Stable isotopes indicate zebra mussels (*Dreissena polymorpha*) increase dependence of lake food webs on littoral energy sources

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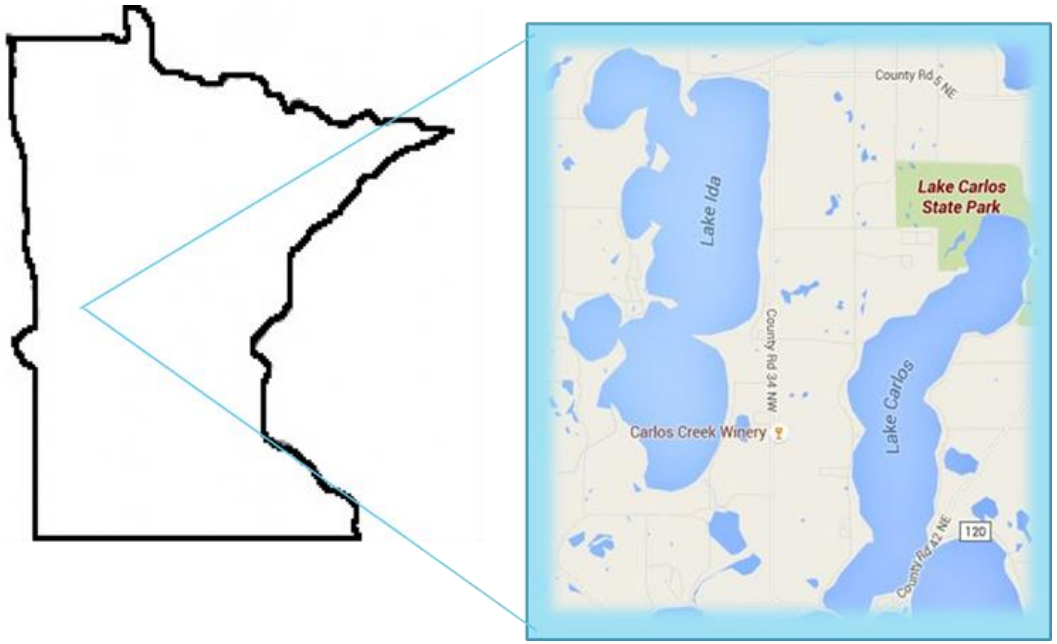
Zebra mussels decrease seston and increase water clarity—what does this mean for fish community?



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How do zebra mussels affect fish communities?

- How does presence of zebra mussels affect reliance on littoral energy?

- How does presence of ZM affect trophic levels of fish consumers?

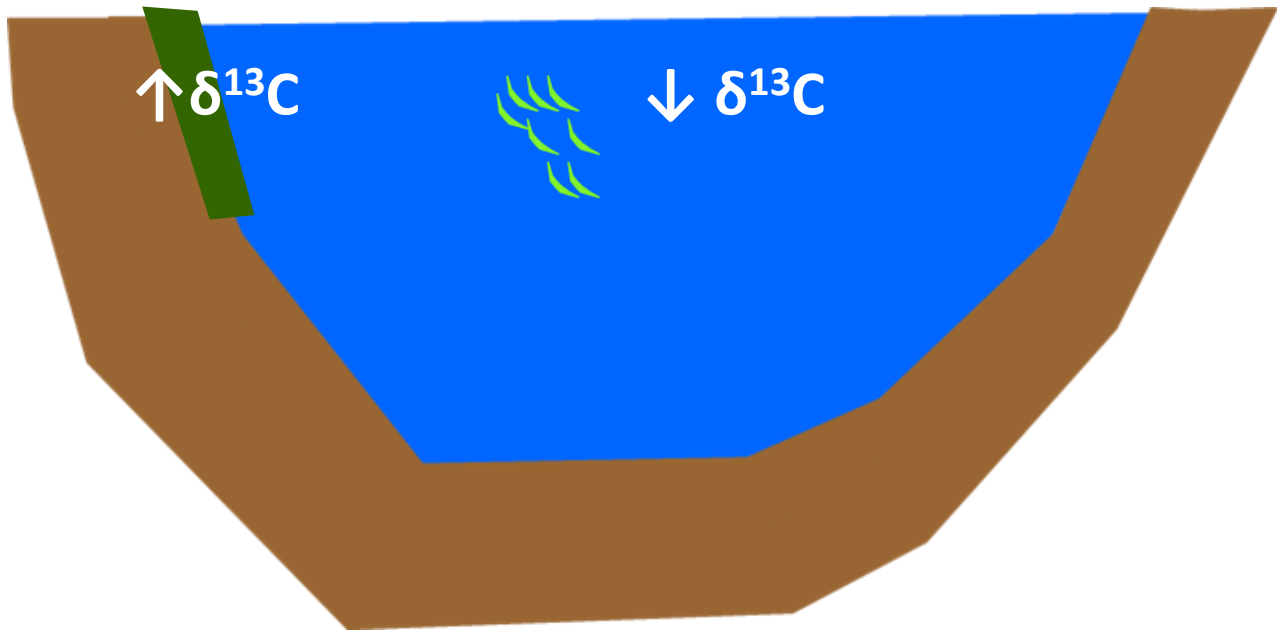
- What are the implications for fish isotopic niches and fish community?

Methods

Using stable isotopes to study energy flow: $\delta^{13}C$

- Depleted (lower) $\delta^{13}C$: indicates pelagic energy sources (Post, 2002)

- Enriched (higher) $\delta^{13}C$: indicates littoral energy sources

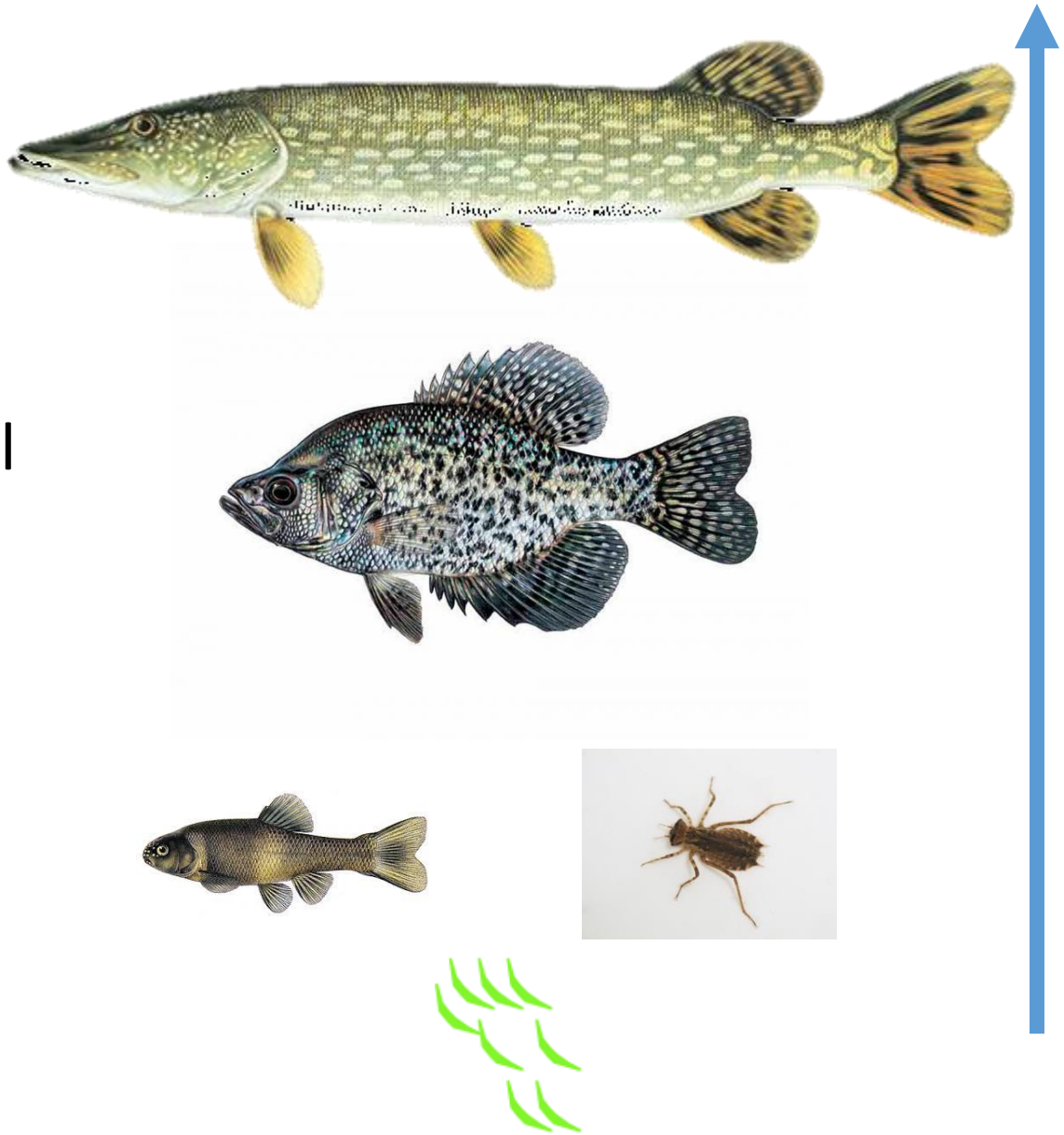


Proportion littoral energy =

$$\frac{(\delta^{13}C_{pelbase} - \delta^{13}C_{2con} + \Delta t_{2con})}{(\delta^{13}C_{pelbase} - \delta^{13}C_{littoralbase})}$$

Using stable isotopes to study energy flow: $\delta^{15}N$

- Increasing $\delta^{15}N$ as trophic levels increase
- 3.4 ‰ enrichment with each trophic level
  (Post, 2002)



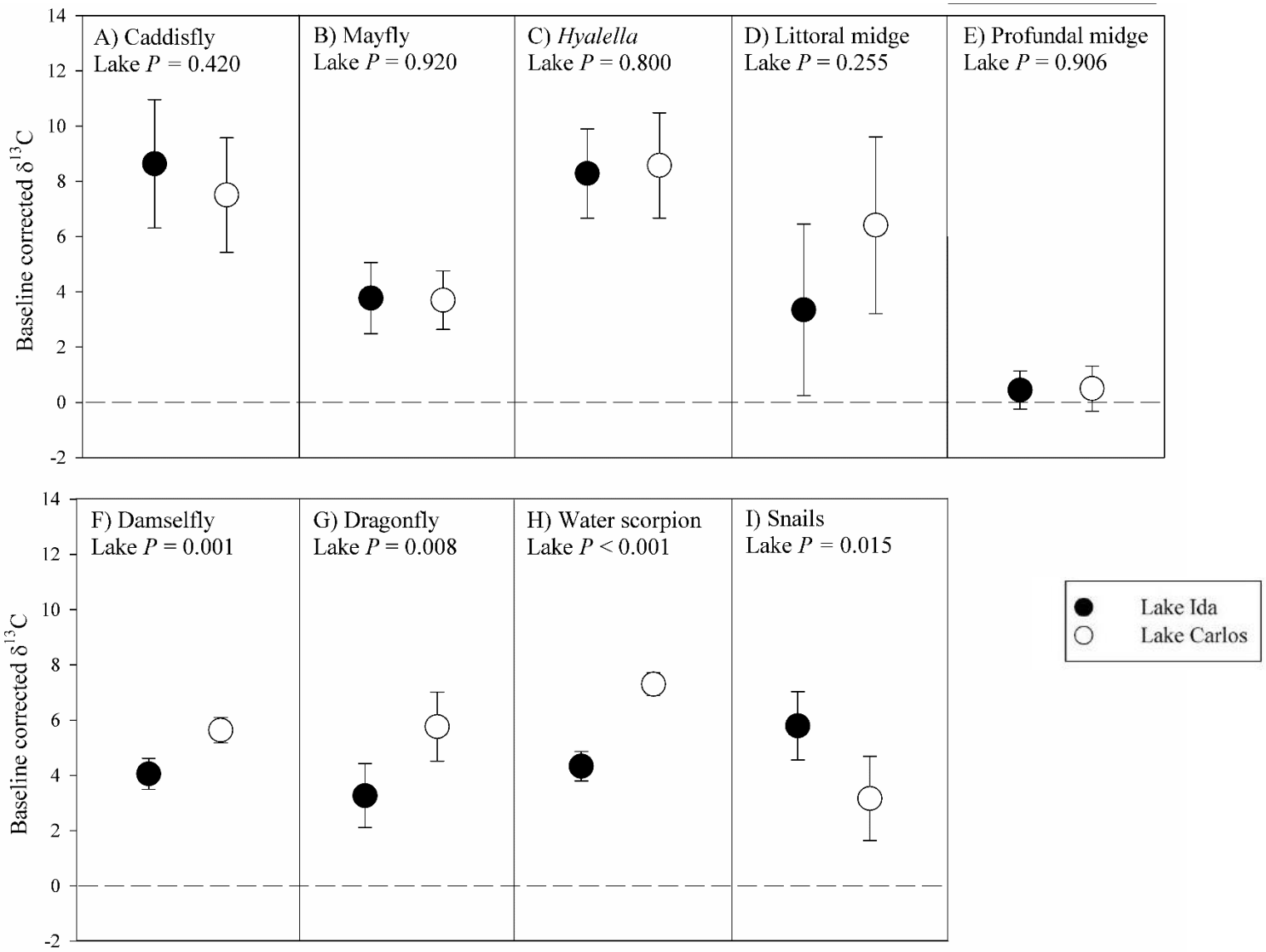
Trophic position =

$$\lambda + \frac{(\delta^{15} N_{2con} - [\delta^{15} N_{litbase} * \alpha + \delta^{15} N_{pelbase} * (1-\alpha)])}{\Delta N}$$

Analysis approach

- Paired t-tests to compare baseline-corrected $\delta^{13}C$ levels in invertebrates between the two lakes
- Mixing models (Post, 2002) to determine and compare between the two lakes:
  - Proportion reliance on littoral energy in fish $\delta^{13}C$
  - Trophic level of fish $\delta^{15}N$
- Sample size-corrected standard ellipse area (SEAc; Jackson et al 2011) to estimate isotopic niche area of each fish species
  - Assess differences in community niche structure by comparing ellipse size and positions on the axes relative to other fish species
  - Estimate the trophic range, range of littoral C reliance, and SEAc for entire fish community in each lake

Secondary invertebrate consumers have significantly higher dependence on littoral energy



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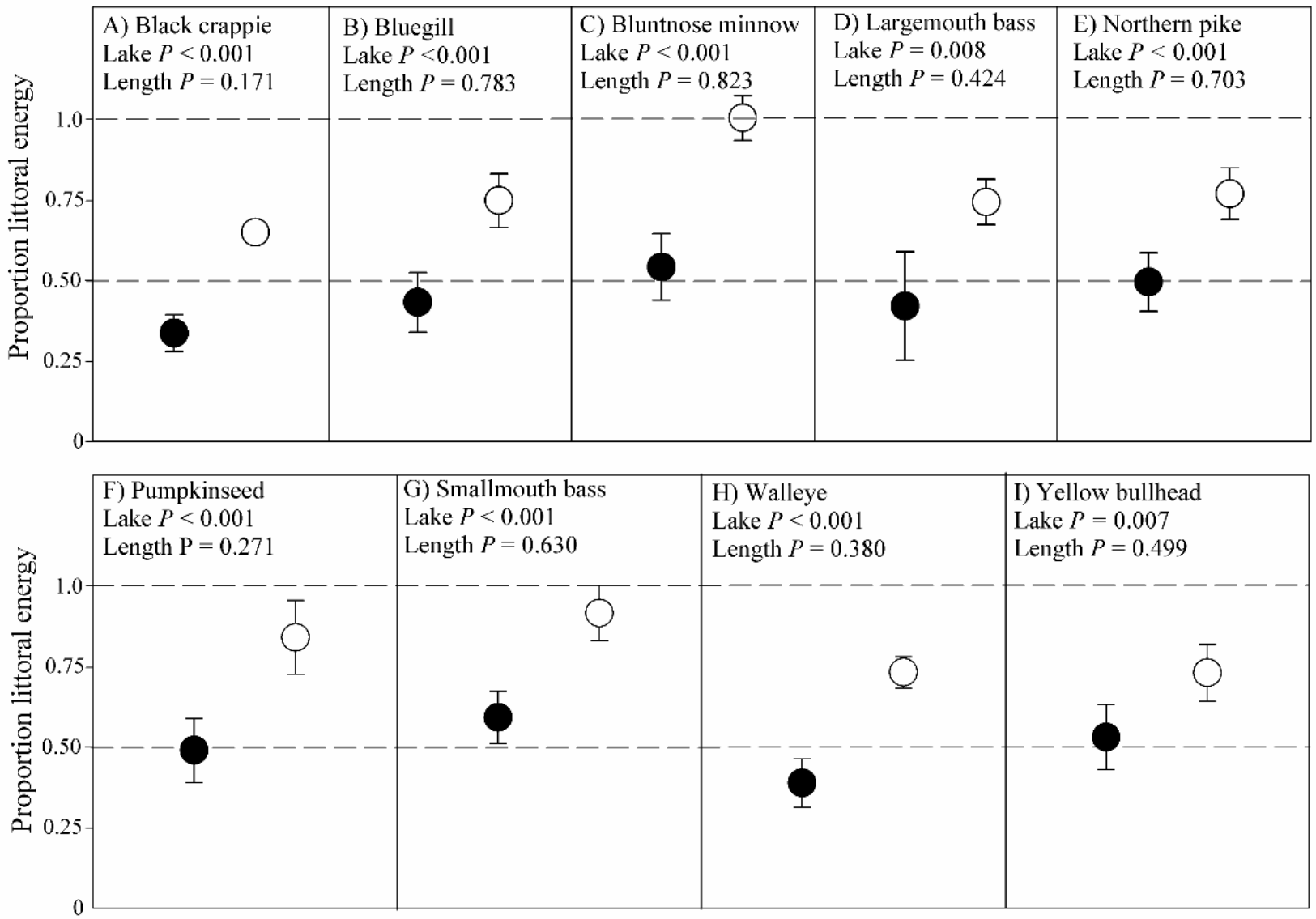
Nine fish species showed higher reliance on littoral energy in Lake Carlos, but no relationship between fish length and dependence on littoral energy



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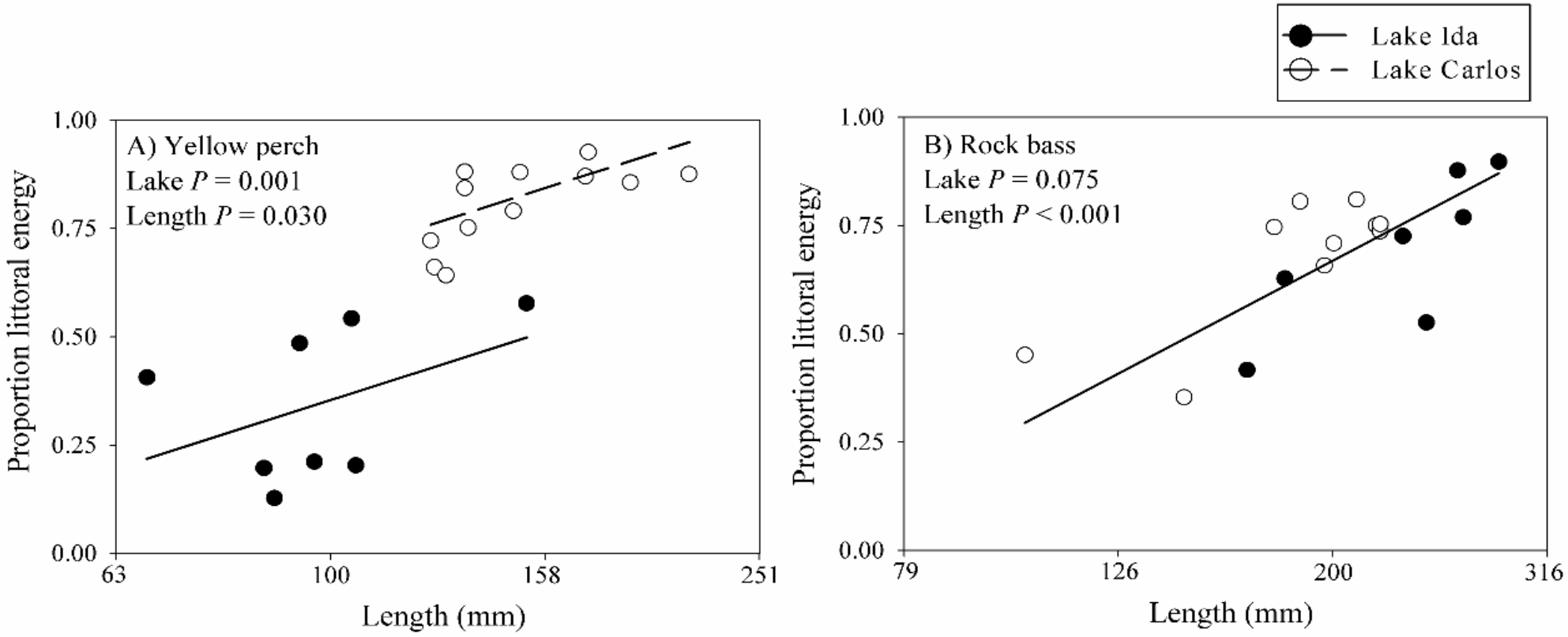
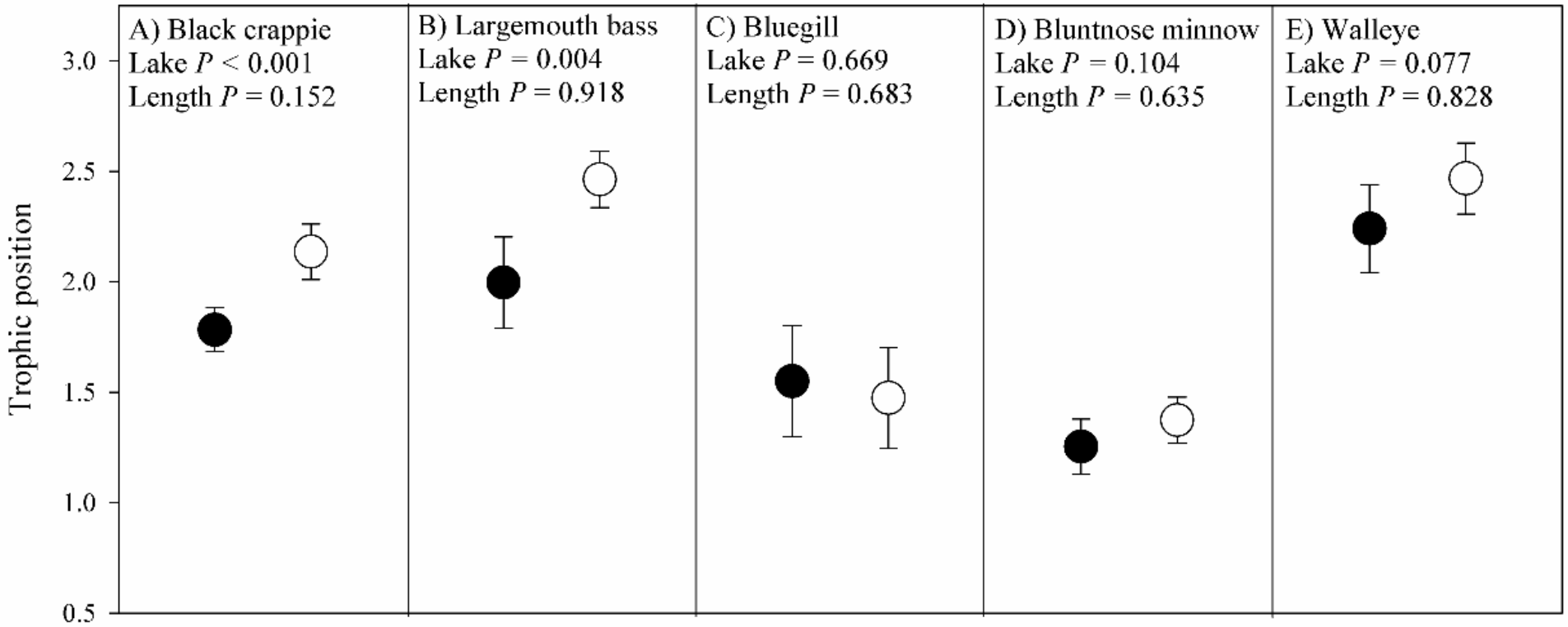
Yellow perch and rock bass showed a significant relationship between fish length and dependence on littoral energy.



Bluegill, bluntnose minnow, and walleye showed no change in trophic position between lakes and no relationship with fish length. Largemouth bass and crappie showed higher trophic position in Lake Carlos than Lake Ida, but neither fish showed a relationship with fish length.



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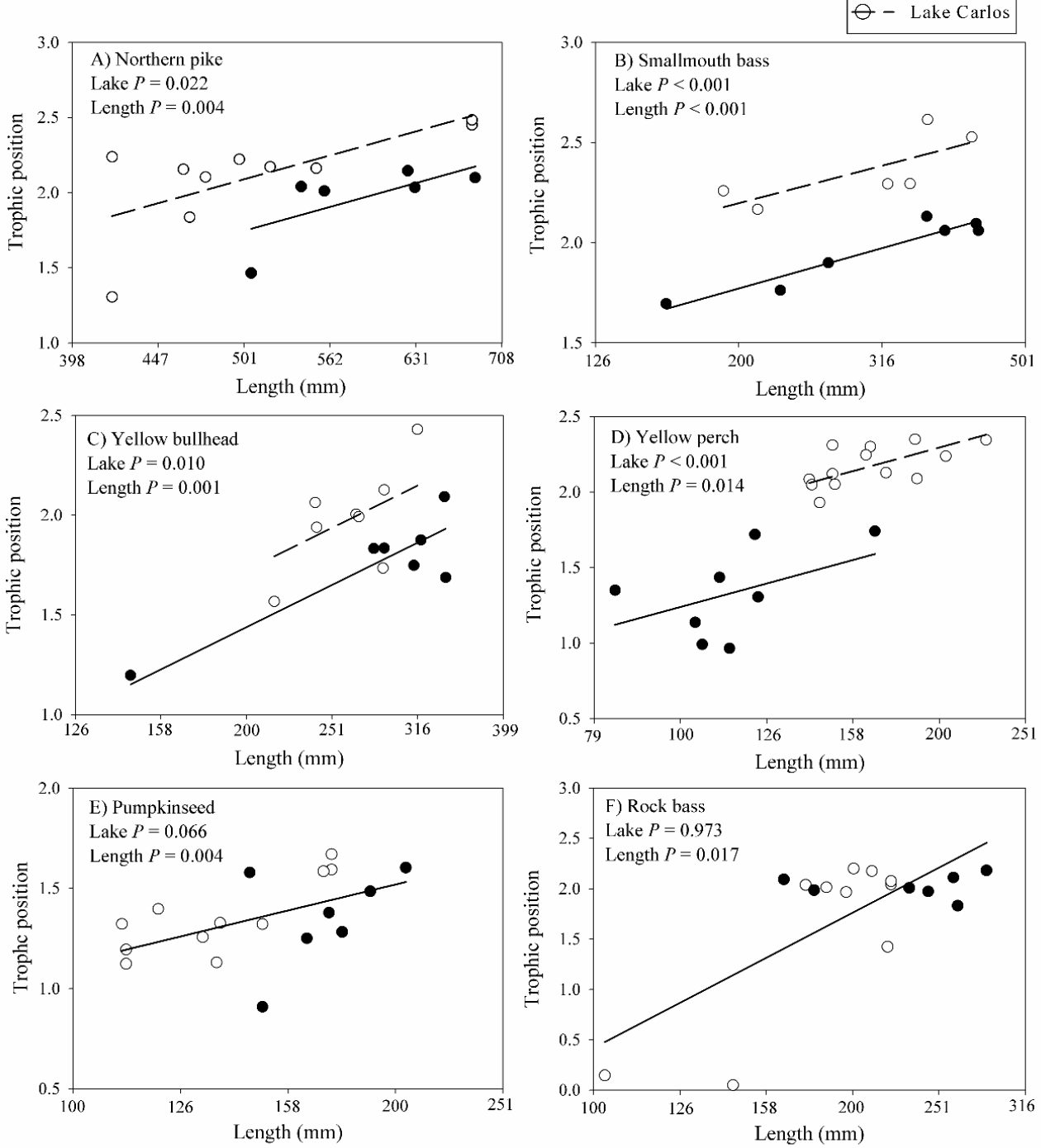

As fish length increases, so does trophic position.

Most fish also showed increased trophic position in Lake Carlos relative to Lake Ida.

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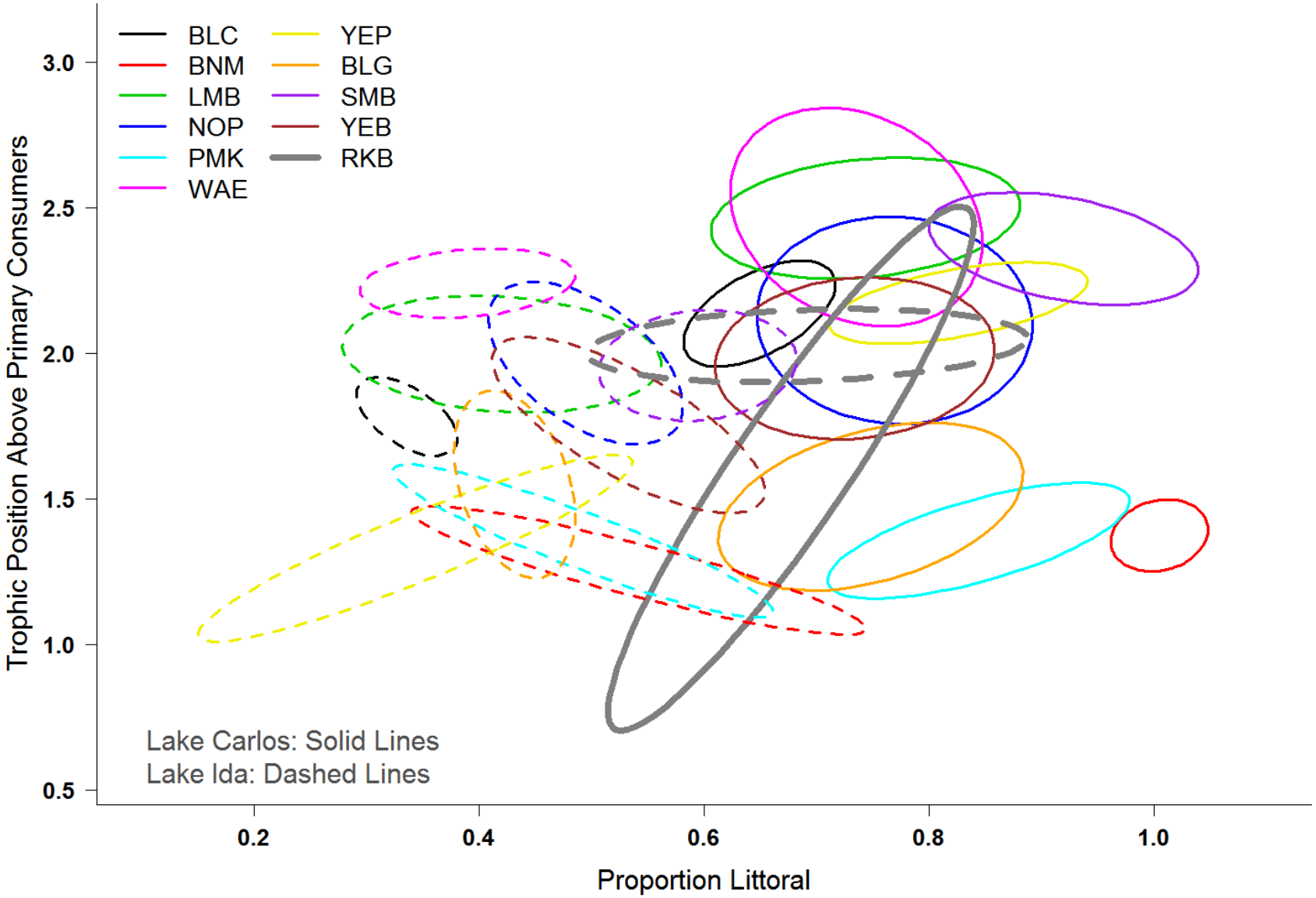
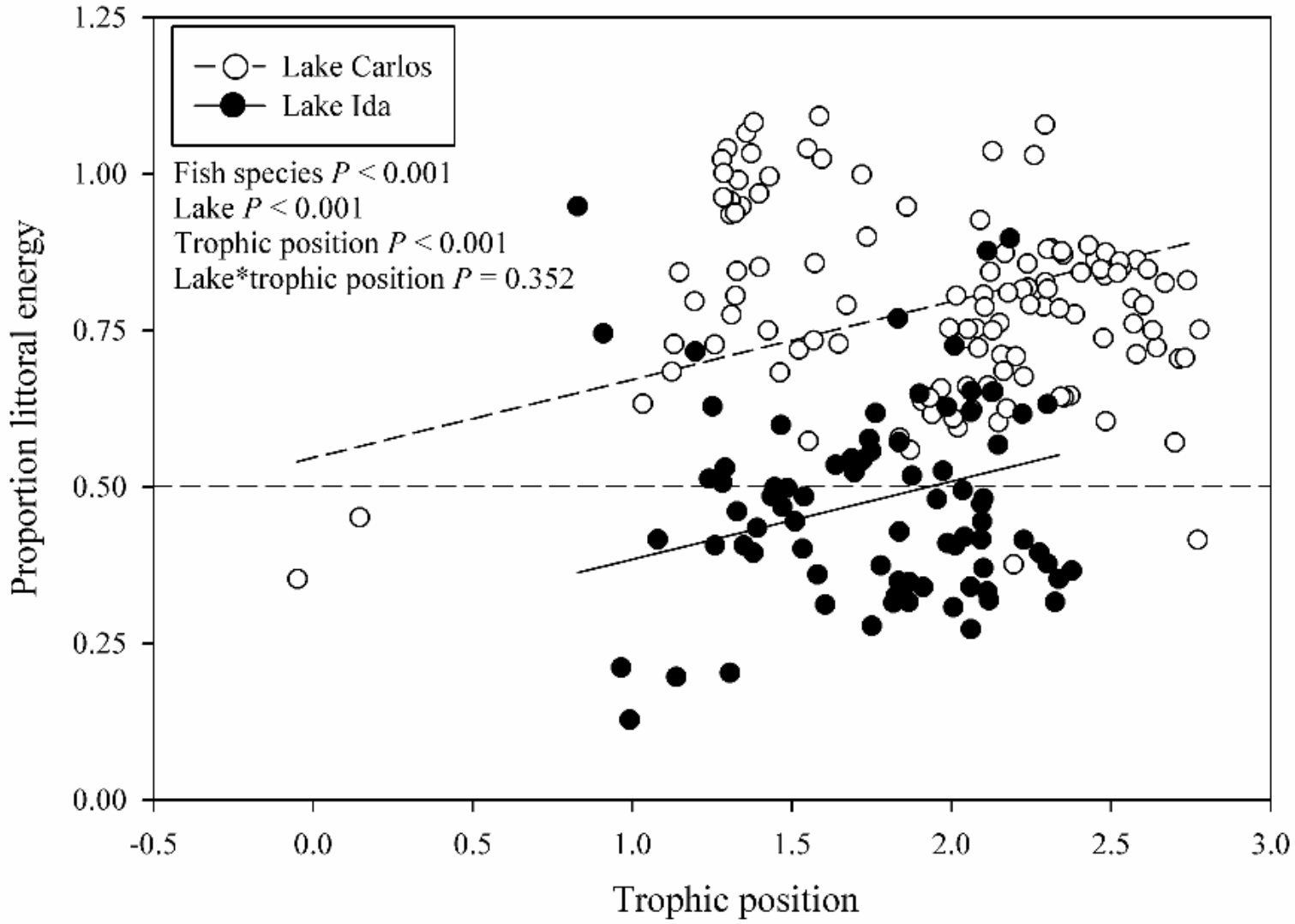
Most piscivorous fish are feeding at higher trophic levels in Lake Carlos than in Lake Ida



The net result was fish at the highest trophic levels integrated more diverse energy sources in Lake Ida than in Lake Carlos.



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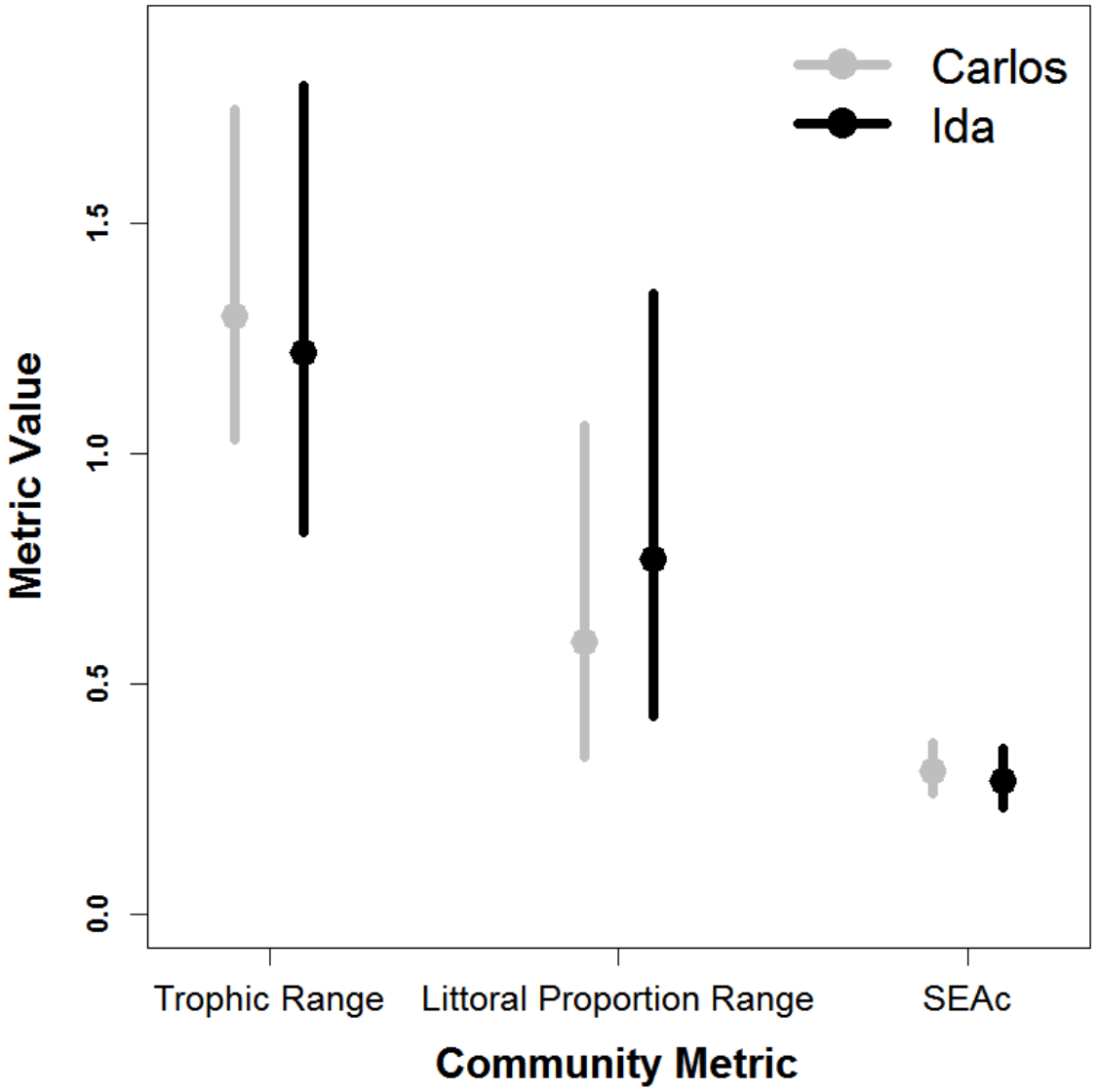
Community-level metrics showed no difference between the lakes



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Summary of results:

- Secondary invertebrate consumers had higher reliance on littoral energy in Lake Carlos
- 10/11 fish species had higher reliance on littoral energy in Carlos than in Ida and statistically different niche ellipses
- 7/11 fish species were feeding at a higher trophic level in Carlos than in Ida
- Predators and larger fish at higher trophic levels are eating from less diverse sources

What does it all mean?

- Zebra mussels have implications for individual fish species and energy flow in the food web, but it's not clear what this means for fish communities as a whole.

- Predators and bigger fish have reduced ability to integrate energy flow between pelagic and littoral food sources, suggesting possible competition at highest levels in food chain

- Increasing reliance on littoral energy sources may impact more pelagic-oriented fish such as walleye and yellow perch…
  and/or increase competition for those energy sources

Lakes may look different after zebra mussels invade

- Greater light penetration → increased primary production in the hypolimnion could compensate for lower phytoplankton abundance
- less pelagic-oriented species, same overall biomass

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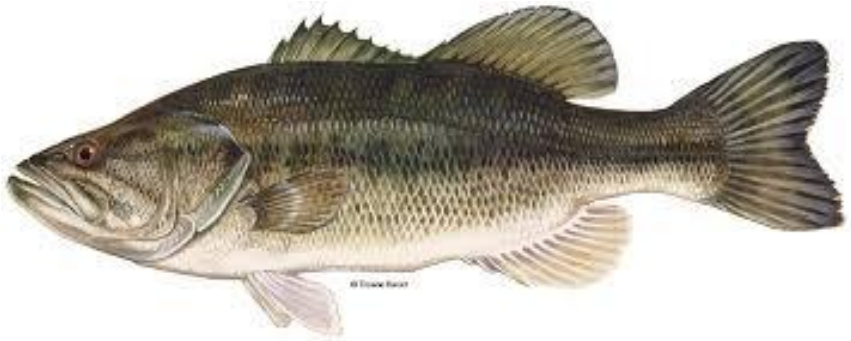

Thank you!

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