Natural Markers Track Populations:

Earbone Identifyers

UCSC biologist Rachel Barnett-Johnson is developing powerful techniques for tracing the migration patterns of fish—by looking at the geochemistry in their ears. Her work is answering burning questions in fisheries science, such as how many of the ocean's Chinook salmon (*Oncorhynchus tshawytscha*) are born in hatcheries instead of in the wild. She's finding the answer to this and other questions using the ratio of strontium isotopes found in salmon earbones, called otoliths.

Much like the rings of a tree trunk, otolith layers are laid down as a fish develops, with each layer recording components of the chemical environment in which it was formed. Since strontium ratios are controlled by the age and composition of rocks and are unique to individual watersheds, their signature in otoliths acts as a natural population marker, identifying the specific birthplace of individual fish. Barnett-Johnson collects Chinook from rivers in California's Central Valley and measures the strontium-87 and strontium-86 ratios in their earbones. She uses the same technique on Chinook caught far out at sea, and can tell with up to 95 percent accuracy where the fish were reared. Her results allow her to calculate how many of the ocean's Chinook salmon have their origins in specific rivers (or hatcheries) in the Central Valley, and to map whether fish from certain drainages tend to congregate at sea.

Central Valley Chinook make up 90 percent—or $60 million dollars worth—of the state's ocean-harvested salmon. Thanks to Barnett-Johnson (also a researcher with the National Marine Fisheries Service), the largely murky waters of Chinook salmon migration are now becoming clear, a critical step in the conservation and management of one of the state's key fisheries.

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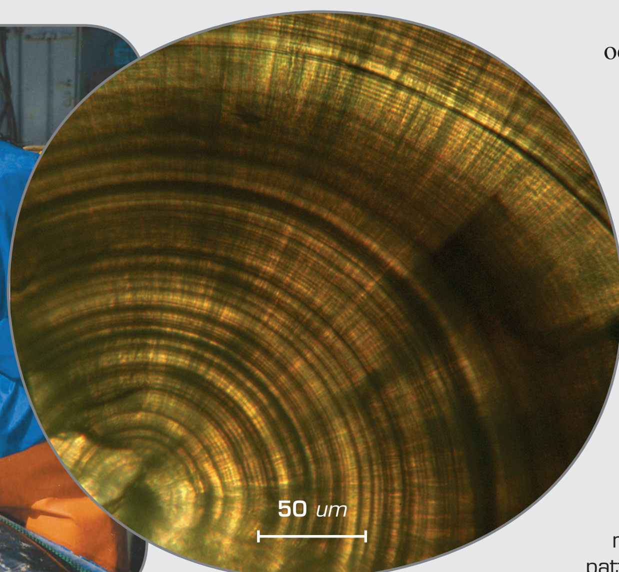

Far left: Rachel Barnett-Johnson with a newly caught Chinook salmon. Immediate left: A magnified image of a Chinook ear bone (otolith) that allows researchers to analyze the ratio of strontium isotopes. The banding pattern encodes daily growth and indicates whether fish are wild or hatchery born.

Rachel Barnett-Johnson et. al. "Validation of Sr isotopes in otoliths by laser ablation multicollector inductively coupled plasma mass spectrometry (LA-MC-ICPMS): opening avenues in fisheries science applications." *Can. J. Fish. Aquat. Sci.*, 62 (2005):2425–2430.

Mussel Shells Trace Larval History

Just as with fish ear bones, some invertebrates record environmental conditions in their hard parts. Mussels, for instance, retain certain trace elements in their early shells that were present when their planktonic larvae were adrift. Decoding where a mussel larva spent its time by looking at the chemical composition in its shell—a technique called elemental fingerprinting—is former UCSD graduate student Bonnie Becker's number one goal.

Reaching that goal required that the researcher test the feasibility of bivalve shells as viable subjects for fingerprinting. She became the first to make this assessment by collecting recently settled mussels (*Mytilus californianus* and *M. galloprovincialis*) from eight sites along a nearly 30-mile stretch of shoreline in San Diego County, then analyzing their shells for multiple elements including lead and strontium. Her findings showed that elemental analysis could, indeed, discriminate between and among open-coast and bay mussels from different regions. The encouraging results indicated to Becker that her methods could have practical applications for the larval ecology of *Mytilus*—a key player in rocky intertidal ecosystems.

Next, Becker established a complete elemental baseline for *Mytilus* larvae from 14 sites across more than