REBUILDING THE SALMON RUNS TO THE STAVE RIVER:

A CO-OPERATIVE EFFORT OF HARVEST REDUCTION,

ENHANCEMENT, HABITAT RESTORATION, AND FLOW CONTROL

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Introduction

Rebuilding of stocks can be accomplished in many ways, depending on the mechanisms that depressed the stocks. Some of these mechanisms include over harvesting, habitat degradation and water removal affecting freshwater survival, and estuary and ocean conditions affecting ocean survival. Enhancement via hatchery releases is only one tool for rebuilding stocks. Reductions in harvesting and habitat restoration are also needed. Enhancement has the ability to rebuild the stocks more quickly than by harvest reduction and habitat restoration alone, especially if ocean survival is not also depressed. Once the stock has been rebuilt, enhancement can cease. Continued assessment of the stock is needed to determine if the stock can maintain itself without enhancement.

The flow of the Stave River is affected by a complex of three dams and associated hydroelectric facilities on the Alouette and Stave Rivers that were constructed between 1910 and 1930. The Ruskin dam at the lower end of Stave River removed about 1.5km of spawning area and limits salmon spawning to 1.5 km between the dam and tidal influence. Water diversion to the Alouette River, flow fluctuations from the peaking hydroelectric facilities and the destruction of habitat during gravel removal operations during the 1950's severely limited fisheries productivity of the Stave River.

Enhancement of chum salmon on the Stave was recommended by Palmer (1972), but was limited by the wide fluctuation in flows to a possible small spawning channel on the right bank and to incubation boxes or ponds supplied by a flow of clean gravity fed water from the dam. The initial success of Japanese-style chum hatcheries by the Salmon Enhancement Program (SEP) allowed for a new option for enhancement of Stave River chum. This technique involved using groundwater to incubate eggs in bulk upwelling incubators and alevins in gravel lined keeper channels, and rearing fry in concrete raceways to approximately 1.5 grams or about five times their ponding size while still releasing the fry at normal wild fry migration timing. In 1980, the Fisheries & Oceans (DFO), Canada Fraser River Geographical Working Group developed a plan to increase the returns of Fraser chinook, coho, chum, and steelhead by use of enhancement and harvest reductions (MacKinlay, 1985). This plan included enhancement of Stave River chum and coho at Inch Creek Hatchery. The goal was to produce 122,000 Stave chum adults from about 8.5 million eggs. Stave coho was added to the plan in 1987 to enhance the small run of coho.

Increased chum escapements as a result of enhancement and harvest reduction would be of little benefit for long term stock rebuilding unless the Stave water flow regime was changed to improve salmon spawning and incubation survival and habitat restoration was undertaken to increase and improve the degraded spawning areas. An interim water use plan and habitat restoration program began in 1990.

Enhancement

Inch Creek Hatchery had an initial target of 4.0 million Stave chum eggs starting with the 1982 brood. This was expected to produce 57,600 chum adults annually (90% egg-to-fry, 80% fry-to-fed fry, 2% fed fry-to-adult survival). Between 1983 and 1998 Inch Hatchery released an average of 4.2 (2.1-5.5) million fed fry at 1.48 (1.0-1.9) g. annually into the Stave River. Between 1985 and 2000, enhancement has produced an estimated average of 68,800 (5,500-1,069,500) adults annually, exceeding the expectation by 19%. This has been the result of better than expected survivals at all stages. Highly variable chum survival is responsible for the wide range in annual returns. This includes an average marine catch of 20,800 (500-332,200) and an average exploitation rate of 27.1% (1.0-52.9)

Exploitation Rate Reduction

From 1953-1979 Fraser chum exploitation rates averaged 53.6% (11.3-92.1). As part of a strategy to increase escapements, rebuild stocks, and probe the optimum sustainable yield of Fraser chum, Fraser chum exploitation rates have been reduced to a 1980-1997 average of 27.6% (3.9-65.1).

Flow Agreement

Flow fluctuations from the peaking hydroelectric facilities severely affected spawning salmon. The highly variable flows disrupted spawning behaviour, stranded adults, and often left redds without flow. A provisional water use agreement was established between B.C. Hydro and DFO in 1990 to increase survival of salmon eggs by maintaining minimum flows for the river downstream of the dam during the salmon spawning and incubation periods (Lamont & Foy, 1996). These including weekly block loading (no peaking) i.e. flows were maintained at a constant level for at least a week at a time without variation, and constraints were implemented on minimum and maximum flows. Further refinements to the flow regime to improve fisheries productivity occurred in 1995 and 1999 (Failing, 1999). Issues affecting spawning, incubation, egg stranding, fry migration, rearing, total gas pressure, and reservoir productivity were addressed as well as non-fish issues such as heritage, recreation, industry, wildlife, and power values.

The new 1995 agreement consisted of the following fish productivity elements:

- Weekly block loading during the fall spawning period.
- Daily block loading during fry emergence.
- A 1999 amendment allows for peaking above 130 cms and limited block loading that allows peaking above 100 cms during spring and fall. This would detrimentally affect spawning but would reduce egg and fry stranding so that overall salmon productivity should improve or at least remain the same.
- Minimum water levels year around.
- A monitoring plan would be put in place and funds made available to maintain restored habitat.

Habitat Restoration

The benefits of increased returns from enhancement and reductions in harvest would have been wasted without the habitat restoration initiatives on the Stave River to increase the spawning ground capacity. Prior to these initiatives, the estimated chum spawning capacity of the Stave River was about 92,000 adults and the real capacity was likely less because of the effects of hydro-electric peaking operations on fish stranding and redd de-watering.

The 1990 flow agreement between the Department of Fisheries and Oceans and B. C. Hydro also allowed for co-operative stream restoration work to be undertaken to maximize the benefits of the improved flow regime as well as provide increased habitat for the progeny of enhanced releases (Lamont & Foy, 1996). During 1990-1994 several re-contouring and construction projects funded jointly by the Department of Fisheries and Oceans and B. C. Hydro increased the chum spawning capacity of the lower Stave River.

These projects included:

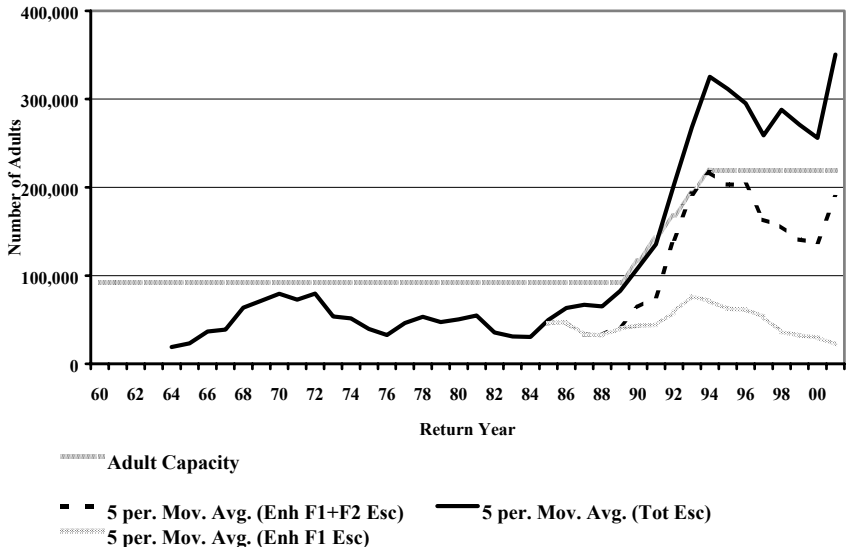
- In 1990, re-contouring of the 360-metre centre channel so that it remained wetted during spawning and incubation flows.
- In 1991-92, the construction of a 400 m spawning channel on the left bank bringing water from the Ruskin dam tailrace through this channel to an improved 1,000 m. former overflow spawning and rearing channel adjacent to the road.
- In 1993, the restoration work continued with gravel additions to upstream areas, re-grading selected river bars, and providing flow to cut-off side channels as well as construction of a 1225 sq. m. spawning beach and 600 sq. m. spawning channel and major re-contouring of gravel along the right bank.
- In 1994, a 2,600 sq. m. spawning beach downstream of the tail-water pool and a side channel immediately west of the centre channel were constructed as well as re-grading of an 3,600 sq. m. of existing spawning beach adjacent to the main left bank channel.

The summation of the work added 118,000 sq. m. of improved spawning area to the existing 84,000 sq. m. of natural area for a total of 202,000 sq. m. which is estimated to support 220,000 spawning chum.

Results of Enhancement, Harvest Reduction, and Habitat Restoration

The combined effect of enhancement, harvest reductions, and habitat restoration to rebuild Stave escapements can be seen in Figure 1. The chart shows 5 year moving averages of escapement estimates in order to smooth out the effect of variable annual survival.

Figure 1. Stave chum escapements-enhanced F1 & F2 & Total



The solid dark top line shows total Stave chum escapements between 1960 and 2001. Escapements from 1960-69 were based on a tag and recovery enumeration program on all Fraser stocks. Between 1970-1988, Fishery officer visual estimates, which in later years were conducted by helicopter, were used. Between 1989-1994, Inch Hatchery staff conducted tag and recovery programs to estimate escapements. Since then, Inch Hatchery staff conducted weekly helicopter flights and Area Under the Curve (AUC) is used to estimate the escapement. The lower solid grey line shows enhanced first generation (F1) returns of enhanced chum releases from Inch Hatchery. This number was calculated from sampling adults on the spawning grounds for adipose coded-wire tags applied to between 50,000 and 150,000 Stave chum fry in each year except the 1983 and 1984 brood years. The middle dark dashed line is the

F1returns plus the estimated second generation F2 returns of the progeny of enhanced F1 returns spawning naturally. This number was calculated by apportioning the returning escapement (less estimated F1 returns) into F2 and wild returns based on the numbers of F1 and wild spawners in the brood year. This assumes that hatchery F1 spawners have the same spawning success and survival to adult as wild spawners. The middle grey solid line shows the spawner capacity before and after habitat restoration.

Total escapements increased gradually after 1985 when enhanced first generation (F1) chum began to return. A dramatic increase in total escapement began in 1990 when (F2) chums began to return. These dramatic increases were also aided by ocean survivals about 50% above average and reduced exploitation rates. The increased return peaked at 400,000 in 1994 and has been more variable since then averaging 297,800 (105,000-625,000) from 1995-2001. Returns have also been reduced by reduced hatchery fry production to 3.1 million in the 1996 brood, 2.1 million in the 1997 brood and no hatchery production since then.

The habitat restoration from 1990-1994 occurred just in time to take advantage of the dramatic increase in escapements starting in 1990.

The average total Stave escapement from 1990 to 2001 has increased to 309,000 a 7-fold increase in just three generations from the pre-enhancement 1960 to 1984 average of 44,000. This is a prime example of how enhancement, harvest reductions, and habitat restoration can be used to rebuild a stock. This is a biological example of the benefits of compound interest, which can show dramatic results when survivals are good and prudent management is undertaken.

Other Benefits

Prior to enhancement, there was a limited sport fishery for cutthroat in the Stave River. Since 1983, the hatchery has released approximately 10,000 adipose clipped cutthroat smolts annually into the Stave River to provide a mark only recreational fishery which will help maintain the naturally spawning cutthroat stocks by diverting effort onto marked hatchery fish.

A plan was developed to rebuild Stave coho stocks and provide an urban recreational fishing opportunity for coho in addition to the cutthroat fishery.

Between 1990 and 1994, Inch Hatchery released 40,000-50,000 Stave coho smolts annually into the Stave River. Since 1994, the hatchery has released an average of 212,000 coho smolts into the Stave River. As a result, coho escapements have increased from about 200 to an estimated 2-4,000 even in the current regime of poor marine survivals of coho. All hatchery coho are adipose fin-clipped and only marked fish are allowed to be retained in the recreational fishery. This allows a recreational fishing opportunity as well as accelerated rebuilding of the naturally spawning coho.

Prior to hydroelectric development, there were reports of chinook salmon in the Stave River but only one report of any chinook since 1969. In order to re-establish chinook in the Stave River and provide a further recreational fishing opportunity, 373,000 Chilliwack white (originally the close by Harrison white stock) chinook smolts were transplanted into the Stave River between 1995 and 1997. In 1997, Inch Hatchery began collecting chinook eggs from the progeny of the transplants to the Stave River and released an average of 196,000 smolts into the Stave River in the last three years.

As part of the rebuilding of Stave coho and cutthroat, habitat restoration was also aimed at increasing rearing benefits for these and other species. The overflow side channel on the left bank, which now has sufficient flow for year round rearing, was deepened and filled with water-laden cedar stumps salvaged from Stave Lake during a drawn-down period. This added 8,000 sq. m. of ideal coho rearing habitat. Other constructed spawning channels and improved side channels also added additional coho rearing habitat. The flow agreement also substantially improved the spawning and rearing habitat in the Stave River.

The addition of angling pools during habitat restoration, the presence of a B.C. Hydro recreation site, parking lot, and boat ramp, and the increased escapements from hatchery returns of cutthroat, coho, and chinook has significantly improved the recreational angling opportunities on the Stave River. The fall sport fishery for coho is expanding rapidly, and the year round cutthroat trout fishery has improved. In addition, with the returns of hatchery chinook in 1997, a fall sport fishery for chinook has also developed.

Additional benefits to wildlife and recreation have also accrued. The large chum salmon escapements provide an abundant food source for bald eagles wintering on the Stave River and the nutrients from the carcasses likely produce an abundant food supply for rearing chinook, coho, steelhead, and cutthroat.

The B.C. Hydro recreation site provides access to the left bank spawning channel, which has become a popular viewing area for salmon spawning.

The Future

With the rebuilding of the natural run of Stave chum to spawning capacity, there was no longer a need for hatchery releases. As a result, Inch Hatchery ceased releases of chum to the Stave River after the 1997 brood. The chum escapements will continue to be monitored to evaluate whether the stock can maintain itself at the current estimated capacity of 220,000 adults. The spawning grounds will be monitored to ensure that the habitat improvements are maintained and further restoration will be performed as required.

The Stave is not the only Fraser chum stock that was enhanced; all major Fraser chum stocks including the Harrison, Chehalis, Chilliwack, Inch, and Alouette stocks have been enhanced. Releases of fed fry from these stocks averaged 21 million between the 1982-1997 broods. In addition, extensive habitat restoration occurred on the Chilliwack, Harrison, and Alouette. Enhancement, habitat restoration, and harvest reduction have resulted in the rebuilding of all the major Fraser chum stocks. As a result, the hatcheries have reduced their releases to about 5 million as a buffer against catastrophic freshwater mortalities in streams. Fraser chum escapements will be monitored in the future to assess whether these stocks can maintain themselves at the current high levels.

Conclusion

Stave River chum rebuilding was accomplished by releases of hatchery chum and reductions in exploitation rate to put the returns from this production on the spawning grounds. Extensive habitat restoration and a flow agreement was undertaken so that spawning and incubation conditions were improved for production of fry from these adults. The result is a 7-fold increase in chum escapements from 44,000 to 309,000. Hatchery releases of coho, chinook, and cutthroat trout have also increased the returns of these species and habitat restoration should substantially increase the natural production of these species. Additional benefits of this enhancement and habitat restoration include sport angling, food for other wildlife, and viewing of spawning. As the salmon life cycle is very dynamic and rivers are always changing, the Department of Fisheries and Oceans and B. C. Hydro will have to be vigilant the ensure that

the conditions on the Stave River remain optimal for spawning, incubation, and rearing success.

References

Failing, Lee. Aug. 1999. Stave River water use plan: Report of Consultative Comm. (DRAFT). Prepared by: Compass Resource Mgmt Ltd.

Lamont, C. and M. Foy. 1996. Structural modifications to fish habitat to mitigate flow fluctuation impacts on the Stave River. Proceedings of the 17th Northeast Pacific Pink and Chum Salmon Workshop, March 1-3, 1995, Bellingham, Washington. H. Fuss and G. Graves Editors. Pp 180-185.

MacKinlay, D.D. 1985. Review of the biological design criteria for the Inch Creek Salmonid Enhancement Facility. Internal Rep. New Projects Unit, Enhancement Operations Div., Salmonid Enhancement Program, Canada, Dept. Fish & Oceans, March 1985.

Palmer, R.N. 1972. Fraser River chum salmon. Can. Dept. of Environment Tech. Rep. 1972-1. 284 p.

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