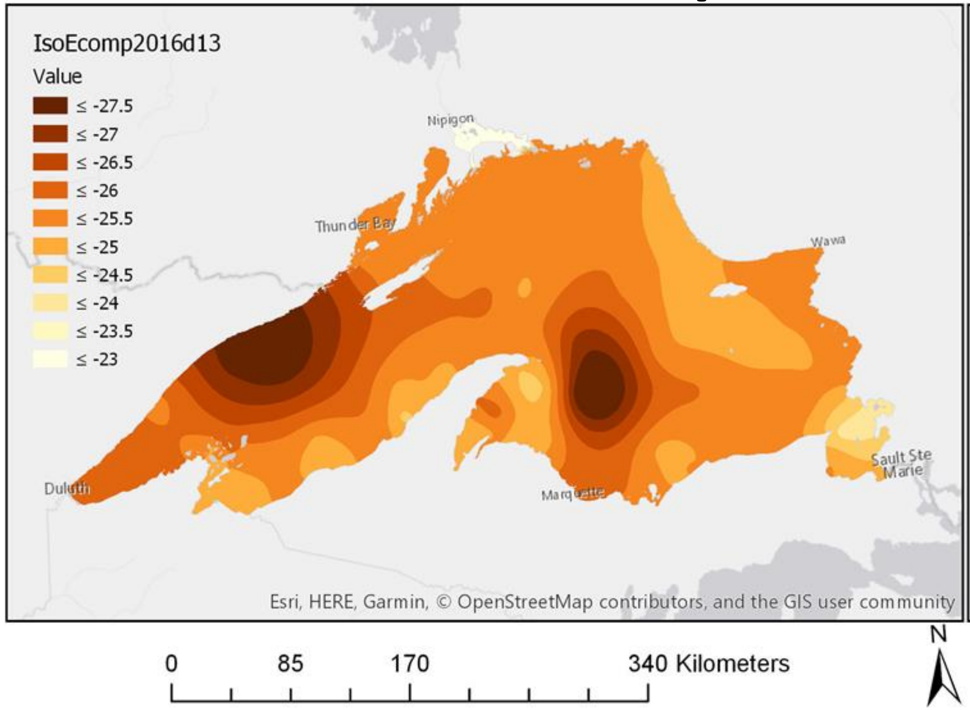
- Nitrogen - coherence reaffirms previous findings
  - No differing trophic modifications exist
  - **Trophic positions comparable**

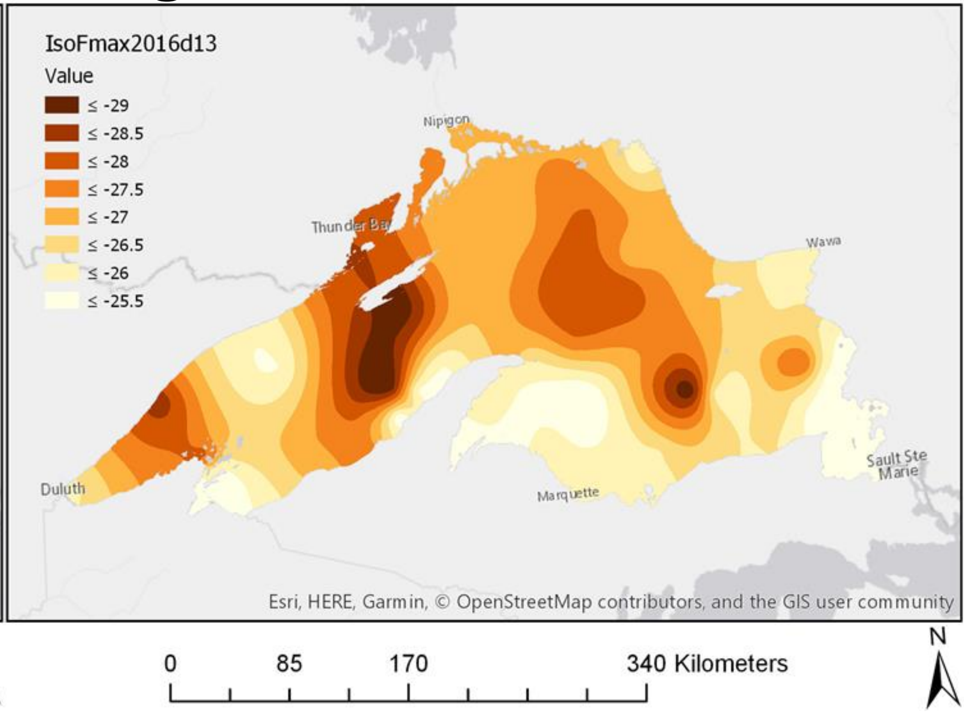


Next steps -

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

$\delta^{13}C$ in particulate organic carbon





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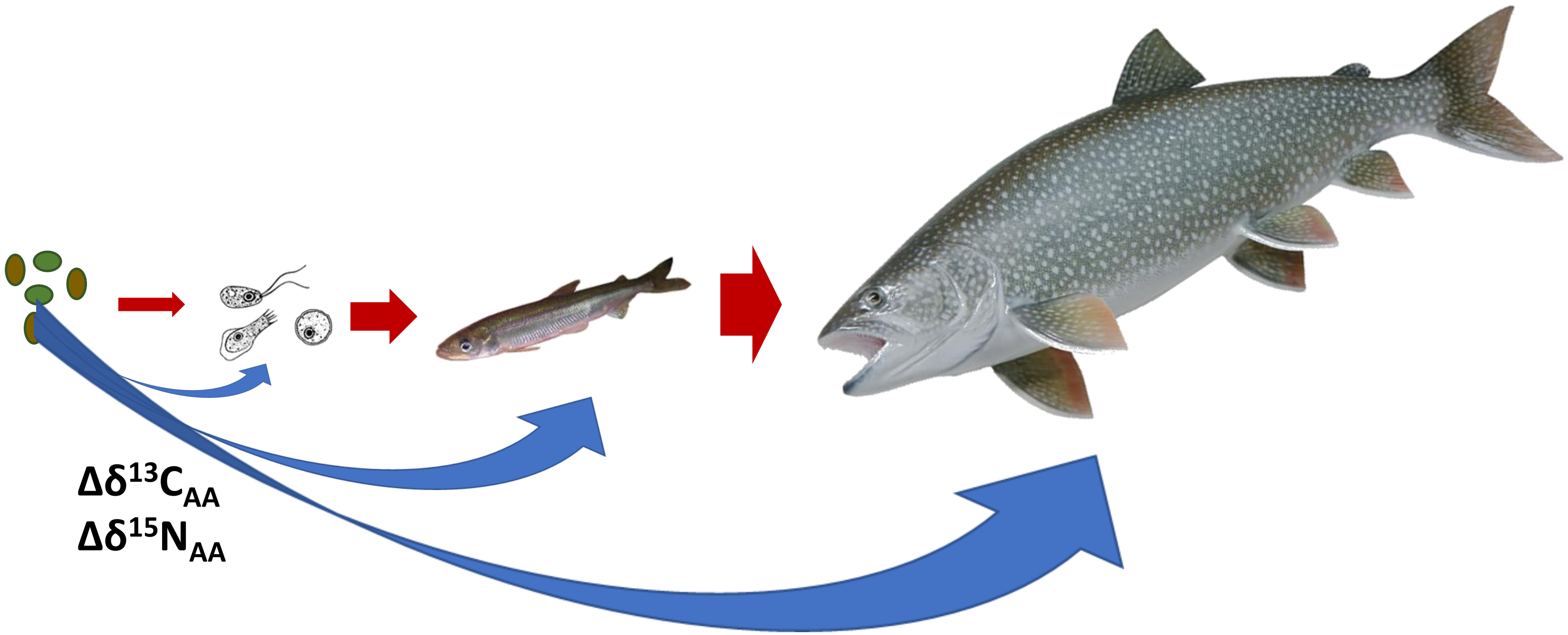
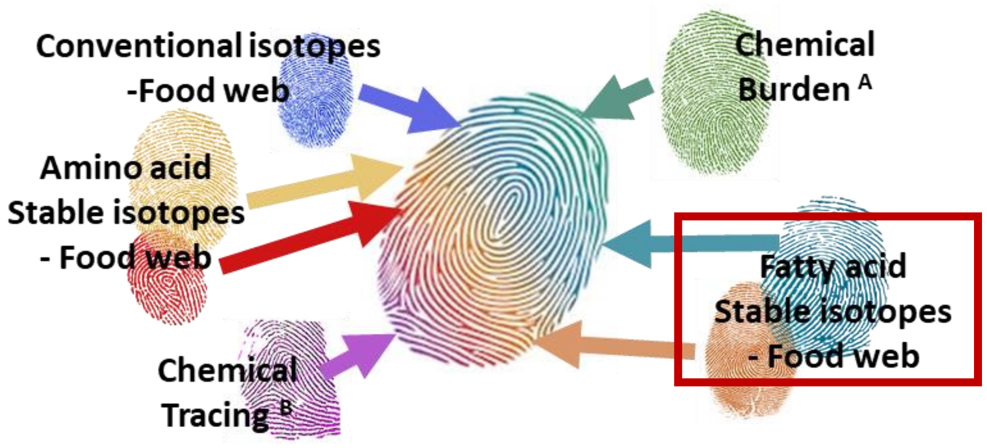
- Construct spatial and vertical isoscapes - in bulk, they exist.
- Understand isotope discrimination between basal items and receptor(s)



Next steps -

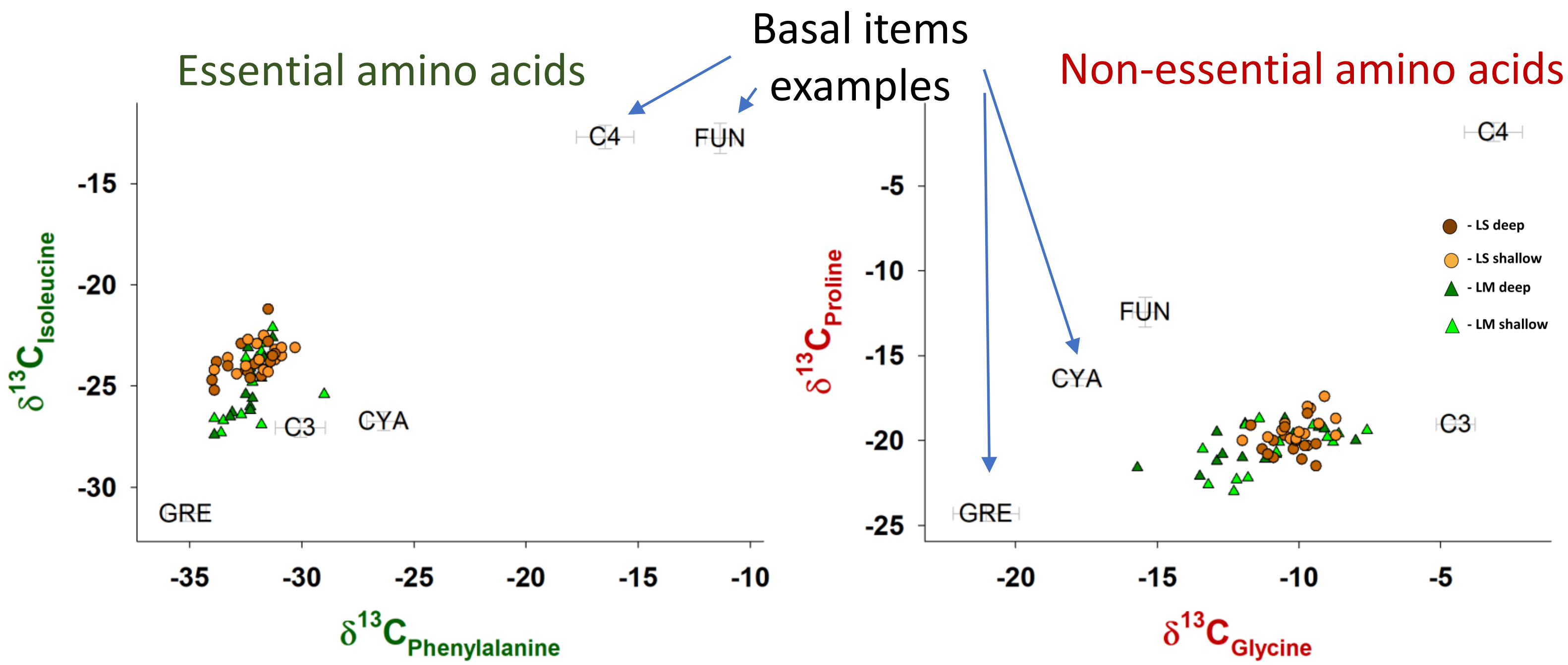
- Construct spatial and vertical isoscapes - in bulk, they exist.
- Understand isotope discrimination between basal items and receptor(s)
- Including other axes of inference



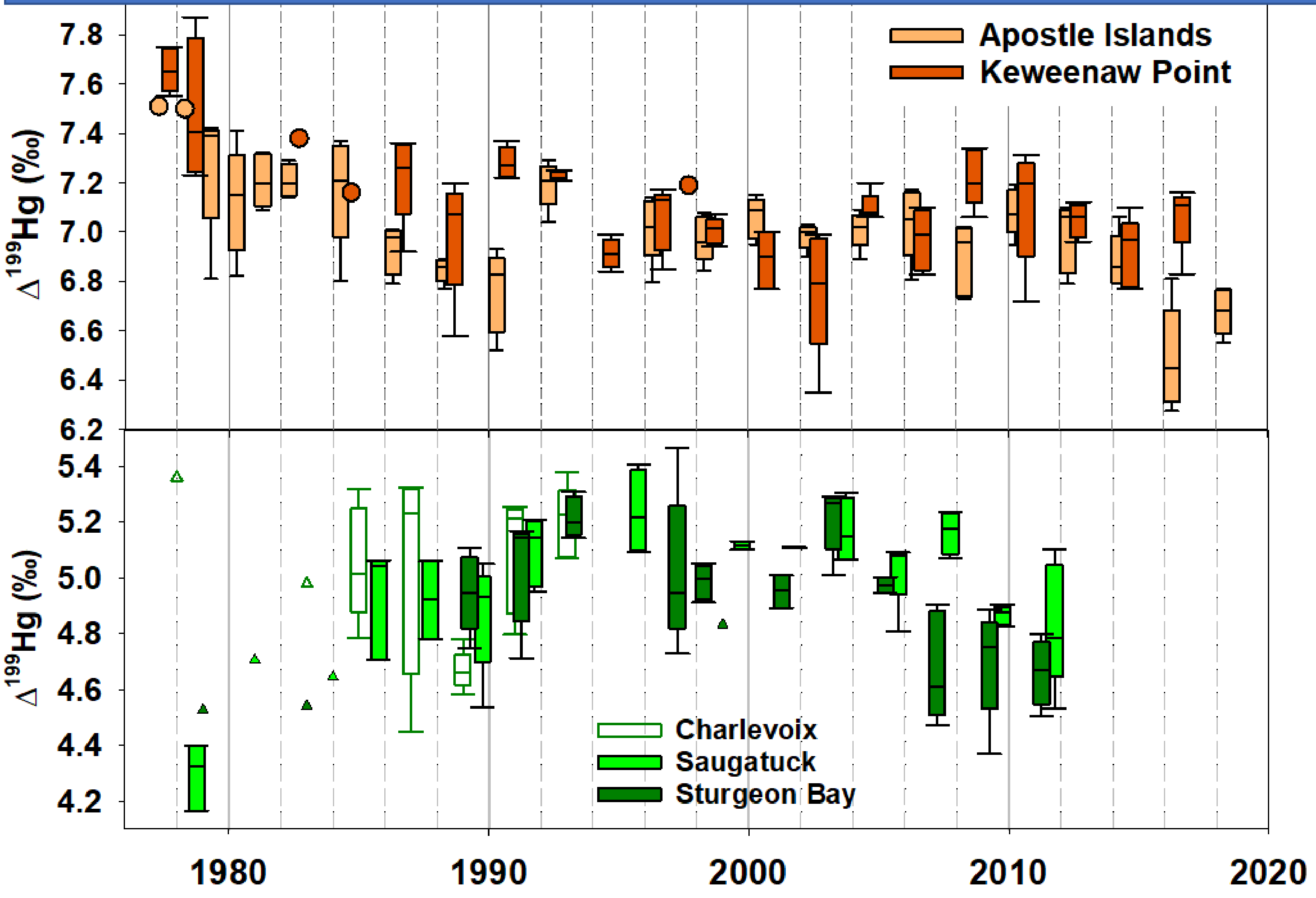
Thank you

- USGS Mercury Research Lab
- Chris Yarnes - UC-Davis
- Rachel Bowes - Karlstad University

rlepak@wisc.edu



Sorry I did not fulfill the objectives outlined in the abstract but stay tuned because this is just chapter one in what promises to be a fun and complex series - enjoy the bonus slide!



What drives mercury isotope variability?

- **Mercury inputs**

<u>Reactions</u>

- Lake-lake incoherence in $\Delta^{199}Hg$ (traces the extent of photochemistry)

<u>Lake Superior</u>

- Decreased reaction rates be linked to changing lake warmth and/or productivity factors or species dietary preference

<u>Lake Michigan</u>

- Improved water clarity followed by fish diet transition – deeper/littoral

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