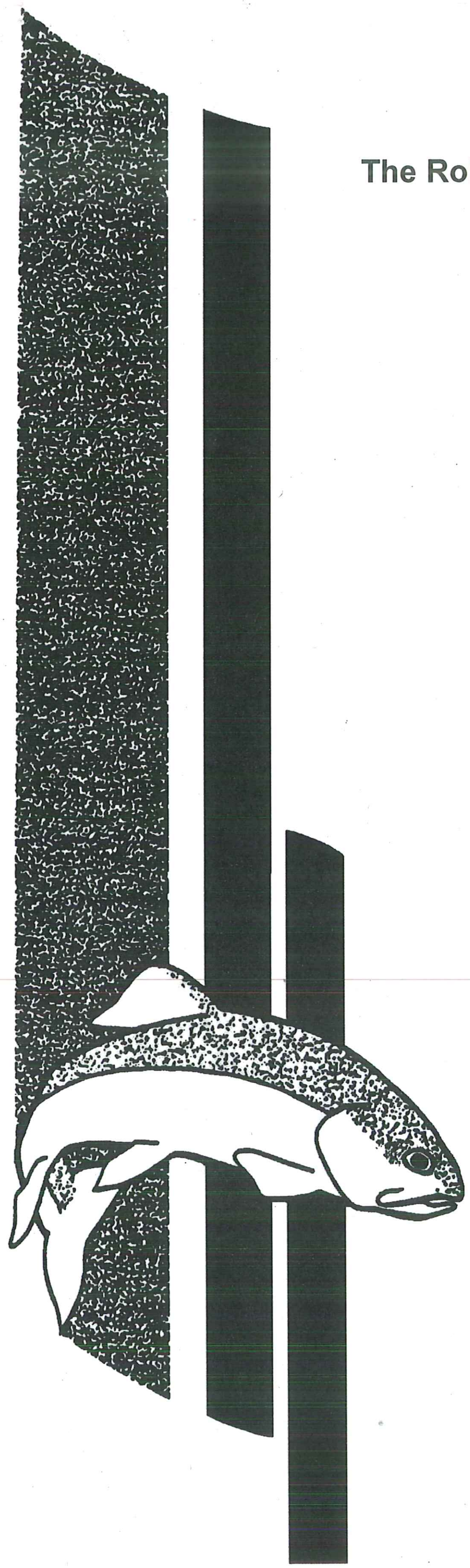

The Roll of Hatcheries in Steelhead Management for British Columbia - A Summary and Recommendations

by

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The role of hatcheries in steelhead management for B.C. – Summary and Recommendations - S. Pollard (revised April 2013)

Introduction

The concept of steelhead enhancement using hatcheries in B.C. is not new. The earliest hatchery initiatives go back to the early 1900s when fish were raised at Fraser Valley Hatchery for release into the Cowichan River in 1902. The federal Salmon Enhancement Program, initiated in 1977 as a way to provide more harvestable salmon, also represented the dawning of major steelhead hatchery initiatives as compensation for incidental catch of wild fish in salmon fisheries. Throughout the 1980s and 1990s, up to 70 or more steelhead streams were stocked (Figure 1). Since this time, stocking has been significantly curtailed, and currently only 16 stocks are augmented annually, all for the purposes of providing retention fisheries, and none for conservation purposes. Termination of programs has been due largely to the inability to obtain enough broodstock to meet production targets, concerns for impacts on wild populations, or the lack of observable benefits to the fishery or natural production. Nonetheless, the Fisheries Program continues to receive requests to increase steelhead hatchery programs. Therefore, a review of the current state of the science may be helpful.

What is the role of hatcheries in steelhead management in B.C.? Objectives for hatchery use in B.C. may have been poorly articulated in the past; even more poorly defined have been performance measures to determine success in meeting these objectives. Artificial fish culture has been proposed in the past as a way to simultaneously address conservation concerns and the lack or decline of sport fisheries. What may not be clear is the fact that a conservation-based objective (i.e. referred to as "hatchery supplementation") is very different from one aimed at sport fisheries enhancement (i.e. referred to as "hatchery augmentation"). So too is the likelihood of success associated with each, at least based on the history of hatchery use to date, based on recent science. In supplementation initiatives, the intent is to increase natural production using the hatchery component to temporarily 'boost' the spawning population. In augmentation initiatives, the sole intent is to provide additional fish to the fishery; there is no intent for the hatchery component to contribution to natural production.

A review of recent science developments on this matter (Ward 2006, 2011) provided an overview of potential genetic and ecological risks associated with the use of hatcheries in salmonid management, and a summary of the Pacific Northwest hatchery experiences, including B.C.'s Living Gene Bank Program (which was part of the Georgia Basin Steelhead Recovery initiative (Lil 2002)). A number of scenarios were considered, and several recommendations were provided. Thus, the purpose of this document is to focus on the role of hatcheries in the two main areas of steelhead management for B.C., provision of a diversity of recreational opportunities and conservation of wild stocks. It is intended to provide guidance to decision makers based on consideration of benefits and risks.

(1) Augmentation of fishing opportunities – When should we use hatcheries to support retention fisheries?

There is no doubt that hatchery augmentation can and does provide substantial numbers of returning adults for harvest opportunities under certain circumstances. If the only management objective was to provide hatchery adults for harvest (i.e., with no consideration of wild stock management and conservation), then the key consideration would be the cost of the program versus return on investment (e.g., number of additional angler days produced). However, current steelhead management policy in BC places the highest priority on conservation of wild stocks. Therefore, hatchery augmentation must consider not only return on investment but also impacts to wild steelhead stocks. The evidence from studies in the nearby U.S. states clearly indicates that allowing significant numbers of hatchery fish to spawn in the wild reduces natural productivity (e.g. Chilcote et al. 2011). Furthermore, work by Chilcote et al. (2011) suggested that for programs in place primarily to provide fisheries, integrated programs fared no better than segregated programs if hatchery fish spawn in the wild. Finally, augmented systems will often attract more anglers; this can result in a mixed stock fishery situation where additional fishing pressure occurs not only on hatchery fish but also on the wild component. Thus, any augmentation program should ensure that the donor stock to be augmented is productive enough to withstand the impacts from naturally spawning hatchery fish and the removal of wild spawners, as well as additional angling related impacts (i.e. handling and related mortality). A slight variation on the augmentation of existing stocks is the situation where hatchery fish are stocked into a system that no longer or never did support a wild stock. Clearly, the receiving stock is not a concern but broader straying concerns with neighbouring stocks still exist.

B.C. steelhead hatchery practices – B.C. steelhead hatchery programs have mainly been in place to provide retention fisheries. Although direct efforts to prevent hatchery fish from spawning have not been made, these programs implement practices consistent with some recommendations from various hatchery reform reviews to minimize risks to wild stocks (summarized in Ward 2011). These practices include:

- marking of all hatchery fish with an adipose fin clip and are harvestable;
- use of only wild broodstock;
- random selection of wild brood;
- maximum 1:1 hatchery:wild ratio in catches; and,
- release of smolts low in the river system.

Recent molecular genetic analyses evaluating changes in genetic diversity in several long-term hatchery augmentation programs (Kitimat, Chilliwack, Chehalis, Alouette, Capilano, and Seymour rivers) suggest that hatchery practices have not altered the genetic structure of the wild population component in any case. These results, however, could also be interpreted to say that the wild populations were sufficiently large and productive enough to absorb any hatchery impacts and/or that numbers of hatchery adult returns spawning in the wild and contributing to the next generation were too insignificant to result in any measurable change (Gow et al. 2011, Heggenes et al. 2006). The results say nothing about impacts to adaptive variation[1] or the ecology of the wild population. These results and associated uncertainty emphasize the need to ensure that all augmentation programs be operated only for wild stocks in the routine management zone (i.e. with no immediate conservation concerns, from Johnston et al. 2002) where recruitment (marine and freshwater) is sufficient to ensure (a) that there is actually a sufficient supply of broodstock fish, and, more importantly, (b) that any negative impacts associated with hatchery-origin spawners do not jeopardize wild stock status.

Experience with creating opportunities where no wild population exists – There are numerous examples in the U.S. where hatchery programs have been established as compensation for the loss of wild stocks associated with elimination of habitat access (e.g., Columbia River and associated dams). These programs have been successful in establishing large numbers of returning adults. However, these programs come at a significant cost. Monetarily, the maintenance of these programs requires significant infrastructure and ongoing resources—the fishery is largely dependent on ongoing hatchery releases and ongoing initiatives to get fish past dams. From an ecological perspective, these programs are

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[1] *Adaptive variation* is characterized by genetic based differences in response to selective factors in the environment.

compensation rather than 'augmentation'. Such compensation-type programs have not occurred on a similar scale in B.C. for steelhead, but the Stave River is one example where the steelhead population has been similarly eliminated by hydro operations and a hatchery-release schedule put in place to provide angling opportunities. This program is considered moderately successful in achieving its goal. However, this is not necessarily representative of other systems with (near-) extirpated wild stocks that have been augmented with hatchery fish. For example, efforts to provide a fishery via augmentation on both the Puntledge and the Campbell rivers failed to generate an increase in returning adults, as a result, the hatchery programs were terminated (M. McCulloch, pers. comm.).

Conclusion and recommendations:

Benefits in terms of providing a retention fishery can be derived from hatchery augmentation under certain conditions. Given that (1) there is limited potential to prevent hatchery adults from reaching the spawning grounds in B.C. and (2) the majority of angled hatchery fish are released (based on 2011 Steelhead Harvest Survey results) and 2010 Survey of Recreational Fishing in Canada, at most 32% are kept regardless of residency status of the angler (Fisheries and Oceans Canada 2012)), we must assume that a significant number have the potential to spawn. It is therefore recommended that:

1) Any consideration of further hatchery development should weigh the ecological, genetic, and economic benefits and costs carefully. Structured decision models that enable consideration of objectives in light of significant uncertainties should be adopted to assist in the decision process ((Irwin et al. 2011).
2) Only moderately to highly productive wild stocks functioning in their Routine Management Zone (Johnston et al. 2002) should be considered for augmentation to provide a retention fishery.
3) Stocks that are naturally unproductive, particularly northern stocks with long juvenile freshwater residencies (e.g. Skeena tributaries) should not be considered for augmentation. Surplus production for such stocks may be fairly minimal even in years when the run is considered relatively strong. For a number of bi ological and logistical reasons, developing an augmentation program for such systems is unlikely to be cost-effective and could put the wild stock at risk.
4) Stocks where marine survival is estimated to be extremely low for wild smolts (regardless of conservation zone) should not be considered for augmentation because hatchery survival at sea will be significantly worse (by 2 or 3 fold).
5) Where hatchery programs can be justified (i.e. moderate to high marine survival and productivity, minimal risk to wild stocks), additional criteria must be met to ensure site-specific net societal benefits are achieved.

6) Finally, establishing hatchery programs in systems that no longer support wild populations of steelhead should only occur after very careful consideration of the full breadth of costs and benefits. Such an undertaking requires significant committed resources to ensure the program can be properly maintained and monitored. Selection of an appropriate source broodstock and the confirmation that the habitat is unable to support a self-sustaining wild population are key factors. In light of these and other significant factors (risks to nearby stocks, marine conditions), the ability to develop such programs seems unlikely.

(2) Supplementation of natural production – When should we use hatcheries to rebuild depressed wild populations?

Direct and circumstantial evidence from recent research and modeling indicates that the use of hatcheries in Pacific salmon management (including steelhead) has provided little to no net benefit to natural production, and in fact is thought to have hindered recovery of wild stocks by depressing reproductive fitness and natural productivity of stocks. The most compelling evidence is from Chilcote et al. (2011) who considered 89 stocks of steelhead, coho and chinook across three states. Regardless of program design (segregated versus integrated[2]), they found that the intrinsic productivity of the stock decreased significantly as the fraction of hatchery spawners increased, thus hampering rebuilding potential. This study reflects the findings of numerous other studies that concluded that hatchery fish had a reduced ability to produce viable offspring even though they may return as spawners in significant numbers (Christie et al. 2012, Leider 1990, Kostow 2004, McClean et al. 2003, Berejikian and Ford 2004, Araki et al. 2007, 2009). These studies also observed that hatchery steelhead performing best in hatchery conditions, performed worst in wild conditions due to rapid domestication effects of the artificial environment, resulting in rapid reduction in reproductive success even within a single generation. Furthermore, Araki et al. (2009) noted that this effect was carried over to the next generation, suggesting that impacts will be cumulative over time. Chilcote (2003) found that in a naturally spawning population of equal numbers of hatchery and wild steelhead, the population would produce up to 63% fewer recruits per spawner than one comprised entirely of wild fish. A newly published account of adult hatchery steelhead out-planting to boost juvenile production similarly found no net benefit to 14 years of out-planting in an Idaho stream. Specifically, no demographic response in

[2] *Segregated* hatchery programs are designed to minimize ecological and genetic interactions through the isolation of hatchery fish from natural production. *Integrated* hatchery programs are designed to manage hatchery fish as an integral contributing component of total production of a stock (i.e. interbreeding between hatchery and wild fish is intended).

terms of increased wild spawner abundance was noted when hatchery adults were placed upstream to spawn naturally even though these fish initially boosted parr numbers (Byrne and Copeland 2012).

In stark contrast to almost all other publications, the Nez Perce Tribe recently published results of a 12- year chinook salmon supplementation initiative in the Columbia basin. This study found that with the use of only local wild-origin broodstock, a boost to the population size was successful with minimal impacts to wild salmon fitness (Hess et al. 2012). One significant difference between this study and steelhead-related study results is the longer freshwater residency time and greater density dependence[3] observed in steelhead. Concerns regarding study design have also been identified, and caution is recommended regarding conclusions given that the study only considered three years of return data and did not demonstrate a sustained increase in wild abundance or effects on productivity (Oregon Fish and Wildlife Scientific Summary Review, unpublished).

While no B.C. studies provide direct cause and effect evidence either way on the question of hatchery supplementation, results from a number of analyses and program reviews support the general findings described above, as follows:

The Living Gene Bank (LGB) program – This experimental rebuilding initiative for three east coast Vancouver Island steelhead stocks (Keogh, L. Qualicum, and Quinsam rivers) was initiated in 1998 (see Ward, 2006, 2011 for summary). Genetic analyses indicated that the broodstock used were representative of the wild population and broodstock and smolt release targets were met, in general. However, subsequent recruitment in the wild (i.e., the rebuilding) from LGB returns appeared to be little or none, given the large number of LGB adults versus low numbers of wild adults that returned to the Keogh River fence (the only system where rigorous monitoring was conducted) and the subsequent wild smolt output in the years that followed (McCubbing 2010). Furthermore, there were significant ecological (e.g. competition) concerns regarding the large number of LGB smolts that residualized. A parentage analysis was ultimately required to determine if the LGB program made any positive contribution to smolt yield. However, this analysis was not supported and later it was concluded to be unjustified based on the lack of a response in smolt recruits. Wild smolt recruitment (smolts/spawner) has improved post-LGB.

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[3] *Density dependence* refers to factors that affect the population according to the density of the population. In this case, density dependence affects juvenile survival and growth while in freshwater; as the population becomes denser, resources become increasingly limiting, affecting growth and survival.

Cheakamus River post-spill steelhead recovery initiative – A two-year hatchery program was initiated for steelhead in response to the caustic soda spill into the Cheakamus River in 2005 by CN rail. Smolts were released in 2007 and 2008. Recent studies have indicated that post-release survival for hatchery smolts was considerably lower (23 to 36%) than wild smolts (69 to 72%) during migration to the Squamish River mouth. This difference was maintained for the first few 100 km of ocean travel (Melnychuk et al. 2009). More recently, it has been concluded that re-seeding of the habitat could have been achieved without any hatchery contribution. The benefits to aiding recovery were illusive and undetermined, and the attempt to offset angling impacts due to potential low returns were modest at best – there was no indication of an increase in catch due to the presence of hatchery fish other than a few returns.

Trends in south coast wild steelhead abundance (Smith and Ward 2000) – This comprehensive analysis of the steelhead harvest survey data that has been collected annually found a number of relationships and trends. Particularly for the rainfall-driven systems of the north and south coasts, abundance of adult steelhead as estimated from catch-per-angler-day was strongly influenced by marine survival. However, after 1990, north coast and west coast Vancouver Island trends diverged from lower mainland and east coast Vancouver Island trends with the former continuing to track upwelling conditions (which improved survival) while the latter continued to decline. A number of hypotheses were proposed, including association with environmental patterns, high hatchery augmentation, urbanization, and high angler use. However, of particular concern was that fact that stronger declines in catch were observed for wild steelhead in hatchery-augmented systems than for wild steelhead in wild-only systems. The underlying reason was unknown, but augmented systems attract angler effort (Smith 1997). Impacts might thus have been either due to by-catch mortality or negative genetic/ecological interactions. Either way, these results suggest an indirect impact on overall production in augmented steelhead rivers.

<u>Conclusion and Recommendations:</u>

There is no substantiated evidence to suggest that hatcheries can provide a sustained positive contribution to natural steelhead production. In fact, the available direct evidence is to the contrary. Furthermore, indirect evidence suggests that where marine survival is depressed, there appears to be a stronger negative relationship for hatchery-supported systems. In comparison, the Cheakamus experience suggested that, when ocean survival is supportive, and there are no freshwater limiting factors (i.e. factors that reduce the capability of freshwater habitat to produce fish), steelhead stocks are capable of rebuilding rapidly without hatchery support. Chilcote et al. (2011) recommended that wild fish should only be brought into a hatchery environment to prevent extinction of a genetic lineage as a last resort. Long-term conservation of wild stocks is best served by minimizing hatchery/wild interactions (e.g. Nickelson 2003). In no case are we currently in a last-resort situation for steelhead populations in B.C., and developing supplemental programs would be a poor investment that could further damage natural production. We therefore recommend that until such time as the risks and uncertainties associated with supplementation have been reduced, and benefits to natural production are evident, supplementation programs should not be considered in recovery initiatives for depressed wild steelhead stocks. Activities instead should focus on directly addressing the source of the problem for these fish.

(3)

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Table 1. Current steelhead hatchery programs as of 2012 and 2013 (some programs only occurred in one or the other year).

Region	Receiving Watershed	Stock Ecotype	Wild Stock Status	Broodstock Source	Annual Smolt Release Target	Hatchery
1	Quatse	winter	~ECC	wild	20,000	Community
1	Cluxewe	winter	~ECC	wild	20,000	Community
1	Stamp/Somass	winter	RMZ	wild	70,000	Federal
1	Stamp/Somass	summer	RMZ	wild	30,000	Federal
2	S. Alouette	winter	RMZ	wild	25,000	Community/FFSBC
2	Capilano	winter	~ECC	hatchery	20,000	Federal
2	Capilano	summer	~ECC	hatchery	10,000	Federal
2	Chapman	winter	?	wild	10,000	Community
2	Chehalis	winter	RMZ	wild	40,000	Federal
2	Chehalis	summer	RMZ	hatchery	25,000	Federal
2	Chilliwack	winter	RMZ	wild	125,000	Federal
2	L. Campbell	winter	CC	wild	10,000	Community/FFSBC
2	Seymour	winter	~ECC	hatchery	10,000	Community
2	Seymour	summer	~ECC	hatchery	20,000	Community
2	Stave	winter	N/A	hatchery	2,000	Federal/FFSBC
6	Kitimat	winter	RMZ	wild	50,000	Federal

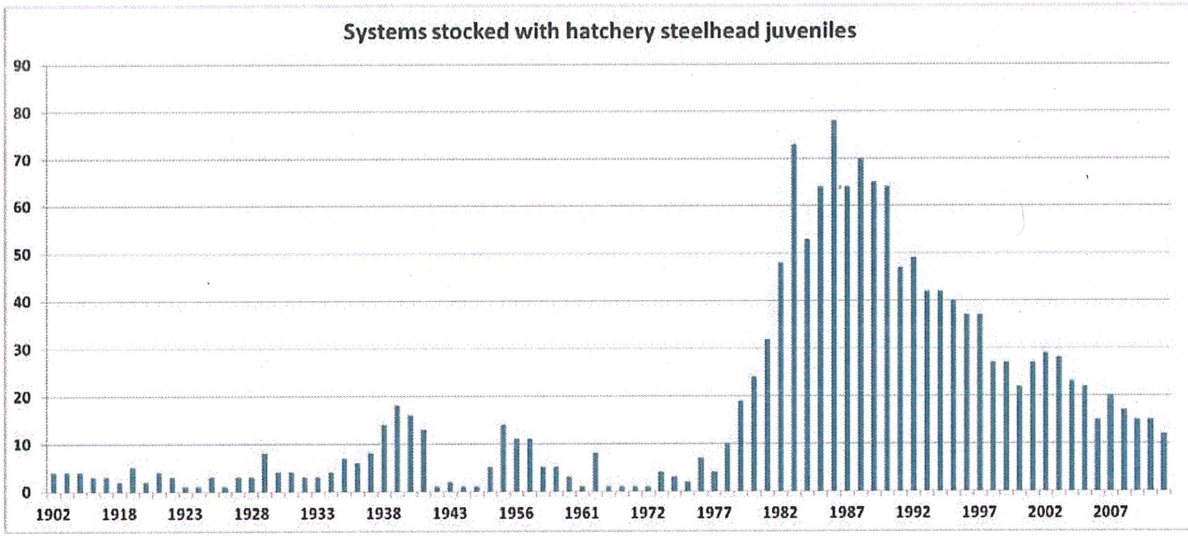

Figure 1. Numbers of waterbodies (almost all are streams) stocked with hatchery steelhead juveniles (including eggs, fry, fingerling, parr and smolts) in B.C.