Island Geoscience

Geoscience issues as they relate to water, land and air protection on Vancouver Island

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To every thing there is a season, and a time to every purpose under Heaven

The book of Ecclesiastes inspired writers and artists across the ages, including the lyrically poetic “Turn! Turn! Turn!” by the Byrds.

So why are these words running through my head today? Well a grand weekend foray up onto King’s Peak, exploiting the late summer sunshine made me acutely aware of the season’s passing.

In an unusual turn of events, spring and summer flowers were only just blooming, desperately trying to get their summer days accounted for alongside leaves already turning with fall colour. The air now holds a crispness and smell that speaks of fall.

To me, one of the harbingers of fall is the anticipation of salmon runs. The salmon run several times a year of course, but the fall runs are always the most spectacular. It is for this reason that I am especially pleased to present a special issue of Island Geoscience with a longer article dedicated to the Geomorphology of Salmon. I ran across a similar article by the author, David Montgomery, earlier this year in GSA Today and subsequently asked him if he would contribute the one that follows.

I hope you will be as interested as I was, and that you’ll get out yourself this year to enjoy the splendour of the seasons! Also look for the book review of a fairly new release from the UK: Engineering Geomorphology.

Comments on any of the articles, or the newsletter can be sent to me at: richard.guthrie@gov.bc.ca

Past issues of Island Geoscience are here: http://www.for.gov.bc.ca/hfd/LIBRARY/Island_Geoscience.htm

Many thanks for your continued interest, and until next time…

Rick.

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Fall is coming to Vancouver Island, with alpine foliation already beginning to show its colour.

Geomorphology and the Restoration Ecology of Salmon

David Montgomery

Natural and anthropogenic influences on watershed processes affect the distribution and abundance of salmon across a wide range of spatial and temporal scales, from differences in species use and density between individual pools and riffles to regional population patterns. Despite the influences of fishing pressure and variable ocean conditions, salmon populations have declined across North America roughly corresponding to the extent and intensity of human development and the attendant effects on the amount, condition, and accessibility of freshwater habitat (Montgomery, 2003). New England's Atlantic salmon (Salmo salar) have dwindled to less than 1% of their historical population and Pacific salmon (Oncorhynchus spp.) account for less than 10% of their historical abundance in the continental United States, whereas British Columbia's salmon are at about a third of their historical abundance and Alaska's Pacific salmon may exceed their historical population (Table 1).

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Although different factors contributed to the decline of salmon in differing (and often unknown) proportions in different watersheds, this general correspondence between the overall condition of salmon populations and the extent of historical changes to their river systems implicates habitat degradation as a major factor in historic decreases in salmon abundance (Frissell, 1993).
Impacts from human activities (e.g., mining, logging, and urbanization) vary among regions and watersheds, as well as between different channel reaches in the same watershed. Consequently, recognizing and diagnosing the nature and causes of differences between historical and contemporary fluvial and watershed conditions and processes can require careful evaluation of both historical and spatial contexts, and adapting general theory to local settings.

Table 1. Average estimates of historical and current salmon populations from different regions in the Pacific Northwest.

Region	Historic (1000's of fish)	Current (1000's of fish)	Current/Historic %
Alaska	175,160	187,470	>100
BC	68,556	24,800	36
California	3,060	278	9
Puget Sound	20,036	1,600	8
OR Coast	3,074	213	7
Columbia River	13,072	221	2
WA Coast	3,935	72	<2

Data from Gresh et al. (2000)

Recent advances in understanding the geomorphology of forest channels in general and the historical ecology of Pacific Northwest rivers in particular have documented some of the effects of anthropogenic changes in geomorphologic processes and disturbance regimes on salmon populations, but it has been recognized for centuries that the health of salmon runs depends on the condition of their streams. Disastrous experiences managing salmon in Europe and New England (Montgomery, 2003) and recent landscape-level research (e.g., Montgomery et al., 1999; Rosenfeld et al., 2000; Pess et al., 2002) indicate strong associations between salmon populations and habitat availability, characteristics, and quality. Hence, it appears self-evident that salmon recovery efforts should be rooted in understanding of both hydro-geomorphic processes and historical changes to rivers and streams.

Salmon habitat is influenced by landscape processes that govern the supply and movement of water, sediment, and wood to and through their rivers and streams (Figure 1). At the most general level, non-marine salmon habitat can be generalized into spawning habitat, summer rearing

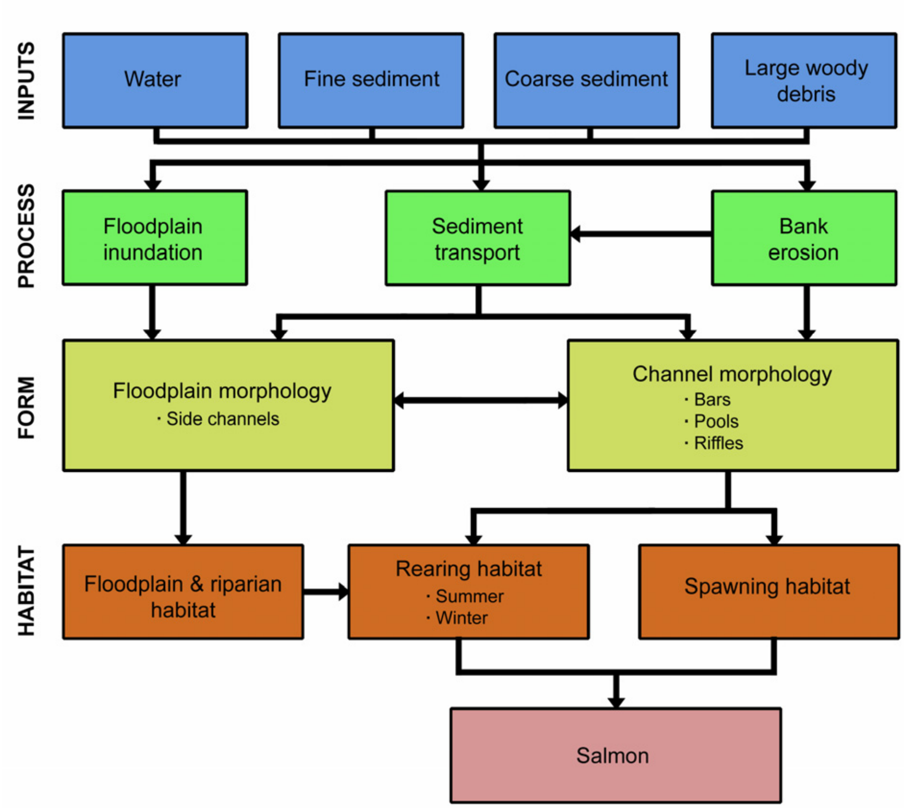

Figure 1. Generalized relationship of watershed inputs to channel processes, channel form, habitat characteristics, and salmon.

habitat, and winter rearing habitat. The size of spawning gravel, and therefore their preferred spawning grounds, varies for different salmonids, with larger salmon generally spawning in the coarser substrate of larger channels (Kondolf and Wolman, 1993). Ideally, spawning habitat includes both appropriately sized gravel and proximity to pools that provide sheltered resting areas. In addition, large fish use deep pools to rest in on their way back up river to spawn. Pools formed by the interaction of high flows and sediment transport, scour into bedrock, and flow around stable logs and log jams provide different types and qualities of summer habitat for juvenile salmon (May and Lee, 2004). Off-channel wetlands and floodplain side channels can provide both summer rearing habitat and refugia from winter high flows (Peterson and Reid, 1984).

The importance of freshwater habitat abundance and quality varies among species of Pacific salmon. Pink and chum salmon, for example, do not spend much time in freshwater, as juveniles migrate to estuarine environments soon after emerging from the gravel. In contrast, juvenile coho and chinook salmon rear for one to two years in rivers and streams before migrating to the marine environment; their abundance has been related to habitat abundance and conditions across a wide range of scales from differences between pools and riffles (Rosenfeld, 2000) to reach-scale differences in channel type and pool frequency (Montgomery et al., 1999), and watershed-scale patterns of land use (Pess et al., 2002).

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Over the past century and a half, many of the changes in the character of salmon habitat in the rivers and streams of the Pacific Northwest resulted either directly or indirectly from loss of stable in-channel wood debris (Figure 2). The huge trees of the Pacific Northwest’s native forests greatly influenced the region’s rivers and played important roles in shaping salmon habitat. Historical changes in the size and supply of the wood delivered to rivers and streams changed sediment routing and storage, channel dynamics and processes, and even channel morphology. Many of the geomorphic effects of wood in rivers

Figure 2. A portion of an immense logjam on the Queets River in Olympic National Park, Washington.

arise from the influence of "key" pieces of wood large enough to obstruct flow and sediment transport, and thereby stabilize other debris in logjams (e.g., Abbe and Montgomery, 1996). In addition to the commonly recognized effects of wood on aquatic habitat at the scale of individual habitat units such as bars and pools (Bisson et al., 1982), an abundant supply of large wood can split flow into multiple channels and maintain complex, anastomosing channel patterns on forested floodplains unconfined by valley walls (e.g., Abbe and Montgomery, 1996; Collins and Montgomery 2001; Collins et al., 2002; O'Connor et al., 2003) (Figure 3). These large-wood-mediated habitat characteristics made Pacific Northwest rivers natural salmon factories with spawning gravel located in proximity to deep pools for summer rearing, and sheltered floodplain side-channels for winter rearing.

Pacific Northwest rivers…present an inconvenient truth…that restoration …require[s]…re-establishing large trees, [and] allowing rivers room to move across their floodplains.

Successful river restoration projects aimed at promoting salmon recovery require an understanding of a watershed and its disturbance history, including the effects or legacies of human actions. Although in simple cases such as removing or modifying salmon-blocking culverts or dams, the solution may be obvious (even if not always politically or economically feasible), the diagnosis of restoration issues and design of projects to address them is often complex and subjective. However, in many cases, the likely historical role of large wood in controlling anastomosing channel planforms in many Pacific Northwest rivers may present an inconvenient truth in that restoration of such wood-influenced rivers would require not only re-establishing large trees, but allowing rivers room to move across their floodplains.

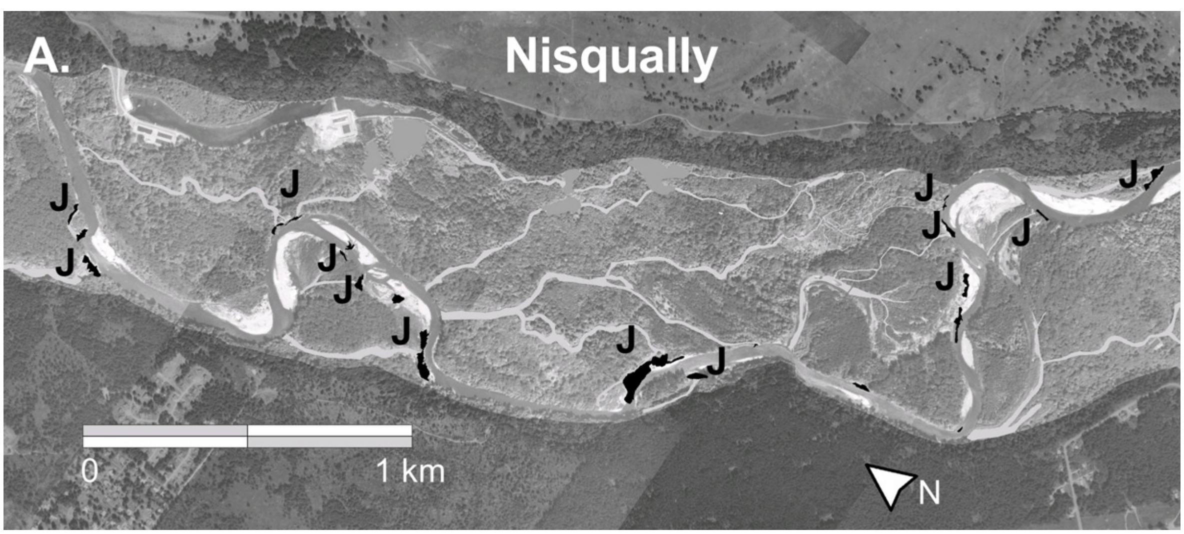


Figure 3. Aerial photograph of a forested reach of the Nisqually River, Washington, illustrating the relationship between the location of large logjams (indicated by Js and black pattern) and inlets to perennial side channels (gray patterns). From Collins and Montgomery (2001).

References

Abbe, T. B., and Montgomery, D. R., 1996, Interaction of large woody debris, channel hydraulics and habitat formation in large rivers: Regulated Rivers: Research & Management, v. 12, 201-221.

Collins, B. D., and Montgomery, D. R., 2001, Importance of archival and process studies to characterizing pre-settlement riverine geomorphic processes and habitat in the Puget Lowland, in Dorava, J. B., Montgomery, D. R., Palcsak, B., and Fitzpatrick, F., eds., Geomorphic Processes and Riverine Habitat: American Geophysical Union, Washington, DC, p. 227-243.

Collins, B. D., Montgomery, D. R., and Haas, A., 2002, Historic changes in the distribution and functions of large woody debris in Puget Lowland rivers: Canadian Journal of Fisheries and Aquatic Sciences, v. 59, p. 66-76.

Frissell, C. A., 1993, Topology of extinction and endangerment of native fishes in the Pacific Northwest and California (U.S.A.): Conservation Biology, v. 7, p. 342-354.

Gresh, T., Lichatowich, J., and Schoonmaker, P., 2000, An estimation of historic and current levels of salmon production in the Northeast Pacific Ecosystem: Evidence of a nutrient deficit in the freshwater systems of the Pacific Northwest: Fisheries, v. 25(1), p. 15-21.

Kondolf, G.M., and Wolman, M. G., 1993, The sizes of salmonid spawning gravels: Water Resources Research, v. 29, p. 2275-2285.

May, C. L., and Lee, D. C., 2004, The relationships among in-channel sediment storage, pool depth, and summer survival of juvenile salmonids in Oregon Coast Range streams: North American Journal of Fisheries Management, v. 24, p. 761-774.

Montgomery, D. R., 2003, King of Fish: The Thousand-Year Run of Salmon: Westview Press, Boulder, 290 p.

Montgomery, D. R., Pess, G., Beamer, E. M., and Quinn, T. P., 1999, Channel type and salmonid spawning distributions and abundance: Canadian Journal of Fisheries and Aquatic Sciences, v. 56, p. 377-387.

O'Connor, J. E., Jones, M. A., and Haluska, T. L., 2003, Flood plain and channel dynamics of the Qunault and Queets rivers, Washington, USA: Geomorphology, v. 51, p. 31-59.

Pess, G. R., Montgomery, D. R., Bilby, R. E., Steel, A. E., Feist, B. E., and Greenberg, H. M., 2002, Landscape characteristics, land use, and coho salmon (Oncorhynchus kisutch) abundance, Snohomish River, Washington State, USA: Canadian Journal of Fisheries and Aquatic Sciences, v. 59, p. 613-623.

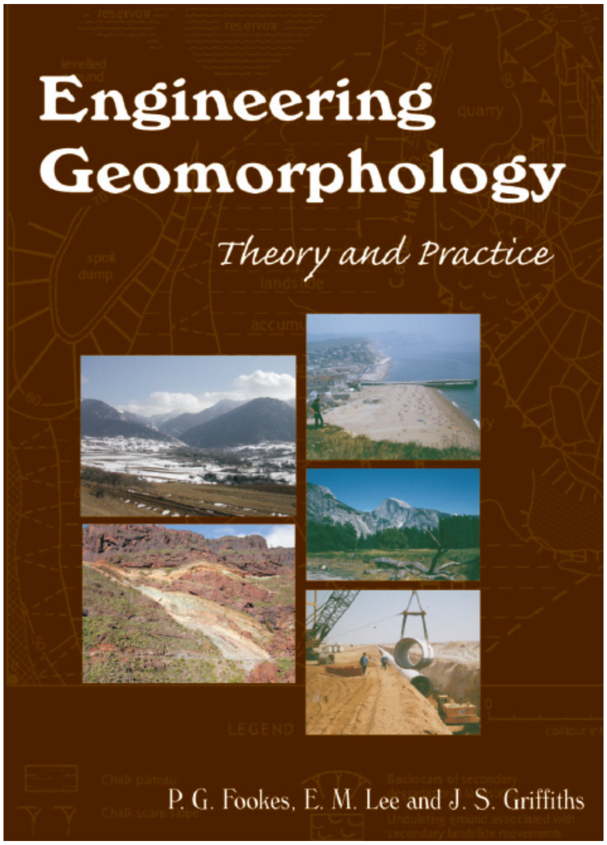
Peterson, N. P., and Reid, L. M., 1984, Wall-base channels: their evolution, distribution and use by juvenile coho salmon in the Clearwater River, Washington, in Walton, J. M. and Houston, D. B., Proceedings of the Olympic Wild Fish Conference: Port Angeles, p. 215-226.

Rosenfeld, J., 2000, Effects of fish predation in erosional and depositional habitats in a temperate stream: Canadian Journal of Fisheries and Aquatic Sciences, v. 57, p. 1369-1379.

Rosenfeld, J., Porter, M., and Parkinson, E., 2000, Habitat factors affecting the abundance and distribution of juvenile cutthroat trout (Oncorhynchus clarki) and coho salmon (Oncorhynchus kisutch): Canadian Journal of Fisheries and Aquatic Sciences, v. 57, p. 766-774.

Large chinook salmon in a Pacific Northwest river. Photo by R Guthrie.

Book Review
Engineering Geomorphology: *Theory and Practice* (Fookes, Lee and Griffiths)



The boys from the UK continue to lead the way in communicating our best understanding of the application of geomorphology to engineering assignments.

Engineering Geomorphology: Theory and Practice is a compact concise introduction to the ways that earth surface systems (particularly those related to water, wind and gravity) can impact engineering design. It is specific to hazards and impacts that are generated in civil engineering (rather than geological) time, from <1 to 1000 years, and considers the nature, scale and consequences of landform change over that timeframe. The authors demonstrate the need for geomorphologists and engineers to work together to achieve better, even brilliant results based on a comprehensive understanding of the problems, systems and forcing mechanisms.

The book is divided into three main parts. The first introduces systems geomorphology, fundamental geomorphological concepts and types and implications of forcing mechanisms (climate change, construction, changes in water levels etc…). The second part is specific to major geomorphological units: slopes, rivers and coastlines, and includes within each subsets of geomorphological problems (landslides, karst terrain, flooding, dunes, cliffs and so forth). Finally there is a section that discusses some of the types of investigations conducted by geomorphologists. This final section is aimed at helping engineers understand that while boreholes do give important information, there is a wide variety of employable tools that are routinely and expertly used.

While I still prefer the comprehensiveness of it's companion (Geomorphology for Engineers – reviewed in the fall 2006 issue), this book provides a starting place for the engineer who asks, "I'm going to work on project *X*, what should I consider over the life of the project?"

As always with these authors, the diagrams and models are helpful, clear, and up to date. If you do engineering works and want them to last, this book is a quick reference to focus your efforts. At just a hair over $100 Canadian, the diagrams alone are worth the money.

-RHG

Introducing:

Mike Wei works in the Water Stewardship Division as a hydro-geologist and deputy comptroller of water rights. He leads the Groundwater and Aquifer Science Section in Victoria, and helped develop and implement the Ground Water Protection Regulation.

Mike immigrated to Vancouver from Hong Kong in 1967and grew up playing hockey, hiking and fishing. He still plays old-timer hockey and loves fly-fishing He intends to hike Northover Ridge in Kananaskis, wonky knees and all!

Mike has a degree in geological engineering from UBC and a Master's Degree in Hydrology from New Mexico Tech (1991). He is in his 25th year with the Ministry's water program and has been blessed to have been influenced, taught, and worked with many talented, dedicated, and passionate colleagues – to advance the management and protection of the groundwater resources of this vast province.

Mike is married, with 2 young daughters in Victoria. He can be reached at (250) 658-4828 or by e-mail at Mike.Wei@gov.bc.ca.

Carnation Creek Workshop:

The Geomorphology subcommittee of the CWRA regrets to announce that the workshop at Carnation Creek on Vancouver Island planned for September 24-26, 2007 has been postponed. The workshop has been postponed because a pre-workshop reconnaissance carried out on September 6, 2007 revealed that vehicle access to Carnation Creek is difficult due to the poor state of the roads, many of which have deteriorated since early 2007.

There are plans to hold the workshop instead in late April/early May 2008. Re-scheduling of the workshop will be in part dependent on the cessation of the logging strike and the renewal of road maintenance on the South Island. Stay tuned.

Please direct all questions to Rowland Atkins at ratkins@golder.com

Next issue:

Change detection: What can we usefully see from space? - *RHG*

Have an article or research paper that you'd like to see here? Let me know at: richard.guthrie@gov.bc.ca

On the Island: View of Elkhorn, Rambler and Mt. Colonel Foster from the King's Peak approach