



# Using Marine-Derived Nitrogen in Tree Rings to Assess Nutrient Flux and Salmon Escapement

Michael L. Johnson  
John Muir Institute of the Environment  
University of California, Davis

*Our research uses long-lived riparian trees to determine historic inputs of salmon vectored marine-derived nutrients to individual watersheds. By examining the stable nitrogen isotope ratios of annual growth rings, we are able to infer changes in salmon abundance over time and reconstruct historic returns for periods where no such information exists.*

Although it is generally accepted that anadromous salmon and trout populations have declined throughout California, trends for individual watersheds are largely based on incomplete or unreliable data and provide little basis for estimating the true extent of the decline. This is especially true in small coastal basins where continuous records of salmon escapement (i.e., the number of fish that return to freshwater to spawn) rarely exceed 10 years and stock-specific population trends are generally unknown.

Our research uses long-lived riparian trees to examine current and historic inputs of salmon transferred marine-derived nutrients to coastal watersheds. A product of living and feeding in the Pacific Ocean is that the tissues of adult anadromous salmon are uniquely enriched with the heavier isotopic forms of many biologically important elements (e.g., nitrogen, carbon, and sulfur) relative to terrestrial or freshwater sources of these same elements. When mature salmon return to their natal streams and die after spawning, these heavy isotopes are liberated during carcass decomposition and ultimately incorporated into both aquatic and terrestrial ecosystems.

Riparian plants, in particular, may greatly benefit from annual inputs of marine-derived nutrients. Salmon carcasses contain many nutrients essential for plant growth and

often provide a large fraction of the nitrogen sequestered by riparian trees. By determining the annual growth and stable nitrogen isotope composition ( $^{15}\text{N}/^{14}\text{N}$ ;  $\delta^{15}\text{N}$ ) of riparian trees, we are able to infer changes in salmon abundance over time and reconstruct historic salmon returns for periods where no such information exists.

Our previous research demonstrated that conifer trees growing adjacent to anadromous salmon streams readily sequestered and incorporated marine-derived nitrogen when available. In fact, annual tree growth, stable nitrogen isotope ratios and wood total nitrogen content were all found to positively correlate with the number of anadromous salmon that returned to spawn the previous year (i.e., a one year time lag existed between salmon-derived nitrogen delivery and tree response).

This past year we focused our research efforts on the Waddell Creek watershed (Santa Cruz County). In addition to supporting populations of both coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*O. mykiss*), this coastal basin contains the necessary combination of mature trees and years of known salmon escapement that allow us to validate our reconstructions. Furthermore, the presence of two long-lived tree species at Waddell Creek (Douglas fir and coast redwood) provides the unique opportunity to evaluate and contrast annual

variation in marine-derived nitrogen incorporation among members of the same riparian community.

In the laboratory, increment core samples were prepared and processed using standard dendrological techniques. All cores were subsequently cross-dated and ring widths were measured using a digital image analysis system. In addition, we continued to refine methods for removing soluble forms of nitrogen (primarily those in sap residues) prior to stable isotope determination. Recent research suggests that nitrogen molecules may be extremely mobile in the xylem of some tree species and such mobility could potentially confound interpretation of marine-derived nitrogen availability at the time of ring formation.

The ability to reliably measure marine-derived nitrogen in tree rings has tangible

ecological significance for California's salmonid restoration efforts. Long-lived riparian tree species may potentially serve as valuable records of past biological events such as salmon declines or extirpations. Moreover, if predictable relationships between tree ring  $\delta^{15}\text{N}$  and salmonid escapement can be routinely derived, it then becomes possible to reconstruct historic salmon returns for the many watersheds where mature streamside trees still exist and escapement records do not.

**For further information please contact:**

**Michael L. Johnson**  
**[mbjohnson@ucdavis.edu](mailto:mbjohnson@ucdavis.edu)**  
**(530) 752-8837**  
**<http://aeal.ucdavis.edu>**