

Instream and Channel Restoration Projects

Based on two phases of research carried out between October 1, 1985 to September 30, 1998. The earlier phase of work is summarized in: Nickelson, T.E., M.F. Solazzi, S.L. Johnson and J.D. Rodgers. 1992. *Effectiveness of selected stream improvement techniques to create suitable summer and winter rearing habitat for juvenile coho salmon (Oncorhynchus kisutch) in Oregon coastal streams*. Canadian Journal of Fisheries and Aquatic Science. 49: 790-794. The second phase of research is summarized in: *Final Report: Fish Research Project, Development of Techniques to Rehabilitate Oregon's Wild Salmonids*, 1998. Oregon Department of Fish and Wildlife, P.O. Box 59, Portland Oregon. 41 pp.

The Contribution of Restored Off-Channel Habitat to Smolt Production in the Coquitlam River

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Project Description

The Coquitlam River is a 4th order tributary that joins the Fraser River 8 km east of New Westminster, B.C. Since the 1970's, a number of groups and agencies have voiced concerns about the decline of salmonid populations in the river. The decline is due, in part, to extensive development of the watershed beginning in the late 1900's. Development includes dam construction, logging, gravel mining and urban growth, which have all contributed to extensive loss and degradation of salmonid habitat. Remaining salmonid habitat occurs primarily in mainstem and tributary reaches of a 12 km long section of the river between the Coquitlam Reservoir and the city of Port Coquitlam.

From 1993 to 1997, an intensive off-channel habitat restoration program occurred in the Coquitlam River, providing ~43,000 m² of artificial pond and channel habitat at six sites. Prior to construction, off-channel habitat represented less than 1% of available habitat in the river. This increased to 14% following restoration. The sites range in size from 845 to 17,300 m². Each site consists of an inlet spawning channel which diverts flow from the Coquitlam River, an outlet channel and one or a series of rearing ponds. The ponds represent the majority of wetted area at each site. The ponds were created by the construction of earthen dikes in low-lying areas of the river's flood plain. Trees and root wads removed during dike construction were added to the ponds to provide cover.

Examined in isolation, groundwater-fed side channels and off-channel ponds have been shown to support relatively high densities of coho smolts, and in some cases, steelhead smolts, but relatively few studies have

compared the proportional use of off-channel versus mainstem habitat at a watershed scale. Initial assessment of off-channel sites in the upper Coquitlam River in 1996 indicated that juvenile coho and steelhead densities in off-channel habitat were high, relative to densities in mainstem habitat. In 1997 and 1999, numbers of smolt outmigrants from off-channel sites were compared to estimated numbers from mainstem and tributary habitat in a 12 km section of the river in order to assess the relative contribution of constructed off-channel habitat to stream-wide smolt production.

Criteria for Restoration Evaluation: Smolt outmigrant populations.

Off-Channel Habitat Sites

During 1996-1999, smolt outmigrant populations from several of the off-channel sites were enumerated at converging downstream weir fish traps, or estimated using minnow traps and single census mark-recapture methodology. Downstream traps were operated from late March to mid-June each year. Minnow trapping was conducted during mid- to late March. *In cases where total captures were low (i.e., < 100) or marked proportions in recoveries were low (i.e., < 15%), mark-recapture estimates were not generated.*

Coquitlam River

Smolt output from a 1.7 km section of the upper Coquitlam River below Coquitlam Dam (reach 4) has been assessed periodically since 1986. As part of this study, we enumerated smolt outmigrants from reach 4 at a downstream fish trap from 1996 to 1999. In 1997,

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smolt abundance was also estimated for reach 3, the remaining downstream portion of the 12 km study section (13.7 km of mainstem and tributary habitat). This was done using stratified mark-recapture methodology: fish captured in reach 4 and the off-channel sites were batch-marked according to capture period, and then recovered along with unmarked fish from the mainstem and tributaries in a fyke net located at the downstream end of reach 3. In 1999, the study was repeated, but a rotary screw trap was used in place of the fyke net and reach 3 was shortened to 5.6 km of mainstem and tributary habitat. Smolt population estimates for the 12 km section were derived by extrapolating mean estimates for reaches 3 and 4.

Restoration Responses

Coho Salmon

Coho smolt densities in off-channel sites were considerably higher compared to those in the Coquitlam River. Between 1996 and 1999, coho smolt densities in the off-channel sites ranged from 5.3 to 84.6 smolts/100 m² and averaged 38.6 smolts/100 m², whereas densities in reaches 3 and 4 averaged just 4.2 and 10.0 smolts/100 m², respectively (see Figure 1).

In 1997, juvenile coho use of off-channel vs. mainstem and tributary habitat was highly disproportionate: four man-made off-channel sites, representing 12% of total rearing area of the 12 km section, were used by an estimated 47% of coho smolts (13,771 of 29,333). Results for 1999 were similar: six off-channel sites,

representing 14% of wetted area, supported an estimated 48% (12,491 of 25,878) of overwintering smolts. This high degree of use suggests that off-channel habitat restoration has strongly influenced the distribution of coho smolt production in the watershed, and may have increased its carrying capacity.

A comparison of annual smolt abundance in reach 4 before and after habitat rehabilitation suggests that relatively high smolt output from off-channel sites has not affected fish production in the mainstem. Prior to construction of the Grant's Tomb and Or Creek off-channel sites in 1995, annual coho smolt production ranged from 81-3227 fish (n = 3) (Figure 1).

Results from experimental fry releases suggested that low recruitment, rather than winter carrying capacity, may have limited coho smolt production in some of the sites. For example, 4000 and 3000 hatchery fry were released in the Archery Pond site during the 1996 and 1997 smolt years, respectively, while 10,000 hatchery and 11,400 wild fry were released in Oxbow Lake site during the 1998 and 1999 smolt years, respectively. Mean smolt numbers from the Archery Pond and Oxbow Lake sites for years when fry stocking occurred (3220 and 2106 smolts, respectively) were greater than numbers for years when no stocking occurred (477 and 1187 smolts, respectively).

Steelhead

Steelhead smolt densities for constructed off-channel habitat were comparable to those for natural mainstem

		Off-channel Sites				Mainstem and Tributaries			
		Grant's Tomb	Or Creek	Archery	Oxbow	Reach 4	Reach 3 ¹		
Year		total density	total density	total density	total density	total density	total density		
Coho	1996	1220 37.0	2864 73.6	1457 52.0	- -	290 1.4	- -		
	1997	679 46.3	11281 84.6	623 10.7	1187 6.9	2773 13.6	15562 5.9		
	1998	1390 42.1	- -	- -	917 5.3	3813 18.6	- -		
	1999	1822 57.0	1138 8.5	3423 59.0	3924 19.0	1331 6.5	2405 3.6		
Steelhead	1996	57 2.7	55 1.5	- -	- -	258 1.3	- -		
	1997	11 0.8	411 3.5	115 2.0	121 0.7	207 1.0	- -		
	1998	- -	- -	- -	275 1.6	421 2.1	- -		
	1999	42 1.3	91 1.2	- -	292 4.3	560 2.7	1781 2.6		

¹Reach 3 consisted of 13.7 km of mainstem and tributary habitat in 1997 and a 5.6 km section in 1999.
²The Or Creek site was 3936 m² in wetted area in 1996 and was expanded to 13,336 m² in 1997.

Figure 1. Summary of coho and steelhead smolt numbers and densities (smolts 100/m²) for off-channel sites and mainstem reaches of the Coquitlam River, 1996 - 1999.

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and tributary habitat. Between 1996 and 1999, steelhead smolt densities in the off-channel sites ranged from 0.7 to 4.35 smolts/100 m² and averaged 2.0 smolts/100 m², whereas densities in reaches 4 of the Coquitlam River ranged from 1.0 to 2.7 smolts/100 m² and averaged 1.8 smolts/100 m² (see Figure 1). In 1997, too few steelhead smolts were recovered in reach 3 to provide a population estimate. In 1999, estimated density in reach 3 was similar to that in reach 4 (2.6 smolts/100 m²).

In 1999, an estimated 7% of steelhead smolts in the 12 km section overwintered in the off-channel sites (520 of 7,444 smolts). Given that off-channel areas represent 14% of available habitat, off-channel use by steelhead was low in proportion to availability. However, extrapolating smolt densities from the upper river mainstem to lower reaches likely resulted in an overestimate of smolt numbers; earlier studies found steelhead densities were lower in downstream reaches compared to reaches 3 and 4. As well, steelhead smolt output from reach 4 in 1999 was relatively high compared to six previous sample years. During 1996 and 1997, steelhead (smolts and parr) use of off-channel habitat in reach 4 was proportional to its availability. The Grant's Tomb and Or Creek sites, representing 45% of wetted area in reach 4, supported 34% of steelhead in 1996 and 67% in 1997.

Similar to results for coho, the construction of off-channel habitat did not appear to adversely affect steelhead smolt production in existing mainstem and tributary habitat. Mean smolt output from reach 4 averaged 362 for post-construction years (n = 4) compared to 207 for pre-construction years (n = 3). However, higher numbers in the mainstem in the post-construction period may have been influenced by increased flow releases from the dam.

Lessons Learned

The pond-channel design appears to be an effective approach to increasing coho smolt abundance through habitat restoration. The Coquitlam River pond-channel projects have been successful in part because they provide critical coho overwintering habitat in a system where natural overwintering habitat is scarce.

- Data for the combined pond-channel projects at Coquitlam River suggests that this type of off-channel habitat may also provide important overwintering habitat for steelhead and cutthroat.
- The tendency for stable off-channel habitat to produce consistent smolt yields may be more important than its ability to augment production in any one year, particularly in a degraded watershed such as the Coquitlam.
- Fry recruitment may be an important factor, particularly in the case of larger off-channel sites with limited access to the stream's mainstem. During construction, effort should be made to enhance the attractiveness of outlet channels to migrating adults and juveniles through the addition of artificial log jams or other debris structures. If hatchery enhancement occurs in the watershed, consideration should also be given to releasing fry in off-channel sites. ▲

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Case Studies of Whole-stream Fertilization in British Columbia

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Project Description

Whole-river fertilization experiments have been conducted in British Columbia on a series of oligotrophic coastal and interior streams that have been affected by past logging practices and/or hydroelectric development. These experiments were designed to determine, under diverse conditions, the effects of

inorganic nutrient addition on water chemistry, periphyton and invertebrate community composition and biomass, and fish growth and abundance. The treated systems include Keogh River, Salmon River, and Adam River, all located on the northern Vancouver Island; Big Silver Creek, located near Harrison Lake