Cycles in Ocean Productivity, Trends in Habitat Quality, and the Restoration of Salmon Runs in Oregon

Peter W. Lawson

ABSTRACT

Conservation management is always a political, as well as a biological, problem. Oregon's coastal natural coho salmon (*Oncorhynchus kisutch*) populations have drawn political attention because abundances are at critically low levels. One of the underlying problems is a long-term trend of habitat degradation. In addition, decadal-scale cycles in ocean survival of coho salmon may lead to cycles in abundance that are independent of freshwater habitat trends. Programs to restore coho salmon populations through stream restoration will take decades to produce long-lasting results. When population abundance varies widely over time, a rise in abundance following the initiation of recovery measures can be taken as an indication of success even when the increase in numbers was independent of the actions taken. Support for recovery efforts must be sustained through the cycle of higher abundance. The true measure of success for such projects is the continued survival of the population through subsequent episodes of low abundance.

Salmon management in the Pacific Northwest is driven as much by politics and economics as by biology. Politics and economics operate on short time scales, from a few months to a few years. Salmon and their habitat, on the other hand, operate on cycles of at least three to six years for coho salmon (*Oncorhynchus kisutch*) and chinook salmon (*O. tshawytscha*), and up to centuries for the forests that structure their freshwater habitat. The interaction of short-term political cycles and long-term biological cycles presents dangers and opportunities for salmon management and conservation. I will explore one aspect of this interaction using a simple model.

In the Pacific Northwest south of Canada, many salmon stocks are at historically low levels (Nehlsen et al. 1991). Increasing concern for the survival of wild runs has led to listings under the Endangered Species Act, overfishing reviews by the Pacific Fishery Management Council, the Oregon Governor's Coastal Salmonid Restoration Initiative, a study by The Center for the Study of the Environment commissioned by the Oregon legislature, and a National Research Council Committee on Protection and Management of Pacific Northwest Anadromous Salmonids. All are attempts to bring a variety of interests together to benefit salmon runs.

One focus of interest is on freshwater habitat. During the past century, timber harvest, agriculture, and land development have caused serious degradation in the ability of rivers and streams to support salmon. While debate rages about exactly how to restore waterways to salmonid production, there is little doubt that expensive, long-term restoration projects will be undertaken soon. Oregon's Gov. Barbara Roberts has proposed spending $10 million for watershed restoration in two regions, including Oregon's south coast watersheds. The atmosphere in which major projects will be designed and funded is highly political and usually has a time horizon of a few years at most. I argue that, to have a reasonable chance of success, these projects must have time horizons of 20 to 40 years, with strong commitments of continuing support. However, the cyclical nature of salmon abundance related to fluctuations in the ocean environment will make it difficult to maintain long-term projects in a short-sighted political arena. While my

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argument is cast in the context of Oregon's coastal natural coho salmon, many aspects apply to conservation of any species with density independent mortality that varies on a long time scale.

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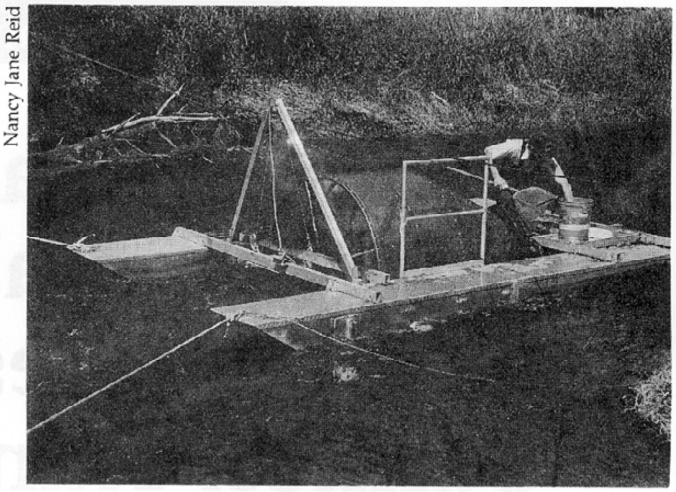
Abundance of naturally spawning coho salmon in Oregon's coastal streams and rivers has been declining ever since records have been kept in the late 1800s (Mullen 1981). Many factors have been implicated in this decline, including excessive harvest and competition with hatchery fish. By far the most ubiquitous change affecting salmonids during this time is alteration of freshwater habitats. In the past 100 years, the activities of humans have profoundly altered virtually every stream and river on the coast of Oregon (Lichatowich 1989). Rivers have been dredged, splash-dammed, cleared, channelled, and diverted. Hydrologic and thermal cycles have been altered, biological productivity modified, and exotic species introduced. Habitat loss was reported as a major problem for 175 of 195 native naturally spawning salmon and steelhead stocks in the Pacific Northwest identified as threatened or endangered by Nehlsen et al. (1991). Holtby and Scrivener (1989) quantified a reduction in coho and chum (*O. keta*) salmon productivity on Carnation Creek, British Columbia, due to stream changes after logging. The extent of habitat loss parallels the growth of human population on the West Coast. The inescapable conclusion is that in the Pacific Northwest the capacity of coastal streams and rivers to produce salmonids has been declining for the past century.

Environmental factors in the ocean strongly influence salmon abundance in the Pacific Northwest (Nickelson 1986; Holtby and Scrivener 1989; Emlen et al. 1990). This variability operates on every time scale from years to centuries (Mysak 1986; Hollowed et al. 1987; Roden 1989; Ware and Thompson 1991). With at most a hundred years of data, long-term cycles cannot be identified with certainty. Evidence is growing for a major productivity cycle with a period of about 40 to 60 years (Ware and Thompson 1991). A shift from high to low productivity occurred off the Oregon coast in 1976, with a resulting drop in the survival rate of hatchery smolts from the Columbia River. The preceding high productivity phase started in the early 1960s.


Nancy Jane Reid

Stuart Ellis from the Oregon Department of Fish and Wildlife operates a smolt trap in Ten Mile Creek, Oregon.

Spawning escapement estimates are the common measure of stock status for coho salmon in Oregon. The success or failure of management programs is frequently evaluated in terms of change in escapements. Estimates of spawning escapements have been used in Oregon to monitor the status of coastal coho salmon populations since 1950 (McGie 1981). Unfortunately, these data are not sufficient to demonstrate the deleterious effects of freshwater habitat change during the past 40 years because escapements are a function of survival in both freshwater and marine environments (Pella and Myren 1974). Likewise, spawning escapement estimates are a poor measure of the success of freshwater habitat reconstruction projects. Holtby and Scrivener (1989) addressed this problem on Carnation Creek, British Columbia, by investigating the coho production system in detail. They were able to partition survival rates among several life history stages and separate factors affecting freshwater and marine survival. Despite these advances in our understanding of coho salmon life histories, the popular measure of both coho salmon abundance and the effectiveness of restoration efforts will remain tied to spawning escapements. This may lead to problems in maintaining public and political support for expensive, long-term restoration projects needed to stabilize salmon production at a higher level in Oregon streams.

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A model of the combined effects of freshwater habitat degradation (Fig. 1a) and oceanic cycles (Fig. 1b) can be created by first characterizing these two factors separately, then in combination, producing a pattern of expected ocean escapements (Fig. 1c). Any short-term fluctuations in ocean environment may mask the long-term downward trend driven by declining freshwater habitat quality. Currently we are near the bottom of an ocean productivity cycle (Fig. 1c, point A). Spawning ground survey data (Jacobs and Cooney 1991) and abundant anecdotal information confirm that spawning escapements are very low. Given the variability in productivities of coho salmon spawning populations, we can expect that some populations already have dropped to zero escapement: extinction. In the future, we can expect to see an increase in ocean productivity with a concomitant increase in coho salmon escapements (Fig. 1c, point B).

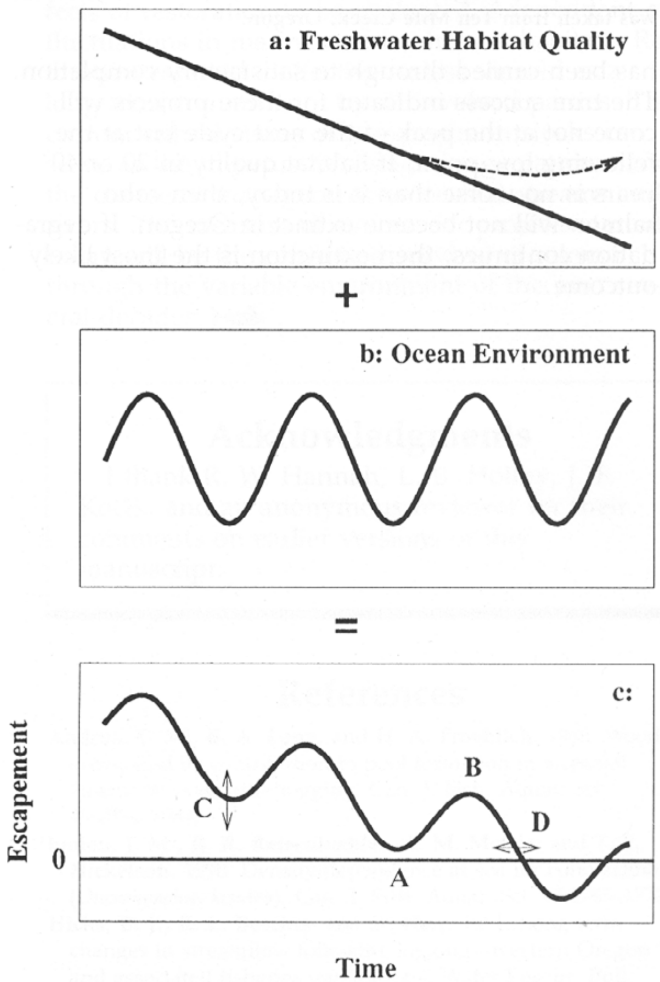

Figure 1. Conceptual model of effects of declining habitat quality and cyclic changes in ocean productivity on the abundance of Oregon's coastal natural coho salmon. a: trajectory over time of habitat quality. Dotted line represents possible effects of habitat restoration projects. b: generalized time series of ocean productivity. c: sum of top two panels where letters represent the following: A = current situation, B = situation in the future, C = change in escapement from increasing or decreasing harvest, and D = change in time of extinction from increasing or decreasing harvest.

From this simple model we can identify the utility of short-term harvest management strategies. Management to manipulate ocean harvest levels can shift the escapement curve up or down (Fig. 1c, arrow C). Higher harvests will lower the curve and move populations closer to immediate extinction. Lower harvests raise the curve, lower the likelihood of immediate extinction, but only shift the point of ultimate extinction into the future (Fig. 1c, arrow D). As long as the overall downward trend in freshwater habitat quality continues, no harvest management strategy can be long effective.

Continued survival of wild salmonid populations in the Pacific Northwest depends on reversing the degradation of freshwater habitat quality (Fig. 1a). While many actions can be taken to increase production quickly, the more important programs involve stream rehabilitation projects that, if started today, may take decades to become effective (Andrus et al. 1988; Hicks et al. 1991). Such projects would involve a major commitment of time and money from private parties and state and federal agencies. Opportunity exists now to get these commitments because escapements are at such a low level, and public concern is high. All those involved must recognize that the commitments cannot be short-term (i.e., three, five, or even 10 years). A 20- to 40-year horizon is necessary if restoration is potentially to increase the productivity of salmon stocks.

Habitat restoration should be planned in three phases: (1) short-term projects, (2) long-term projects, and (3) monitoring. Short-term projects include activities such as addition of debris structures, creation of off-channel pools, and cleaning of spawning gravel. These actions can increase smolt production quickly, with measurable results in two years or less, but are apt to be short-lived, destroyed by floods, bed movement, and siltation. Long-term projects include replanting riparian zones and even forests to restore the hydrological regime and debris sources in a watershed to a stable and favorable condition for salmonids and other native aquatic species. These projects may take 100 years or more for plantations to reach maturity. Appropriate monitoring is essential for all projects. Counts of spawners and juveniles or smolts in treated and untreated sites before and after restoration can be used to measure the effectiveness of stream improvements independent of fluctuations in ocean survival (Nickelson et al. 1992b). Freshwater survival rates combined with assessments of marine survival rates would produce a more complete picture of factors affecting spawning escapements (Pella and Myren 1974; Holtby and Scrivener 1989). Biologists should use results from these monitoring programs to provide politicians and managers with objective and appropriate measures of progress.

The projected increase in ocean productivity brings both an opportunity and a serious potential pitfall. Many coastal streams do not have enough spawning adults to fully "seed" the available habitat with juvenile fish (Nickelson et al. 1992a). If other factors such as winter habitat are not limiting, under-seeded streams could produce more smolts with higher spawning escapements. Higher ocean productivity may make it easier to achieve adequate spawning escapement. Fish would occupy expanded areas of suitable habitat, and streams with extinct populations would receive stray spawners, potentially returning the streams to production. In addition, ocean populations would be higher. Higher escapements, if they occur, would allow testing of theories about limiting factors and seeding levels (Nickelson et al. in press).

The risk is this: with higher survivals and more fish evident, managers and politicians will have a tendency to relax and claim success for their projects. Agencies that fund the habitat improvement projects will see the increase in escapements as an indication of success and may redirect funds to other "high priority" programs before restoration has been carried through to satisfactory completion. The true success indicator for these projects will come not at the peak of the next cycle but at the following low point. If habitat quality in 20 or 40 years is no worse than it is today, then coho salmon will not become extinct in Oregon. If degradation continues, then extinction is the most likely outcome.

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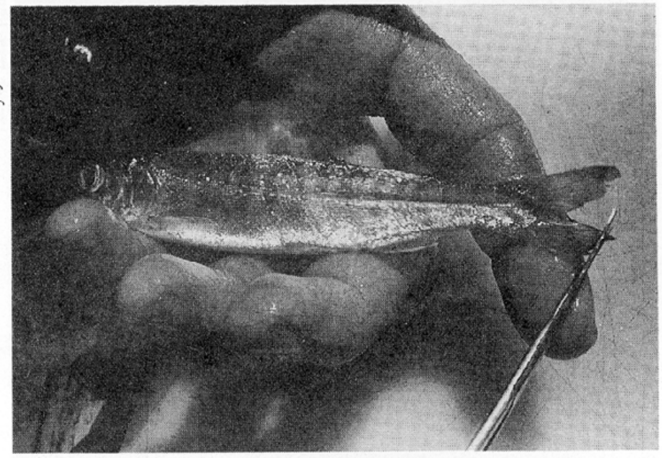

Caudal fin from this coho salmon smolt is clipped as part of a mark-recapture program used to estimate trap efficiency. Smolt was taken from Ten Mile Creek, Oregon.

The most effective way to restore freshwater salmon habitats is a matter of much debate. The best strategy will include both short-term and long-term actions with appropriate monitoring. Short-term projects could be designed to provide habitat so stocks can survive long enough for the long-term, permanent projects to mature. Monitoring

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should be conducted in a way that allows the effects of restoration to be evaluated independent of fluctuations in marine and freshwater habitats. Restoration cannot be effective unless viewed as a long-term commitment by all involved parties. The current critical status of many salmon stocks can serve as the impetus to change usage patterns and the course of management on coastal streams and rivers. The measure of success for projects started today will be the continued survival of salmon through the variable environment of the next several decades.

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References

Andrus, C. W., B. A. Long, and **H. A. Froehlich.** 1988. Woody debris and its contribution to pool formation in a coastal stream 50 years after logging. Can. J. Fish. Aquat. Sci. 45:2080–2088.

Emlen, J. M., R. R. Reisenbichler, A. M. McGie, and **T. E. Nickelson.** 1990. Density-dependence at sea for coho salmon (*Oncorhynchus kisutch*). Can. J. Fish. Aquat. Sci. 47:1765–1772.

Hicks, B. J., R. L. Beschta, and **D. Harr.** 1991. Long-term changes in streamflow following logging—western Oregon and associated fisheries implications. Water Resour. Bull. 27:217–226.

Hollowed, A. B., K. M. Bailey, and **W. S. Wooster.** 1987. Patterns in recruitment of marine fishes in the northeast Pacific Ocean. Biol. Oceanogr. 5:99–131.

Holtby, L. B., and **J. C. Scrivener.** 1989. Observed and simulated effects of climatic variability, clear-cut logging, and fishing on the numbers of chum salmon (*Oncorhynchus keta*) and coho salmon (*O. kisutch*) returning to Carnation Creek, British Columbia. Pages 62–81 *in* C. D. Levings, L. B. Holtby, and M. A. Henderson, eds. 1989. Proceedings of the national workshop on effects of habitat alteration on salmonid stocks. Can. Spec. Publ. Fish. Aquat. Sci. 105.

Jacobs, S. E., and **C. X. Cooney.** 1991. Improvement of methods used to estimate the spawning escapement of Oregon coastal natural coho salmon. Oregon Department of Fish and Wildlife, Annual Progress Report, Portland, OR.

Lichatowich, J. A. 1989. Habitat alteration and changes in abundance of coho (*Oncorhynchus kisutch*) and chinook salmon (*O. tshawytscha*) in Oregon's coastal streams. Pages 92–99 *in* C. D. Levings, L. B. Holtby, and M. A. Henderson, eds. 1989. Proceedings of the national workshop on effects of habitat alteration on salmonid stocks. Can. Spec. Publ. Fish. Aquat. Sci. 105.

McGie, A. M. 1981. Trends in the escapement and production of fall chinook and coho salmon in Oregon. Oregon Department of Fish and Wildlife, Information Report 81-7, Portland, OR.

Mullen, R. E. 1981. Oregon's commercial harvest of coho salmon, *Oncorhynchus kisutch* (Walbaum), 1892–1960. Oregon Department of Fish and Wildlife, Information Report 81-3, Portland, OR.

Mysak, L. A. 1986. El Niño, interannual variability and fisheries in the northeast Pacific Ocean. Can. J. Fish. Aquat. Sci. 43:464–497.

Nehlsen W., J. E. Williams, and **J. A. Lichatowich.** 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho, and Washington. Fisheries (Bethesda) 16(2):4–21.

Nickelson, T. E. 1986. Influences of upwelling, ocean temperature, and smolt abundance on marine survival of coho salmon (*Oncorhynchus kisutch*) in the Oregon production area. Can. J. Fish. Aquat. Sci. 43:527–535.

Nickelson, T. E., J. D. Rodgers, S. L. Johnson, and **M. F. Solazzi.** 1992a. Seasonal changes in habitat use by juvenile coho salmon (*Oncorhynchus kisutch*) in Oregon coastal streams. Can. J. Fish. Aquat. Sci. 49:783–789.

Nickelson, T. E., M. F. Solazzi, S. L. Johnson, and **J. D. Rodgers.** 1992b. Effectiveness of selected stream improvement techniques to create suitable summer and winter rearing habitat for juvenile coho salmon (*Oncorhynchus kisutch*) in Oregon coastal streams. Can. J. Fish. Aquat. Sci. 49:790–794.

———. In press. An approach to determining stream carrying capacity and limiting habitat for coho salmon (*Oncorhynchus kisutch*). Proceedings of the coho workshop, Nanaimo, BC.

Pella, J. J., and **R. T. Myren.** 1974. Caveats concerning evaluation of effects of logging on salmon production in southeastern Alaska from biological information. Northwest Sci. 48:132–144.

Roden, G. I. 1989. Analysis and interpretation of long-term climatic variability along the west coast of North America. Geophys. Monogr. 55.

Ware, D. M., and **R. E. Thomson.** 1991. Link between long-term variability in upwelling and fish production in the northeast Pacific Ocean. Can. J. Fish. Aquat. Sci. 48:2296–2306.