Ecosystem Productivity and Fish Community Trophic Structure Across Freshwater and Marine Ecosystems

Halimah Budeir and Nicholas S. Green

Department of Ecology, Evolution, and Organismal Biology, Kennesaw State University

Contact:
hbudeir@students.kennesaw..edu
ngreen62@kennesaw.edu

Introduction

Background

- Fish trophic level (position in the food chain) reflects how energy moves through ecosystems.
- Environmental factors (e.g., temperature, productivity, habitat) shape aquatic food webs.
- Freshwater and marine systems differ in dominant energy pathways (detrital/plant-based vs. plankton-driven).
- These differences may lead to distinct patterns in fish community structure.

Study objective

- Evaluate how environmental and productivity variables predict fish trophic structure.

Hypothesis: Resource availability drives fish community trophic structure.

Methods

- Integrated data from KSU fish collections with NOAA fish community surveys
- Calculated weighted mean fish trophic level for each sample using trophic levels from FishBase and abundance of fish species within each sample.
- Used linear models to test for effects of habitat, year, latitude, and species richness.

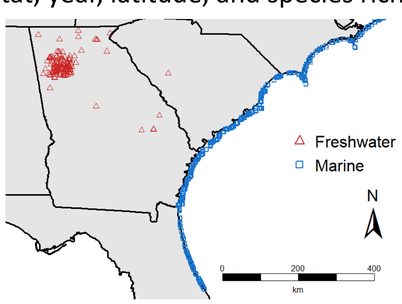

Figure 1. Freshwater fish communities from inland Georgia and South Carolina were compared to fish communities from marine sites spread along the east coast of the USA from Florida through North Carolina.

Results

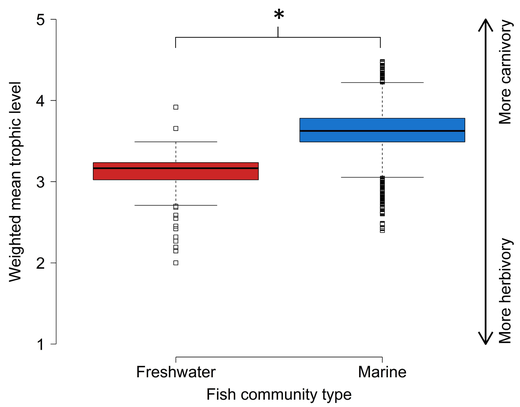

Figure 2. Weighted mean fish trophic level was greater in marine than in freshwater systems (t = 33.81, 245 df, $P < 0.001$). Estimated difference was 0.52, 95% confidence interval (CI) = [0.49, 0.55].

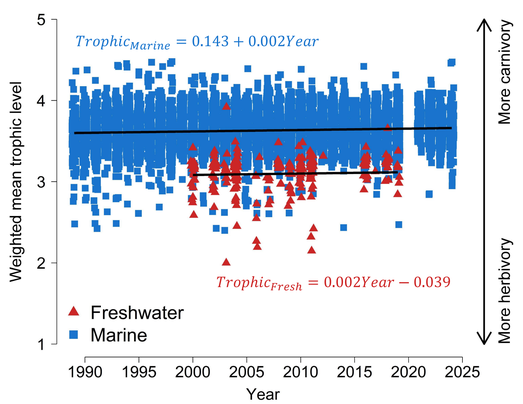

Figure 3. Fish trophic levels increased slightly over 1990–2024 for marine (blue) and freshwater (red) systems ($F_{2,9025}$ = 662.6, $P < 0.001$), but habitat explained more variance in trophic level (partial R^2 = 0.12) than year (partial $R^2 < 0.01$).

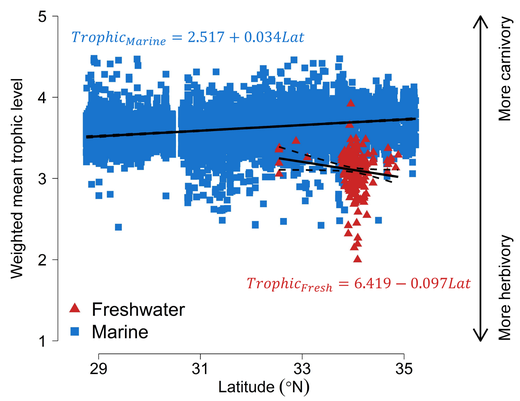

Figure 4. Weighted mean fish trophic level decreased with latitude in freshwater systems, but increased with latitude in marine systems ($F_{3,9038}$ = 702, $P < 0.001$, R^2 = 0.189).

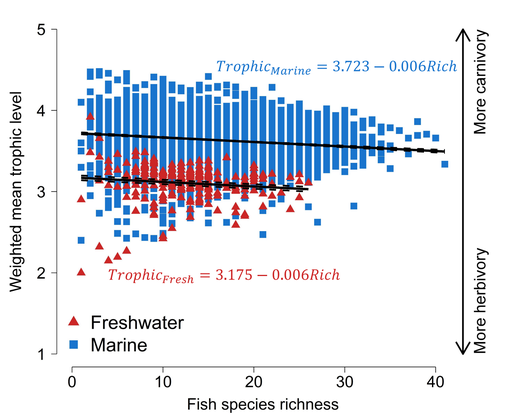

Figure 5. In both freshwater and marine systems, weighted mean fish trophic level decreased with increasing fish species richness ($F_{2,9039}$ = 780.6, $P < 0.001$, R^2 = 0.147). However, habitat type explained almost 12 times as much variance as species richness.

Discussion

- Habitat type was consistently the strongest predictor of weighted mean fish trophic level, supporting the hypothesis that fish marine systems are less reliant on herbivory.
- Weighted mean fish trophic level varied slightly over time, across latitude, and with community diversity, but none of these factors had as much explanatory power as habitat (marine vs. freshwater).
- This may reflect differences in resource availability between marine and freshwater systems.
- Marine systems support longer food chains, contributing to higher trophic levels.
- Trophic structure was more compressed in freshwater systems compared to marine systems.

Key Takeaways

- Identifying the drivers of trophic structure can improve predictions of how fish communities may respond to environmental change.
- Shifts in productivity may redistribute energy across trophic levels, altering the balance between lower and higher trophic species.
- Large, publicly funded and openly available datasets can facilitate investigation of basic ecological questions.

Data Sources

- NOAA 1989–2019, Southeast Fisheries Science Center Community Abundance Surveys (SEAFiSh), NOAA Fisheries Data Portal.
- Froese, R., & Pauly, D. (eds.). *FishBase*. World Wide Web electronic publication. www.fishbase.se
- Fish collections made over 2ooo – 2018 by Dr. Bill Ensign of Kennesaw State University