Can otolith carbon stable isotopes be used to estimate field metabolic rates in freshwater fishes?

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ABSTRACT:

Metabolism is a key factor influencing how fish can survive within their environments, but it is difficult to measure in the wild. Recently, measurement of stable carbon isotopes (δ13C) in the otoliths of fish has been shown to reflect metabolic rates, but validation of this method has focused on marine species. In this study, we sought to test the validity of otolith δ13C derived metabolic rates (the proportion of respired carbon or Cresp) by comparing these estimates to metabolic rates measured in the same individuals using modern respirometry techniques. We repeated this test for three case studies: brook trout raised in the lab under three temperatures (5, 15, 20˚C), Atlantic salmon raised in lab under one temperature (18˚C), and wild caught lake trout from four boreal lakes with differing food webs. For both lake trout and Atlantic salmon, we did not find any relationships between measured metabolic rates and Cresp or otolith δ13C values. These findings may have been in part due to low sample size, not enough variation in metabolic rates, or issues with the timing of sample collection or measurement of the incorrect otolith material. However, for brook trout, we found clear relationships for both otolith Cresp and otolith δ13C values with measured standard and routine metabolic rates. Brook trout otoliths, water, and food were all sampled immediately following respirometry, and thus this data set was the most reliable of the three. In addition, the range of temperatures brook trout were raised certainly contributed to the larger degree of variability in metabolic rates compared to the other two test species, likely making it easier for variations in otolith δ13C and in turn Cresp to be detected. Overall, our results, particularly for brook trout provide confidence that otolith Cresp can be an accurate proxy of standard and routine metabolic rates in fish. However, future studies trying to evaluate this relationship need to take care to sample the exact region of the otolith corresponding to when metabolic rates were measured and to obtain water and accurate food item δ13C values that correspond the period where otoliths are analyzed. Moreover, when examining the δ13C and Cresp of archived otoliths or trying to examine among population or species differences, one must consider if enough environmental variation exists to produce meaningful and measurable differences in otolith δ13C. With careful consideration and planning, we believe that this method could be highly applicable to many fisheries questions relevant to the Great Lakes, including understanding the metabolic underpinnings of variations in larval growth and recruitment or long-term changes in the growth, condition, and abundance of valuable species.