EXPLORING ORGANIC CARBON SEQUESTRATION POTENTIAL IN ICHTHYOCARBONATE

Amanda M. Oehlert, Kat Arista, Jazmin Garza, Erik J. Folkerts, Sarah Walls, Sadegh Tale Masoule, Clément G.L. Pollier, Rachael M. Heuer, Amel Saied, Peter K. Swart, Ali Ghahremaninezhad, and Martin Grosell

PROJECT OBJECTIVES

- Determine amount and distribution of organic matter in carbonate produced by marine fish.
- Quantify the overlooked contribution of ichthyocarbonate-associated organic matter in the biological pump, which sequesters CO_2 in the ocean.
- Test the hypothesis that organic matter content plays a role in ichthyocarbonate dissolution.

PROJECT RATIONALE

Marine carbonate mineral and organic matter production in the ocean are important biogeochemical processes that drive the global carbon cycle, and thus Earth's climate and CO_2 through time. Marine fish were recognized as important carbonate producers in 2009, when global marine bony fish biomass (0.812-2.05 Gt) was estimated to produce 3-15% of new carbonate production in the oceans each year (0.34 to 0.95 Pg $CaCO_3$ yr^{-1}; Wilson et al., 2009). Since this initial estimate, substantial upwards (2.5-10× greater) revisions of global fish biomass have been reported, suggesting that carbonate production by marine fish may be significantly greater than previously appreciated (Jennings et al., 2015; Bianchi et al., 2021). However, it is currently unknown how embedded organic matter within ichthyocarbonate contributes to the biological pump, the activity of which reduces atmospheric concentrations of carbon dioxide. Assuming a conservative factor of 5× increase in fish biomass and presuming that this is linearly reflected in carbonate production by marine fish (hereafter called ichthyocarbonate), extrapolation of production rates from Wilson et al. (2009) suggests that marine fish could plausibly produce as much as 1.7 to 4.7 Pg $CaCO_3$ yr^{-1}, comparable to or even exceeding

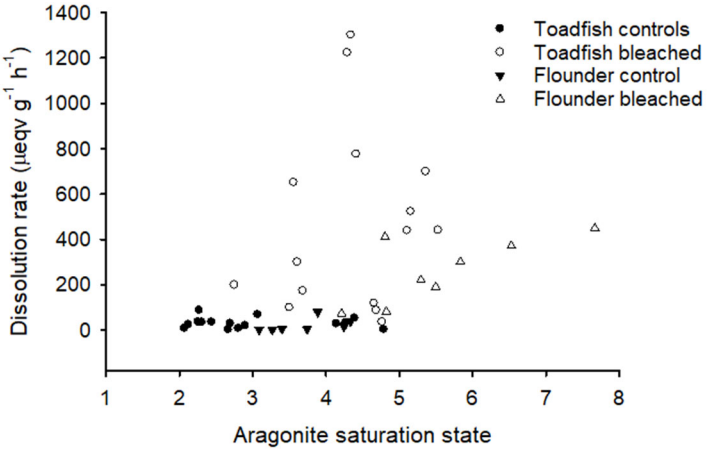

Figure 1: Comparison of dissolution rates for bleached (open symbols) and untreated (black symbols) ichthyocarbonate produced by the Gulf toadfish (circles) and the Olive Flounder (triangles). Aragonite saturation states were calculated from in situ measurements of pH and TA using CO_2sys.

contributions of coccolithophores and foraminifera (both ~1.0 Pg $CaCO_3$ yr^{-1} (Broecker and Clark, 2009; Langer et al., 2008). We hypothesize that ichthyocarbonate associated organic matter occurs in high quantities and plays a key role in ichthyocarbonate dissolution rate.

APPROACH

We will assess the quantity and distribution of organic matter in ichthyocarbonate produced by two species of marine fish using geochemical and microCT approaches. Initial results from geochemical analyses of total organic carbon (TOC) content indicate that ichthyocarbonate produced by both species contains significant TOC, with toadfish ichthyocarbonate containing 5.5 ± 1.9% (n=6) and flounder ichthyocarbonate containing 6.3 ± 1.6% (n=3). Dissolution rate will be assessed on natural ichthyocarbonate, and samples treated with bleach to oxidize the outer coating of organic matter on ichthyocarbonate. Preliminary results indicate that dissolution rates are significantly ($p<0.05$) faster for bleach treated samples than natural ichthyocarbonate (Fig. 1). Multiple linear regression indicates that dissolution rates for toadfish ichthyocarbonate (n=15) were not dependent on aragonite saturation index ($p=0.613$), while initial experiments conducted on flounder ichthyocarbonate (n=8) suggest that dissolution rate is significantly impacted by aragonite saturation index ($p<0.001$).

SIGNIFICANCE

Marine fish are prodigious producers of carbonate in the oceans, and our initial results suggest that the ichthyocarbonate they produce also contains significant quantities of organic carbon. Rapidly sinking ichthyocarbonate likely increases the probability that this organic matter will evade shallow ocean remineralization and be sequestered in the deep sea or in marine sediments.

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