FISH DIET IMPACTS THE ROLE OF ICHTHYOCARBONATE IN THE GLOBAL CARBON CYCLE

Amanda M. Oehlert, Amy Feltz, Sydney Cloutier, Matthew Maron[1], Katie Hastings[2], Jonathan Cordle[2], Sarah Walls[2], Bret Marek[2], Jacob Belkin[2], John Stieglitz[2], Martin Grosell[2], and Rachael Heuer[2]

3) College of Engineering, University of Miami, Coral Gables, FL USA

4) Department of Marine Biology and Ecology, Rosenstiel School of Marine, Atmospheric, and Earth Science, University of Miami, Miami, FL, USA

PROJECT OBJECTIVE

- Determine how diet impacts ichthyocarbonate production rate and composition through controlled experiments.
- Improve understanding of how ichthyocarbonate contributes to carbon fluxes in the global carbon cycle.

PROJECT RATIONALE

Figure 1: Ichthyocarbonate, observed as white grains on left of image, produced by the Gulf toadfish.

Marine fish are important participants in Earth's global carbon cycle. In their intestine, marine fish produce organic matter and carbonate minerals that are subsequently excreted to the water column. This carbonate, "ichythyocarbonate," is a significant contribution to carbon fluxes in the ocean (Wilson et al., 2009; Saba et al., 2021). New research by our team suggests that the magnitude of ichthyocarbonate production is likely ~4x greater than previously estimated, and the composition of these minerals are anomalous when compared to that produced by other marine calcifiers (Oehlert et al., 2024). Through a stable carbon isotope mass balance, we found that ichthyocarbonate produced by four species of marine fish is enriched in carbon arising from diet (28-56%, but up to 81%) compared to carbonate produced by other marine calcifiers (<10%). Since dietary carbon originates from photosynthetic organisms in the marine food web, the impacts of ichthyocarbonate formation on surface ocean carbonate chemistry may not conform to canonical expectations for net carbon dioxide release from marine calcification. Consequently, it is critical to understand the factors that control ichthyocarbonate production rate and dietary carbon incorporation to quantitatively define the role of ichthyocarbonate in the global carbon cycle.

Fish metabolic rate controls the demand for osmoregulation, the key physiological process responsible for ichthyocarbonate formation, however, the impact of feeding and diet composition on ichthyocarbonate production rate and composition is poorly quantified. In this study, we will report the results of two controlled studies that evaluate: 1) how the feeding state of the Gulf toadfish affects ichthyocarbonate production rate, and 2) how the proximate composition (crude protein, carbohydrate, and dietary fiber) of fish diet impacts dietary carbon incorporation, crystallite morphology, and elemental chemistry of ichthyocarbonate.

APPROACH

To test the impact of feeding state on ichthyocarbonate production rate, we will collect ichthyocarbonate from fed and unfed Gulf toadfish (*Opsanus beta*), noting the elapsed time between feedings. Samples will be siphoned from the bottom of tanks each day of the experimental period. Wet weight will be measured, and size of ichthyocarbonate will be assessed using ImageJ. Daily production rate will be normalized to fish mass, and statistical tests will be employed to determine whether feeding induces a significant change in ichthyocarbonate production rate. Next, we will conduct a diet switch experiment at the University of Miami Experimental Hatchery to test whether proximate composition of fish diet impacts ichthyocarbonate composition. Ichthyocarbonate produced by the Olive flounder (*Paralichthys olivaceus*) and fed with two diets with different proximate composition will be collected and prepared for analysis of total organic carbon content, stable carbon isotope ratios, crystallite morphology, mol% $MgCO_3$ and phosphorus content.

SIGNIFICANCE

Marine fish are currently not incorporated into fully coupled carbon climate models used to model the Earth system, due to knowledge gaps regarding their production magnitude, composition, and fate (Saba et al., 2021). Our research indicates that the role of marine fish in the global carbonate budget is underestimated (Oehlert et al., 2024), and that marine fish contribute significantly to shallow ocean alkalinity cycles (Folkerts et al., 2024). However, lingering uncertainty impacts extrapolation of our findings to the ~13,000 species of marine fish residing in the global oceans. Experiments like those proposed here and others that investigate the influence of fish lifestyle, size, and oceanic conditions on ichthyocarbonate production rates, composition, and fate are critically needed. Consequently, results of this study will reduce uncertainty around the factors that currently preclude the incorporation of marine fish into Earth system models.

REFERENCES

Folkerts, E.J., Oehlert, A.M., Stieglitz, J.D., Heuer, R.M., and Grosell, M. (2024). The role of marine fish-produced carbonates in the oceanic carbon cycle is determined by size, specific gravity, and dissolution rate. Science of the Total Environment, 916, 170044.

Oehlert, A.M., Garza, J., Nixon, S., Frank, L., Folkerts, E.J., Heuer, R.M., Benetti, D.D., del Campo, J., Gomez, F., Grosell, M. (2024). Implications of dietary carbon incorporation in fish carbonates for the global carbon cycle. Science of the Total Environment, 916, 169895.

Saba, G.K., Burd, A.B., Dunne, J.P., Hernández-León, S., Martin, A.H., Rose, K.A., Salisbury, J., Steinberg, D.K., Trueman, C.N., Wilson, R.W. and Wilson, S.E., 2021. Toward a better understanding of fish-based contribution to ocean carbon flux. Limnology and Oceanography, 66(5), pp.1639-1664.

Wilson, R.W., Millero, F.J., Taylor, J.R., Walsh, P.J., Christensen, V., Jennings, S. and Grosell, M., 2009. Contribution of fish to the marine inorganic carbon cycle. Science, 323(5912), pp.359-362.