Losing Levels: Shifts in Reef Fish Trophic Dynamics Across a Coral Habitat Gradient

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Introduction

- Climate change threatens coral reef ecosystems, shifting reefs from growth to erosion and reducing biodiversity.[1]
- In 2023, a record-breaking marine heatwave occurred in the Florida Keys.[2]
- This study investigates the impacts of the heatwave and reef spatial variation on fish trophic dynamics, providing insight into reef community response to global change.

Figure 1. Map of 15 reef sites across a coral reef habitat gradient ranging from shallow, nearshore patch reefs with high rugosity and coral cover to deeper, offshore shelf-edge with low rugosity and hard coral cover. Imagery from Google Earth.

Hypotheses & Predictions

- Year influences reef fish biomass across trophic groups.
  - Reef fish biomass and diversity will differ across years, with a decrease in 2023 during the marine heatwave.
- Region influences reef fish diversity and biomass across trophic groups.
  - Reef fish diversity and biomass will differ among regions, with nearshore reefs supporting higher diversity and greater biomass than mid-channel and offshore reefs due to higher coral cover and rugosity.

Methods

- Diver video surveys along a 50-meter transect.
- Video data analyzed to tally abundances of each species.
- FishBase used for trophic positions and common lengths.

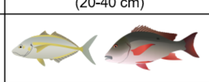
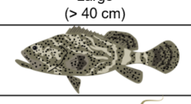
Trophic Position	Size Class (SL)		
	Small (< 20 cm)	Medium (20-40 cm)	Large (> 40 cm)
FG3 Predator (TP > 4)			
FG2 Omnivore (TP = 3-4)			
FG1 Herbivore (TP = 2-3)			

Table 1. Size class and trophic positions from FishBase used to group fish species into nine functional trophic groups.

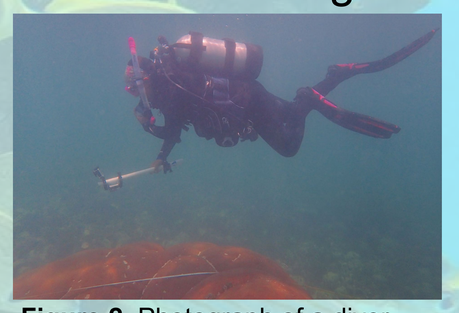


Figure 2. Photograph of a diver conducting a fish survey.

Results

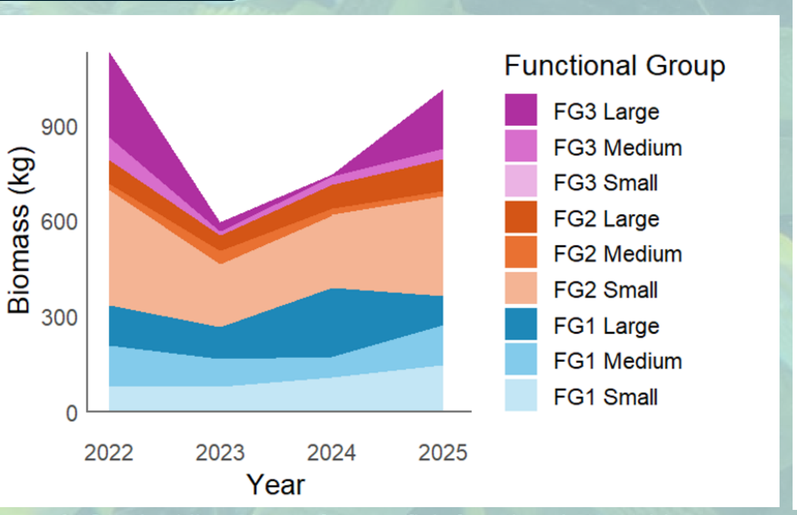


Figure 3. Stacked line chart of mean fish functional group biomass (kg) by year. Total biomass differed significantly by year (mixed-model ANOVA, p = 0.0321) (Tukey's HSD, 2023 ~< 2022 = 2024 ~< 2025).

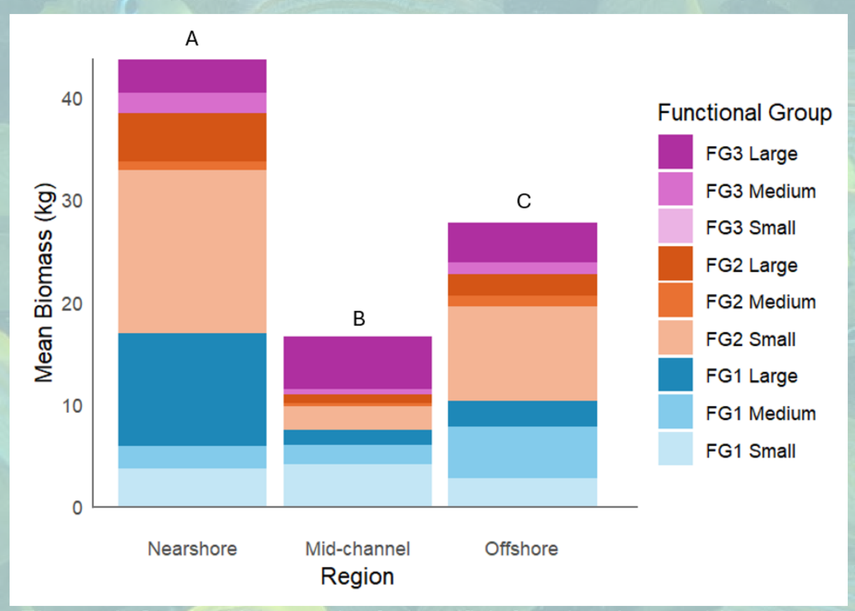


Figure 4. Stacked bar graph of mean fish functional group biomass (kg) by region. Total biomass differed significantly among regions (mixed-model ANOVA, p < 0.001) (Tukey's HSD, mid-channel < offshore < nearshore).

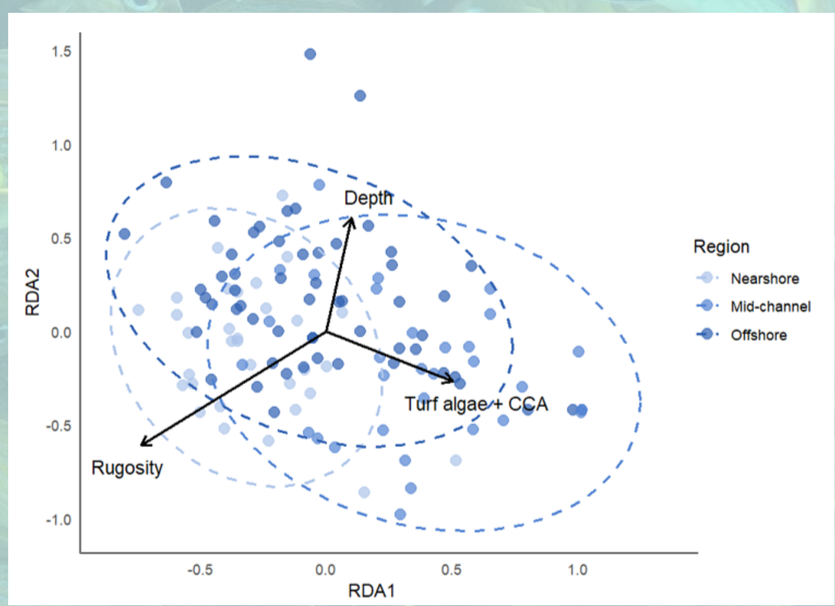


Figure 5. Redundancy analysis showing the relationship between reef fish biomass and environmental variables. Arrows indicate significant environmental predictors (RDA, p = 0.001).

Conclusion & Future Directions

- Biomass is a more sensitive indicator than diversity.
- Regional differences influence fish trophic dynamics more than yearly differences.
- Fish in higher trophic positions may be more vulnerable to global change.
- Stable isotope analyses will build on these findings to uncover the mechanisms driving regional trophic differences.

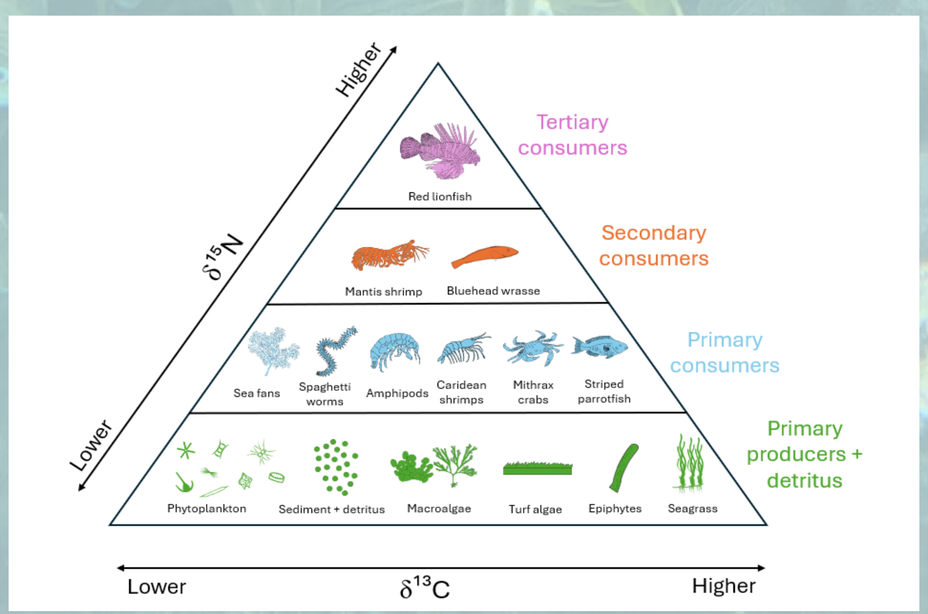


Figure 6. Diagram of collected samples and predicted variations in $\delta^{13}C$ and $\delta^{15}N$ values. Modified after Bocherens (2009).[3]

Hypothesis & Predictions

- Region influences reef fish $\delta^{13}C$ and $\delta^{15}N$ variability.
  - Nearshore reefs will exhibit broader $\delta^{13}C$ and $\delta^{15}N$ ranges, reflecting the use of diverse carbon sources and a complex trophic structure.
  - Offshore reefs will have narrower ranges, reflecting a reliance on fewer resources and a compressed trophic structure.

References

1. Hughes TP et al. 2017. Coral reefs in the Anthropocene. Nature. 546(7656):82–90. https://doi.org/10.1038/nature22901
2. Hoegh-Guldberg O et al. 2023. Coral reefs in peril in a record-breaking year. Science. 382(6676):1238–1240. https://doi.org/10.1126/science.adk4532
3. Bocherens H. 2009. Neanderthal Dietary Habits: Review of the Isotopic Evidence. In: Hublin J-J, Richards MP, editors. The Evolution of Hominin Diets: Integrating Approaches to the Study of Palaeolithic Subsistence. Springer Netherlands; p 241–250. https://doi.org/10.1007/978-1-4020-9699-0_19.

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