Otolith Chemistry and Chinook Salmon

Otoliths are crystalline structures, comprised primarily of calcium carbonate, located in the inner ear of bony fishes, which function as balance organs. Otoliths grow by continuous deposition of calcium carbonate, which generates growth increments much like the annual rings on a tree. Therefore, an otolith provides a permanent chronological record. If fish reside in water masses with different chemical compositions and/or temperatures, those properties will be reflected in the otolith composition. Certain elements, such as strontium and barium, and isotopes, which are forms of the same element that have different atomic masses, can tell different things about the life of a fish. Studies that examine a suite of elemental ratios, i.e., Ba/Ca, Sr/Ca, Mg/Ca, within otoliths can provide information on whether fish collected from different areas mixed together during past periods. This combination of elements within the otolith is often referred to as the otolith elemental signature. By examining the Sr/Ca ratio across the otolith growth axis, information on when an anadromous fish, such as Pacific salmon, entered the ocean can be determined. By measuring the oxygen isotope ratio in otoliths, we can learn about the temperature of the water the salmon lived in. The oxygen isotope analysis rely on the relatively well-established assumption that the oxygen isotopic ratios present in fish otoliths are in equilibrium with, or close to, seawater. The proportion of a heavier isotope, ^{18}O, incorporated into otoliths increases as water temperature decreases so that, all other things being equal, otolith carbonate precipitated at colder temperatures will be enriched with ^{18}O compared to otolith carbonate precipitated at warmer temperatures. All of these chemical analyses can be combined with microstructural analyses, i.e., counting of daily or annual increments within the otoliths, to provide information about discrete periods in the life of a fish.

Because otoliths grow continuously, spatially-explicit sampling methods can provide information from distinct periods in the life history. Laser Ablation-Inductively Coupled Plasma Mass Spectrometry (LA-ICPMS) and micromilling techniques combined with Isotope Ratio Mass Spectrometry (IR-MS) allows for the determination of elemental and isotopic otolith composition at discrete regions on the otolith. Therefore, otolith chemical and structural analyses can be combined to provide novel information on individual life histories.

The otoliths of a subset of Chinook salmon collected during the CROOS (Collaborative Research on Oregon Ocean Salmon) project will be examined to determine:

1) If, and when, Chinook salmon from different stocks resided in waters with similar chemical characteristics. This will provide information on whether we can use otolith chemistry to learn more about stock-specific ocean migration and mixing in Chinook salmon.

2) The temperature history of individual Chinook salmon. Although we have information on the temperature of the water where fish were captured, we don't know much about the temperature history of individual fish. We will take a subset of individuals from 3 or 4 stocks and mill portions of the otolith to generate estimates of the temperature history of those fish. This can provide information about the ocean residence of the fish and whether there are stock-specific differences in the preferred ocean temperature.

3) If the ratio of $^{87}Sr/^{86}Sr$ can be used to distinguish fall vs. spring Chinook. It is important to be able to determine the run time of a fish for ecological, conservation, and management reasons. Currently, genetic information cannot always readily separate fall vs. spring Chinook.