

Understanding Coho Production at the Chilliwack River Hatchery



Juvenile coho in a holding tank prior to marking by adipose fin-clip (*Image courtesy of Bob Stanton*)

Further Information

For general information about Pacific salmon go to www.pac.dfo-mpo.gc.ca/species/salmon.

For up-to-date information on smolt releases, and for additional background about the hatchery, go to www-heb.pac.dfo-mpo.gc.ca and follow the links to > [Salmonid Enhancement Programs](#) > [Chilliwack](#).

For a schedule of upcoming consultations and supporting information, go to the Consultation Secretariat website at www-comm.pac.dfo-mpo.gc.ca/pages/consultations/consult_e.htm.

NOTE: This report has been prepared for the Chilliwack Coho Working Group. All statements need to be verified and should not be misconstrued as official DFO policy.

1. Introduction

Pacific salmon hatcheries have been at the center of much controversy. Advocates present hatcheries as a conservation tool for salmon stocks at risk, but opponents warn of potential interactions between hatchery fish and wild populations.

This handout provides a brief overview of coho production at the Chilliwack hatchery and is intended as a companion piece for presentations and discussions throughout the Chilliwack watershed during the Fall of 2005. To support these discussions, this handout describes the points at which we can intervene in the life cycle of hatchery coho, some of the choices we have to make, and the sources of uncertainty that influence our strategy. The goal is to improve public understanding of coho production at the hatchery, and lead into a discussion of alternative objectives.

2. History of Coho Production at the Chilliwack Hatchery

The Chilliwack River Hatchery accommodates the freshwater life history of Pacific Salmon. Adults are trapped, held and spawned. Eggs are fertilized, incubated and hatched. The juveniles are then reared until they are sea-ready. The hatchery infrastructure consists of engineered incubation, juvenile rearing, and adult holding ponds.

The hatchery, completed in 1980, is located on the Chilliwack River, centered in a section of the river that is accessible to migrating salmonids. At the time of hatchery construction there were only a few, very small coho populations spawning in this stretch of the Chilliwack River, while the largest natural spawning areas were in the upper Chilliwack watershed and within the Vedder River tributaries. The hatchery started its coho enhancement program with broodstock taken from three tributary populations representative of the three main spawning areas within Chilliwack watersheds: Dolly Varden Creek (upper watershed, early spawn timing), Post Creek (middle watershed and middle spawn timing), and Salwein Creek (Vedder tributary population with a late spawn timing). Since 1985, the broodstock has been taken exclusively from adults returning to the hatchery, and the run has built up to about 65,000 adults, of which about 6,000 are intercepted along the adult migration, about 10,000 are caught in the local recreational fisheries, about 10,000 spawn naturally elsewhere in the watershed, and about 40,000 return to the hatchery. This results in a substantial surplus over the up to 2,000 spawners needed for full hatchery production, and this surplus provides fish for First Nation's communal use, as well as economic opportunities when possible.

Although the coho program at the Chilliwack River Hatchery started as a rebuilding and production initiative rather than a conservation effort, DFO is now evaluating the relative benefits and risks of different production targets (i.e. different numbers of smolt to be released) in the light of wild salmon conservation, protection, and preservation.

3. Conservation Considerations under the Wild Salmon Policy

In June 2005, DFO released the *Wild Salmon Policy* (WSP) which outlines the principles for the conservation of wild Pacific salmon. Over the next few years the Department will work with First Nations and stakeholders on necessary research and practical implementation.

One key element of the *Wild Salmon Policy* is the concept of *Conservation Units* (CU), which describe aggregates of salmon populations that are genetically independent of each other. Each CU contains one or more spawning *populations*, and spawners from each population may use several specific spawning sites, called *demes*. Coho currently spawn in at least 25 distinct natural sites throughout the Chilliwack River and its tributaries, not including 14 man-made spawning channels. As the WSP is implemented, these natural spawning sites would probably be grouped in about 25 demes within the *Lower Fraser/Southern Georgia Strait Conservation Unit for Coho*, but conservation units are still being finalized.

Under the *Wild Salmon Policy*, salmon are considered wild if they are offspring of fish that spawned and grew up in natural surroundings. This means that there are three types of coho in the Chilliwack River watershed:

- **Wild coho** (*Not marked*): Spent their entire life cycle in the wild and originate from parents that were also produced by natural spawning and continuously lived in the wild (2 consecutive generations spawning naturally)
- **Hatchery coho** (*Marked*): Reared in the hatchery until smolt stage, matured in natural surroundings, fin-clipped prior to release.
- **Naturally spawning coho with hatchery parents** (*Not marked*): Hatched and grew up in natural surroundings, but have at least 1 hatchery-reared parent.

The contribution of hatchery-marked coho to naturally spawning populations in the Chilliwack River watershed varies from year to year, with substantial contributions to as few as 5, and as many as 16, of the 25 spawning sites, and with higher occurrence near the hatchery (called the *footprint*).

The intent of the *Wild Salmon Policy* is to conserve each salmon species by protecting the abundance and genetic diversity of wild salmon in the natural spawning sites (*demes*) within the appropriate conservation units, such as the *Lower Fraser/Southern Georgia Strait Conservation Unit for coho*. However, understanding the potential hatchery-wild interaction is a challenge, with year-to-year variability in hatchery contribution to each spawning population, changes in abundance, straying between populations, and different degrees of mixing. The potential influence of the hatchery program on abundance and genetic diversity of coho in the Chilliwack watershed are reflected in the management objectives described later in this handout.

4. Life Cycle of Chilliwack Coho

Chilliwack coho, like most coho stocks, generally follow a 3 year life cycle, illustrated in Figure 1. While some Chilliwack coho return at age 2 (~6 out of every 100) and a few return at age 4 (less than 1 in 1000), the examples and illustrations in this handout use only the 3-year life cycle for simplicity.

The hatchery follows a regular annual schedule, with adult coho collected to represent three relatively distinct timing groups (Early, Middle, Late). Broodstock collection coincides with natural spawning from late October to late December, and is designed to represent the full diversity of adults returning to the hatchery site. Hatchery staff collect roe and milt, and incubate the fertilized eggs until spring, when the young coho hatch in the *alevin* stage. As *emergent fry* they are transferred to rearing containers, and then into larger ponds where they grow until *smolt* stage the following spring. Smolts have completed the physiological changes necessary for transition into saltwater, and in late April access to the Chilliwack River is provided so that the smolts can begin their down-river migration (*volitional release*). By the time it is released, each coho smolt has been carefully raised at the Chilliwack River Hatchery for 18 months.

Chilliwack coho then remain at sea for 16 to 18 month before returning to complete the cycle. Coho from the Fraser River tributaries have been intercepted throughout the eastern Pacific from Alaska to Oregon, but most remain off the Southern B.C. coast. The majority of Chilliwack coho either hold in the Strait of Georgia and Puget Sound (*inside distribution*) or along the West Coast of Vancouver Island (*outside distribution*), which has been predominant in recent years. Historically, coho were exposed to much higher fishing pressure during years with inside distribution, but fishing regulations have also changed since then.

After a year at sea, coho begin the migration to their native watershed for spawning. Most of the hatchery coho return to the hatchery site, but a variable portion disperses to other spawning sites. Marine fisheries intercepting Chilliwack coho take place each summer along the marine migration route. Freshwater sport fisheries occur in the fall along the Fraser River and throughout the lower Chilliwack River. First Nations have access to salmon at the hatchery site for communal use and economic opportunity.

Coho from the 2005 brood year hatch in the spring of 2006, are reared in the hatchery until the spring of 2007, mature at sea until the spring of 2008, migrate south along the BC coast during the summer and early fall of 2008, and finally return to the Chilliwack River in the fall of 2008.

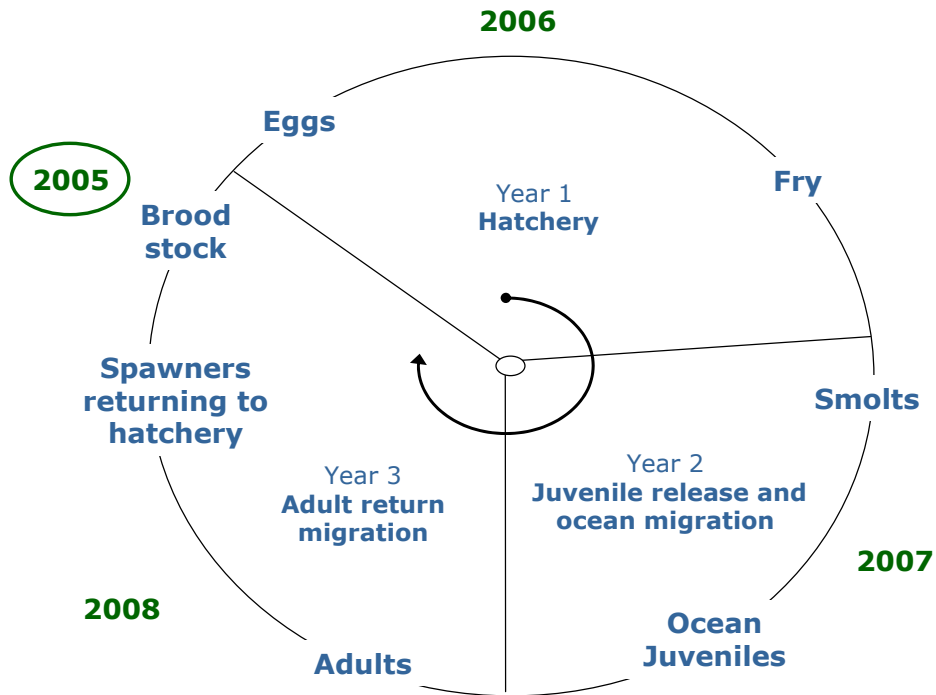


Figure 1: Life cycle of coho from the Chilliwack River Hatchery.

Note: This diagram only shows the typical 3-year life cycle, not the 2-year life cycle for small numbers of jacks or the rare 4-year life cycle.

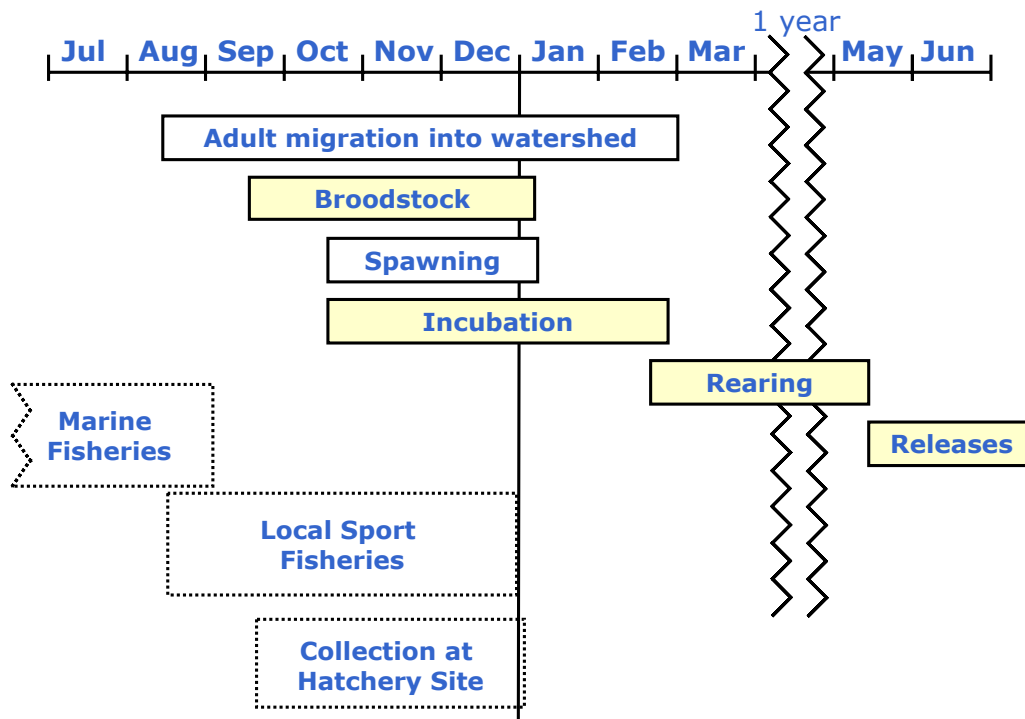


Figure 2: General timeline of coho production at the Chilliwack River Hatchery

Note: This diagram only shows the part of the lifecycle that occurs at the hatchery.

5. Intervention Points and Sources of Uncertainty

DFO can intervene at three points in the life cycle of Chilliwack coho: (1) hatchery operation, (2) harvest management, and (3) habitat condition. Any action with respect to one of these can affect the others. In terms of the coho enhancement program, we have to deal with two aspects: (1) the number of adult salmon returning for any given number of released smolts, and (2) the effects of the hatchery program on wild coho, other salmon species, and the whole watershed.

Over two decades, the coho program at the Chilliwack River Hatchery has successfully built up the return of adult coho, and hatchery staff have refined the day-to-day procedures for raising juvenile coho. Detailed protocols have been developed with an emphasis on keeping hatchery coho genetically similar to wild coho in the watershed, and releasing healthy smolt (e.g. minimal handling, reduced stress, broodstock screening, optimum densities, feed quality checks). Operational protocols for the Chilliwack River Hatchery are available upon request, and formal *Fish Health Management Plans* are being drafted. The hatchery achieves a consistently high survival, requiring only about 1,250 spawners to produce 1.2 Million smolts (compared to about 70,000 in the wild). Under current marine conditions, we can expect between 2 and 5 adults in the ocean for every 100 hatchery smolts we release (1.5% to 4.5% marine survival, compared to 10% to 15% in the 1970s).

Chilliwack coho are harvested in marine fisheries, and in terminal fisheries within the Fraser River and the Chilliwack River watershed. The total marine exploitation depends strongly on the geographic distribution of Chilliwack coho and fisheries regulations, but with the current outside distribution (off the West Coast of Vancouver Island) and existing conservation measures (e.g. marked-only retention and closures to protect Thompson coho), marine harvesters take between 8 and 12 of every 100 hatchery adults. Harvest in the mainstem of the Fraser River tends to be small and incidental. Fishing effort in the recreational fishery in the Chilliwack River is more substantial. In recent years it reached up to 270,000 angler hours and took between 15 and 26 of every 100 hatchery coho returning into the watershed. Recreational fishing effort and the resulting local economic benefits are influenced by multi-year trends in individual angler satisfaction, which is directly linked to catch-per-effort for all species, but hatchery coho are an important part of this fishery. Of every 100 hatchery fish that return to the Chilliwack River, 5 to 15 spawn naturally.

In recent years the Chilliwack coho program has produced a consistent surplus of about 40,000 adults in addition to the 1,000 to 2,000 adults needed for broodstock. This surplus is available to First Nations for communal use, or for economic opportunities.

The resilience of wild coho in the Chilliwack watershed strongly depends on the availability and quality of different types of habitat for each of the freshwater life stages. However, coho habitat is affected by many factors that fall outside DFO's mandate, such as urban development, agricultural

practices, and logging. This is a big issue which requires watershed-wide discussion and co-ordination of efforts to protect and restore valuable salmon habitat.

6. Objectives

Two groups of objectives influence coho production at the Chilliwack hatchery: Conservation and sustainable fisheries. To achieve these objectives, the hatchery works towards specific operational goals, described below. For each of these objectives, we have to develop clear performance measures and targets (some suggestions included below). NOTE: Some of these objectives will be refined during WSP implementation.

Conservation

- Build and maintain abundance of wild coho in their natural habitat
- Preserve genetic integrity of wild coho populations
- Keep hatchery coho genetically similar to wild coho
 - Proportion collected from each timing group
(*early, middle, late*)
 - Proportion of unmarked fish in broodstock
(*10-15%, collected at hatchery site*)
- Facilitate selective fishing and monitoring of hatchery fish
- Improve understanding of wild coho populations and potential interactions with hatchery coho

Sustainable Fisheries

- Provide fish for First Nations' communal use
- Maintain stable opportunity in local recreational fisheries, with reasonable expectation to catch
 - Angler hours in the watershed per year
(*Recent Performance= 150 to 250 thousand angler hours/year*)
 - Local recreational catch-per-effort
(*Recent Performance= Avg. 4-8 hours to catch 1 coho*)
- Provide economic harvest opportunities when possible.

Operational Goals

- Maintain or adapt abundance of hatchery coho to meet conservation and fisheries objectives
- Adapt to changes in long-term environmental conditions (e.g. marine survival)
- Avoid drastic changes in hatchery production to minimize fishery-related impacts
- Maximize efficiency of coho production (maximize survival from egg to adult, minimize cost)
- Adequately assess status of wild coho and hatchery operating protocols
- Improve public understanding of hatchery operations and the balance between objectives
- Improve public understanding of stewardship and habitat protection (i.e. conservation objectives)

7. Choices and Possible Consequences

The most fundamental question for the coho program at Chilliwack hatchery is the production target for juveniles:

We currently use the existing facilities at the Chilliwack River Hatchery to produce around 1.2 Million coho juveniles. Is this the production target that achieves the best balance between considerations for wild salmon and harvest-related benefits?

As described earlier, the average survival from smolt to adult currently is between 1.5% and 4.5%, so we can expect 1,500 to 4,500 extra adults in the ocean for every 100,000 additional smolts released. Given the year-to-year variability in catches, migration mortality, and hatchery adults spawning naturally, smolt releases need to change by several 100,000 before any real difference in performance can be detected.

The production target for coho seeks to find a balance between a range of objectives, but also needs to adapt to ever-changing circumstances. For example, if survival from smolt to adult was poor for several consecutive years, the hatchery would have to choose between alternative approaches such as:

- *Reduced* hatchery production to reduce possible wild/hatchery interactions while wild populations are at lower productivity.
- *Increased* hatchery production to compensate for reduced returns and maintain escapement into the watershed while sustaining harvest opportunities and local economic benefits.

The process of developing production targets can benefit from two separate pieces of information:

- A *conceptual model* of plausible outcomes, to illustrate the range of scenarios. This rough sketch can be developed quickly, and has the added benefit of transparency in discussions with stakeholders. However, it is a starting point, not a substitute for a full analysis (Figure 4).
- A *detailed model*, which more realistically captures all the components of the hatchery coho life cycle, interactions with wild populations, and harvest dynamics, and how all of these components depend on each other and change over time. This detailed model, though ultimately needed, is still in the early stages of development.

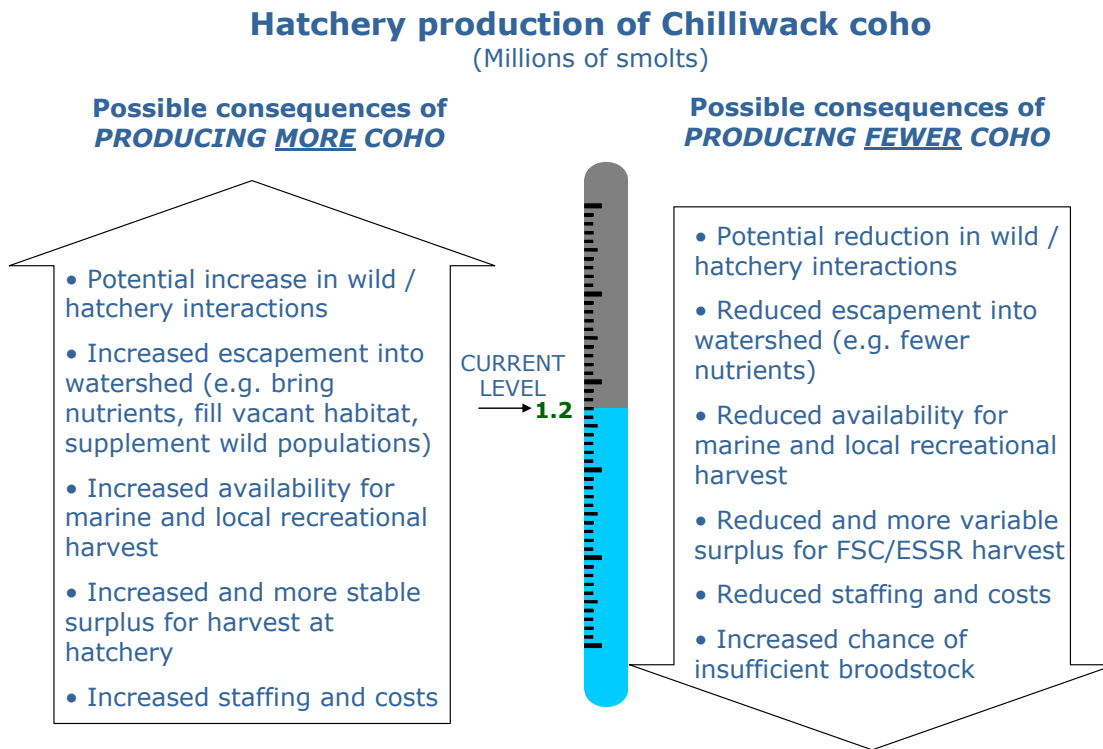


Figure 3: Possible consequences of changing coho production targets

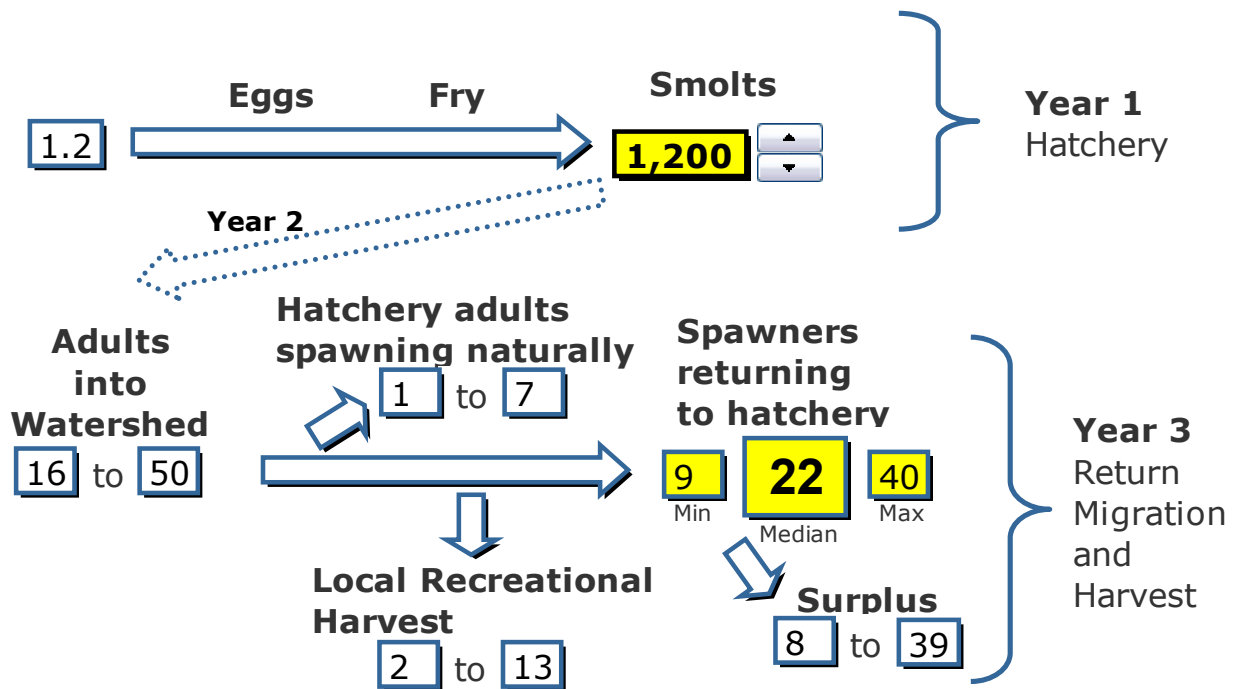


Figure 4: Rough evaluation of alternative production targets (Virtual Napkin)
(NOTE: All numbers in 1000s of simulated hatchery fish)

8. Operational Measures to Address Potential Conservation Concerns

Each step of the coho production program at the Chilliwack River Hatchery has been carefully developed to reduce potential harm to wild salmon stocks and the environment. This section lists some commonly raised concerns associated with salmon hatcheries, and a brief description of relevant measures in the Chilliwack River Hatchery.

Potential Concern: *Broodstock Collection*

Three distinct concerns are frequently mentioned with regard to broodstock collection: (1) indiscriminate movement of fish from one watershed to another, (2) changing run timing by collecting brood stock solely from the early part of the run, (3) and maintaining production by unsustainably collecting broodstock from populations at low abundance.

Response: *These concerns do not apply to the Chilliwack coho program.*

Hatcheries throughout B.C. follow strict guidelines for broodstock collection, and all fish movements are reviewed by the *Introductions and Transfers Committee*. For the Chilliwack coho program, the original broodstock was collected from the same watershed (Dolly Varden Creek, Post Creek, and Salwein Creek) and since then the broodstock has been carefully collected from the entire run returning to the hatchery, not just the early part. After the original broodstock was collected from wild populations, the hatchery has been stocked exclusively with adults returning to the hatchery, which include wild and naturally-reared fish (10-15 of every 100). These measures serve to keep the hatchery population similar to wild coho in the watershed (see objectives on Page 7).

Potential Concern: *Competition with wild coho?*

Ecological effects of hatchery salmon can include displacement of wild juvenile salmon in freshwater rearing environments as well as competition for food and space. There are also concerns about the impacts of enhanced salmon on wild salmon in the marine environment during times when the carrying capacity of the ocean may be limited.

Response: *Available data do not support this concern, and guidelines are in place to minimize the potential consequences.*

The potential severity of competition depends on the factors that are limiting coho productivity in the watershed, and the operation of the hatchery program. Potential competition with wild coho during the down-river migration of smolts and the early stages of marine growth can be minimized by releasing juveniles of appropriate size at the right time. Hatchery-specific rearing and release guidelines are in place to address this, and available data show that it is not an issue for Chilliwack coho. The potential consequences of hatchery adults spawning naturally are complex and specific to each watershed, because hatchery fish can supply much-needed nutrients, fill vacant habitat, and supplement wild populations, but may also compete for spawning sites. In the Chilliwack watershed, Fisheries and Oceans Canada monitors the contribution of hatchery adults to natural spawning populations (see below), and available data show that competition at this stage in the coho life cycle

is not a concern. If wild coho returns are suppressed by limited ocean capacity, then the cumulative effect of all hatchery releases could be potentially harmful. However, we do not have sufficient advance warning of changes in ocean capacity to adjust the number of hatchery fish released, nor do we understand how production targets could correspond with ocean capacity. Relevant research could provide better information for incorporation in operational guidelines.



Potential Concern: *Hatchery production leads to increased harvest of wild stocks?*

Hatchery production could be used to maintain or build up fisheries, and mask the effects of declining wild stocks.

Response: *This is not an issue for coho production at the Chilliwack hatchery.*

Since 1998, Fisheries & Oceans Canada has implemented stronger conservation measures to protect weak coho stocks. As a part of region-wide conservation measures for coho, commercial fisheries intercepting coho have been closed or severely constrained, and most marine and in-river recreational fisheries only permit retention of hatchery-marked coho. All Chilliwack hatchery coho are marked by fin clips.



Potential Concern: *Genetics*

Each salmon population is uniquely adapted to the particular conditions of its migration route and spawning site. Two potential concerns exist with regard to the genetics: loss of genetic diversity and domestication. Loss of genetic diversity could occur if individual fish from the local enhanced population stray to other systems or if hatchery fish from non-local brood stock mate with local fish. Domestication (i.e. adaptation to an artificial environment) could be caused by different selective pressures in the early life stages (in hatchery vs. in the wild) or by mating of close relatives in the hatchery. These processes can result in genetic differences between the hatchery population and the wild population, which may lose its adaptation to a particular watershed through on-going interbreeding.

Response: *Guidelines are in place to keep hatchery coho similar to wild coho, and hatchery contribution to wild spawning populations is monitored.*

Hatchery-specific operational guidelines prescribe the collection of broodstock (discussed above) and their use in appropriate spawning designs to maintain genetic diversity. At the Chilliwack hatchery, a large number of broodstock are spawned which reduces the likelihood of mating close relatives, and only local broodstock is used. Straying is managed through the use of appropriate rearing and release practices. Finally, overall hatchery performance is measured in terms of survival rate over the full life cycle, not just by the number of smolts released. The Chilliwack River Hatchery has successfully produced juveniles that exhibit similar survival as wild fish. Hatchery fish are marked by fin-clips, and Fisheries & Oceans Canada monitors the hatchery contribution to wild spawning locations (i.e. *demes*).

9. Questions for public discussion (Examples)

While preparing this information handout, we identified a series of questions for further discussion, and are now seeking your feedback. To provide responses to the questions below, please contact one of the Working Group members listed in the Contact Information below. Written responses are the most useful.

- Did this information package give you a better understanding of coho production at the Chilliwack hatchery?
- What additional information would you like to see in future versions of this package?
- Based on considerations for wild salmon and harvest-related benefits, how can we find a balance between different objectives?
- Based on the objectives listed on Page 7, do you support the general approach of the coho enhancement program at the Chilliwack River Hatchery?
- Given the wide range of factors that influence the life cycle of hatchery coho (Page 6), which information should we consider when setting a production target for coho smolts?

Contact Information

Management Direction

Bob Stanton (DFO – Chilliwack)
Phone: (604) 858-7227
E-mail: StantonR@pac.dfo-mpo.gc.ca

Team Lead

Tom Cadieux (DFO – Annacis)
Phone: 604-220-3455
E-mail: CadieuxT@pac.dfo-mpo.gc.ca

Lead Author

Gottfried Pestal (SOLV Consulting Ltd. - Vancouver)
Phone: 604-420-1528
E-mail: gpestal@solv.ca
Web: www.solv.ca

