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Bony fish and their contribution to marine inorganic carbon cycling

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Conventional understanding of the marine inorganic carbon cycle holds that $CaCO_3$ (mostly as low Mg-calcite and aragonite) precipitates in the upper reaches of the ocean and sinks to a point where it either dissolves or is deposited as sediment. Thus, it plays a key role controlling the distribution of DIC in the oceans and in regulating their capacity to absorb atmospheric CO_2. However, several aspects of this cycle remain poorly understood and have long perplexed oceanographers, such as the positive alkalinity anomaly observed in the upper water column of many of the world's oceans, above the aragonite and calcite saturation horizons. This anomaly would be explained by extensive dissolution of a carbonate phase more soluble than low Mg-calcite or aragonite, but major sources for such phases remain elusive. Here we highlight marine bony fish as a potentially important primary source of this 'missing' high-solubility $CaCO_3$. Precipitation of $CaCO_3$ takes place within the intestines of all marine bony fish as part of their normal physiological functioning, and global production models suggest it could account for up to 45 % of total new marine $CaCO_3$ production. Moreover, high Mg-calcite containing >25 % mol% $MgCO_3$ – a more soluble phase than aragonite – is a major component of these precipitates. Thus, fish $CaCO_3$ may at least partially explain the alkalinity anomaly in the upper water column. However, the issue is complicated by the fact that carbonate mineralogy actually varies among fish species, with high Mg-calcite (HMC), low Mg-calcite (LMC), aragonite, and amorphous calcium carbonate (ACC) all being common products. Using data from 22 Caribbean fish species, we have generated a novel production model that resolves phase proportions. We evaluate the preservation/dissolution potential of these phases and consider potential implications for marine inorganic carbon cycling. In addition, we consider the dramatic changes in fish biomass structure that have resulted from overfishing throughout the past century, and how these changes could be affecting marine carbon cycling. Given that rising sea surface temperatures and 'ocean acidification' are both predicted to promote increased fish $CaCO_3$ production rates, the role of fish in the marine inorganic carbon cycle could become increasingly important in the future. Consequently, it is conceivable that fish stock management could become an important carbon-regulating service employed in the face of challenges such as climate change mitigation, so it is vital that this role is properly comprehended.