

Salmon Enhancement Efforts: a hatchery perspective

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What is happening?

Since the late 1980s, Pacific salmon stocks throughout Canada and the U.S. have been subject to decline, influenced by climate change, habitat degradation, over-fishing and pathogens^{1,2}. In Átl'ka7tsem/Txwnéwu7ts/Howe Sound, Pacific salmon (*Oncorhynchus* sp.) are important species socially, culturally and economically. There are concerted efforts from community all the way through to federal-level government to conserve and restore salmon populations throughout the Átl'ka7tsem/Txwnéwu7ts/Howe Sound



Pink salmon, *Oncorhynchus gorbuscha*. (Credit: Tracey Saxby)

i) Pathogens – Disease-causing agent

watershed (see [Salmon](#), Ocean Watch Howe Sound Edition [OWHS] 2017). However, the current lack of comprehensive, local data on wild salmon populations in Átl'ka7tsem/Txwnéwu7ts/Howe Sound is a key

challenge in moving these efforts forward. This lack of information has also led to the primary focus of this article being hatchery enhancement efforts.

What is the current status?

Citizen science groups play an important role in protecting and restoring salmon habitat (See [Citizen Science](#), OWHS 2020). For example, the Bowen Island Fish and Wildlife Club (BIFWC) monitor the health of local creeks, work on restoration projects in impacted waterways and engage with schools and communities to educate about salmon conservation.³ There has also been mobilization on multiple projects in the Sk̓wx̓wú-7mesh/Squamish area aimed at reducing threats to salmon populations and restoring habitat, undertaken by the Squamish River Watershed Society and the Squamish Streamkeepers Society, amongst others.

Tenderfoot Creek Hatchery, funded and run by Fisheries and Oceans Canada (DFO), and the Bowen Island Terminal Creek Hatchery, run by BIFWC, under the supervision of DFO, are playing a key role in salmon conservation and restoration in Átl'ka7tsem/Txwnéwu7ts/Howe Sound. Adult females are caught before laying their eggs. The eggs are harvested and cared for at these salmon hatcheries, before being released as juveniles. Bowen Island Hatchery produce chum and coho for release yearly, and pink during odd years.³

Hatchery-raised salmon theoretically have higher survival rates than their wild counterparts, due to experiencing fewer environmental impacts (e.g., flooding, predation, lack of nutrition); however, this is not conclusive.⁴ Conditions during the young salmon's early marine period impacts their growth, and in turn their survival rates, and this can vary between and within years.⁵ Regardless, these programs are an effective tool to help increase salmon populations.

There are currently no comprehensive escapementⁱⁱ data or stock assessment programs available for Átl'ka7tsem/Txwnéwu7ts/Howe Sound salmon populations. Instead, DFO salmon stock assessments occur for the entire Strait of Georgia Conservation Unitⁱⁱⁱ. The limited data that are available in Átl'ka7tsem/Txwnéwu7ts/Howe Sound for five Pacific salmon species (i.e., Chinook, chum, pink, coho and sockeye) show high variability between years with no clear trends in the numbers of adult salmon returning to spawn in the Sound's rivers. Information on individual species is detailed below.

ii) Escapement – the number of salmon that are not caught in fisheries (commercial, recreational, ceremonial) and return to their freshwater spawning areas.

iii) Conservation Unit – a group of salmon that is isolated enough from other groups that the population would struggle to repopulate if extirpated.

Chinook salmon (*Oncorhynchus tshawytscha*)

Overall, Strait of Georgia Chinook populations appear to be bouncing back from historic lows noted in 2009. Chinook returns have doubled since the program started in 2014. The Tenderfoot Creek Hatchery Chinook brood program produces over 200,000 smolts^{iv} and fry^v that are released back to their natal rivers each spring.⁶ All returning adults, used as brood stock, are caught via tangle nets or set nets in the Cheakamus, Mamquam, Ashlu, Shovelnose, and Elaho river systems.

Hatchery staff have observed strong returns of hatchery-bred adults in all enhanced river systems in 2018 and 2019.⁶ For the first time since the program began, in 2018 and 2019, many large four- and five-year-old returning hatchery fish were observed and caught by hatchery staff in the aforementioned rivers, and intercepted in recreational fisheries along the B.C. coast.⁶ Not enough data have been collected to assess



DFO staff capture brood stock via nets, before transferring to hatchery grounds. (Credit: Jordan Uittenbogaard)

the overall success of the hatchery programs; however, preliminary observations suggest the program is on track to meet the intended conservational goals of bringing the populations back to historical levels.⁶

Outside of hatchery data collected by Tenderfoot staff, no concrete escapement data for Átl'ka7tsem/Txwnéwu7ts/Howe Sound are available. Most stock status is calculated using details from hatchery staffs' daily catches during the Chinook brood program (July-September). Skwxwú7mesh Úxwumixw/Squamish Nation conduct a dead-pitch program^{vi} during spawning season to better estimate escapement data and determine population health.

Conversely, in the Cheakamus River, a tributary to the Squamish River, a B.C. Hydro study from 2018 showed that estimates for Chinook salmon have followed the trend of low-abundance years since 2014.⁷



Juvenile chum salmon getting ready to be released at the Bowen Island Hatchery. (Credit: Bowen Island Hatchery; Bowen Island Fish and Wildlife Club. Reproduced with permission from Tim Pardee.)

- iv) Smolts – a young salmon, when it becomes the adult silvery color and migrates to the ocean for the first time.
- v) Fry – small, young fish that are just emerging from their gravel nest.
- vi) Dead-pitch program – population assessment program where carcasses are recovered to get population numbers.

Chum salmon (*O. keta*)

The Tenderfoot Hatchery began a long-term chum stocking program in 2012 in response to low stocks in the Squamish River system (Figure 1). This program identifies suitable watercourses for an enhancement period, whereby chum fry are released annually for four years. At the conclusion of the four years, another suitable watercourse is selected, and the program continues. Enhanced watercourses are more accessible,

with appropriate habitat for chum salmon. Data from 2017 onwards have not yet been analyzed. Chum returns remain below the long-term average; however, with the introduction of hatchery chum throughout the Átl'ka7tsem/Txwnéwu7ts/Howe Sound watershed, chum returns in the area are increasing, especially in urban settings.⁶ Additionally, as of November 2019, the recreational chum salmon fishery was closed.⁸

NUMBER OF CHUM SALMON RELEASED PER YEAR BY THE TENDERFOOT HATCHERY

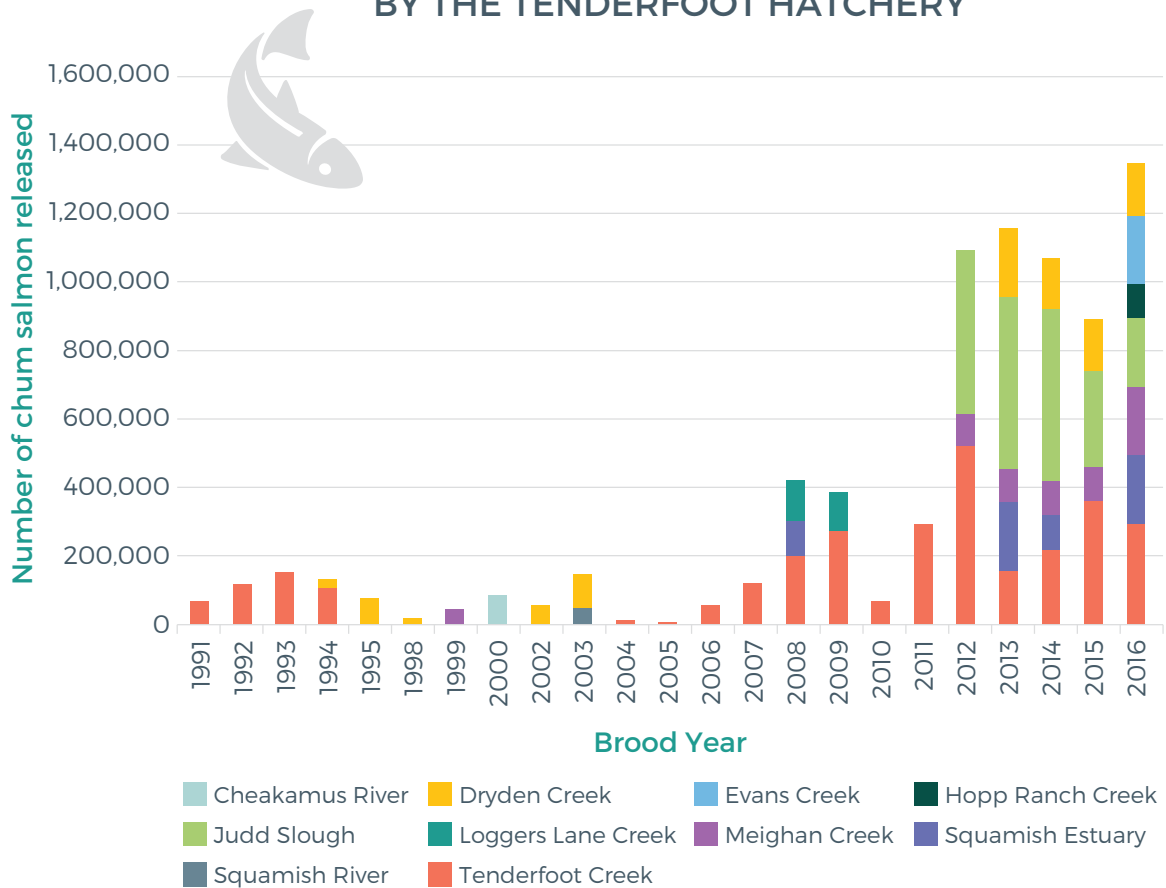


Figure 1: Number of chum salmon released per year at sites within Tenderfoot Hatchery’s stocking program. Note increased efforts in 2012, aligned with the start of the chum stocking program.

Pink salmon (*O. gorbuscha*)

Pink salmon return to spawn every two years. The population occurring throughout Átl'ka7tsem/Txwnéwu7ts/Howe Sound return in odd years.⁹ In 2013 and 2015, large returns of pink salmon (*Oncorhynchus gorbuscha*) were recorded in the Squamish River by Tenderfoot Hatchery staff, prompting the unheard-of opening of a commercial fishery for this species in the area in 2013 (see [Salmon](#), OWHS 2017). However, due to a lack of comprehensive data, DFO scientists decided it was not prudent to allow a commercial fishery to continue.¹⁰ The fishery was shut down in August 2015.¹¹

Data from the Cheakamus River indicate there has been a decline in juvenile pink salmon abundance since 2015⁷ with lower returns in 2017. In 2019, pink salmon returns rebounded in some river systems compared to 2017. Within the 2019 hatchery production plan for the Átl'ka7tsem/Txwnéwu7ts/Howe Sound area, there is a target to transfer 100,000 pink salmon eggs to the Tenderfoot Hatchery.¹²

After spawning occurs, young of year (YOY) salmon^{vii} leavethewatershedearlythefollowingyear(even-numbered years). For 2012 and 2014, data from the Cheakamus River showed the mean abundance of YOY pink salmon to be unusually high compared to the previous and subsequent years (Figure 2).⁷ Estimates of YOY

abundance were generated using a standard model^{viii} that estimates weekly abundance. Despite observations in rivers, no escapement data are available. Annual monitoring is ongoing by B.C. Hydro to gauge the impacts of the hydroelectric dam on fish populations of the Squamish River.

In September 2019, B.C. Hydro reduced the flow from Daisy Lake Dam into Cheakamus River, an event known as “ramping”^{ix}. This ramping event caused water levels to fall, resulting in the stranding of hundreds of pink salmon.¹³ Ramping down, in combination with low rainfall, resulted in large numbers of pink salmon dying off before spawning, potentially impacting future numbers.¹⁴



DFO catching broodstock. (Photo credit: Jordan Uittenbogaard)

vii) Young of Year (YOY) – salmon born within the past year.

viii) Standard model – BTSPAS Mark-recapture model, see Bonner and Schwarz 2011 for more information.

ix) Ramping – changing of the level of stream discharge by an upstream hydroelectric facility.

Coho salmon (*O. kisutch*)

Coho escapement and return data are collected via passive count methods in Tenderfoot Creek, using a counting fence (see Methods). Based on these data, the coho stock status is considered healthy, with fairly consistent survival of hatchery fish for the past decade.¹⁰ Some coho stocks have seen dramatic decreases

in returns due to high river levels upon their migration, in part due to flooding events and ramping. The Mamquam and Ashlu river systems have seen a decrease in numbers of returning adults due to high waterflows from these flooding events for the past five years.¹⁰

Sockeye salmon (*O. nerka*)

Sockeye data are limited to some sockeye observations by hatchery staff in 2016 to 2019 during Chinook brood capture.¹⁰ The sockeye recreational fishery was

opened in August 2018 for areas within Átl'ka7tsem /Txwnéwu7ts/Howe Sound (Subareas 28-1, 28-2 and 28-7), with a limit of four fish per day.¹⁵

ABUNDANCE OF PINK SALMON YOUNG OF THE YEAR IN THE CHEAKAMUS RIVER

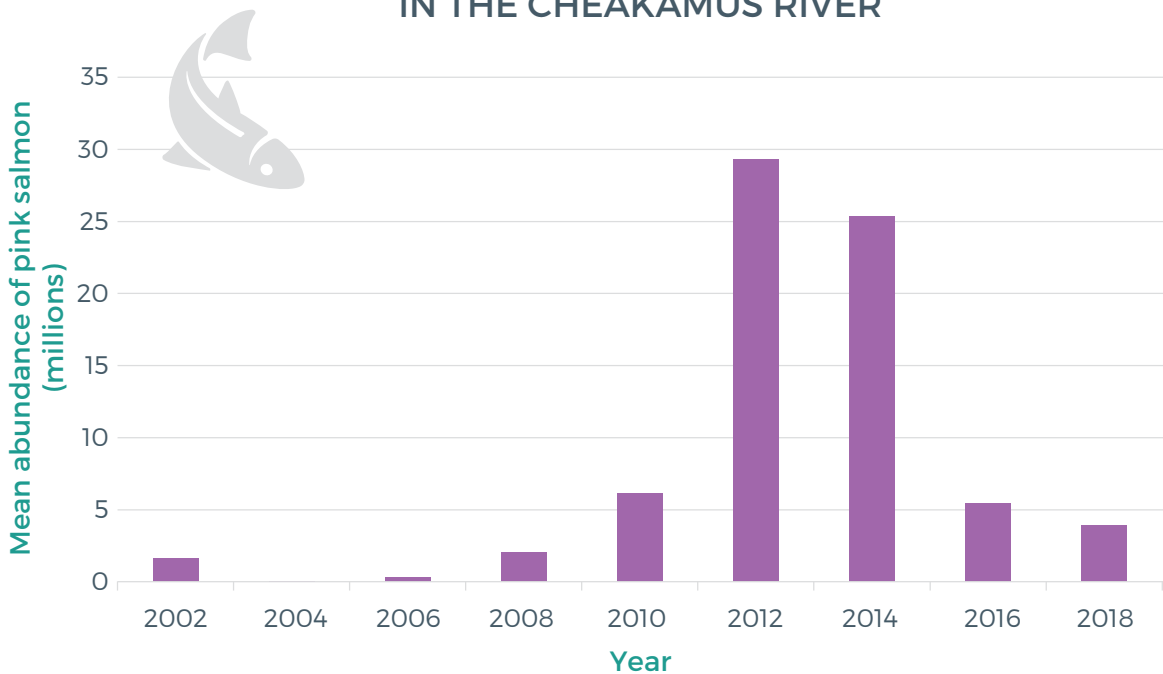


Figure 2. Mean annual abundance estimates of young of year (YOY) pink salmon collected bi-yearly in the Cheakamus River from 2002 to 2018, adapted from Lingard 2018.

Success Story

ELAHO RIVER PROJECT CHINOOK SALMON RESTORATION AND RELEASE

Industrialization in the Elaho River area in the 1960s-70s resulted in blockages of part of the river canyon by large boulders and debris, impacting the flow regime of the river. The blockages effectively prevented salmon migration in the Elaho Valley watershed, leading to local extinction. Blasting to remove the boulders and restore key Chinook habitat was undertaken in November 2017 and September 2018 by Sḵw̱wú7mesh Úxwumíxw/Squamish Nation, Squamish River Watershed Society, and DFO, with funding from the Fish Habitat Restoration Initiative Fund and Pacific Salmon Foundation (see photos below of this location on different dates). Additional funding was received in 2019 from the B.C. Salmon Restoration and Innovation Fund.



The large boulder blocking the river.
(Credit: Edith Tobe and Global Rock Works, 2019)



The boulder after it had been blasted apart.



Boulder fragments were moved to allow water flow to resume.

After the removal of the blockages from the river, a plan to introduce Chinook fry from Shovelnose Creek began in July 2019, when 5000 hatchery-raised Chinook fry were released into the upper Elaho River. Additional fry will be released each spring from the Tenderfoot Hatchery into this waterway to restore a natural spawning population of Chinook throughout the reaches of the Elaho River. Currently, 10,000 Shovelnose smolts are being reared to be released into the upper Elaho in May 2020.⁶ Monitoring will be required to establish whether the barrier removal was effective, and whether the population has been re-established successfully.

What are the potential impacts of climate change on salmon species?

Pacific salmon has been identified as one of the most vulnerable species groups to climate change in B.C.² Ocean warming and changes in river water conditions, including temperature, timing and discharge levels (see [Streamflow](#), OWHS 2017) were identified as the greatest threats due to impacts on migration, growth and survival of various life stages. Salmon that spend more time in freshwater (i.e., river-type^x Chinook) have been experiencing higher population de-

clines than those that spend less time in freshwater (i.e., pink, chum, river-type sockeye, and ocean-type Chinook), suggesting that climate change will have different impacts on different species.⁹ Other threats include ocean acidification (see [Ocean Acidification](#), OWHS 2020) that could have impacts on the food web by limiting prey availability and potentially increase harmful algal blooms that could trigger mass fish kills.²

What has been done since 2017?

The table below reports on progress made on recommended actions from the previous 2017 article, where identified. Many of these require ongoing action.

2017 ACTION	ACTION TAKEN
INDIVIDUAL AND ORGANIZATION ACTIONS	
Join local restoration efforts to help monitor and maintain freshwater salmon habitat.	<ul style="list-style-type: none"> • A number of restoration efforts have been made in the Squamish River and central Squamish Estuary in the last three years. Details can be found in Squamish Estuary, OWHS 2020. Examples include the Central Estuary Restoration Project (CERP), which is ongoing, and repair and maintenance of channel intakes at Ashlu Creek. See Resources for more information, and links to the Squamish River Watershed Society (SRWS) website (www.squamishwatershed.com). • Since the publication of the previous report, another citizen science project, in conjunction with DFO, relating to salmon, commenced (2019). Various creeks within Howe Sound with salmonid-bearing habitat are monitored for temperature by volunteers from various Streamkeeper groups. Additional details can be found in Citizen Science, OWHS 2020.

x) River-type – young fish remain in fresh water longer than the ocean-type and are therefore larger when entering saltwater. Adults return earlier to fresh water than the ocean-type and remain there longer before spawning.¹⁴

2017 ACTION	ACTION TAKEN
GOVERNMENT ACTIONS AND POLICY	
<p>Increase focus on data collection in order to get accurate, high-quality counts of spawners. Use tagging methods over visual counts where feasible.</p>	<ul style="list-style-type: none"> • In 2018, a new five-year Wild Salmon Policy Implementation Plan was released by DFO with the assistance of public consultation. This plan aims to standardize monitoring in order to assess salmon stocks more accurately. Notably, it concludes that the goals can only be achieved with the support and collaboration of the community. • DFO is developing a new parentage-based tagging system that could enable higher accuracy and greater coverage of juvenile salmon identification. • Pacific Salmon Explorer – An online tool is being developed by the Pacific Salmon Foundation that incorporates data on salmon populations and habitats into an interactive map (www.salmonexplorer.ca). Five regions on the B.C. coast are covered: Nass, Skeena, Central Coast, Fraser, and Vancouver Island & Mainland Inlets. The latter two are still in progress, with Howe Sound falling under the Mainland Inlets region. A link is provided in Resources. Funding for this project was provided by government, community groups and philanthropic donors.
<ol style="list-style-type: none"> 1. Increase support for community habitat restoration efforts including spawning channels, rearing channels, reconnection of side channels and weirs. 2. Reclaim and rehabilitate estuary habitat that has been modified by past development. 3. Promote and fund the rehabilitation of modified rivers and streams such that salmon habitat is enhanced. This includes promoting shaded riparian areas to help maintain cooler stream temperatures. 4. Recognize the importance of estuary habitat for spawning and rearing salmon. 	<p>Applies to all four actions</p> <ul style="list-style-type: none"> • The Coastal Restoration Fund has provided support to two community groups operating in the Sound (SRWS and SeaChange Marine Conservation Society) in part to restore estuarine habitat for Pacific salmon. • Research and remediation efforts have increased in the area with the support from Government (as detailed in “What is being done” above).
<p>Continue to monitor water quality and treatment, and support ongoing remediation at Britannia Mine.</p>	<p>Golder Associates continues to undertake environmental monitoring in the vicinity of the historical contamination site, on behalf of the provincial government.</p>
<p>Increase monitoring and enforcement of fishery limits, openings and closures.</p>	<p>According to the Integrated Fisheries Management Plan 2018–2019, the current compliance strategy aims to utilize technology to monitor and to work with stakeholders to improve regulatory compliance.</p>

What can you do?

A detailed overview of recommended actions relating to climate change is included in *The path to zero carbon municipalities* (OWHS 2020). In some cases, no progress was identified on previous recommended actions; these remain listed below. Additional actions marked as **NEW** also follow.



Individual and Organization Actions:

- Monitor fishery status and limits. Ensure you are fishing within current regulations.
- Eat sustainable seafood, look for the Ocean Wise symbol in restaurants and grocery stores.



Government Actions and Policy:

- Protect all estuary habitats from residential, commercial, or industrial development.
- Increase public education on the status of salmon, and how people can help salmon stocks recover.
- **NEW** Establish citizen enforcement officers throughout the Sound, who are granted limited enforcement powers, such as checking catch size, species, and fishing method, and handing out fines for fisheries infringements.

Methods

All coho and chum estimates are approximated using counting fences. Counting fences are placed instream, blocking the width of the river, apart from a small diversion channel. The migrating salmon must swim through this narrower channel, where they are counted. The diversion channels often have a white bottom, in contrast to the salmon, making them easier to count.

Chinook status stock methodology is based on catch per unit efforts of hatchery netting program. Dead-pitch numbers are also used. Long-term monitoring in remote river systems such as the Elaho River will

include environmental DNA (eDNA) sampling to determine the extent of usage in the upper reaches by all life stages of chinook salmon.

A brief literature scan was undertaken using ResearchGate and Google Scholar to find new articles relating to salmon and climate change, released since 2017. Key words used included a combination of salmon, climate change, B.C., Canada, Pacific, ocean acidification.

Resources

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A pink salmon stranded after a ramping event in the Stawamus River, Squamish. (Credit: Tracey Saxby)