

Watershed Review

updates on water and watersheds



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The behavior and ecology of Pacific salmon and trout

The following an excerpt from the new book, The Behavior and Ecology of Pacific Salmon and Trout, by Thomas P. Quinn, CWWS affiliate faculty member and Professor in the School of Aquatic and Fishery Sciences, published by the University of Washington Press in May 2005.

Pacific salmon are a remarkable group of animals, and the connections to their ecosystems and to humans are complex and profound. They are among the most valuable commercial fishery resources of the United States, and are also the target of recreational fisheries with significant value to local economies. Perhaps more important than the amount of money spent in pursuit of salmon is the psychological uplift (often mixed liberally with frustration) that comes with time spent outdoors fishing alone or in the company of family and friends. Salmon hold a special place in the culture, nutrition

and economy of peoples native to the coast of the North Pacific Ocean, and they have been adopted as the region's icon by non-native peoples as well. One need only visit the gift shops from San Francisco to Anchorage and beyond to see that salmon are readily embraced by modern society. The image of the salmon, leaping a waterfall in its heroic but tragic effort to get home, reproduce, and die, is among the most recognizable in the natural world, and it strikes a chord with us.

Salmon are not only important for our consumption and culture but their

conservation and management affect seemingly unrelated human activities. Mining, farming, hydroelectric production, flood control, forestry, shoreline development and urbanization all affect salmon. Increasingly, the pursuit of these activities is regulated in part by their effects on salmon. One cannot understand water management in the Columbia River system or forestry on the Oregon coast without understanding salmon. Besides the complex roles that salmon play for people, they play equally important and complex roles for other organisms. Most streams they inhabit are nutrient-poor, and the annual return of salmon to spawn and die provides a pulse of food that directly and indirectly enriches the plants and animals in nearby aquatic and terrestrial ecosystems. Finally, the

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Director's message

Anne C. Steinemann

Our 15th Annual Review was a success—thanks to our superb speakers, volunteers, judges, sponsors, moderators, staff, and all of you. More than 300 people attended this year. It was wonderful to meet and see so many of you at this event, and witness the support and enthusiasm for the Center.

Congratulations to our student award winners this year, listed below. All of our students deserve special recognition, too, because each one was first-place quality.

Annual Review Speakers: First Place—Lauren Mollot; Second Place—Mindy Roberts; Third Place—Vivek Shandas

Annual Review Posters: First Place—Lauren Urgenson; Second Place—Deanna Matzen; Third Place—Stephanie Kampf

Annual Review Rehearsal: First Place (tie)—Mindy Roberts and Stephanie Carlson

I am pleased to announce that we now have presentations from the Annual Review on our website: <http://depts.washington.edu/cwws/> (Click on "Presentations" in the left hand column.)

It will be an exciting year for the Center, especially with water and watershed issues prominent in the media and political discussions. As always, I welcome your feedback and suggestions on how we can help you. (Please e-mail me at cwws@u.washington.edu.) ♦

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salmon's influence on their ecosystem is not limited to natural processes but they have indirect effects through humans as well. Because salmon are so important, people will modify landuse practices to benefit them when they would have shown no interest in amphibians or less charismatic fishes. Put simply, salmon are special.

The natural history of salmon is important for people seeking to understand these fishes, the North Pacific ecosystems in Asia and North America, and their management by humans. The life history of salmon includes a number of traits that are very unusual (though not unique) among fishes, and this suite of interrelated features determines the dynamics of their populations and their resilience or vulnerability. The ability and tendency of salmon to migrate to sea and back (termed anadromy) is shared by < 1% of all fish species. It allows them to grow much more rapidly at sea than they could have in fresh water, and to spawn at much higher densities than could be sustained by resident populations. However, it also makes them vulnerable to exploitation and habitat degradation along their entire migratory route. The

Number of salmon (1000s)		
Area	Recent	% of historic
Alaska	187,466	107.0
British Columbia	24,800	36.2
Puget Sound	1,600	8.0
Washington coast	72	1.8
Columbia River	221	1.7
Oregon coast	213	6.9
California	278	4.7

Table 1. Estimated recent numbers of salmon escaping fisheries to spawn in rivers, and the % of historic levels that they represent.

Region	Healthy	In jeopardy	Extinct	Unknown	Total
Southeast Alaska	10.0	0.1	< 0.1	89.9	9,228
British Columbia	48.3	9.7	1.3	40.7	9,038
Washington	37.5	22.2	16.1	24.2	248
Coastal Oregon	32.6	49.7	6.4	11.3	141

Table 2. Status of Pacific salmon and steelhead populations in southeast Alaska, British Columbia and the Yukon Territory, Washington (including the Columbia River system), and coastal Oregon, compiled from a variety of sources. Data are expressed as the percent of the total number of populations in the different status categories.

tendency to return to their natal site for spawning (termed homing) is also not unique but is probably more highly evolved in salmon and trout than other fishes. Homing leads to the evolutionary adaptation of populations for their home river system (enhancing their productivity) and it also necessitates the incredibly complex population-specific management and conservation regime that we have today. Finally, the mortality of salmon after a single season of reproduction (termed semelparity) is also unusual (though, again, not unique) and it is linked to both

the high productivity of salmon populations and their role in bringing nutrients from the ocean upstream to lakes, streams and riparian areas for uptake by organisms from bears to fishes to insects and trees.

These three key traits (anadromy, homing and semelparity—including the important exceptions) are the very essence of the salmon's life cycle, and it is important to appreciate them fully, with all their ramifications, before we can successfully engage in conservation and restoration activities. I have my own views on such matters but this book is not designed for advocacy. My goal was to inform and excite the reader, not sway opinion. The book is designed to encourage critical thinking and the development of new ideas. I will have succeeded if I have conveyed some of my enthusiasm for salmon and if I have stimulated readers to question my ideas, formulate and test their own hypotheses, and expand our knowledge of salmon.

Having provided information about salmon and trout, and their habitats, the book concludes with an assessment of the current abundance of salmon and their future prospects. In the last two decades the total abundance of adult salmon (in Asia and North America, wild and hatchery, catch and escapement) has averaged 534 million fish. This startlingly large number reflects both the recent strong runs of wild salmon in the northern part of their range, where they were always most abundant, and the production of salmon in hatcheries. It therefore hides the dramatic declines in wild salmon in much of the southern part of the range (Table 1). Inventories by agencies of the number of populations in their respective regions, and the status of those populations have also indicated progressively greater losses towards the southern end of the range (Table 2). Perhaps more surprising, at least to some people, is the high degree of uncertainty regarding the status of many populations. This is especially true in the north but even in the Puget Sound area there are many populations with little or no reliable assessment.

The declines in abundance and range constriction have made some experts question whether salmon will persist in this region in the future. However, salmon populations are highly productive and mobile, making wild salmon resilient. Given the high fishing rates, habitat loss and degradation, careless transfers of fish among basins, overzealous hatchery propagation, and other stressors, the remarkable thing is not that salmon are in danger, but that they still persist at all. Their chances of recovery are good if we would only take our collective foot off their neck. If we preserve habitat they will use it, and if we restore habitat and make it accessible they will find it. We must be patient, and ground our conservation efforts in a thorough knowledge of salmon biology. I hope my

book serves this goal in some small way by providing information about salmon. It is up to us all to put the knowledge to use and to give wild salmon the chance they need to thrive and prosper. Salmon will respond, so the choice is ours. ♦

Snapshot of current research

Measuring and modeling spatially distributed hydrologic processes: Preliminary results for test plots at the University of Washington Center for Urban Horticulture

Stephanie K. Kampf, Graduate Student, Civil and Environmental Engineering

In many hydrological applications, we want to be able to simulate the pathways of moisture through a watershed. One way to do this is to use a distributed hydrologic model, which simulates in two or three dimensions the movement of water as runoff along the ground surface, infiltration through the unsaturated zone of the soil, groundwater flow, evapotranspiration, and stream flow. Few data sets exist, however, to test how well models simulate all of these hydrologic processes simultaneously. In this study, we are collecting a complete set of hydrologic measurements for the purpose of testing distributed hydrologic models. The measurements are collected at a 24 m² hydrologic test plot at the Center for Urban Horticulture at the University of Washington. To mimic a gently sloping, shallow soil hillslope, the plot has a 5% grade and is grass-covered, containing one foot of till soil above an impermeable base. To monitor the mass balance of water for the plot, we measure rain with a series of gauges and track moisture flow with a series of piezometers, two soil moisture sensors, and tipping buckets that record surface and subsurface flow out of the plot. To track energy transfer through the plot, we measure incoming short and longwave radiation, net radiation, air temperature, humidity, wind speed, soil temperature at various depths, and soil heat flux. These measurements provide a comprehensive data set with which we can evaluate how well hydrologic models simulate both energy and mass transfer through the plot. ♦

Thesis and dissertation abstracts

Below are abstracts from recently completed theses and dissertations of affiliated graduate students. The web site has a list of all affiliated students who have graduated, many of their abstracts, and some entire theses or dissertations (<http://depts.washington.edu/cwvs/Theses/abstracts.html>).

Effect of salmon spawning on seasonal changes in structure and function of stream macroinvertebrate communities

Jon M. Honea, PhD, Forest Resources

Macroinvertebrates play a vital role in the uptake and retention of resources in riverine food webs; however, this function is mediated by processes of natural disturbance. I investigated the hypothesis that spawning salmon affect macroinvertebrates negatively and positively—the former due to the disturbance of redd excavation and the latter due to nutrients released during spawning and salmon carcass decomposition. To test this hypothesis, I monitored changes for five seasons in density, biomass, and salmon-derived carbon (C) and nitrogen (N) in the benthic macroinvertebrates of a small stream with a large run of chum salmon. Stable isotope analysis showed that the macroinvertebrates contained salmon-derived C and N year-round, as indicated by the results of pre-spawning samples: 20–41% salmon-derived C and 25–50% salmon-derived N, representing 22% of total macroinvertebrate biomass. Near the end of the spawning run, all macroinvertebrates sampled showed increases in salmon-derived C (41–68%) and N (51–87%) incorporated into their tissues; however, the total macroinvertebrate biomass decreased due to redd excavation. The percentage of salmon-derived C and N in macroinvertebrates remained high 3 months after spawning (49–88% and 60–97%, respectively). Because total macroinvertebrate biomass also increased, this period had the highest salmon-derived macroinvertebrate biomass (2.71 g m⁻²). Six months after spawning, no differences in total macroinvertebrate biomass were detected between reaches with and without salmon. In general, macroinvertebrates slowed the export of salmon nutrients, likely prolonging their availability to higher consumers, including juvenile and resident salmonids. ♦

Land-use effects on suspended sediment in Puget Lowland salmonid streams

James J. Packman, MS, Forest Resources

Suspended sediment samples were collected from streams in eight watersheds in the Puget Lowland—two agricultural, three forested, and three urbanized—and the concentration and grain size distribution data were related to watershed conditions that have the potential to mobilize and transport sediment. The suspended sediment data were also used in a model to estimate potential effects of suspended sediment on salmon.

A multitude of factors were found to affect sediment concentrations and grain sizes, which created an unavoidable scatter in the data. However, a few watershed conditions similar within each land-use were determined to be primary controllers for suspended sediment. These conditions include: impervious surfaces and low soil permeability in the urban watersheds; moderate to high soil permeability and in-channel sediment storage in the forested watersheds; and topography and gradient in the agricultural watersheds.

Potential effects of suspended sediment on Pacific salmonids were estimated based on a published model. For exposure of one hour at observed median suspended sediment

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Upcoming events

Details for these events can be found at <http://depts.washington.edu/cwws/Outreach/Events/seminars.html>

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|---------------------|--|
| March 29–
May 31 | Tuesday Morning Seminar Series, 8:30 a.m. to 9:20 a.m., 22 Anderson Hall, UW Campus |
| March 31–
June 9 | Monster Seminar Jam, 11 a.m. to 12 p.m., NW Fisheries Science Center, 2725 Montlake Blvd E |

Professional development programs

For more information on cost, registration, and other details, see <http://www.engr.washington.edu>

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| April 26–27 | Stormwater treatment by media filtration |
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concentrations, the model predicted potential effects to be minor (or less). However, exposure for longer periods could have more significant effects, especially for eggs and alevin in urban streams. The model results should be considered in the context of other factors that can affect fish response to suspended sediment, including stream habitat, fish condition, and cumulative effects from multiple exposures. ♦