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Do fossil fish otoliths faithfully record paleo-environmental conditions? A trace-element study of Recent and fossil Morone species

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Otoliths are aragonitic structures located in the inner ear of fish. Otolith growth occurs throughout the fish's life and results in a series of concentric layers that reflect seasonal periodicities, thus documenting age and growth history of fish. Abundances of trace-elements (TRE) including Sr, Mn, Mg, and Ba may vary considerably between layers and are controlled mainly by variations in environmental conditions, e.g. chemical composition and temperature of the ambient water. In addition, Sr isotopes may distinguish between fresh or ocean-water habitats, while oxygen isotopes reflect temperature conditions. Despite an ongoing debate regarding the causes of TRE systematics in Recent otoliths, it is desirable to analyse fossil samples for paleo-environmental and climatic studies. A prerequisite is that both the TRE and isotope composition have not been altered during diagenesis or weathering. Traditionally, the absence of calcite replacing original aragonite is taken as evidence for the otolith's primary composition. Here, we show by means of laser ablation ICP-MS analysis of unaltered otoliths of different species of the genus Morone from various habitats that Recent and fossil (15 -30 Ma) otoliths display comparable TRE patterns. However, some elements (e.g. the REE, Th and U) are significantly enriched in fossil samples. This suggests that the degradation of the finely dispersed interstitial organic matrix opened pathways for diagenetic fluids that contaminated the otoliths without altering, however, the original aragonite to calcite. In samples where environment-sensitive elements such as Ba and Mn covary with diagenetically introduced elements, the first should be interpreted with caution. In contrast, Sr does not seem to be affected and both Sr/Ca and Sr isotopes may, in our samples, be considered robust paleo-environmental proxi.

Our results suggest that in-situ analysis of TRE is indispensible for any meaningful paleo-environmental and climatic study using otoliths.