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
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In the midst of a busy flood protection works schedule, Draycor Construction Ltd. accommodated BCCF snorkel crews surveying nearby side channels. Westcan Terminals provided access to perimeter sites in the estuary around the Westcan Causeway.

BCCF field crew members included Gary Horncastle, Wayne Paige Jr., Shawn Stenhouse, Jamieson Atkinson, Kevin Pellet, Craig Wightman, James Craig and Michelle Kehler. Michelle (now an Environmental Impact Assessment Biologist, Ministry of Environment, Nanaimo) coordinated the surveys and tracked data results.
Introduction

In spring 2013, 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. Monitoring included a series of snorkel surveys in main stem and off-channel sites as well as biological, water quality and stream flow sampling. The majority of surveys were focused on lower-river and intertidal locations, although a subsample of middle to upper reach sites was also assessed. The primary objective was to identify key habitats in the lower Cowichan River occupied by juvenile Chinook between fry emergence from redds and ocean entry. Results of this study are expected to direct habitat compensation works in 2014 associated with construction of flood protection works in the lower floodplain in summer 2013. This document presents a summary of methods, locations, results and recommendations for future surveys focused on juvenile Chinook rearing habitat needs and limitations.

Methods

Site Selection

The primary focus area for this survey was located between the Highway 1 Bridge in Duncan downstream to the Cowichan River estuary. Several habitat types were encountered in this section including main stem, secondary channels, constructed side-channels, intertidal bifurcations and alcoves. In each habitat type, one or more representative 25 m sections were flagged during an initial site visit on April 3, 2013 in conjunction with the first series of reconnaissance-level snorkel surveys (Appendix A, Photos 1-5). Additional sites in the estuary and mid to upper river were added early in the study to compare the density and distribution of Chinook juveniles in other parts of the watershed (Figure 1).

![Figure 1. Map of the Cowichan River; red circles indicate the 2013 study areas within the watershed.](image-url)
A total of eight index sites were selected in lower reaches of the river during the initial site visit on April 3 (Figure 2, upper). An additional four sites in intertidal reaches of the north and south arms were selected later and initially surveyed on May 7 (Figure 2, lower). These twelve sites were regularly surveyed for the duration of the study; additional sites in the main stem and in Cowichan Bay were investigated opportunistically. These latter sites included a reconnaissance survey of areas around the Westcan Causeway and Terminal.
Snorkel Surveys
Sites were swum by two-person crews to investigate the distribution of juvenile salmonids with a focus on Chinook fry between April 3 and June 25, 2013. The number and species in each site were recorded by the crew while moving upstream in parallel within the flagged section. Surveying slowly in an upstream direction maintained transparency in shallower sites such that observer efficiency was not affected. In main stem sites, crews surveyed a 4-5 m wide lane that allowed accurate fish speciation to be maintained. Side by side and 2 m from the bank, swimmers closest to the bank counted fish below and towards the bank, while the “deep” swimmer counted below and towards the thalweg. One survey was conducted per site per week, and generally by the same personnel.

With concerns that water temperature may still be low and that fish may be in cover, the first survey on April 3 was conducted at night with dive lights. All subsequent surveys were conducted mid-day, often between 1000h and 1500h. Surveys of intertidal sites were scheduled to be near or at high tide so that habitats were similarly wetted and survey results would be comparable.

Main stem discharge (provisional) varied over the study from a high of 75 m$^3$/s on April 3 down to 7 m$^3$/s on June 25 during the last survey (Figure 3). Discharge in side channel sites varied with main stem flow but no changes to intake valve settings occurred over the study period.

**Figure 2.** Aerial photos of the lower Cowichan River (upper) and estuary (middle and lower) indicating the locations of snorkel survey sites. Red lines indicate the approximate path of each survey.
Figure 3. Cowichan River discharge as measured at the Water Survey of Canada station 08HA011 near Duncan, Feb 1--July 1. Error bars represent one standard deviation from mean daily discharge measurements. Historic data provided by Lynne Campo (WSC) and provisional 2013 data obtained from [HTTP://WWW.WATEROFFICE.EC.GC.CA](http://www.wateroffice.ec.gc.ca).

All fish observations (salmonids and non-salmonids) were noted on swim slates. Survey crews wore neoprene dry suits, felt boots and neoprene hoods/gloves. Safety gear included rescue throw bags and extraction vests made from ballistic nylon. Safety tailboards were conducted prior to all surveys.

**Fish Sampling**

In addition to snorkel surveys, juvenile Chinook were captured using a 6 m x 1.5 m pole seine constructed of ¼” stretch mesh netting (appendix A, Photo 7). Fish capture occurred in close proximity to swim sites, and in habitat similar to that of the swim sites. Sets were intended to capture enough fish to obtain statistically viable mean lengths and weights at each location (~20-50 fish), while swims were intended to estimate local abundance. The primary objective was to look for differences in size between sites and over time. Secondly, by looking for adipose fin clips (AFC), sampling allowed a determination of hatchery contribution to the catch of Chinook (see Table 1). Coho were also measured. Other salmonid and non-salmonid species were enumerated only.
Fish that were measured were first anesthetized in the holding bucket with a few drops of an ethanol/clove oil solution (10:1). A standard length board (Appendix A, Photo 8) was used to derive lengths while weights were recorded using a digital scale and a small plastic weigh-boat zeroed (tare weight) prior to each fish. Fish were released back into the site when they demonstrated normal swimming behavior following a 10-15 minute recovery period.

### Results

#### Snorkel Surveys

**Index Sites**

Aggregate Chinook abundance from the 12 sites varied from 100 to 806 between April 3 and June 7, before dropping off sharply on the last two surveys (Figure 4). The first survey on April 3 yielded a total count of 437 which was above average considering the intertidal sites were not included (first surveyed on May 7), and the count occurred at night. The origin of fish observed on April 3 was very likely wild because hatchery fish stocked at that time were released in the lower estuary and had since experienced high flows of 70 to 200 m³/s. The largest count of 806 occurred on May 30 and was driven mostly by an estimated 700 Chinook observed at the hatchery fence site (see Figure 2, above). Chinook were observed actively migrating through upper portions of the water column such that the density of fish within the site was changing instantaneously. The next highest count at this site was 41 on April 3 (Appendix B).

The density of Chinook varied between the four habitat types surveyed (Figure 5). Main stem sites consistently had the highest count per lineal meter while only one Chinook was observed in the alcove over all survey days. Side channels had a lower density than main stem sites with the exception of the May 30 sample. Intertidal sites were first surveyed on May 7 and had a consistent density of 0.2 to 1.1 juvenile Chinook per lineal meter. All sites showed a dramatic decline in Chinook to essentially zero fish between June 7 and June 19, re-confirmed by the June 25 survey. Main stem discharge (at Lake Cowichan) was reported as 22 m³/s on June 7 and decreased to 11 m³/s by June 19 before arriving at the summer base flow of 7 m³/s on June 22.

---

1 MY WEIGH i2600 - 2600 g capacity, 0.1 g resolution.
2 500,000 unmarked fry with a mean weight of 1.64 g were stocked March 1 (J.R. Elliott, Manager, Cowichan River Hatchery, pers. comm.).
Figure 4. Total juvenile Chinook count in all sites over nine sample intervals between April 3 and June 25, 2013.

Figure 5. Juvenile Chinook density in four habitat types by survey date, April 3 – June 15, 2013.
Although Chinook were the primary focus of the study, other salmonids were also enumerated. The aggregate number of Chum fry observed from all sites was highest on the first survey and declined sharply by May 16. The aggregate Coho fry count increased to 8,700 on May 22, then declined to approximately 5,000 for the rest of the survey period (Figure 6). Steelhead/Rainbow counts were relatively minimal throughout the study but abundance was notably higher on April 30 and consisted mainly of parr/smolt-sized individuals.

**Figure 6. Total abundance of other salmonid species in all sites over 9 sample intervals between April 3 and June 25, 2013.**

**Non-Index Sites**
In addition to the regular index swims, several exploratory surveys were completed in other parts of the watershed. Sites 25 m in length were surveyed at the Road Pool near Lake Cowichan, Stoltz Pool in Cowichan River Provincial Park, and Integrated Flood Management Plan sites CR1 and CR6 in the lower river on May 30. The Road Pool and Stoltz sites were classified as main stem and were found to have significantly higher densities of Chinook juveniles at 1.8 and 2.2 per lineal meter compared to 0.6 at the lower river main stem index sites (Figure 7).

On April 30, crews surveyed two areas around the Westcan Terminal/Causeway during a low and receding tide under sunny conditions. One team surveyed rip rap, mud flats, piers supported by pilings, and various wharves at the eastern end of the terminal. They observed several small schools of Chinook, Chum fry and Coho smolts in varying "edge" habitats offering cover – no fish were observed in “open water.” Chinook and Coho were
observed around and, in particular, between the various wharves, using them effectively as escape cover. The other team surveyed mainly the edges of open tidal channels on both sides of the causeway, from 200 to 500 m west of the terminal. They observed 185 Coho fry, 20 Chinook fry and 15 Chum fry along 250 m of edge habitat on the north side of the causeway (South Arm Cowichan River), and just 2 Coho fry along 200 m of similar edge habitat on the south side of the causeway. Refer to Appendix C for the full report on these activities.

![Figure 7. Density of juvenile Chinook in index (blue) and non-index (yellow) sites, May 30, 2013.](image)

**Fish Sampling**

A total of 562 juvenile Chinook were captured via pole seine over three days at five sites (Table 2). Of these, 330 were measured including 7 AFC fish (2.1%). The mean size for all fish collected on each sample day increased significantly over time from 62.8 mm on May 23 to 71.9 mm on June 18 (Figure 8). However, of the 330 fish sampled only 20 were collected on the last sampling day due to low abundance (confirmed the following day by a combined snorkel count of one fish across all sites). Although differences were displayed between habitat types on each sample day few were found to be significant. Only fish collected from the side channel sites were significantly larger than those from the intertidal reaches on May 31 only (69.8 mm vs. 63.0 mm, respectively).
**Table 2. Summary of fish capture data by date, species and location in the Cowichan River, 2013. Note: CN - Chinook, CO – Coho, RB - Rainbow**

<table>
<thead>
<tr>
<th></th>
<th>Fence</th>
<th>Major Jimmy's</th>
<th>Mainstem</th>
<th>South Fork</th>
<th>North Fork</th>
</tr>
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<tbody>
<tr>
<td>23-May</td>
<td>CN 10</td>
<td>26</td>
<td>33</td>
<td>58</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>CO 200</td>
<td>245</td>
<td>485</td>
<td>1569</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>RB 0</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>31-May</td>
<td>CN 50</td>
<td>54</td>
<td>65</td>
<td>180</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>CO 25</td>
<td>164</td>
<td>154</td>
<td>45</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>RB 0</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>18-Jun</td>
<td>CN 2</td>
<td>3</td>
<td>8</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CO 392</td>
<td>888</td>
<td>270</td>
<td>142</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RB 2</td>
<td>2</td>
<td>5</td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 8. Mean lengths of non-AFC Chinook captured in three habitat types (N=324) between May 23 and June 18, 2013. Error bars represent 95% confidence intervals for each sample mean.**

A length frequency plot was also created for the three habitat types with sufficient fish capture data (Figure 9). The distribution of lengths at main stem and side channel locations was clustered between 55-75 mm while fish captured at intertidal sites (north and south fork) were found to be more abundant in the 45-65 mm range. The smallest fish captured was 42 mm while the largest was 91 mm. By comparison, 5 of 6 AFC Chinook captured ranged from 83-89 mm with one individual at 106 mm.
When the mean size at each of the sample sites was looked at individually there appeared to be a higher degree of variability compared to habitat types alone (Figure 10). Fish collected from the fence site were significantly larger than all other sites on May 23, while fish collected from the south arm were significantly smaller than other sites on May 31. No clear differences were apparent on June 18 although the sample size was greatly reduced due to decreased abundance, a result supported by snorkel observations on June 19.

**Figure 9.** Length frequency histogram for Cowichan River juvenile Chinook (non-AFC) captured between May 23 and June 18, 2013 in three habitat types.

**Figure 10.** Mean lengths of non-AFC Chinook captured at five sites during three sample intervals between May 23 and June 18, 2013. Error bars represent 95% confidence intervals for each sample mean.
Water Quality Monitoring

During the spring juvenile salmon migration period, BCCF undertook a water quality and flow monitoring program in the lower Cowichan River floodplain. Water quality monitoring sites are shown in Figure 11.

![Figure 11. Water Quality monitoring site locations for the Cowichan River 5-Fingers Channel Complex, 2013.](image)

A description of the specific locations (by UTM coordinates) of water quality monitoring sites in the lower Cowichan River floodplain is presented in Table 3.

**Table 3. Locations and Names of Lower Cowichan River Floodplain Water Quality Monitoring Sites.**

<table>
<thead>
<tr>
<th>Site #</th>
<th>UTM</th>
<th>Site Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10 U, 449610 E, 5402280 N</td>
<td>DFO Intake valve</td>
</tr>
<tr>
<td>2</td>
<td>10 U, 449753 E, 5402298 N</td>
<td>Intake Channel u/s road</td>
</tr>
<tr>
<td>3</td>
<td>10 U, 449759 E, 5402216 N</td>
<td>Marine Harvest Channel u/s road</td>
</tr>
<tr>
<td>4</td>
<td>10 U, 450108 E, 5402201 N</td>
<td>John Charlie’s Channel behind Roger George’s</td>
</tr>
<tr>
<td>5</td>
<td>10 U, 450059 E, 5402281 N</td>
<td>Connecting Channel to Alcoves</td>
</tr>
<tr>
<td>6</td>
<td>10 U, 449959 E, 5402497 N</td>
<td>NW portion of Alcoves</td>
</tr>
<tr>
<td>7</td>
<td>10 U, 450206 E, 5402672 N</td>
<td>Mainstem Site 1</td>
</tr>
<tr>
<td>8</td>
<td>10 U, 450411 E, 5402597 N</td>
<td>Upper Major Jimmy's Channel</td>
</tr>
<tr>
<td>9</td>
<td>10 U, 450691 E, 5402408 N</td>
<td>Lower Major Jimmy's Channel</td>
</tr>
<tr>
<td>10</td>
<td>10 U, 450682 E, 5402365 N</td>
<td>Off-channel Pool</td>
</tr>
<tr>
<td>11</td>
<td>10 U, 450762 E, 5402436 N</td>
<td>Upper 5-Fingers Channel (Hatchery Channel)</td>
</tr>
<tr>
<td>12</td>
<td>10 U, 451233 E, 5402370 N</td>
<td>Mainstem at DIDSON site</td>
</tr>
<tr>
<td>13</td>
<td>10 U, 451250 E, 5402288 N</td>
<td>Mid 5-Fingers Channel (Hatchery Channel)</td>
</tr>
<tr>
<td>14</td>
<td>10 U, 451470 E, 5402173 N</td>
<td>Mainstem Site 2</td>
</tr>
<tr>
<td>15</td>
<td>10 U, 451685 E, 5402062 N</td>
<td>Lower 5-Fingers Channel (Hatchery Channel) - Smolt Fence</td>
</tr>
</tbody>
</table>
Full results of water quality monitoring for all sites to-date are included in Appendix D. The data are generally unremarkable so far, except for very low dissolved oxygen measurements periodically sampled at sites 5, 6, 8 and 10. These results are directly attributed to lack of surface flow continuity at these four locations as the mainstem Cowichan River declined to summer base levels (i.e., 7 m$^3$/s or lower) in early July. Consideration of modifications to side channel connectivity and increased conveyance flows to enhance summer-early fall water quality for juvenile salmonids is now underway. A final round of 2013 water quality sampling is scheduled for October when river flows respond to fall rain storm events.

Flow monitoring results will be presented as an addendum to this report at a later date. These results will also be included as an appendix in an on-going Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) fisheries flow study in the Cowichan, downstream of the Catalyst Paper Pump House. BCCF currently has four Solinst level loggers and one staff gauge installed in the network of lower Cowichan side-channels (i.e., DFO Intake; Upper Major Jimmy’s; Middle Major Jimmy’s; DFO/Hatchery Smolt Fence), as well as one in the lower mainstem river (opposite the new South Side Spur connector dike). MFLNRO has a series of level loggers and staff gauges in the lower Cowichan River in relation to an on-going ground water/surface water interaction study (Robin Pike and Pat Lapcevic, FLNRO, pers. comm.). It is expected that preliminary results of both in-stream flow studies will be available by March 2014.

**Discussion**

In terms of abundance over time, there did not appear to be a gradual reduction in the number of fish present in the lower river but instead a relatively steady abundance at all sites followed by a dramatic decline to essentially zero between June 7 and June 19. Exceptions to this observation include a high abundance in main stem sites on the April 3 survey followed by another spike on May 22. Also, biologists filmed (by “GoPro”) significant downstream migration of Chinook juveniles at the hatchery fence site on May 30 (archived in BCCF files). The latter two events may be linked to a release of 500,000 hatchery Chinook at the Road Pool on May 15, but few marked fish were observed in the swims or sampling (~2%). Considering that 450,000 of the release were AFC, this suggests the majority were naturally reared juveniles.

In general, the highest densities of Chinook were observed in main stem sites over the duration of the study. In side channel habitats, higher counts were associated with higher velocities - sites with low or no velocity held few, if any, juveniles. Alcoves where little to no water was flowing were essentially devoid of Chinook during our surveys, observations commonly reported by Groot and Margolis (1991). This trend was also documented as swimmers moved into and between main stem sites and routinely observed concentrations of Chinook in higher velocity habitats and on the bottom in runs up to 4 m in depth.

Non-index surveys in the middle and upper reaches of the river provided insight into the distribution of Chinook within the watershed. Swims conducted at the Road Pool and Stoltz Pool on May 30 suggested that Chinook (less than 1% AFC) were equally or more abundant compared to lower main stem sites. Juveniles were routinely observed in higher velocity habitats, as well as mid-column in the thalweg of deeper pools.
Several intensive assessments of juvenile Cowichan River Chinook have been previously conducted over a larger window in the spring migration period. In these studies, two migrant groups were identified: fry and fingerlings. Fry (40-55 mm) are the first to reach the estuary from March to mid-April while the fingerlings (60-75 mm) follow in May and peak in June (Lister et al. 1971; Argue, Patterson and Armstrong 1979; Nagtegaal et al. 2001, Groot and Margolis 1991). Lister et al. (1971) indicated the vast majority of Cowichan Chinook migrants are fry while fingerlings accounted for approximately 17% of the population. Most of the 2013 snorkel survey and fish sampling activities were likely timed with the fingerling migrant population, based on observed fish size and survey timing. The most likely habitats for fry (intertidal reaches) were not surveyed until May 7, which was nearly a month later than their peak migration timing described in previous studies.

In the lower Columbia River and estuary, Bottom et al. (2011) suggested there are also size-dependent patterns, both in migration and habitat use among many Chinook juveniles, reflected in the following key findings:

1. **Extensive wetland loss has substantially decreased the quantity and quality of wetland habitats that support salmonid food webs and provide off-channel rearing areas for sub-yearling Chinook migrants with estuary-resident life histories.**

2. **Salmon habitat use and residence times vary with fish size, but all wetland habitat types in the lower estuary are utilized by the smallest sub-yearling size classes, which tend to remain in the estuary for the longest periods.**

3. **Naturally produced sub-yearling salmon dominate in shallow wetland channels and may benefit most directly from restoration of wetland habitats. 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.**

4. **The response of the estuarine ecosystem to large subsidies of hatchery fish and estuary interactions between hatchery and naturally-produced salmon remain poorly understood. Such interactions may ultimately determine whether estuary restoration is an effective tool for salmon recovery. Because hatchery production could undermine the effectiveness of recovery measures for at-risk populations, we strongly recommend that additional estuary studies be designed and conducted to examine more explicitly the ecological interactions between hatchery and naturally-produced Chinook salmon.**

5. **Wetland-derived food webs support juvenile salmon throughout the estuary, including larger individuals that do not typically occupy wetland channels. Future studies should examine whether Chinook salmon target specific taxa within the Chironomid family as evidence for microhabitat selection within tidal channels.**

Some or all of these observations may apply to Cowichan Chinook, but results from the 2013 surveys must be considered preliminary at this time, especially given the early migrant population of small fry was not consistently detected by field surveys launched in late April.
Recommendations

If we adopt the idea the majority of Chinook migrants are fry (as opposed to fingerlings), and 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.

We recommend focusing future studies on the earlier component of juvenile Chinook by investigating habitat use and density in the February 1 to April 15 period. Main stem flows in Duncan at this time average 55-110 m$^3$/s, a discharge that ensures connectivity to most or all existing wetland and secondary channel habitats. In other studies, all wetland types were found to be utilized by the smallest sub-yearling size groups, especially shallow secondary channels and peripheral (marsh bench) habitats (Bottom et al. 2011). In Cowichan, these habitats may have been dry during the 2013 juvenile surveys.

Other activities should focus on the relative contribution of each migrant group to the adult population. The earlier fry make up the majority of the juvenile population but the larger fingerlings, which likely survive at higher rates, may contribute disproportionately to future adult returns. Efforts to increase the growth and survival of the more numerous fry population may result in the greatest increase to adult returns.

Without answers to the above, 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.

Using existing Habitat Suitability Index (HSI) curves for summer Chinook rearing it appears that habitat as shallow as 22 cm can support the highest probability of sub-yearling use (Figure 12). Similarly, velocities as low as 0.25 m/s are highly suitable for Chinook sub-yearlings. However, since these curves were developed for summer use when juveniles are larger, both curves likely under-estimate the probability of use for 40-60 mm Chinook fry in shallow (< 20 cm) low velocity wetland or marsh habitats. Perhaps more importantly, these shallow wetland habitats may be responsible for the majority of invertebrate food production which is transported via tides and tidal currents to all parts of the estuary.
Fish Habitat Compensation Options

Several conceptual fish habitat compensation options have been identified to offset impacts from recent dike construction (Tier 2) activities. Each option has potentially significant benefits for juvenile Chinook and other salmonids that utilize habitats in the lower Cowichan River. A brief summary of each option is presented below, including linkages back to results from this study and published literature from other watersheds.

**Option 1: Breaching the Westcan Terminal Causeway in the Cowichan Estuary**

**Biological Rationale**

Inter-tidal habitats in the Cowichan estuary comprise an estimated 277ha, of which 135ha (49%) were historically impacted by industrial log storage, milling and shipping practices (Williams and Langer 2002). These impacts, in addition to those from agriculture, flood control and commercial developments have reduced the quality and areal extent of productive fish and wildlife habitats.

In the Cowichan watershed, Chinook fry make up the largest component of downstream migrants which rely heavily on shallow wetland habitats for foraging and early growth before entering the marine environment. Few fry appear to enter Cowichan Bay at a size of less than 60 mm and, therefore, they are unlikely to readily occupy the south side of the estuary where direct access is almost completely blocked by the Westcan Terminal Causeway, originally built by the CNR as a tidewater shipping facility in the 1920’s (i.e., Chinook juveniles sampled in the bay by DFO in 2013 averaged 71 mm; Dr. R. Sweeting, PBS, pers. comm.).

---

**Figure 12. Habitat Suitability Index (HIS) Curves for Summer Chinook Rearing. Curves obtained from Ministry of Environment and BC Hydro Water Use Planning.**
Additionally, beach seining locations on the south side of the bay rarely yield Chinook juveniles (Dr. R. Sweeting, PBS, pers. comm.). Consequently, re-connecting the river’s south arm with the south side of the estuary would open up a large area of additional habitat for rearing Chinook, prior to entering Cowichan Bay.

At this stage, professional opinion suggests the availability of shallow estuary marsh/wetland habitat appears to be a potential limiting factor for juvenile Chinook production in the lower Cowichan watershed. Consequently, distributing migrant juveniles to a much broader area of estuarine habitat could potentially reduce predation-related mortality and intra and inter-specific competition.

Currently, there are two complementary proposals to either breach the Westcan Causeway or re-connect the river’s south arm to the south side of the estuary through pre-existing culverts. BCCF and NHC Ltd. are investigating the latter concept to divert a portion of the river’s flow through existing twin cast iron culverts (~2mØ and 20m long) that pass under the causeway approximately 350m east of the Tzouhalem Road intersection (Figure 13).

**Figure 13. Approximate location of the proposed re-connection of south arm Cowichan River with the south side of the estuary through the Westcan causeway (red polygon), and potential area of additional habitat for Cowichan River juvenile salmonids (yellow shading).**
The second, sponsored by the Cowichan Estuary Restoration and Conservation Association (CERCA), proposes to breach the causeway and install a new bridge approximately 1.3km south-east of the Tzouhalem Road intersection (Figure 14). Preliminary engineering design/cost studies have yet to be undertaken for the causeway breach and bridge concept, but these may begin in October 2013.

For the first proposal, project feasibility includes detailed hydraulic modelling of connector channel flows (volumes) and velocities given a range of head differences and tides between a proposed river intake and the inter-tidal channel terminus, immediately south of the Westcan causeway. Private property negotiations and regulatory approvals are also implicit at this early stage of investigation.

**Figure 14. Proposed Westcan Causeway Breach and New Bridge Location (Red Polygon) Proposed by CERCA.**

The 2.5km wide estuary is currently divided by the causeway, resulting in approximately 1.6 km of immediately useable rearing area for Cowichan juvenile salmonids, and 0.9km of fragmented (“more distant”) habitat. The fragmented section represents approximately 30% of estuary’s total area (>80ha), so re-connecting this habitat directly to the river could result in a major gain of accessible rearing area compared to existing conditions.

**Option 2: Controlled Introduction of Cowichan River Flow through the South Side Spur Dike to Upper John Charlie’s Alcoves**

**Biological Rationale**

Following the spring 2013 snorkel surveys, a network of alcove habitats (i.e., upper John Charlie’s) was found to be nearly devoid of juvenile Chinook and other salmonids. In contrast, other side-channels of a similar size but
with enhanced flows were comparatively well used, suggesting there may be an opportunity to upgrade the alcove channels. For Chinook and Coho (particularly), increasing habitat suitability in the alcoves could potentially represent a major gain in rearing area in the river’s lower floodplain. Based on snorkel observations, shallow (<0.5 m), moderate velocity (0.2-0.5 m/s) riffles and glides, as well as pools with in-stream or overhanging cover, were preferred by juvenile Chinook during spring conditions. The upper alcoves and “blind” channels currently have reduced flow connectivity and seasonally low dissolved oxygen in parts, so enhancing flows intuitively seems like a prudent first step. This can be done by constructing a controlled flow intake just below the new Mission Road connector dike, through the now obsolete South Side Spur Dike (Figure 15).

**Figure 15. Proposed location for new intake through the South Side Spur Dike and potential area of improved habitat for Cowichan River juvenile salmonids (area within red polygon).**

NHC Ltd. is currently working with BCCF in designing a new intake through the South Side Spur Dike to provide additional flow to the John Charlie alcove network. The objective is to have the new flow connector operate principally in the late winter/spring period (i.e., early March – mid June), during the seasonal Chinook fry and fingerling migration. The intake design must be effective in passing both target flows and migrant fry so juveniles can more fully occupy preferred rearing habitats “outside” of the mainstem river environment. This should promote better growth and survival of juveniles as they transition to sea-going smolts by late spring and early summer.

Detailed designs, including enhanced alcove flow connectivity, needs to be first vetted by Cowichan Tribes’ leaders and individual property owners, adjacent to the off-channel network. A provincial water licence is needed for a new intake structure, and we are currently unsure of who will hold this licence (but most likely Cowichan Tribes).
**Option 3. Exercising Existing Flow Control Valves on the DFO Intake Pipe and Five Fingers Side-Channel Pipe**

### Biological Rationale

There is one existing DFO-licenced intake valved-pipe (60cm Ø; BC water licence C 115415) servicing flow requirements to the existing John Charlie and Five Fingers alcove/side-channel networks in the lower Cowichan River. This licence provides for diversions of up to a maximum of 0.283 m$^3$/sec, and is not to exceed 10% of the adjacent mainstem river flow at the point of diversion (Figure 16).

![Figure 16. Overview of Lower Cowichan River Floodplain and Network of Side-Channels and Alcoves.](image)

Additional water through the alcoves and channels is provided by a surface water discharge from the Marine Harvest Freshwater Farms Hatchery on Boys Road (average of 0.066 m$^3$/sec or up to 0.166 m$^3$/sec during peak periods of fish production). Approximately one-third of the Marine Harvest Hatchery discharge is diverted to the DFO intake channel leading to John Charlie’s alcove (Lance Page, Marine Harvest, pers. comm.)

Sean Wong, Senior Biologist, Ministry of Transportation and Infrastructure, indicated that DFO and Cowichan Tribes installed a short 60 cm valved-pipe between Major Jimmy’s side-channel and the top of Hatchery side-channel to augment flows in the latter about 2001. In 2009, Sean directed re-building of a ‘Newbury riffle’ downstream of the Major Jimmy’s wing intake to ensure low summer flows still passed through the pipe into Hatchery channel.

For the record, there appears to be little in the way of a “paper trail” documenting operational protocols and maintenance for either valved-pipe. Presently, both gate valves appear to be set to about ‘20% open’ and there is every indication they have not been routinely opened wider in response to seasonal downstream fish habitat needs for several years. Although it has been suggested that Marine Harvest and/or Cowichan Tribes Hatchery
were originally vested with operational responsibility for the pipes, Tom Rutherford of DFO has recently indicated that no such written agreements presently exist.

Consequently, BCCF is proposing to begin a series of gate valve adjustments by late fall 2013 to test the serviceability of both pipes, and to monitor downstream fish habitat and channel responses. This will only occur following consultations with all major parties, and coincidentally with the river’s natural rising hydrograph in response to fall rains. It is expected that some fine sediment will be mobilized, especially below the DFO intake pipe near the Marine Harvest Hatchery. This can be partially mitigated by slowing the rate of valve opening over several days.

There are two additional steps that need to be taken with respect to this potential compensation option. The first involves development of a written operational protocol for both pipes that reflect the seasonal water/habitat requirements of native fish species, especially Chinook salmon. BCCF can prepare a draft protocol for presentation to the parties who would be responsible for implementation and, if necessary, provide field training in valve adjustments and subsequent flow measurements.

BCCF can also lead field investigations designed to consider replacement of the Major Jimmy’s pipe intake with a clear span bridge, especially given the 2013 Hatchery Road dike upgrades (i.e, provides additional flood protection for nearby properties/residences). This will most certainly result in significantly more flow into the Hatchery/Five Fingers side-channels, which should result in significant improvements for juvenile Chinook rearing. Should this eventually be done, BCCF can work with Cowichan Tribes and DFO to increase structural cover and habitat complexity in this valuable side-channel network.

**Option 4: Affinity Guest House Inter-Tidal Channel Enhancement**

**Biological Rationale**

The Affinity Guest House is located near the end of Samuel Road, approximately 200m south-east of the Tzouhalem Road intersection. An inter-tidal floodplain, just east of the Guest House, was apparently enhanced by Ducks Unlimited Canada several years ago when an old dike was breached (Figure 17). BCCF has conducted a preliminary assessment of the property’s potential for fish habitat restoration, in conjunction with the owner, Tanner Elton.

As of early October, 2013, more baseline monitoring (including spring, 2014) is required to document current juvenile salmonid use and habitat conditions, as a basis for developing potential restoration concepts. Issues around contiguous land ownership, The Nature Trust’s restrictive covenant and inter-agency regulatory concerns also need to be addressed (Figure 18).

Based on our on-site meeting with Mr. Elton on August 28, 2013, he appears receptive in principle to fish habitat restoration ideas, including stronger physical links between the property’s two freshwater ponds and the nearby inter-tidal channel, immediately adjacent to his dike and walking trail. This could potentially lead to enhanced passage of salmonid fry into the ponds for rearing prior to smolting and ocean entry. It is noted that both ponds
currently contain invasive bull frogs, which would likely need to be removed as part of a broader fish habitat restoration initiative.

**Figure 17. Affinity Guest House property in the Cowichan River estuary.**

**Cowichan Property - Rodenbush**

**Figure 18. Affinity Guest House property with more detailed lot lines and depicting TNT’s Restrictive Covenant area.**
**Option 5. Jayne’s Side-Channel Enhancement**

Biological Rationale

The natural inlet to Jayne’s side-channel is located approximately 100m downstream of Cowichan Tribes’ Quamichan (Kwa’mutsun) Village site, on the left bank (viewing d/s) of the Cowichan River (Figure 19). The side-channel’s intake appears to be controlled by a lateral gravel bar, which has accumulated above/below an old log jam. Much of the LWD appears to be in a state of decay and partially covered by river bedload.

The channel is an estimated 300m long and recessed from the river about 80-100m (at most). It is bounded to the immediate east by the Quamichan dike and road and is “protected” from mainstem floods by the lateral gravel bar and a stand of relatively large, well-anchored second growth conifers and deciduous species.

The channel features a series of alternating pools, riffles and glides over gravel-cobble substrate under typical spring flow conditions (i.e., 60→15 m³/s mean monthly flow, March – June, respectively). Under summer base flows (7 m³/s or less) there may be little surface water connectivity in the side-channel. While well-shaded by the coniferous canopy, the channel presently contains little stable LWD as juvenile fish “escape” cover. Nonetheless, it likely provides summer rearing habitat for Coho and possibly for Chinook fry in the spring period.

**Figure 19. Jayne’s side-channel on the lower Cowichan River, downstream of Quamichan Village.**
An opportunity to enhance Jayne’s side-channel would likely entail modification of the channel’s intake to ensure its continued durability and improved flow function, and additions of ballasted LWD to increase rearing habitat complexity along its full length. To date, specific engineering plans have not been developed in that regard.

**Option 6. Broadway Run Slope Stability Remediation**

**Biological Rationale**

Point source sedimentation of Cowichan River fish habitats has been an ongoing and high priority issue for the Cowichan Stewardship Roundtable since 2005. With completion of the Stoltz Bluff remediation project (2006-2008), efforts have now shifted to assessing major sediment sources further upstream, above Skutz Falls, in arguably the most productive reach of the river for Cowichan Chinook salmon.

The greatest point source sediment threat, known locally as “Broadway Run,” adjacent to District Lot 51 (a.k.a. Block 51), is an active right (west) bank slide area containing a high proportion of silt/clay (very similar to Stoltz Bluff), known to be extremely damaging to salmon egg-to-fry survival (Figure 20).

Total suspended sediment (TSS) from Block 51/Broadway Run constituted ~29–36% of the overall TSS load measured at the Catalyst Paper pump house during the winter of 2010/11 (i.e., 18.3km below Stoltz Bluff; Gaboury and Robichaud 2011). This is likely to increase (possibly dramatically) in future, if slope failures worsen at the Broadway site.

Increasing failures at Broadway threaten to compromise substantial habitat gains realized from the earlier success of Stoltz Bluff remediation, approximately 10km downstream (Gaboury, Robichaud and Damborg 2012). DFO staff have commented that, “Bank stabilization and restoration at Stoltz has significantly reduced sedimentation in (the) lower river, (and) egg to fry survival has increased greatly (Wilf Luedke, Chief Stock Assessment Biologist, DFO, Nanaimo in a July 7, 2011 presentation to the Cowichan Watershed Board).

Therefore, this project provides added insurance for sustained water quality and fish habitat conditions in future for this Canadian/BC Heritage River.

![Broadway Run Slope Stability Site](image)

**Figure 20. Broadway Run slope stability site in the upper Cowichan River.**
Since 2008, BCCF has worked closely with a team of geoscience and river engineers, as well as fish habitat restoration and environmental impact specialists, in developing an appropriate remediation plan for the Broadway Run slope (Gaboury, Silvestri and O’Brien, 2008; Gaboury 2010; Sykes and O’Brien 2010; Sutherland and Murray 2013). The current preferred design involves building a set-back, rip-rap lined trench inside the toe of the Broadway slope to ensure the toe is not undercut if the river channel continues on its present erosion path (Figures 21, 22). By securing the slope’s toe, engineers believe the risk of catastrophic slope failure into the river can be largely eliminated, although smaller surficial failures will not be totally averted, in future.

**Figure 21.** Overview of Broadway Run slope stability site in the upper Cowichan River, with conceptual setback armoured toe trench.

**Figure 22.** Cross-sectional view of setback armoured toe design for Broadway Run.
Estimated cost of this project is still being refined, but may exceed $0.75M for access development, construction, remediation, monitoring and final reporting. It is hoped the project can start in summer 2014, but much depends on BCCF fund-raising success and approvals by regulatory officials over the next 8 months. It is also expected that remediation will need to be completed over 2-3 years, given annual funding limitations for large projects of this kind.

**Option 7. Maintenance of the Stoltz Bluff Slope Stability Project**

**Biological Rationale**

Stoltz Bluff is located within Cowichan River Provincial Park, immediately upstream of Stoltz Pool Campground (Figure 23). The bluff is an extensive left bank (viewing d/s) deposit of glacial sediment that extends for approximately 800 m at the outside of a natural meander bend. Total height of the exposed deposit is about 50–60 m and it consists of nine major strata of distinct sediment layers. A pooled grain size distribution was estimated for this deposit and included 24% gravel and coarser material (>2mm), 21% sand, 37% silt and 17% clay (KWL Associates Ltd. 2005).

From TSS (total suspended sediment in mg dry weight/L) and air photogrammetry analysis, it was estimated that Stoltz Bluff contributed 10,000-28,000 m$^3$/year of fine sediment to the river between 1993 and 2004 (variation between years occurred as a result of precipitation and flows). Contribution of suspended sediment from Stoltz Bluff alone comprised 35–45% of the total estimate sampled at Vimy Road, approximately 10 km further downstream (KWL Associates Ltd. 2005).

**Figure 23. Location of Stoltz Bluff, in Cowichan River Provincial Park, 27km upstream of Cowichan Bay.**
Following comprehensive geotechnical, fluvial and fish habitat impact analyses, a decision was made to remediate Stoltz Bluff starting in 2006 (Wightman, Murray and Gaboury 2008). The project was successfully completed over two years (2006/07), and has been subject to annual maintenance since then. In September 2013, BCCF undertook a comparatively large-scale maintenance upgrade of the project to provide significant additional containment capacity for the several tonnes of fine sediment still unravelling from the bluff each winter (Figure 24).

All maintenance tasks were successfully completed in September at an estimated cost of $10,000. This work should provide several years of reduced maintenance, notwithstanding unanticipated volatility on the bluff caused by excessive rain or rain-on-snow events. Since initial construction, typical annual maintenance costs have ranged from $2,500 to $10,000 per year.

Elimination of most fine sediment from this site continues to be applauded by provincial water quality biologists (Deb Epps and John Deniseger, MoE, Nanaimo; March 27/12 letter on file at BCCF) as important progress in protecting source drinking water and aquatic ecosystem health in the Cowichan Valley. The Stoltz project has been partially credited with enhanced Chum and Chinook salmon returns to the river over the last two brood years, in particular (Wilf Luedke, DFO, pers. comm.), and with reduced annual costs of “raw” water treatments (i.e., alum and settling basins) at the Crofton mill of Catalyst Paper Corp. (B. Houle, P.Eng., Catalyst Paper, pers. comm.).
References


Appendix A
Photographic Record
PHOTO 1. LOOKING DOWNSTREAM INTO THE 5 FINGERS SWIM SITE, APRIL 3, 2013.
Photo 2. Looking downstream into the fence site, April 3, 2013


PHOTO 5. LOOKING FROM RIGHT BANK INTO THE MAIN STEM 1 SWIM SITE, APRIL 3, 2013.

PHOTO 8. TWO CHINOOK JUVENILES ON A LENGTH BOARD AT THE TZOUALEM ROAD SITE ON MAY 23, 2013.
### Appendix B

**Snorkel Survey Data**

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Appendix C

Westcan Terminal Reconnaissance Report
Cowichan Estuary – Westcan Terminal Recons, Apr 30, 2013

Weather: warm, sunning, light wind

Tides: 2.9 m at 0732h, 0.6 m at 1505h

Crew#1: JC/WP. Start at ~1400, end at 1515

Red lines: routes swum by snorkelers. Brown polygons: mud flats exposed at the time. Blue arrow: Koksilah water flowing SE, <1 m³/s.

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Notes: Visibility relatively poor, estimated at 1.5 m maximum. Suspended sediments, and general brown cloudiness. No salmonids observed in eel grass bed (marker 2). At marker 6, a large school of fry could be observed dimpling the surface, but very evasive to surveyor observation.
Crew#2: MK/GH. Start at ~1400, end at 1515

Red lines: routes swum by snorkelers.

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Notes: At the time of the survey ~95% of the flow from south fork was following the northern side (i.e., adjacent points “1” and “2”) with ~5% flowing adjacent point “3.” Visibility in the Cowichan south fork was 1-1.5 m with a salt lens in isolated pockets of water. Some stickleback in the south fork. Sculpin were observed in the vegetation/eel grass near points “4” and “5.” Jelly fish on the south side of the road. Visibility on the south side of the road was also 1-1.5 m with a visible salt lens.
Appendix D
Water Quality Data
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