Report for 2004CA91B: Using Marine Derived Nitrogen in Tree Rings to Assess Nutrient Flux and Salmon Escapement

There are no reported publications resulting from this project.

Report Follows

RESEARCH PROGRAM:

Problem Statement:

Pacific salmon (*Oncorhynchus* spp.) have disappeared from approximately 40% of their historic range in Washington, Oregon, Idaho, and California. Declining salmon populations represent much more than just a cultural and economic loss as these fish play a key role in the ecological integrity of many rivers and their watersheds. Adult salmon migrating to freshwaters to spawn transport substantial quantities of biologically important marine-derived nutrients (MDN) in their body tissues. The decomposition of post-spawning carcasses liberates these nutrients into their natal watersheds where they are utilized by aquatic and terrestrial plants and animals. Overwhelming recent evidence from streams and rivers along the Pacific coast suggests that MDN vectored by spawning salmon improve aquatic and terrestrial productivity in their natal watersheds and help enhance the growth and survivorship of future generations of salmon.

Successful conservation of anadromous salmon populations, and restoration of many freshwater ecosystems, will likely require mitigation for the loss of marine nutrients to spawning and rearing habitats. Current fisheries management, however, is hindered by a scarcity of data regarding historical escapement (i.e., number of fish that escape the ocean fishery and return to freshwater to spawn) to individual watersheds. Trends for individual watersheds are largely based on anecdotal information and provide little basis for estimating the true extent of the decline.

Research objectives:

Our research aims to develop a novel method to reconstruct historic salmonid escapement at the scale of individual watersheds. This objective is achieved through chemical analysis of naturally abundant stable isotopes in riparian trees growing adjacent to salmon streams. A fortunate product of feeding in the marine environment is that adult anadromous salmon are uniquely enriched with heavier isotopic forms of many elements (e.g., N, C, and S) relative to terrestrial or freshwater sources of these same elements. Recent advances in stable isotope analytical techniques allow the quantification of marine-derived nitrogen (MD-nitrogen) in annual growth rings of riparian trees. This innovation makes it possible to assess yearly variation in the uptake of this important nitrogen source over the life of the tree. Annual growth rings formed by a tree represent an integration of the environmental conditions under which it grew and recent research suggests that levels of MD-nitrogen in annual tree rings are directly related to densities of salmon in adjacent spawning reaches. We use non-destructive increment core (tree ring) samples collected from live riparian trees to quantify annual sequestration and incorporation of MD-nitrogen. Yearly nitrogen isotope levels are correlated to known annual salmon escapement data, tree growth, and stream proximity. The resulting relationships are then used to model historic salmon returns for periods where no such information exists and provide otherwise unobtainable data regarding watershed-specific population trends. Our research has three specific objectives:

1) Determine if there is a relationship between $\delta^{15}N$ in annual rings of riparian trees and historic salmonid escapement.

2) Determine if tree growth and $\delta^{15}N$ are related to the number of fish returning to spawn in the year the ring was formed or if growth is a product of accumulated nitrogen from previous years; i.e., is there a time lag present between numbers of salmon spawning and the growth and $\delta^{15}N$ content of the tree rings.
3) Determine if $\delta^{15}N$ in annual tree rings decreases as a function of distance from the active stream channel.

Methodology:

To examine the relationship between annual salmon escapement and tree ring nitrogen levels we have initiated research in three northern California watersheds: Mill Creek, a tributary of the Smith River; the Salmon River, a tributary of the Klamath River; and Waddell Creek, a small coastal watershed in Santa Cruz County. In each study watershed we established a series of 8 transects that run perpendicular to the active stream channel. Four transects were adjacent to active spawning reaches (salmon sites) and 4 transects were adjacent to reaches located upstream of impoundments that block migrating fish (reference sites). Along each transect, we sampled the nearest conifer tree at distances of 5, 10, 25, 50 and 100 from the stream. For each tree sampled we measured diameter at breast height, distance from the stream channel, canopy cover, and transect slope. Additionally, paired increment cores were collected using manual increment borers. A large diameter (12.0 mm) increment core was used to determine total N and stable nitrogen isotope ratios. The second core sample (5.15 mm diameter) was extracted and prepared for dendrological analysis using standard techniques.

In the laboratory, small-diameter increment cores were dried, permanently mounted, and sanded for analysis of annual growth rings. Prepared cores were converted to digital images and ring widths measured using an image analysis system. Annual growth from large diameter cores was excised using a razor blade and dissecting microscope at 10X magnification. Individual wood samples were transferred to stainless steel capsules and ground to a fine powder in high-speed amalgamator. Samples of ~30 mg of powdered wood were weighed into 8 x 5 mm tin capsules for stable nitrogen isotope analysis ($\delta^{15}N$).

Principle Findings:

Our results to date demonstrate that riparian trees growing adjacent to salmon-bearing streams are significantly enriched in salmon-derived nitrogen ($\delta^{15}N$) relative to control sites and the importance of this nitrogen source generally attenuates with increasing distance from the stream. Moreover, annual tree growth, percent nitrogen content of the wood, and $\delta^{15}N$ are all positively correlated with the number of salmon returning to spawn in previous years (a time lag exists between salmon-derived nitrogen delivery and tree response). We used quantitative relationships between annual tree ring variables ($\delta^{15}N$, % N, and growth) and the number of spawning salmon (escapement) to create a predictive model specifically for the Mill Creek watershed. The overall efficacy of our model was validated for years of known salmon returns (1980-2003) and used to reconstruct returns for the period 1946-1979 (23 additional years). We are currently processing additional samples from the Mill Creek site that will enable us to further extend our reconstruction and provide many additional years of previously unobtainable

salmon abundance information. Moreover, we are developing similar models for the Salmon River and Waddell Creek watersheds.

Significance:

The ability to determine current and historic contributions of MD-nitrogen to riparian trees provides a novel opportunity to assess the transfer of marine nutrients into riparian and freshwater ecosystems. Long-lived riparian tree species serve as valuable records of past biological events such as salmon declines or extirpations. Our preliminary research has determined that secondary and tertiary-growth trees routinely allow us to build chronologies that extend back more than 80 years, while old-growth forests provide centuries of historic data. Once predictable relationships between tree ring nitrogen levels and salmonid escapement are derived, it then becomes possible to reconstruct historic salmon returns for watersheds where old-growth trees still exist and escapement records do not. Nearly all recovery programs are built upon very uncertain estimates of population sizes prior to European settlement. Robust determination of such information would greatly assist resource managers in identifying and establishing appropriate restoration targets.

1. Provide publication citations associated with the research project.

No publications to date.

INFORMATION TRANSFER PROGRAM

This project is not designed as an information transfer project.

2. Provide publication citations associated with the information transfer project when applicable.

No publications to date.

STUDENT SUPPORT

	Total Project Funding		Supplemental Awards	Total
	Federal Funding	State Funding		
Undergrad.				
Masters				
PhD.	$14,276	$14,224		
Post-Doc.				
Total	$14,276	$14,224		$28,500

NOTABLE ACHIEVEMENTS AND AWARDS

None to report.

PUBLICATIONS FROM PRIOR PROJECTS

None to report.