Estuarine and Freshwater Risk Factors Limiting the Productive Capacity of Cowichan River Fall Run Chinook

Workshop Report January 29 2016

BACKGROUND

Watershed Health

The people of the Cowichan Valley have agreed that the health of Cowichan River and watershed is an important goal for the community. As a Canadian Heritage River this goal also becomes important for the people of Canada. Yet the Cowichan River and estuary have and continue to undergo considerable change, bringing into question the health of the ecosystem.

Watershed health is governed by many factors. Four general areas of interest (hydrology, physical habitat, water quality and biological communities) are proposed as focal attributes to manage for in the Cowichan River watershed.

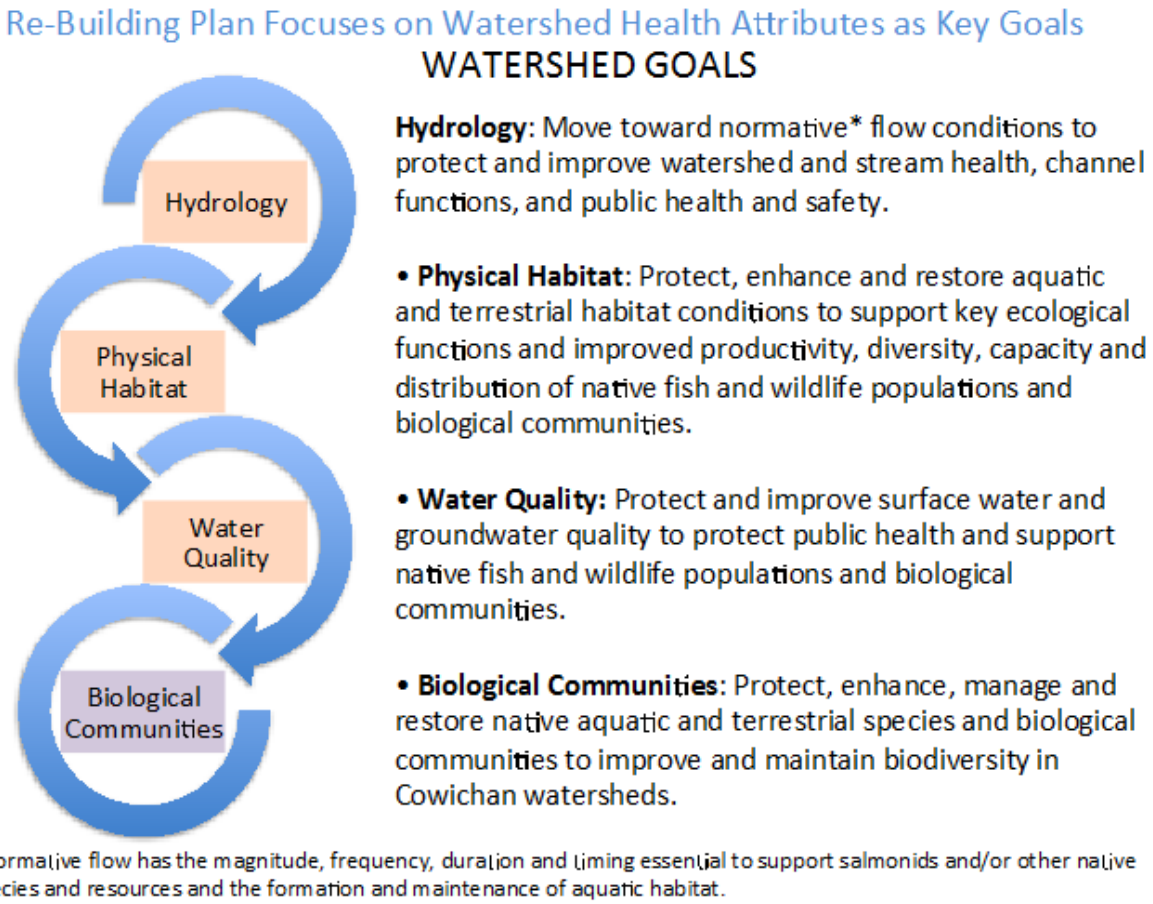

Figure 1: Four Key Goals for Watershed Health (adapted from Portland, 2005)

Cowichan River chinook are regarded as an indicator of biological health of this ecosystem and provide a means to monitor watershed health. Chinook salmon in the Cowichan watershed are affected by all four attributes of watershed health. The hydrology of the Cowichan has had a tremendous impact on migrating salmonids as low flows in the river impede migration. Water quality has also impacted Chinook and recent efforts to decrease sediment impacts of Stoltz Bluff are thought to have greatly increased egg-fry survival rates. Physical habitat in the lower river has been shown to be a key factor for juvenile rearing and biological communities, including predators are a critical limiting factor to adult and possibly juvenile survival.

Cowichan Chinook

The return of Cowichan chinook declined from 10,000 spawners in the early 1990's to a low of only a few hundred natural spawners in 2009. It is likely that change in the Strait of Georgia marine environment was the dominant factor in this decline. However, there is increasing understanding that marine survival is linked to health of the chinook leaving the river and estuary. For example, Rugerone (2010) highlighted the importance of the lower river and estuary in ensuring sufficient growth and refuge to maximize potential for survival in the marine waters.

In this light, considerable efforts have been expended in recent years to improve the productive capacity (fish health and numbers) in the river and the estuary.

- In 2005, DFO initiated the implementation of the Wild Salmon Policy (WSP). The WSP strategies strive to incorporate habitat and ecosystem considerations into salmon management and to establish local processes for collaborative planning throughout BC. On a more targeted level, in 2005 the Cowichan Tribes developed a watershed wide, multi-species Recovery Plan for the Cowichan watershed (LGL 2005). This work has formed the basis of the business plan of the Cowichan Stewardship Roundtable, an action oriented community based organization that has implemented habitat focused restorative programming worth over 2 million dollars since its inception in 2004 (T. Rutherford, pers. comm.).

- In 2007, the Cowichan Basin Water Management Plan was prepared by Westland (2007) and was instrumental in establishing fall pulse flows to facilitate upstream migration of Chinook spawners.

- In 2009, DFO initiated a comprehensive ecosystem based planning process to rebuild the Cowichan Chinook stock through development of a Cowichan River Watershed Health and Chinook Initiative. The first priority of this initiative is to provide a collaborative process to develop a holistic, ecosystem based plan for rebuilding and sustaining the severely declining fall Chinook run. Over the longer term, the intent of the Initiative is to sustain all salmon species in the Cowichan River.

- There have also been millions of dollars spent on projects to improve the river, e.g. the remediation of Stoltz Bluff mentioned above.

These efforts appear to be beneficial to the salmon returns. Juvenile chinook have been observed in the lower river in July, long after the historic observations of timing out of the river. Moreover, returns to the river have increased annually since the low return in 2009. However, these numbers still fall short of the 2005 biologically based escapement goal for adult fall Chinook of 6500 adults.

COWICHAN CHINOOK RISK ASSESSMENT – 2013 & 2016

In 2013, DFO developed a Risk Assessment Procedure (RAP) to provide a systematic tool to prioritize known habitat based limiting factors to chinook production (Pearsall et al 2014, i*n progress*). This methodology is adapted from Hobday (2007) to assess the impacts of stressors or limiting factors (LFs) on the productivity and capacity of a population and its habitat using a life history model. It is used for data-deficient systems and focuses on qualitative information. The RAP helps identify and prioritize limiting factors to salmonid production now and in the future under various climate change scenarios. The primary function of the risk assessment is to describe the relationship between different environmental attributes and measures of biological performance.

There are 3 main elements of biological performance that are all linked.

- **Life History Diversity** – distribution potential of a population (loss of diversity may indicate a decline in health of a population).
- **Capacity** – the number of organisms a given habitat can support
- **Productivity** – reproductive potential (total number of eggs/adult spawner) and density independent survival (both in fresh water and marine environments).

These 3 elements describe the persistence, abundance and distribution potential of a population. The risk assessment focuses only on the Capacity and Productivity elements.

The first part of the risk assessment procedure was to compile a comprehensive list of potential threats or habitat based limiting factors (LF) to fall chinook production in the Cowichan River. This list was one of the initial steps towards developing a re-building strategy for Cowichan chinook, as it provides a starting point for further review and discussion by a group of technical experts.

This initial group of limiting factors was based on interviews and the existing literature including a May 2010 review by DFO that identified the following 10 major threats to salmon production: sedimentation, lack of lower river rearing habitat, in river predation, lack of estuary habitat and productivity, high early ocean mortality, ocean predation, ocean fisheries, terminal mortality (seals and fishing), in-river mortality (water flow and temperature) and loss of spawning habitat (W. Luedke in CT 2010). As well in 2010, the Cowichan Stewardship Roundtable identified that the highest risks or limiting factors to the fall chinook run in the freshwater environment included: water flow, high water temperatures and accelerated fine sediment loading from bank erosion (CVRD 2010).

On March 4-5, 2013 a number of scientific, biological, and local knowledge experts, with over 300 years combined experience working on the Cowichan, came together to review information, identify gaps, and determine the freshwater and estuarine risks faced by Cowichan River fall run chinook. They agreed upon a total of 33 habitat based limiting factors to chinook production and carried out a scoring process to rank these factors to determine which pose the greatest threat currently and in the future under climate change.

A smaller group of experts met on January 29 2016 to review the 2013 risk assessment results; numerous projects and studies have been carried out since 2013, and the group wished to examine how the results of these studies may have either ameliorated conditions for Cowichan chinook or provided more

information that could allow us to a) reduce the uncertainty around scoring risk or b) reduced the any of the knowledge gaps.

The limiting factors developed at the 2013 workshop were grouped into categories relating to any of the 4 key watershed processes: biological, hydrology, habitat, or water quality (Figure 1 above). They could also be related to either human activity or deemed to be issues of natural origin. Some of the factors are large scale issues such as the effects of climate change, while others have impacts at a local scale e.g. Stoltz bluff sediment source. But all of the limiting factors affect the availability or utilization of critical habitat.

Note that for both 2013 and 2016, the risk assessment was applied to the freshwater life history phases of chinook ***only*** and did not include the estuary and marine life history phases at this time. Future work is needed to include review and prioritization of marine related habitat based factors that are limiting chinook production in the Cowichan River. In addition, the risks posed by fisheries, both in the ocean and in the river, as well as the possible impacts of salmonid enhancement activities on fall run chinook were not addressed as part of this workshop. The latter risks will be considered in dedicated workshops during 2016.

Results of Risk Assessment 2013

A repeatable risk assessment process was used to score and quantify risk using expert knowledge and opinion and culminated in a ranked list of limiting factors/issues. A number of factors were identified as posing a very high or high risk to Cowichan chinook. A number of recommendations and knowledge gaps were also identified at the workshop.

2013 Results

Key limits to productivity of Cowichan River fall run chinook during the In-migration and Spawning phase included predation by seals, inadequate chinook migration flows, loss of key instream habitat features critical for migration and sediment management. Low flows were found to exacerbate the majority of key concerns in the lower river including increased seal predation and poaching, lack of high quality holding pools and blockages to migration in the lower and middle reaches of the mainstem.

Limiting factors for the adult phase were scored for both a “low flow” and “adequate flow scenario”. For the former scenario, 8 limiting factors were found to have a Very High, High or Moderate risk rating whereas this risk level decreased to Low/moderate for all 8 limiting factors under the latter scenario. It was thus agreed that adequate flows are critical to minimize predation, facilitate passage through the lower river and falls reaches, maintain water quality in the lower river and to provide adequate instream cover and complexity throughout their migration route.

The experts agreed that the upper river is in relatively good condition and is providing high quality incubation habitat. The most productive spawning and incubation habitat was noted to be located from the 70.2mile trestle upstream to Greendale area and therefore located upstream of the majority of existing or potential landslides. An average of approximately 80-90% of the chinook run spawns upstream of Skutz Falls providing there is adequate flows and unlimited passage through the lower river. However, in years where low flows limit upstream migration of chinook and a greater proportion of chinook spawn in the lower river, then egg to fry survival could be reduced due to the effects of sedimentation.

The rearing phase for fall run chinook takes place from February through June with the majority of chinook fry migrating out of the lower river into the estuary by June. Therefore, chinook fry are not as susceptible to low flow issues as chinook adults are during their holding and migration period in the lower river and estuary during the late summer and early fall low flow period.

Based on the risk assessment results, key issues limiting the productivity of Cowichan River fall run chinook during the Incubation and Migration Phase were largely associated with habitat degradation and the loss of access to as well as the quality (i.e. in-stream complexity) of both mainstem and off channel rearing habitat in the lower river and into the estuary interface. Another key concern was the overall loss of valuable rearing habitat within the floodplain reach relative to the historical rearing habitat quantity over the floodplain reach.

All the experts agreed that the lower river is the area of greatest concern to both adults migrating upstream and juvenile fry migrating downstream and looking for rearing areas. In addition, the current available habitat is limiting in the lower river, therefore if juvenile chinook abundance increases might not mean an increase in stock abundance (may worsen whether due to rebuilding or hatchery production increases). Some of the identified causes of habitat loss are lack of water storage and loss of flow from top to bottom of the river, channelization from flood control measures, gravel accumulation in the lower river, urban development and agriculture, etc. Seals and harvest in the lower river were compounding concerns during periods of low flow.

Research and monitoring of the critical habitat for juveniles was deemed a critical need.

2013 Knowledge gaps

The key knowledge gaps identified in 2013 included the following:

- Lack of knowledge regarding distribution, preferred habitat types, utilization and capacity of the lower floodplain reach by chinook fry.
- Lack of knowledge regarding the available food supply and rearing capacity in the Cowichan Estuary.
- Timing and utilization of the estuary/lower river interface by chinook fry
- The amount of aquatic rearing habitat that has been lost in the lower river over time
- Annual freshwater juvenile production needs to be estimated on an annual basis for fall chinook to determine egg to fry survival and hatchery effectiveness. This was also highlighted as an important action item and assessment tool in the 2005 Cowichan Recovery Plan (LGL 2005).
- Extent of seal predation on chinook spawners
- Lack of information and focus on the spring chinook run in the Cowichan River, including rebuilding potential
- Lack of information regarding the existing and potential use of the Koksilah River by chinook
- Target levels for freshwater productivity in the Cowichan River.
- Uncertainty of the density dependent effects of large hatchery releases of chinook fry on the survival rates of wild raised chinook fry.

Results of Risk Assessment Review 2016

On January 29 2016, a small group of experts gathered to review the 2013 risk assessment results; numerous projects and studies have been carried out since 2013, and the group wished to examine how the results of these studies may have either ameliorated conditions for Cowichan chinook or provided

more information that could allow us to a) reduce the uncertainty around scoring risk or b) reduced any of the knowledge gaps.
The meeting participants were provided with the following materials:

- The Risk Assessment results from 2013
- A Backgrounder of the Risk Assessment process
- A series of summary documents providing details of the key results from projects carried out during 2013-2016, and projected impacts of such activities on identified limiting factors.

2016 Results

A review of the 2013 risk assessment rankings and limiting factors resulted in a number of changes. Firstly, identified redundancies in some of the factors led to pooling of some limiting factors. Conversely, some factors were split to reflect differences in impacts in the lower versus the upper river (e.g. LF8 was split into LF8a and 8b). In most cases, risk rankings were not changed with the exception of the following LFs.

LFs with reductions in biological risk:

Adults

LF4: Aggradation creates a migration barrier in the lower Cowichan mainstem during summer and early fall period. Risk reduced from Very High to High.

LF9: Limited access through Skutz Falls & Fishway. Risk reduced from High to Moderate.

Egg-Smolt

LF17. High suspended sediment loads that reduce egg to fry survival and emergence of alevins. Risk reduced from High to Moderate.

LFs with increases in biological risk:

Adults

LF 8b. Lack of good quality pool refuge habitat in lower reaches. Risk raised from Moderate to High.

LF 8a. Lack of good quality refuge habitat in close proximity to spawning habitat (middle and upper reaches of the river). Risk raised from Low to Moderate.

LF5: High water temperatures in the lower river and estuary during the late summer/early fall migration period can increase migration mortality and sublethal stress. Risk raised from Low to Moderate.

Egg-Smolt

LF25: Lack of high quality rearing habitat ie natural instream complexity (deep >1m holding pools, functional LWD, boulder cover, riparian cover) in mainstem and side channels. Risk raised from High to Very High.

LF18: Predation of eggs, alevins, fry, smolts in river by Merganser, Brown trout, sculpins, etc. Risk raised from Moderate to Very High.

LF27B: High water temp in the mainstem river and OC areas. Risk raised from Low to Moderate.

Tables 1 and 2 below provide details on the risk scores, and reasons for the changes listed above.

Table 1. Risk rankings for Adult Migration and Spawning.

Adult migration and spawning

Watershed Goal	Life History Requirement	Issue or Limiting factor & id number	Flow Level	Confidence	Current Biological Risk category	Future Biological Risk Category	Change in Ranking	Comments	Recommendations
Biological Communities	**Safe holding habitat in estuary and lower river**	**LF1**: Predation of adults in the estuary and lower river by pinnipeds when flows are lower than 15cms	Low	M	Very High	Very High	No change.	This LF could also pose a threat to early run chinook. Confidence score may be increased once more data is available through UBC	
Physical Habitat	**Stable channel morphology, maintenance of channel capacity and natural level of sediment transport**	**LF4:** Aggradation creates a migration barrier in the lower during summer and early fall period in the North Arm and mainstem	Low	H	High	Very High	Slight reduction in risk due to lowered temporal score- reduced 5 to 3	Currently this LF has been ameliorated due to CVRD gravel removal. Baseflows currently split 50:50 and max channel wetted for rearing: more flow in one channel over another may be preferential. However, this LF could be a serious issue again in the future should current amelioration be discontinued.	Continued gravel removal
Hydrology	**Adequate passage flows to facilitate upstream migration (FLOW RELATED)**	**LF2:** Limited or delayed spawner access through lower river and Skutz Falls reach to prime habitat upstream of Skutz Falls	Low only	M	High	Very High	No change		

Watershed Goal	Life History Requirement	Issue or Limiting factor & id number	Flow Level	Confidence	Current Biological Risk category	Future Biological Risk Category	Change in Ranking	Comments	Recommendations
Physical Habitat	**Clear and safe passage with adequate refuge habitat**	**LF3:** Loss of safe migration route through the lower mainstem Cowichan River due to channelization, loss of habitat complexity and instream cover features	Low	M	High	Very High	No change		Importance of discussions with diking committee around riparian restoration and shrub planting on dikes
Physical Habitat	**Clear and safe passage with adequate refuge habitat**	**LF 8b.** Lack of good quality pool refuge habitat in lower reaches.	Low	L	High	Very High	Current risk raised from M to H	This LF was split into two components (8a for upper and middle river, 8b for lower river). Risk is greater for former area, where pools have generally disappeared/declined. Confidence around this factor remains low due to this being a knowledge gap.	Further studies to assess prevalence of critical pool habitats
Water Quality	**Suitable water quality**	**LF5:** High water temperatures in the lower river and estuary during the late summer/early fall migration period can increase migration mortality and sublethal stress	Low	M	Moderate	Very High	Current and future risks raised from L and H to M and VH	Temporal scale increased from 3 to 4. This LF is believed to pose a greater risk than previously thought. This LF also impacts in-river predation.	
Physical Habitat	**Unrestricted migration and passage; mainstem and off channel habitat**	**LF7:** Potential delays in upstream migration due to the counting fence	Low	M	Moderate	High	No change		This LF could be assessed using PIT tag methods and array.

Watershed Goal	Life History Requirement	Issue or Limiting factor & id number	Flow Level	Confidence	Current Biological Risk category	Future Biological Risk Category	Change in Ranking	Comments	Recommendations
Physical Habitat	**Clear and safe passage with adequate refuge habitat**	**LF 8a.** Lack of good quality refuge habitat in close proximity to spawning habitat (middle and upper reaches of the river)	Low	L	Moderate	High	Current and future risks raised from L and M to M and H.	Pool habitat is lacking, often not providing a temperature refuge.	Further studies to assess prevalence of critical pool habitats
Physical Habitat	**Good quality and quantity of spawning habitat in Cowichan River**	**LF12:** High suspended sediment loads can reduce spawning habitat quality by compacting gravel and reducing interstices critical for egg deposition and incubation	Low	L	Moderate	High	No change	This LF is for adult spawning but impacts would be felt on eggs/alevins. Could be removed and score LF17 only.	Complete the Sediment Management plan
Physical Habitat	**Unrestricted migration and passage; mainstem and off channel habitat**	**LF9:** Limited access through Skutz Falls & Fishway	All flows	L	Moderate	Moderate	Current and future risks reduced from H to M due to change in spatial score- 5 to 2, and reduced future trend from was 4 to 2.	Fishway cleaned up by Doug Poole 2015. Only 10% of PIT tagged jacks used the fishway in 2015. Risk is currently reduced but this factor does require ongoing maintenance and possible re-design.	Continued maintenance of fishway

Table 2. Risk rankings for Egg Incubation, rearing to smolts leaving the river into the estuary.

Egg incubation, rearing, to smolts leaving river - estuary

Watershed Goal	Life History Requirement	Issue or Limiting factor & id number	Confidence	Current Biological Risk category	Future Biological Risk Category	Change in Ranking	Comments	Recommendations
Physical Habitat	**High quality rearing habitat characteristics with good instream complexity**	**LF25:** Lack of high quality rearing habitat ie natural instream complexity (deep >1m holding pools, functional LWD, boulder cover) in mainstem and side channels	H	Very High	Very High	Current risk increased from H to VH, but Confidence is reduced from H to M	Risk is raised as this LF was redefined to include lack of high quality habitat both in the mainstem as well as the lack of available off-channel habitats. Focus has also shifted from just the lower river to include the entire river. High confidence that rearing habitat, edge and flows are important but confidence is reduced from H to M for this LF as there is uncertainty as to which habitat is priority for maintenance and when?	Continued research into relative importance of mainstem and side channel habitats.
Physical Habitat	**Unrestricted migration and passage; mainstem and off channel habitat**	**LF23:** Limited or no access to historical tributary or off channel habitat	H	Very High	Very High	No change	The lack of off-channel habitat can be attributed to 1) lack of such habitat availability or 2) lack of access to such habitat. Lack of availability of habitat is the primary issue and is reflected in LF25 above. Connectivity is lost at flows <18cms, but can even be lost at <25cms in March. Access is lost due to sedimentation or flows. This is still a significant risk.	Continued monitoring of relationship between access and flows recommended.
Physical Habitat	**High quality rearing habitat characteristics with good instream complexity**	**LF 31.** Lack of good quality estuarine and nearshore habitat.	H	Very High	Very High	No change but Confidence is reduced from H to M	Still a very high risk, but confidence is reduced as there is still some uncertainty as to how much Chinook use the estuary.	Continued studies recommended

Watershed Goal	Life History Requirement	Issue or Limiting factor & id number	Confidence	Current Biological Risk category	Future Biological Risk Category	Change in Ranking	Comments	Recommendations
Biological Communities	**Minimal predation to eggs, alevins, fry and smolts**	**LF18**: Predation of eggs, alevins, fry, smolts in the middle and upper river by Merganser, Brown trout, sculpins, etc.	M	Very High	Very High	Current and Future Risk increased from M to VH.	Recent work by BCCF highlights the possibly high predation impact by brown trout. Temporal score increased from 3 to 5.	Repeat the Rotary Screw Trap and In-River PIT tagging studies to determine if a similar high in-river mortality occurs during 2016. Sample brown trout to assess if predation is a key cause of this mortality.
Water Quality	**Suitable water quality- Acceptable levels of suspended sediments**	**LF17a.** High suspended sediment loads that reduce egg to fry survival and emergence of alevins	H	Moderate	High	Current and Future Risk is reduced from H and VH to M and H.	Stoltz Bluff was historically the worst spot: now improving. Thus spatial score reduced 3 to 2, and impact from 5 to 3.	Sediment Management Plan. Continued remediation work.
Hydrology	**Adequate water levels and connectivity**	**LF22**: Increased stranding in isolated off channel habitat and tributaries	L	Moderate	Moderate	No change, but temporal scale increased from 3 to 4.	Wording of LF changed slightly. Chinook are less subject to stranding than coho.	
Biological Communities	**Minimal predation to eggs, alevins, fry and smolts**	**LF 30**. Predation in lower river and estuary	M	Moderate	Moderate	No change	Brown trout predation likely occurs in upper river- not in estuary- further clarification of this will occur during 2016. If PIT studies show predation levels are high in the lower river and estuary, this LF score will be raised.	
Water Quality	**Suitable water quality conditions**	**LF27B**: High water temp in the mainstem river and OC areas	M	Moderate	Moderate	Current and future risk both increased from L to M	Spatial score increased 2 to 3, temporal 2 to 3 as this LF deemed to be an increasing issue impacting CN juveniles throughout much of their rearing.	

Summary

The results of the discussion and scoring process suggested the following factors were limiting the productive capacity of this stock. These risk factors are summarized below, identified by one of two life history phases: i) adult migration and spawning, or ii) fry rearing and migration through the lower river and estuary into the ocean. The LF codes identify specific Limiting Factors and the order in which they were identified and assessed.

Very High Risk Factors

- Adults: Low water in late summer and early fall is preventing or delaying chinook migration through the lower river which makes them extremely vulnerable to seal predation in the estuary and lower river. (LF 1)
- Fry -smolt: Lack of high quality rearing habitat ie natural instream complexity (deep >1m holding pools, functional LWD, boulder cover, riparian cover) in mainstem and side channels (LF25)
- Egg-smolt: There is a significant lack of off-channel habitat in the lower river, mainly due to loss of access to historical tributary and off channel habitat. (LF23)
- Egg-smolt: There is a lack of good quality estuarine and nearshore habitat, whether through loss of the habitat or loss of access. The estuary and the lower river are linked; chinook salmon likely move between the two several times. The lack of connectivity between the north and south side of the estuary, due to development and road building was specifically identified as an issue. (LF31).
- Fry - smolt: Predation of eggs, alevins, fry, smolts in the middle and upper reaches of the river by predators such as birds (e.g. merganser), fish (e.g. brown trout), and to a lesser extent mammals (e.g. bears). (LF18)

High risk factors

- Adults: Under low flow conditions, aggradation creates a migration barrier in the lower Cowichan mainstem during summer and early fall period. (LF 4)
- Adults: Under low flow conditions upstream migration of adults through the lower and middle reaches of the river is being impeded. Spawners may not reach the spawning grounds or are subjected to stress (e.g. high water temperature) which impact spawning capacity. (LF2)
- Adults: Loss of safe migration route through the lower mainstem Cowichan River due to channelization, loss of habitat complexity and instream cover features (LF3)
- Adults: Lack of good quality pool refuge habitat in lower reaches. (LF8b)

Moderate risk factors

- Adults: High water temperatures in the lower river and estuary during the late summer/early fall migration period can increase migration mortality and sublethal stress (LF5)
- Adults: The upstream migration of adults can be delayed or impeded by the counting fence. (LF7).
- Adults: Lack of good quality (e.g. deep pools) refuge habitat in close proximity to spawning habitat. (LF8a)
- Adults: High suspended sediment loads can reduce spawning habitat quality by compacting gravel and reducing interstices critical for nest building and egg deposition. (LF12)
- Adults: Skutz Falls and fishway are periodically blocked by debris impeding upstream migrating adults from reaching the upper river spawning areas. (LF9)
- Fry -smolt: High suspended sediment loads, especially from numerous clay banks in the middle and upper reaches of the river pose a significant threat to egg incubation and

emergence of alevin out of the spawning gravels. While the sediment load is much reduced after the remediation of Stoltz bluff, there are other banks which could become significant issues. (LF17)

- Fry - smolt: Increased stranding in isolated off channel habitat and tributaries can occur with rapid changes to discharge. This issue was highlighted in May 2012 where low water inputs and flow regulation resulted in stranding of fry in the lower river (LF22).
- Fry - smolt: Predation in the lower river and estuary. (LF30)
- Fry -smolt: High water temp in the lower mainstem river and off channel habitats due to removal of riparian trees for dyke maintenance. (LF27B)

Low risk factors.

- Adults: Under adequate river flows predation of adults in the estuary and lower river by pinnipeds (e.g. seals) is significantly reduced (LF1).
- Adults: Under adequate river flow the lack of good quality refuge habitat in close proximity to spawning habitat in the middle and upper reaches of the river. (LF 8)
- Adults: Under adequate river flow the access through Skutz Falls & fishway is general low risk. (LF9)
- Adults: Under adequate river flow high suspended sediment loads can reduce spawning habitat quality by compacting gravel and reducing interstices critical for egg deposition and incubation (LF12)
- Fry -smolt: Lower flows may reduce access to seasonally available off channel rearing habitat (LF21)
- Fry -smolt: Increased incidence of peak flows in winter can scour and disturb redds and reduce incubation survival (LF15).
- Fry -smolt: High suspended sediment loads can reduce egg to fry survival and emergence of alevins. (LF17)
- Fry -smolt: Reduced egg to fry survival due to chum overspawn. (LF19)
- Fry - smolt: Salinity in the estuary during the juvenile chinook residence period may be affected by lack of freshwater due to low river flow. (LF32)

Other factors were discussed, determined to be very low risk, and so not included in this summary. However, some of these low risk factors increased in risk in a future with climate change.

DISCUSSION

In summary, the highest risk factors limiting productivity of Cowichan chinook continue to be related to low river flows, lack of availability of high quality rearing habitat, both along the mainstem and side channels, sedimentation, lack of good quality estuarine and nearshore habitat, and predation.

The 2013 risk assessment workshop results focused on the importance of the lower river over the middle and upper Cowichan river. However, it was suggested on January 29th 2016 that the entire river is of importance for chinook rearing. Studies by BCCF concluded that mainstem and large side channel edge habitats with suitable velocities and intact overstream and/or instream riparian vegetation cover were critically important for Chinook fry rearing, particularly early in the season. The need for intact riparian vegetation was important in both upper and lower river environments.

Recent studies (Rotary Screw Trap and PIT tagging) have suggested a much higher level of in-river mortality than previously believed. This high level of mortality may be related to brown trout predation and will be further investigated. Thus, limiting factors associated with in-river predation received inflated risk rankings. Recent studies to examine pool refuges have also suggested that many of the current pools do not provide adequate temperature refuges. Thus, limiting factors associated with lack of good quality pool refuges also received inflated risk rankings. Finally, recent work to monitor water temperatures have highlighted the risk of increasing lower river and estuary temperatures, particularly during the late summer/early fall migration period. Those limiting factors associated with high water temperatures also received inflated risk rankings

Conversely, projects such as the Stoltz bluff and Broadway Run Slope Stability Remediation have had positive impacts on sedimentation, while recent work to remove debris from Skutz Falls and the fishway have had some success. Risk factors associated with suspended sediment loads and access through the fishway had reduced risk scores.

Since 2013 there have been a number of detailed studies by the BC Conservation Foundation group on the early life history and critical rearing habitat requirements of Cowichan chinook. These studies have reduced some of the knowledge gaps identified in 2013, namely, the lack of knowledge regarding distribution, preferred habitat types, utilization and capacity of the lower floodplain reach by chinook fry, as well as lack of information on timing and utilization of the estuary/lower river interface by chinook fry. There have also been focused studies by UBC researchers Austen Thomas, Ben Nelson under the supervision of Dr. Andrew Trites on the extent of seal predation on chinook spawners which addressed another identified knowledge gap.

In summary, the key findings of importance to Cowichan chinook included the following:

- Adequate water velocity is crucial to fry in Feb/March- low velocity edges are important for fry seeding
- Preferred fry habitat includes instream vegetation, especially shrubs/bushes as well as SWD/LWD.
- Connectivity of side channels to the mainstem is important. Fish are using side channels in March-April and moving out of them in May/June. If flows are too low, then they can become stranded in the side channels. The recent pressure to reduce spring flows to less than 15cm in April and May could result in significant negative impacts on chinook.
- BCCF data suggested that the fry population distributed from upper river spawning areas to occupy all suitable edge habitat, from natal to intertidal reaches, until a minimum size was attained for outmigration. The suggestion is that fry may be forced to leave the river before attaining this critical size should adequate edge habitat not be available.
- Most of the impacted banks are in the lower river, so preferred habitat is lacking there.
- Dikes are likely a higher risk factor than previously believed. Tree removal for diking, and loss of cover will negatively impact chinook, even if adequate velocities are present.
- Releasing hatchery Chinook in upstream habitats or earlier in the season may increase competition with wild fish for habitat.
- Several downstream survival estimates were created from RST and PIT tag data collected in 2015. Initial results from the RST data suggest the survival of hatchery fish released in the upper river to river km 3.0 was 19.4% for the early release and 10.8% for the late. Recoveries of PIT tags at the lower river array and RST suggest survival to tidewater (river km 0) for the late

hatchery release was 25%. Wild fish appeared to fare better at 49% survival to tidewater over a 40 km migration.

- The relative recapture rates of hatchery and wild fish in the marine environment were used to produce similar survival estimates. The survival estimate for hatchery fish from the lake release to river km 0 was reduced to 14% while the similar estimate for wild fish was only 27%. As these estimates are relative to freshwater releases only, they suggest that fish which travel a long distance in the river experience an early marine mortality rate that is approximately twice as high as those arriving from lower river habitats.
- These results suggest that in-river mortality associated with migration to tide water could be significant in terms of how may Chinook smolts even reach the marine environment. Currently, this mortality is lumped into marine survival estimates. Realistically, marine survival for hatchery fish (i.e., from tide water to adult return) could be 5-10 times higher and twice as high for wild Chinook. There is evidence that this high in-river mortality could be due to predation by brown trout. This will be further investigated in 2016.

A number of the 2013 knowledge gaps have been addressed by recent studies. These include:

- Lack of knowledge regarding distribution, preferred habitat types, utilization and capacity of the lower floodplain reach by chinook fry.
- Timing and utilization of the estuary/lower river interface by chinook fry
- Extent of seal predation on chinook spawners

Ongoing 2013 knowledge gaps include the following:

- Lack of knowledge regarding the available food supply and rearing capacity in the Cowichan Estuary.
- The amount of aquatic rearing habitat that has been lost in the lower river over time
- Annual freshwater juvenile production needs to be estimated on an annual basis for fall chinook to determine egg to fry survival and hatchery effectiveness. This was also highlighted as an important action item and assessment tool in the 2005 Cowichan Recovery Plan (LGL 2005).
- Lack of information and focus on the spring chinook run in the Cowichan River, including rebuilding potential
- Lack of information regarding the existing and potential use of the Koksilah River by chinook
- Productivity benchmark for freshwater productivity in the Cowichan River (we don't know how many wild Chinook are coming out of the system entering marine water currently).
- Uncertainty of the density dependent effects of large hatchery releases of chinook fry on the survival rates of wild raised chinook fry.

Additional questions/knowledge gaps from the 2016 meeting include the following:

- What are impacts of aquatic invasive on passage, and of invasive plants in riparian areas on cover and rearing?
- What is the key migration period for early run chinook
- Some of the LFs that affect fall run chinook likely impact early run chinook as much or even more: for example, woody debris, gravel, log jams, water temperature etc.
- What flows are required to allow for appropriate sewage dilution?
- 2014 and 2015 were very different years but there were still large numbers of fish in the bay. It would be useful to see how fish behave with each incremental drop in flows.
- What accounts for the high level of in-river mortality as evidenced by the BCCF PIT tagging studies and DFO's Rotary Screw Trap Studies?

Recommendations & Action Items:

Appendix 1 lists a number of recommendations that have been provided in recent reports of work done on the Cowichan River. Meeting participants made the following recommendations:

- Shrub planting along dikes should be carried out rather than use clean washed riprap lacking any vegetation at all.
- High value habitats should be identified as critical habitats and protected.
- If the majority of Chinook migrants are fry (as opposed to fingerlings), and we acknowledge their relative dependence on lower tidal channels and the estuary for rearing, this component of the Chinook population may best respond to future habitat restoration in lower-river reaches and the estuary.
- Efforts to increase the growth and survival of the more robust fry population may result in the greatest increase to adult returns.
- Immediate restoration activities should focus on re-connecting historic lower river wetland habitats which have the highest potential to be used by smaller sub-yearling migrant fry earlier in the season, rather than creating new habitats which may or may not be limiting to Chinook production. Later restoration activities could then be more strategic, based on findings from on-going monitoring and the incremental benefits of re-connected historic habitats.
- Continued gravel removal and slope remediation should be done in the river or the benefits of recent work will be lost.
- Further studies should be carried out to assess the prevalence of critical pool habitats.
- Continued maintenance of fishway should be carried out.
- Continued research into the relative importance of mainstem and side channel habitats.
- Continued monitoring of the relationship between access to off-channel habitat and flows is recommended.
- A repetition of the Rotary Screw Trap and In-River PIT tagging studies should be done to determine if a similar high in-river mortality occurs during 2016. Sample brown trout to assess if predation is a key cause of this mortality.

A number of action items were agreed upon:

- Action Item 1: DFO should move forward to discuss the need for replanting dikes and provision of appropriate edge habitat/riparian cover with the diking committee.
- Action Item 2: Digitize Cowichan maps from the 1850s onwards, and assess true riparian and other habitat loss.
- Action Item 3: CT land use planning should include wording around riparian protection.
- Action Item 4: Other land use plans should also include wording around riparian protection.
- Action Item 5: Repeat the Rotary Screw Trap and In-River PIT tagging studies to determine if a similar high in-river mortality occurs during 2016. Sample brown trout to assess if predation is a key cause of this mortality.

NEXT STEPS

There will be a number of subsequent meetings. These will include:

1. Cowichan Watershed Health and Chinook Initiative Critical Habitat, Critical Limiting Factors and Threats Meeting. February 22 2016. The objectives of this meeting are:
   - Review a draft list of critical habitat for Cowichan Chinook
   - Review a revised list of Critical Limiting Factors for Cowichan Chinook production
   - Identify and prioritize the threats or causal mechanisms
   - Identify and list relevant jurisdictions for each threats
   - Agree on a path forward for Action Planning

2) Programmatic Actions Meeting. Date TBD. This will involve Planners and Practitioners and will aim to identify tools and barriers

3) An integrated management and governance discussion

4) Dedicated meetings to address the risks associated with hatchery release and fisheries on wild Cowichan chinook.

Appendix 1. Cowichan Chinook Meeting Jan 29 2016 Report recommendations

WATER

1. Hydrology

Cowichan Lake Storage Climate Change Assessment KWL

Project Overview

- Cowichan Tribes (CT) retained KWL to carry out an assessment of storage at Cowichan Lake for the purposes of optimizing fisheries flow enhancements and downstream water supply, reviewing options to increase storage at Cowichan Lake, and reviewing projected climate change impacts on water availability in the upper Cowichan watershed.

Recommendations

1. All Cowichan stakeholders review and discuss conservation flow requirements for meeting fisheries values as well as all other water requirements along the river and select the final conservation flow to be used;
2. Complete a water level regime assessment to determine the effect of increased weir elevation on seasonal water levels in the lake;
3. Review the effects of change in water level regime on flood risk, private property, erosion, riparian and near-shore habitat, recreation, etc; and
4. Cowichan stakeholders select and recommend, relying on technical input from studies listed above, the final weir crest elevation to move forward with detailed planning and design.

2. Water Temperatures

Cowichan River Low Flow Mitigation Strategy, 2015

For: Brian Houle, P.Eng. Catalyst By: J.D.C. Craig, BCCF & T. Kulchyski, Cowichan Tribes January 2016

Project overview

- Concerned with potential related impacts to Cowichan juvenile fish standing stocks, returning Chinook adults and the ecosystem, stakeholders including Cowichan Tribes (CT), the fisheries agencies, Catalyst Paper, conservation groups and provincial and local governments initiated the **Cowichan River Low Flow Mitigation Strategy**.
- This report summarizes results of field work by BCCF and Cowichan Tribes between July 31 and September 30, and discusses implications and strategy options for 2016.

Recommendations

1. Discharge measurements at the Allenby Road station are recommended every two weeks once flows leaving the lake have dropped below the 7.08 m3/s target.
2. To eliminate the influence of DFO/CT's fish fence on local river height and therefore discharge at the Duncan WSC station, they recommend Catalyst continues to pursue an option to re-locate the station's levelogger upstream.
3. Flow monitoring and associated habitat observations to determine conditions in the Cowichan's North and South arms were valuable. Because successful adult migration from the arms to the larger holding pools above bifurcation is a high priority due to seal predation concerns,

continued monitoring of the proportion of flow to each arm and the associated habitat conditions is recommended.

4. Maintain a natural spring flow regime**. If the weir is brought on line (control) earlier than normal due to a dry spring and/or low snowpack condition, connective habitats between the mainstem and tributaries or active side-channels may de-water and the ability of overwintering juveniles to migrate downstream from these habitats compromised**
    - Burns et al. (1988) found a 28,008 m2 reduction in active channel wetted area when flow was reduced from 20 to 7.08 m3/s, and a further 17,897 m2 loss when flow was reduced from 7.08 to 4.48 m3/s.
    - Monitoring side-channel connectivity at eight sites over spring flows of 50.5, 26.5, 21.5 and 15.8 m3/s, Wright and Pellett (2006) found the most substantial changes occurred when flows were reduced from 50.5 to 26.5 m3/s; side-channels lost an average of 78% of the discharge they had under the 50.5 m3/s mainstem flow condition.
5. Rearing area and off-channel connectivity are important and critically affected by spring flows. Adequate spring flow can help reduce density-dependent growth suppression during the peak of the optimum growth period; sacrificing spring flows to increase the odds of maintaining augmented summer flow until fall rains return would be counterproductive from an overall productivity standpoint. **This highlights the critical need to develop more storage on Cowichan Lake.**

An Analysis of the Effects of Water Temperature on Adult Chinook Salmon in the Cowichan River

Jason J. Smith LGL April 2015

Project Overview

- Funded by the Habitat Stewardship Program, 2014-2015 Prevention Stream, Cowichan Tribes contracted LGL Limited to conduct an overview and analysis of the potential effects of water temperature on Chinook salmon in the Cowichan River.
- Included a lit review to summarize existing in-river migration and spawning information for fall-run Chinook salmon, & the potential lethal and sub-lethal effects of elevated water temperatures on the survival and behaviour of Chinook salmon during in river migration and spawning.
- Available Cowichan River discharge, water temperature, dissolved oxygen, and air temperature data presented. Relationships between Cowichan River water temperatures, discharge, and air temperature were also evaluated using correlation and regression analyses.

Recommendations

- Elevated thermal regimes may be particularly relevant for any future efforts to re-build the spring-run of Chinook salmon that might hold in the upper Cowichan River and Cowichan Lake during the summer. The relative abundance, run timing, and distribution of these early-run fish be assessed (e.g., through the use of fixed-site sonar and/or radio-telemetry).
- For both run-types of adult Chinook salmon, future research should evaluate the specific temperature profile of individual fish, both temporally and spatially, during their freshwater residence (e.g., through the use of radio tags equipped with temperature loggers). This information would help to identify the location and significance of thermal refugia, and to quantify the potential effects of elevated thermal regimes on Chinook salmon survival and behaviour.

Cowichan River Temperature Monitoring Report 2014-2015

Prepared for: Cowichan Tribes Cowichan Valley Regional District Fisheries and Oceans Canada
Prepared by: Shawn Stenhouse, BCCF July 2015

Project Overview

- During summer 2014, Cowichan Valley Regional District (CVRD) and Fisheries and Oceans Canada (DFO) were concerned with higher water temperatures in the Cowichan River resulting from extreme low flows to 5 m3/s, and higher than average summer air temperatures.
- BCCF retained to install temperature loggers between Cowichan Lake downstream to near the river's tidal boundary.

Recommendations

- Leave the network of temperature loggers in-situ to provide hourly temperature data from the lake to the lower end of the Cowichan River.
- This could address ongoing speculation about thermal stress on fish, & provide empirical evidence for the relationship of temperature loading and river discharge levels (along the whole river corridor).

3. Flood Protection

Lower Cowichan-Koksilah Floodplain Risk Mitigation and Management Program Tier 3 Works 2013-14 Final Post-Construction Monitoring Report

December 2014 Prepared for: Cowichan Valley Regional District. Prepared by: Current Environmental

Project Overview

- This document was prepared to meet monitoring and reporting requirements stipulated in Fisheries Act Authorization 13-HPAC-PA7-00235 issued for Tier 3 - Lower Cowichan-Koksilah Floodplain Risk Mitigation and Management Program instream works completed in 2013 at the Black Bridge (CR1) and Tooshley Island (CR-6) sites on the Cowichan River.
- The project work here is part of a larger sediment and debris management plan to abate flood risk in the lower Cowichan River.

Recommendations

- No negative impacts to fish habitat were observed that resulted from the project works.
- Without continued sediment and debris management in the floodplain reach of the Cowichan River, fish habitat and flood management gains realized as a result of this work will likely disappear in the near future.
- Already in North Fork: uppermost pool of the Pilot Channel largely infilled during the winter 2013-14 season, and downstream habitats also showed sediment accumulation.
- Adult chinook passage and flow connectivity through the North Fork at very low flows (4.5 cms release volume at the Cowichan Lake Weir) were maintained throughout the low flow period in 2014; but any additional flow reductions (e.g. a release volume of 3.0 - 3.5 cms) would have negatively impacted adult migration.
- This project resulted in a significant increase in Cowichan River chinook, coho, and trout productivity while meeting flood management objectives. The methodologies employed and project results provide a strong technical rationale and framework for the implementation of a Sediment Management Plan.

FISH AND HABITAT STUDIES

Early Life History and Critical Rearing Habitat Requirements of Cowichan River Chinook Salmon

Prepared for Salish Sea Marine Survival Project, Strait of Georgia Program, Fisheries and Oceans Canada, Living Rivers – Georgia Basin/Vancouver Island
Prepared by J.D.C. Craig, AScT BCCF March 2015

Project Overview

Between March 4 and June 23, 2014, juvenile Cowichan Chinook Salmon were enumerated and sampled weekly at night by snorkel crews to track abundance and behavior from natal spawning areas to the estuary. Counts and sampling occurred at eight representative index sites, typically consisting of a single stream edge 50 m in length, established in the upper, middle and lower river including several intertidal locations. Crews also documented juvenile Chinook spatial distribution and habitat preferences including physical structure and micro site velocities for comparison to existing habitat suitability curves. Additional surveys of a wide range of intertidal habitats assisted in estimating the relative abundance of stream-reared and estuary-reared fry through the rearing period.

Recommendations

The following stock or habitat assessment and research activities can improve our understanding of Cowichan Chinook early life history from the river to the inner estuary:

- Life History Research. Otolith ablation and microchemistry analysis could be used to determine the length at ocean entry of a representative adult return. This will help focus habitat restoration and stock recovery efforts because we will know the degree to which “fry” and “fingerlings” each contribute to current day adult recruits.
- A detailed inventory of Lower River Riparian Habitats is required. Such inventory could form the basis of a long term riparian rehabilitation program.
- Habitat Use Assessment Using PIT Tags. Continue work commenced in 2014 (Pellett 2015, in prep.) to confirm timing and duration of use of various habitats including mainstem, side channel and estuary by size and origin using PIT tag technology.
- Juvenile Standing Stock Population Estimate. An instantaneous population estimate prior to emigration would greatly improve subsequent survival estimates, particularly those of early marine stages (i.e., subyearling). This might be accomplished through a well-designed multiple “closed site” mark re-capture using VIE tags.
- Estuary Rearing Habitat Inventory. Closely examine all intertidal habitats to determine their current and, with rehabilitation, potential ability to support rearing Chinook. Prioritize subsequent restoration based on potential to create optimal conditions for salmonids, particularly Chinook.
- Spring Run Chinook Timing, Distribution and Abundance. Identify the presence/abundance, timing and distribution of the remnant spring run of Cowichan Chinook. Determine and deliver effective strategies to recover this run and promote its sustainability.

Preliminary Investigation of Habitat Preferences and Abundance of Juvenile Chinook Salmon in the Lower Cowichan River Floodplain (Spring, 2013), with Reference to Habitat Compensation Options

Prepared for Cowichan Valley Regional District, Duncan, BC Fisheries and Oceans Canada, Nanaimo, BC Living Rivers - Georgia Basin/Vancouver Island, Surrey, BC

Prepared by K. Pellett, J. Craig, C. Wightman, BCCF, October 2013

Project Overview

In 2013, BCCF was contracted to identify and implement fish habitat compensation project(s) for recent flood protection works along the lower Cowichan River.

Through spring 2013 workshops, projects focusing on Chinook recovery were prioritized by local stakeholders. Accordingly, juvenile Chinook habitat preferences were documented during this spring 2013 study. BC Conservation Foundation (BCCF) and Cowichan Tribes fisheries personnel conducted a preliminary investigation of Cowichan River juvenile Chinook salmon abundance, habitat preferences and migration behavior in the lower river floodplain and estuary.

Recommendations

- **If the majority of Chinook migrants are fry (as opposed to fingerlings), and we acknowledge their relative dependence on lower tidal channels and the estuary for rearing, this component of the Chinook population may best respond to future habitat restoration in lower-river reaches and the estuary.** Bottom et al. (2011) reported, "Dike removal or other actions to restore fish access to lower-estuary wetlands will thus tend to target naturally produced juveniles with sub-yearling migrant life histories." The broad spatial distribution of fingerlings in the watershed and their potentially reduced dependence on lower river and estuary habitats (i.e., larger size, later arrival) suggest restoration efforts should be focused on fry, although all size classes will benefit. Nagtegaal et al. (2001) reported that hatchery Chinook migrated to the estuary within one week of their river release which also suggests **restoration works in freshwater habitats may be less utilized by hatchery releases than by the wild population.**
- **Efforts to increase the growth and survival of the more numerous fry population may result in the greatest increase to adult returns.**
- Immediate restoration activities should focus on re-connecting historic lower river wetland habitats which have the highest potential to be used by smaller sub-yearling migrant fry earlier in the season, rather than creating new habitats which may or may not be limiting to Chinook production. Later restoration activities could then be more strategic, based on findings from on-going monitoring and the incremental benefits of re-connected historic habitats.
- 7 options were presented to CVP and DFO for compensation, ranging from upper river slope stabilization to control sediment, to estuarine causeway breaches to improve early marine productivity. The Chosen project was the controlled introduction of Cowichan River flow through the South Side Spur Dike (SSSD) into a large, existing side-channel complex downstream of Hwy 1.

Water Temperature, River Discharge, and Adult Chinook Salmon Migration Observations in the Cowichan Watershed, 1988-2014

J.G. Damborg, H.W. Stiff, K.D. Hyatt, G. Brown, and S. Baillie 2015. Canadian Manuscript Report of Fisheries and Aquatic Sciences 3028

Project Overview

Historical daily mean air and water temperatures, stream discharge and adult Chinook salmon upstream migration data were assembled for the Cowichan River, British Columbia. Long-term air temperature time-series were statistically related to intermittent water temperature time-series to hind-cast daily water temperatures for the Lower Cowichan River from 1913-2014.

Recommendations

1. Extend the retrospective pulse flow analysis (Hop Wo et al. 2005) to include pulse flow experiments since 2004 to quantitatively evaluate the extent to which pulse flows have been effective in stimulating Chinook migration past the adult counting weir.
2. Investigate fish passage at Skutz Falls, and the efficacy of the fishway at various flows and water temperature levels, to provide greater insight into Chinook migration behaviour and holding patterns upstream of the counting fence. This could be accomplished with the use of PIT tag studies.
3. Supplement PIT tag observations with continuously recording archival time and temperature tags (e.g., Fryer et al. 2011) to provide insight into fish behaviour and duration of exposure to specific conditions of temperature and oxygen in the Cowichan estuary and the availability and use by Chinook of freshwater thermal refugia related to groundwater sources.
4. Perform a tagging experiment to evaluate, in the absence of pulse flow interventions, the mortality and survival consequences for Chinook holding for extended periods near the mouth of the river.
5. Design a series of controlled pulse flow experiments to further investigate the conservation risks and benefits of flow augmentation strategies on enabling Chinook migration. Incorporate elements of Recommendations 1-4 to quantitatively assess downstream and upstream migratory effects due to flow augmentation, such as estimating the proportion of fish remaining in the marine environment post-pulse; and tracking the movements of fish upstream under various environmental conditions.
6. Assemble and analyze environmental and biological data during spawning and early life history stages to quantify environmental impacts on Cowichan Chinook spawn timing, reproductive success, incubation and fry emergence timing, and fry/smolt production.
7. Implement a "Fish and Water Management Tools" project (Hyatt & Stockwell 2003; 2013) to develop a set of decision support models to improve the basis for seasonal water management decisions that influence annual production variations of Cowichan Chinook.
8. Forecast, based on down-scaled climate model outputs, potential changes in the frequency and duration of migration delay events due to changing thermal and hydrological conditions in the Cowichan watershed under a range of future climate scenarios.
9. If investigations above support controlled flow augmentation as a viable migration enhancement method, and thermal barriers are projected for future decades, investigate cost effectiveness of cold-water release methods based on obtaining water from the cooler depths of Cowichan Lake.

PHYSICAL HABITAT RESTORATION

Five Finger Channels, Busy Creek and Oliver Creek

Sean Wong
Ministry of Transportation and Infrastructure

- Concern that culverts placed to only receive high flows could bring river sediments (which are much higher in volume during high flow/flood conditions) into a channel causing it to infill causing loss of habitat (depth) and spawning impairment (settling of fines over gravel). Issue for the South Side Spur Dike project?
- Chinook will use atypical habitat if they can be accessed.g. some outplanted to John Charlie's Channel.
- Under Integrated Floodplain Management diking works lead to cut-off and infilling of many important aquatic and riparian habitats .
- While some efforts may be targeted to specific stocks or species, almost any salmonid habitat will benefit chinook as welle.g. Oliver Creek restoration was mainly for coho and resident trout but chinook found using newly accessible and restored habitats.
- Chum spawning often seen in restored offchannel habitats. This generates additional food (the chum fry are preyed upon by many species, including chinook) and other ecosystem contributions (e.g. carcasses to feed other parts of the food web from invertebrates to trees).

LOCAL STEWARDSHIP PROJECTS

Cowichan Shoreline Stewardship Project (CSSP) Annual Report 2014

Provided by Craig Wightman

Recommendations include developing a more effective plant survival monitoring program.