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Sr Isotope Markers in Otolith Growth Increments of Atlantic Salmon

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Introduction

Interpretation of the chemistry of otoliths (aragonitic ear bones) is becoming increasingly popular as a method of reconstructing the environmental history of fish and in discriminating among geographically distinct fish stocks. The use of natural geochemical signatures as a population marking technique (Kennedy et al. 1997) is based on the observation that fish tissues incorporate particular elements (e.g. strontium) via both water and food sources (Farrell and Campana 1996). Natural Sr isotope signatures are incorporated into both exchangeable (e.g. vertebrae) and non-exchangeable (e.g. otoliths) calcified tissues. Previous studies have focused on the geochemical signatures stored in otoliths because of their unique properties as a permanent time-series chemical record. In an effort to develop a method for distinguishing between Atlantic salmon populations using their isotopic signatures Kennedy et al. (2000) compared the isotopic signatures of scales, bulk otoliths and vertebrae. After spending two years in tributary streams after stocking, smolts from many stocking regions become mixed and indistinguishable as they migrate to the ocean. 90% of adults returning from the ocean are used for brood stock, thereby eliminating the possibility of determining their natal rearing habitat. In order to be able to track migrating salmon from one rearing location to another and to establish the natal origins of returning adult salmon, we employed a micro milling procedure (Dettman and Lohmann, 1995) to investigate single growth bands of otoliths. By dividing each growth band into several 50 micron wide paths, it is possible to distinguish the different Sr isotope sources during a life of an individual salmon. We used hatchery raised salmon to test our method and to investigate the variability in the $^{87}Sr/^{86}Sr$ ratio preserved in the otolith of a salmon raised in a single site.

Methods and results

We sampled 4 four-year-old mature Atlantic salmon, water and food from the White River National Fish Hatchery in Bethel, Vermont USA. Vertebrae, otoliths and scales were digested in quartz-distilled concentrated nitric acid. Otolith growth bands were sampled by using a Merchantek Inc. xyz-stage Micromill. Sr was separated using Sr-specific cation exchange resin. The Sr isotopic compositions were measured using a Finnegan MAT 262 thermal ionization mass spectrometer. All studied otoliths, scales and vertebrae from hatchery adults have essentially the same isotopic signature (Figure 1). Within the three individuals, for which all three tissue types where analyzed, otoliths had the lowest $^{87}Sr/^{86}Sr$ ratios and scales had the highest. At the hatchery dissolved $^{87}Sr/^{86}Sr$ ratios reflect the local groundwater (0.71460). The salmon diet is much less radiogenic (0.70923), reflecting the marine origins of the major food ingredients (i.e. fish meal; marine $^{87}Sr/^{86}Sr$ = 0.70918, Hodell et al. 1989). The average $^{87}Sr/^{86}Sr$ ratio of hatchery adults (0.71080) suggests that approximately 66% of the Sr in calcified tissues is derived from their diet and 33% is from the water (Figure 1). Spatially resolved analysis of an otolith from salmon D shows that variations in the Sr isotope ratios are small but easily resolved between the core and the subsequent growth bands, probably reflecting the greater importance of food intake compared to absorption from the water during a time of rapid growth. The $^{87}Sr/^{86}Sr$ ratio of the core (0.71028) suggests that the food source contributes 80% of the Sr during this period. Conclusion Sr isotopes can be used as physical tags to distinguish fish populations from different geographical areas. Preliminary results of spatially resolved Sr analysis show that Sr signatures from different sources are preserved within the otolith growth bands, making it possible to distinguish the hatchery signal from a tributary and sea water signal. We are currently applying this method to investigations of movement patterns of salmon between stocking sites and to determine the rearing origins of adult salmon returning from the marine environment.

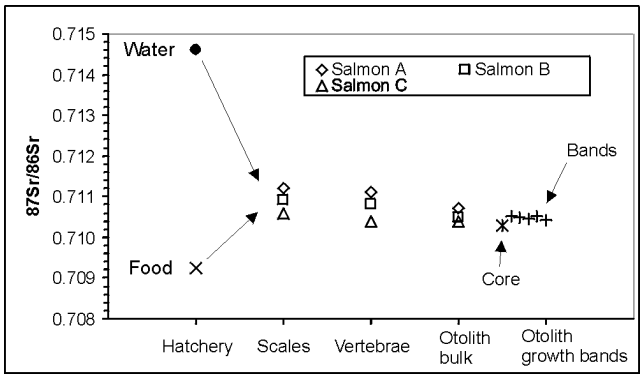

Fig.1: $^{87}Sr/^{86}Sr$ isotopic signature of hatchery raised salmon samples

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