Cowichan River

Low Flow Mitigation Strategy, 2015

Snorkeller and the coho fry he is observing in the cold water plume of a small tributary upstream of Stoltz Bluff, August 4, 2015.

for:

Brian Houle, P.Eng.
Catalyst Paper Corporation
Crofton, BC

by:

J.D.C. Craig, AScT, BC Conservation Foundation
T. Kulchyski, Cowichan Tribes

January 2016

Table of Contents

List of Figures.

List of Tables.

List of Appendices.

Acknowledgements

The Cowichan Watershed Board Flow Committee provided technical guidance and terms of reference for the work completed. Steve Baillie, Ian Mathews and Nicki Watson of Fisheries and Oceans Canada (DFO) contributed data, field equipment and expertise for stock assessment components. Ruth Withler (DFO) provided preliminary DNA results and interpretation for fry salvaged from Cowichan Lake tributaries. Neil Goeller and Mike McCulloch of the Ministry of Forests, Lands and Natural Resource Operations provided water level and historical snorkel data.

Field data were collected by Lawrence George, Harold Joe, Daniel Norris and Wayne Paige Jr. of Cowichan Tribes, and Jamieson Atkinson, Kevin Pellett, Shawn Stenhouse and Craig Wightman of BC Conservation Foundation (BCCF). Michael Friesen (BCCF) and Shawn Stenhouse assisted with data compilation. Kenzie Cuthbert of Cowichan River Wilderness Lodge provided river access and information on upper river cold water refugia. Fry salvage data for 2015 were provided by Bob Crandall and Ashley Pifkoe of Cowichan Lake Salmonid Enhancement Society (CLSES), Parker Jefferson of One Cowichan (OC) and Gary Roland of Cowichan River Hatchery.

Brian Houle of Catalyst Paper provided funding for this project as well as support for adult fence operations and materials and power for the weir DIDSON.

The assistance and support from these individuals and organizations is gratefully acknowledged.

Independent of this project, many members of CLSES, OC, Cowichan Lake and River Stewardship Society, Lake Cowichan First Nation, Cowichan Tribes, Cowichan Fly Fishers Association and Environmental Dynamics Inc. volunteered countless hours of fish salvage effort in 2015 to reduce mortalities in drying Cowichan River mainstem and off-channel habitat, and in Cowichan Lake tributaries. Volunteers included Ashley, Bob, Chris, Cliff, Daphne, Diana, Don, Fern, Gary, Harvey, Joe, Kirk, Kristen, Lorraine, Parker, Perry, Rob, Robby, Sam, Sandy, Trish, Vincent, and Willa. This list is no doubt incomplete – our apologies for volunteers we missed.

1.0 Introduction

Following the lowest snowpack in 21 years of record[1] and the driest May and June mean monthly flows in 53 years of record[2], 2015 marked one of the driest overall summers on record for the Cowichan River and many other watersheds on Vancouver Island, BC. Concerned with potential related impacts to Cowichan juvenile fish standing stocks, returning Chinook adults and the ecosystem at large, stakeholders including Cowichan Tribes (CT), the fisheries agencies, Catalyst Paper, conservation groups and provincial and local governments agreed early in the season that developing and refining plans to monitor and mitigate drought effects would be prudent, if not a mandatory strategy.

During base flows from late spring to early fall, the Cowichan's flow volume and temperature are the most significant factors influencing the quantity and quality of habitat available to fish and other aquatic species. Under license, Catalyst annually stores 61,300 cubic decameters of water on Cowichan Lake (equates to 97 cm of depth), releases the water to the river, and may ultimately divert from river kilometre 8.0 up to 2.83 m^3/s for its Crofton Mill[3]. Accordingly, the company's management of this storage has the greatest effect on fish and their habitats through the summer. While Catalyst's releases have obvious effects on discharge in the river, water temperature is also affected. The company must not only meet its water license obligations, but it must also satisfy an increasingly concerned community of stakeholders whose diverse issues range from fisheries and stock recovery to civic waterworks to waste water dilution.

In drought years when Catalyst has to reduce outflows early in an effort to acquire sufficient summer storage, or when it subsequently must seek approval from the Province to reduce the release from the conditional 7.08 m^3/s, the company must build consensus between stakeholders, particularly CT, DFO and FNLRO, that the reduction is warranted to avoid running out of storage before fall rains return. Should storage be exhausted prematurely, a number of prospective scenarios arise including but not limited to higher water temperatures, drying fish habitat, impacts on rearing and resident fish and other aquatic life, adult salmon unable to migrate and more prone to predation, insufficient dilution for sewage outfalls, reduced drinking water supply to the Town of Crofton, and curtailment of Catalyst's mill operations and associated jobs. Given the 2015 drought situation, the seasonally low storage forecasts by July, and the company's desire to further reduce flow releases and extend storage to at least late September, Catalyst committed to support several DFO-recommended monitoring tasks and potential actions to mitigate impacts on fish. Agreement from DFO, CT and the Province's Regional Water Manager for further flow reductions soon followed.

Accordingly, the **Cowichan River Low Flow Mitigation Strategy** was initiated. The strategy's project components, their locations, frequency and the party(ies) responsible were originally framed in a draft Cowichan Drought Response Resourcing Table developed at the Cowichan River Hatchery by CT and DFO

---

[1] FLNRO website http://bcrfc.env.gov.bc.ca/data/asp/realtime/asp_pages/asp_3b23p.html for Jump Creek snow pillow station, Nanaimo River watershed.

[2] Provisional data, Environment and Climate Change website http://wateroffice.ec.gc.ca for hydrometric station 08HA011 Cowichan River near Duncan.

[3] Through ongoing mill efficiencies, Catalyst's diversion has declined and typically ranges from approximately 1.3 to 1.8 m^3/s through the summer.

in early July, and further defined in late July meetings of the Cowichan Watershed Board (CWB) and its Flows Committee (a sub-committee of the CWB Technical Advisory Committee) which included DFO, CT and Catalyst experts. The final task list effectively formed the terms of reference for field work conducted, and Catalyst requested BC Conservation Foundation (BCCF) and CT to complete the tasks. Stakeholders agreed that activities in 2015 should, in light of altered weather and hydrology patterns expected from climate change, contribute to a preliminary response template for future years if/when such conditions are repeated. 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. To meet a request from the CWB Flows Committee, the report includes results of independent low flow mitigation efforts (e.g., fry salvage) and stock assessment by other stakeholders in the Cowichan Valley.

2.0 Methods

In developing the strategy, the CWB Flows Committee designated responsibility for certain tasks to DFO, Cowichan Tribes, BCCF or Catalyst. In some instances, tasks were taken on by a partnership of two or more of these entities. The following describes the methods used for most of these tasks.

2.1 River Discharge

Discharge measurements were conducted following procedures described in the Manual of British Columbia Hydrometric Standards (Province of BC 2009). Crews used the 0.6 depth area-velocity method and a SonTek handheld-ADV discharge measurement instrument (model FlowTracker) with its customary top setting rod. For each discharge, a minimum of 20 verticals were measured across the metering section, inserting verticals as identified by the meter to ensure no station exceeded 10% of the aggregate flow. CT biologists deployed the meter with instruction and close oversight from BCCF staff experienced in hydrometric measurements.

In all locations and on each day out, the best possible metering sections (single thread laminar tailouts, small substrates, majority of flow 90^{o} to tag line, etc.) were selected in each reach identified by the Flow Committee experts or as requested by Catalyst. However, because the magnitude and range of flows over the study period were low in each case, actual metering section locations changed little.

2.2 Water Quality

2.2.1 Temperature

The river temperature monitoring component borrowed heavily from an existing network supported, at one time or another, by CVRD, DFO, Ministry of Environment, CT or BCCF. Spot and continuous water temperatures were recorded using digital thermometers, the FlowTrackers described above, and Onset data loggers (models: HOBO Pro v2, HOBO TidbiT v2). Instrument accuracy was +/-0.1°C from -20° to 50°C for FlowTrackers and +/- 0.21°C from 0° to 50°C for HOBOs.

For the continuous data loggers, a number of site locations were previously established and had loggers continuously operating from the fall of 2014. Additional loggers were deployed to ensure even coverage of the mainstem from Cowichan Lake to the tidal reaches of the North and South Arms. Typically, loggers were attached to either 90 cm lengths of rebar pounded into the stream bed or cables/chains secured to trees, brush or heavy roots in a stable stream bank. They were downloaded with a field laptop and docking port or a HOBO Waterproof Shuttle.

Crews measured temperature profiles of potential holding areas in the upper river. Measurements were made from a raft or by wading using a handheld multiparameter meter with 20 m cable and sonde (YSI Inc. Professional Plus; Quatro probe). The meter was regularly calibrated through the study period using the "1-point calibration in water-saturated air" technique. In slow, deep water where rafts were used, measurement locations and depths were determined using a GPS unit (Garmin model 60CSx) and the marked meter cable, respectively. The raft was held in position while the temperature sonde stabilized at the surface and at the bottom of the water column. In runs, crews attached the probe to a marked wading staff to determine depths being measured, and used a grid of stretched 50 m tapes to locate themselves relative to a known cold water source (i.e., tributary confluence).

2.2.2 Dissolved Oxygen

Spot dissolved oxygen (DO) levels were measured with the YSI multiparameter meter, cable and sonde unit described above.

2.3 Juvenile Monitoring and Salvage

In 2015, independent of the Cowichan River Low Flow Mitigation Strategy, a number of community and First Nation groups performed small to large-scale juvenile research or salvage operations throughout the Cowichan Valley. In the early spring (March-May), First Nation and community stewards conducted Gee-trapping in a focused effort to acquire presence/abundance data and DNA samples of juvenile Chinook in Cowichan Lake tributaries. These efforts were supported by AFSAR[4] funding, Sidney Anglers and DFO. By mid-May and due to unusually low flows, fry salvage became a high priority in lake tributaries as well as along the Cowichan mainstem, as it has to varying degrees in years past. With DFO assistance/oversight, DNA sampling continued opportunistically as lake tributary salvage ramped up. The goal of all salvage operations was to decrease mortality during drought-exacerbated summer flows.

Community and FN crews used traditional methods and equipment including beach seines, pole seines, hand nets and Gee-traps to capture juvenile salmonids from habitats perceived to be drying. For Cowichan Lake tributaries, fish were released either immediately to Cowichan Lake or temporarily to larger, deeper stream habitat, to be re-captured later and released to the lake as necessary. For Cowichan mainstem peripheral habitats (e.g., side-channels, alcoves), fish were released directly into

[4] Aboriginal Funding for Species At Risk.

the mainstem. Salvage events were regularly recorded but detail on exact numbers, species, temperatures and specific locations varied. Data were assembled in a modified DFO fry salvage spreadsheet; during July CWB Flow Committee meetings DFO indicated their intention to initiate a database to track and report on these data in future.

2.4 Adult Monitoring

Adult monitoring activities focused on the Cowichan's spring and fall run Chinook stocks but, where practical, accounted for all fish species observed during surveys. With only minimal recent data, the status of spring run Chinook was poorly understood but the population was thought to be a small fraction of its original size as described by CT elders. Migration timing of whatever remains of the stock is also speculative but believed to be May through July. The more abundant fall run stock enters between August and November. Because field activities commenced in late July, snorkel surveys were the initial and primary tool used by BCCF and CT to assess distribution and abundance of spring run fish. Fall run fish were monitored using lower river snorkel surveys and stream walks throughout intertidal reaches.

Of particular note and prior to the start of this project, DFO's South Coast Stock Assessment Division installed Dual Frequency Identification Sonar (DIDSON) equipment to enumerate migrating salmon (targeting spring run Chinook) at two stationary locations on the Cowichan River: a mid-valley shallow run at river km 24, and in the Cowichan Lake weir bay through which storage releases occurred (river km 49.3). The DIDSON product is a video-like sonar data file that displays a top-down view of white objects (fish, boulders, etc.) on a black background (stream bed cross-section). The software's measurement tool allows individual target lengths to be estimated, though target definition is subjective and can be affected by water turbulence (e.g., swimming fish).

Additionally, in partnership with CT, DFO installed and operated an adult counting fence at river km 6.7, just below Allenby Road bridge, to enumerate returning salmon, primarily fall run Chinook. A fence operation of one kind or another has been undertaken annually since 1988 (S. Baillie, DFO, Nanaimo, pers. comm.).

2.4.1 Snorkel Surveys

Crews used standard snorkel survey techniques employed by DFO and FLNRO (e.g., McHugh and King 2015). Two person crews of swiftwater certified experienced personnel, wearing dry suits or wet suits with floatation, would snorkel in parallel an average of 3 to 6 km on each survey. Surveys often required multiple teams in order to cover target reaches of the river. The number of adult fish by species, size, condition and location were recorded regularly on slates and/or in data books as surveys progressed. Observations of juvenile fish abundance and behavior, environmental conditions, and other information such as mortalities or cold water inputs were also documented.

On the first survey downstream of the DFO/CT adult fence at river km 6.7, CT snorkel crews established locations such as key holding pool tail outs at which they would consistently stop and record the fish numbers and related observations. This practice had not previously been undertaken and was adopted to allow comparisons of local distribution over time.

2.4.2 Stream Walks

To investigate the numbers, condition and behavior of Chinook attempting to enter the lower river and harbour seals that may be following or predating on them, stream walks were regularly conducted in September by a Cowichan River Steward (CRS). The CRS also monitored the status of key constrictions or migration impediments in the North and South Arms that may have influenced predation or caused undue stress to migrating adults.

In mostly daylight hours, the CRS followed a specific circuit three days/week through the Cowichan's North and South Arms, including tidal reaches downstream of both Tzouhalem Road bridges. The numbers of seals and fish by species were recorded by location and time. The CRS employed patience and stealth during the survey – seals were otherwise too wary to be observed at close range. An occasional evening survey during low light was performed to contrast activity to that observed in the daytime.

2.4.3 Non-Stationary Sonar Surveys

As an experiment, DFO staff partnered with CT and BCCF to deploy a DIDSON unit on a mobile basis in upper river canyon habitat. The objective was to evaluate the practicality of using DIDSON technology to scan deep water river habitats difficult to effectively snorkel survey for Chinook adults. After an attempt to suspend the DIDSON unit from a small bodysurfing-style flotation board, a technician in a dry suit ultimately held the DIDSON unit just below the surface, pointing it towards deeper sections of the canyon pool investigated. Crew along the canyon banks managed the laptop and power source (12 volt car battery) connected to the DIDSON by cable. While the bank crew watched for signs of Chinook, the DIDSON swimmer followed one bank upstream, crossed over and returned along the opposite bank to the starting point.

In a similar experiment, two DFO staff members used a raft-based DIDSON unit to scan a large pool known to seasonally hold adult salmon just below the South Shore Road bridge in the Town of Lake Cowichan. While quietly rowing the raft back and forth across the pool, the unit was deployed over the side and pointed down and/or angled to 45^{o} to survey the pool bottom and any fish holding in the immediate or adjacent water column.

3.0 Results and Discussion

The following results refer often to specific locations and corresponding river kilometres (rkm). We used Google Earth to establish the river kilometre distances, assigning 0.00 river kilometres to the Tzouhalem Road bridge (aka Pembury bridge) over the Cowichan's North Arm. This results in the Catalyst storage weir being located at rkm 49.3 (Fig. 1).

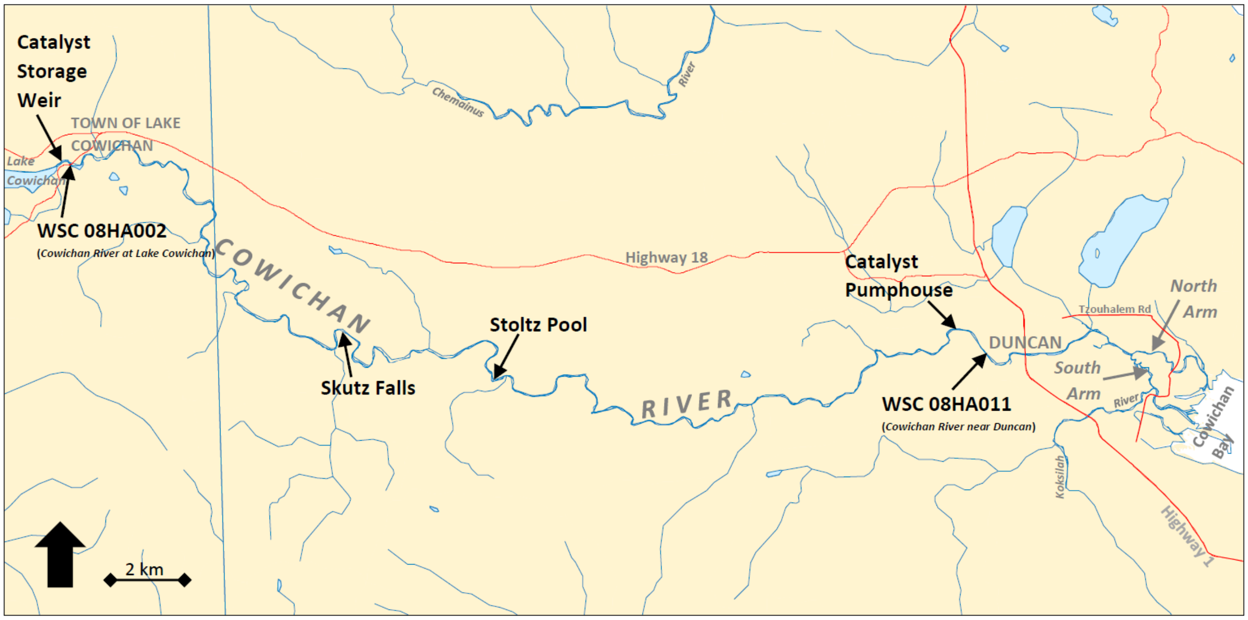


Figure 1. Map of Cowichan River from headwaters at Cowichan Lake to mouth at Cowichan Bay.

3.1 River Discharge

It should be noted that Water Survey of Canada (WSC) data referred to here-in are provisional and will not be 100% quality controlled until some point in 2016. However, in acknowledgement of the watershed's high profile and significant water management issues particularly in summer, WSC staff affect temporary shifts to their Cowichan stage/discharge curves within a day or two of their on-site measurements to help ensure their web based real-time reporting is within 5% of reality (R. Mathewson, WSC, pers. comm.). As a result, we expect minimal changes to the low flow record available at time of writing.

To address a number of strategy objectives, lower Cowichan River discharge measurements occurred bi-weekly from the start of the strategy until cumulative September rains refilled Cowichan Lake and Catalyst was able to increase releases to values greater than 7.08 m^3/s (September 22). Measurements were performed to help develop relationships between water released at the weir, diversions at Catalyst's Pumphouse (rkm 8.0), flows in the lower river just above the bifurcation at rkm 2.15, and flows in the Cowichan's North and South Arms (Fig. 1). Measurements also occurred to check provisional discharge data from WSC's lower river station (08HA011), one of the points to which licensed minimum flows must be delivered in-season by operators of Catalyst's storage weir. Lastly, coordinating with Catalyst, measurements were performed to document the difference, after no pumping rate changes for 90 minutes, between simultaneous measurements of discharge immediately below the diversion (rkm 7.7) and at the WSC 08HA011 station site (rkm 6.8), versus provisional discharge reported by the station on the WSC website.

Table 1 details lower river discharge measurements for each of the five days surveyed. For reference, it includes WSC provisional discharge data for Cowichan Lake outlet and Cowichan River in Duncan (see Appendix A for a complete summer record). To identify the specific discharges at these two stations that created the conditions we documented in the lower river and North and South Arm, WSC data in the table account for the time it takes water to flow between the stations (12 hours, Hop Wo *et al.* 2005) and the 1.4 hour travel time from Duncan station to our "Mainstem above Bifurcation" site (rkm 2.15; Photo Plates 1 and 2). For each set of field measurements, preliminary results were circulated to stakeholders same day or the day following via email or at CWB Flow Committee meetings in Duncan.

Table 1. Discharge measurements, listed in downstream order, completed July 31 to September 16, 2015 in the lower Cowichan River, and related provisional reporting from lake outlet and lower river WSC stations.

Location/Source	Purpose	rkm	Measured Discharge (m^3/s) *and time (PDT) of measurement*				
			Jul 31	**Aug 10**	**Aug 25**	**Sep 2**	**Sep 16**
Cowichan Lake Outlet/WSC (08HA002)[1]	Monitor lake release	48.5	5.81 *(July 30, ~2100h)*	5.19 *(Aug 9, ~2100h)*	4.69 *(Aug 25, ~0010h)*	4.73 *(Sep 1, ~2240h)*	4.66 *(Sep 15, ~2050h)*
300 m downstream of Catalyst Pumphouse/BCCF	Monitor lower river flow below diversion	7.7	-	3.701 *(1314-1359h)*	-	-	-
Allenby Road in Duncan/WSC (08HA011)[2]	Monitor lower river flow below diversion	6.9	4.02 *(0852-0936h)*	3.36 *(0850-0917h)*	2.559 *(1145-1230h)*	3.98 *(1007-1102h)*	3.39 *(0831-0921h)*
Allenby Road/BCCF	Monitor lower river flow below diversion (Aug 10). Assess possible WSC station 08HA011 reporting error (Aug 25)	6.9	-	3.584 *(1306-1343h)*	3.025 *(1145-1230h)*	-	-
Mainstem above Bifurcation/BCCF-CT	Monitor flow and habitat conditions near last point before mainstem splits	2.15	3.619 *(1016-1100h)*	3.059 *(1014-1041h)*	-	3.440 *(1131-1226h)*	2.992 *(0955-1045h)*
South Arm upstream of Hatchery Channel confluence/BCCF-CT	Monitor South Arm flow and habitat conditions	1.2 [3]	1.869 *(1025-1055h)*	1.664 *(1030-1104h)*	-	2.051 *(1400-1445h)*	1.652 *(1110-1143h)*
North Arm ~40m downstream of last split to South Arm/BCCF-CT	Monitor North Arm flow and habitat conditions	1.2	1.811 *(1240-1318h)*	1.569 *(1113-1136h)*	-	2.250 *(1500-1555h)*	1.439 *(1300-1340h)*
North Arm, western channel at CR6 access ramp/BCCF-CT	Monitor North Arm flow and habitat conditions in right and left-hand channels around CR6 island.	0.6	0.121 *(1240-1305h)*	0.064 *(1151-1208h)*	-	0.164 *(1623-1639h)*	0.051 *(1420-1440h)*

Location/Source	Purpose	rkm	Measured Discharge (m^3/s) *and time (PDT) of measurement*				
			Jul 31	Aug 10	Aug 25	Sep 2	Sep 16
North Arm, eastern channel[4] opposite CR6 access ramp/BCCF-CT		0.6	1.69	1.505	-	2.086	1.388

1. Data account for WSC's website reporting in local standard time. To enhance comparability, WSC data reported are from 13.4 hours earlier to account for distance between WSC station 08HA002 and the "Mainstem above Bifurcation" site. Data are the mean of at least six 5-minute interval values. WSC data are provisional and were downloaded December 10, 2015.

2. Data account for WSC's website reporting in local standard time. To enhance comparability, WSC data reported are from 1.4 hours earlier to account for distance between WSC station 08HA011 and the "Mainstem above Bifurcation" site. Data are the mean of 5-minute interval values generated over the same length of time required to measure discharge at "Mainstem above Bifurcation". WSC data are provisional and were downloaded December 10, 2015 with one exception: the value for August 25 was the product of a station reporting error which was subsequently corrected.

3. Distance from Tzouhalem Road bridge over South Arm.

4. Flows inferred, not measured.

When examining the results of dry season hydrometric measurements in the lower Cowichan River, whether they are conducted by BCCF/CT or by WSC, the effect of Catalyst's diversion must be considered. To maintain supply reservoirs and depending on mill operations, Catalyst may use three, four or five pumps during a typical summer day. Pumps may turn on and off frequently, sometimes creating up to 20 oscillations per day (~0.83/hour) that alter discharge below the pumphouse depending on the number of pumps operating. As a result, reductions in river flow vary from 0.3 to 0.8 m^3/s, as evident in a typical WSC Station 08HA011 record (Fig. 2). Because standard discharge measurements require 40-60 minutes to complete, they capture whatever variance is occurring in the river – in this case an often changing scenario influenced by diversion rates. As a result, each discharge measurement

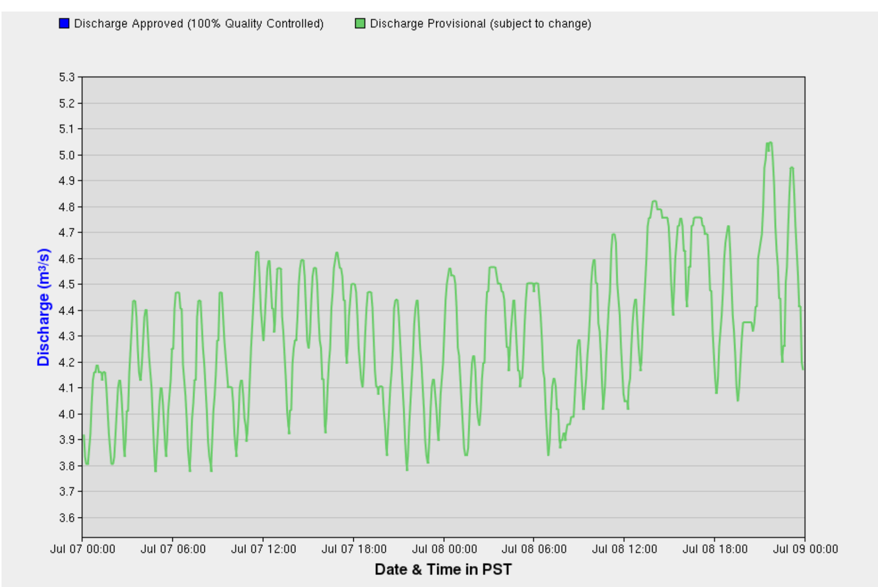


Figure 2. Preliminary WSC Station 08HA011 hydrograph showing pumping-related variability in flows over 48 hours (July 7-9, 2015).

has a certain amount of error that should be considered relative to the supply conditions, be they declining, increasing or averaging out. Also, with up to 0.83 oscillations/hour, measurements taken downstream an hour apart can be significantly different, even though background flow upstream of diversion may have changed little.

Keeping the caveats above in mind, July 31 results indicated that discharge immediately above bifurcation was 90% (0.40 m^3/s loss) of that reported at Allenby Road. Similarly, differences documented August 10, September 2 and September 16 ranged from 86% (0.54 m^3/s loss) to 91% (0.30 m^3/s loss), averaging 89% overall. Likely reasons for this ~11% loss include side-channel diversions and losses to the stream bed (groundwater). The former would have been minimal at the time of survey because the vast majority of both the DFO and CT fisheries side-channel diversions re-entered the mainstem (via Major Jimmy Side-Channel) just upstream of our "Mainstem above Bifurcation" site. The remainder that feeds Hatchery Channel and ultimately enters the South Arm typically constitutes 0.020 to 0.040 m^3/s in summer. Additionally, these side-channels also receive year-round inputs from the Marine Harvest Hatchery outfall, averaging 0.066 m^3/s or up to 0.166 m^3/s during peak production (Pellett *et al.* 2013). As a result, there are likely minimal gains/losses to the mainstem from the side-channel network.

With respect to losses to the stream bed, several medium to large scale wells are situated in the lower Cowichan River floodplain, operated by local and provincial government organizations and commercial enterprise. Effects of these operations on adjacent streamflow are not clearly identified but have been subject to investigation by FLNRO hydrologists since 2012. Their preliminary 2014 results suggested losses of approximately 10% occurred between WSC Duncan and the province's "Hatchery Road" site (aka "Mainstem above Bifurcation"), but measurement error remained an issue due to "constantly changing flow" (N. Goeller, FLNRO, Nanaimo, pers. comm.).

Other potential inputs to the mainstem between the Duncan WSC station and our "Mainstem above Bifurcation" site included the outfalls of the Vancouver Island Trout Hatchery (VITH) and the Duncan-North Cowichan Joint Utilities Board (JUB) sewage treatment facility, both at rkm 3.7, and Somenos Creek at rkm 3.0. Low flow season discharge from the latter likely goes to zero (Ministry of Environment and Parks 1986). VITH outfall contributed an estimated 0.080 to 0.096 m^3/s to the Cowichan between June and September 2015 (B. Munroe, VITH, Duncan, pers. comm.), while the JUB's monthly outflow in July and August, assuming an even release over 24 hours, averaged 0.124 m^3/s (D. Conway, Municipality of North Cowichan, Duncan, pers. comm.).

July 31 results also first indicated how, in 2015, mainstem flow was split between the Cowichan's North and South arms, on its way to Cowichan Bay (Photo Plates 3-11). With flows of 1.811 and 1.869 m^3/s respectively, the South Arm conveyed 50.8% of the aggregate flow on July 31, although measurements were performed 2.25 hours apart and WSC data suggest flows that created the North and South Arm conditions were near the top and the bottom of a pumping-related oscillation, respectively.

Flow splits documented on August 10 and September 16 were 51.5 and 53.4% to the South Arm, respectively, very close to the July 31 result. The outlier was September 2 when South Arm flow was 47.7% of the total, but the North Arm was measured at 1500h, an hour after the South, and late morning heavy rain appeared to add approximately 0.5 m^3/s to river flow in the afternoon.

By comparison, the North Arm carried the majority of Cowichan River flow in summer 2014. On July 3 and August 13, Fleenor (2014) documented the North Arm's share of lower river discharge was 52.8 and 54.5%, respectively. Results in 2015 suggest the mainstem invert that controls the split may have aggraded somewhat over the winter of 2014/15, pushing a greater portion of the flow to the South Arm.

Between July 1 and August 30 when there were consistent diversions and few if any weather related changes, relatively consistent flow rates at the two WSC stations were observed, enabling prediction (r=0.78) of discharge at the lower station by using discharge from the upper. A task identified in the Flow Committee's terms of reference, this relationship is shown in the lower graph of Appendix A but may only be of anecdotal use and would change to some degree each year depending on the level of dryness.

Simultaneous discharge measurements in the Catalyst Pumphouse pool tailout and at the Duncan WSC (08HA011) site on August 10 varied by just over 3% (Table 1). Both transects and measurements appeared to be of high quality, with zero warnings or errors indicated in QC/QA procedures. Measurements occurred between 1.5 and 2.5 hours after Catalyst's diversion was fixed at a four pump withdrawal rate for 10 hours, eliminating pump-related fluctuations in discharge at the WSC station. The close results demonstrated that the site 300 m below the pumphouse may be suitable for ongoing measurements or a new (or transferred) hydrometric station[5]. Comparing our measurement at the WSC site with discharge provisionally reported by the WSC website during the same time frame (3.26 m^3/s), we documented a 10.1 to 13.6% deviation from the current curve, outside the 5% maximum deviation below which curves are not adjusted in-season. Accordingly, WSC subsequently used our measurement and applied a shift to the curve they were using at that time. Because Catalyst uses the website's provisional data to meet license requirements and manage storage on Cowichan Lake, such shifts can have significant effects with respect to compliance, storage releases and long term planning.

During comparisons of the August 10 measurements and with Catalyst's assistance, we examined Cowichan River background flow characteristics (i.e., unaffected by diversion) at the Duncan WSC site. Results indicated that, during the early August scenario, a gradual increase in the order of 200-300 L/s occurred each afternoon, peaking between 1500h and 1600h. Causes for this were not confirmed, but matching diurnal behavior, offset by 12 hours of water travel time between stations, was also evident in the somewhat noisy stage data of WSC's *Cowichan Lake near Lake Cowichan* station during this timeframe. The diurnal variation in lake stage is most likely explained by lake evaporation and evapotranspiration from sub-basins feeding the lake, but a number of other factors may contribute to this pattern (C. Sutherland, KWL & Associates, Victoria, pers. comm.). Regardless, the lower river's natural daily fluctuation has implications with respect to meeting minimum flow standards and managing storage.

[5] A flow management issue identified by the CWB Flows Committee was the late-season effect the DFO/CT fence has on real-time discharge levels reported by the Duncan WSC station 140 m upstream. Water levels at the station increase when the fence is in, and vary according to the debris load on the fence. Though WSC can, once the fence is installed, apply a one-time shift to their stage/discharge curve to temporarily correct the reporting issue, the debris load variance continues to impact station data. Catalyst inquired to WSC about moving the station upstream, out of the influence of the counting fence, but no solutions had been identified at time of writing.

Based on observations made during discharge measurements, and while certainly not ideal, conditions between late July and mid-September 2015 in typical North and South Arm habitats appeared to allow returning Chinook and pinks to migrate upstream. No fish or migrations were observed during the July 31 or August 10 measurements. But on both September 2 and 16, crews observed, photographed and took video of adult and jack Chinook navigating upstream through riffles 20-30 cm deep in the mainstem and in both arms. With flows of ~1.5 to 2 m^3/s in each arm, observed migrations were typically "noisy", with backs of fish showing and an abundance of predator-attracting "splash". Migration through the major log jams in each of the arms was not studied in detail, but a reasonable pathway through the North Arm jam was identified during a spot snorkel survey. Additionally, observing bright adults moving upstream through the North Arm discharge site confirmed effective passage through the North Arm jam. Lastly, CT fishers reported to crews on September 16 that adult Chinook were successfully migrating upstream through the South Arm's western-most thread to the mainstem. Conditions observed there were conducive to spearfishing; several fish had been harvested. Lower river observations like these complemented snorkel surveys and were useful in evaluating migration conditions/success early in the season, prior to the start of fence counts.

Throughout the base flow study period, the North Arm's western (right-hand) channel at the CR6 access ramp received minimal flow (0.051-0.164 m^3/s) and offered inferior depth and velocity characteristics relative to the eastern (left-hand) channel that carried 93-96% of North Arm flow (Table 1). The western channel offered no upstream access for adults; maximum riffle depths at pinch points were commonly 10 cm, allowing only juvenile movement between pools and glides. Accordingly, we paid particular attention to the western channel's connectivity, and were prepared to mobilize a shovel crew to adjust the gravel/cobble invert at the top of the reach if flows had dropped to zero and deteriorating habitat conditions warranted. In light of how close the channel came to being isolated, it should certainly be included in any lists of potential fish salvage zones in future.

3.1.1 2015 vs. Seasonal Flow Targets and Existing Habitat-Flow Study Results

In a discussion of science-based rationale for the Cowichan's current flow targets written for BC's Environmental Appeal Board, Wightman (2015) described key considerations for some of the river's instream flow requirements (IFR).

> **<u>Spring:</u>** In spring, flow required for rainbow/steelhead spawning and salmon fry incubation and emergence have led to two general flow targets:
>
> - *"maintain an optimal 25 m^3/s in the river prior to May 1, if conditions allow; and*
> - *maintain a minimum 15 m^3/s in the river prior to June 15".*
>
> These targets and associated ramping protocols (Vessey *et al.* 2008) were established "*to minimize risk to the Cowichan's valuable fish resource, while conserving water for licensed use before the seasonal period of scarcity*". However, Wightman noted that, due to lower snowpack and declining precipitation from June to September, annual summer inflow to the lake is trending downward significantly, reduced by 35% from the late 1950s to 2008 (Chapman 2011). As a result, summer and early fall reductions in flow from the lake, such as those that occurred in 2015, are becoming much more frequent and demonstrate the inability of Catalyst's current storage to regularly supply the 7.08 m^3/s conservation flow.

In addition to the primary spawning, incubation and emergence issues above, maintenance of comparatively high spring flows for the trout sport fishery, side-channel connectivity and more recently spring-run Chinook migration are also challenging for Catalyst given their current licensed storage. Doing so means a delay in going on weir control, and in dry years sometimes foregoing their ability to start the weir control period at the full supply level (FSL; 162.37 m). By the time the weir's gates are fully raised there is insufficient inflow to fill the lake to the FSL.

Summer: First citing Burns *et al.* (1988) and their observation that active side-channels lost an estimated 17,897 m^2 of wetted habitat when summer river flow was reduced from 7.08 to 4.48 m^3/s, Wightman also re-affirmed the value of the 7.08 m^3/s summer flow target. In a late 1980s in-stream study, he found riffle meso-habitats, preferred by rainbow/steelhead trout, were most affected by flow-related reductions in wetted width and concluded the 7.08 m^3/s target strongly supported the combination of fish habitat preservation, growing summer recreational use, and sustained water quality (Wightman and Ptolemy 1989). Additionally, FLNRO has, over time, generally adopted a modified Tennant[6] method that expresses environmental flow targets in terms of percentages of mean annual discharge (MAD); the biological requirement for juvenile summer-fall rearing is 20% MAD (Province of BC 2010), equating in the case of the Cowichan to 9.0 m^3/s leaving the lake outlet and 10.6 m^3/s at WSC Duncan. Such criteria may make FLNRO more reticent to see lower summer flows adopted without thorough consideration/implementation of alternatives.

A key constraint that can reduce the likelihood of Catalyst delivering the 7.08 m^3/s summer flow target is its inability to legally capture in-season rainfall as extra storage if the company started the control period at FSL. For this to occur, the province's Water Stewardship Division requires Catalyst to seek a new license. In BC, water licenses typically allow storage of a specified volume of water just once per calendar year.

Fall: With respect to the fall season, Wightman summarized that though augmented flow targets have been tried or are a current tool to enhance migration conditions for returning Chinook (e.g., post-September 15 "migration assistance" flows of 9.91 m^3/s; 48-hour "pulse flows" of ~16-20 m^3/s between September 17 and October 11), they can only be achieved if late summer-early fall precipitation increases inflows and at least partially refills Cowichan Lake. More commonly in recent years, storage levels are at or below the current rule curve and, to extend remaining storage through late October, Catalyst has sought approval to reduce the release rate below 7.08 m^3/s. To even consider initiating a pulse flow of 18 m^3/s, lake level must physically be at or above 161.72 m (zero storage=161.40 m) and stakeholders must be willing to risk either having to adopt extraordinary measures to maintain minimum releases, or running out of storage and the associated consequences (fish and fish habitat impacts, mill shut down, water supply shortages, exceedance of effluent guidelines, etc.).

These flow targets and the complex issues associated with delivering them will not likely be met or resolved, particularly in the face of climate change, without additional conservation storage that a rebuilt weir could provide.

---

[6] Tennant, D.L. 1976. Instream Flow Regimens for Fish, Wildlife, Recreation and Related Environmental Resources. AFS *Fisheries* Volume 1, Issue 4. P 6-10

To investigate how fish habitat in the Cowichan River is affected by summer flows, LGL Ltd. completed habitat-flow assessments in 2013 (lower river below Catalyst Pumphouse) and 2015 (middle and upper river), both commissioned by the Fisheries Section of FLNRO. Studies combined meso-habitat surveys with detailed depth-velocity and habitat data collected over a range of low flows from representative and topographically surveyed transects in the study reaches. Using the results and habitat suitability indices for steelhead, Chinook and coho, the studies employed RHYHABSIM (River Hydraulics and Habitat Simulation) software to generate weighted usable area-discharge relationships and determine optimal rearing flows by species and age class.

Listed below are some key summary points and conclusions from the middle and upper river study (LGL Ltd. 2015; WUA=weighted usable area):

- *Summer rearing habitat is considered to be one of the primary limiting factors of Coho, Steelhead, Chinook, Rainbow Trout and Cutthroat Trout production within the watershed due to naturally occurring low summer baseflows.*
- *Median river flows in the Middle and Upper Cowichan River, as measured immediately below Lake Cowichan, meet the recommended minimum flow specified in the Water License for the Catalyst Paper weir with discharge values >7.28 m^3/s during the summer period.*
- *Historic median flows in June to October (7.28-15.60 m^3/s) in the Middle and Upper Cowichan River generally meet the habitat preference conditions for CO, CH and ST rearing in riffles, glides and pools.*
- *Maximum WUA for ST, CH and CO fry occurred at discharges between 0.4 and 3.2 m^3/s in the riffles and glides of the three survey sections.*
- *ST parr had discharges at maximum WUA ranging from 6.4 to 11.4 m^3/s.*
- *Although median flows in July-September (7.28-7.99 m^3/s) are less than the discharge at maximum WUA for ST parr in glides of 8.9 m^3/s, the preferred habitat type for ST parr is riffles where the discharge at maximum WUA was determined to be 6.8 m^3/s.*
- *At the lowest 90% exceedance discharge of 5.92 m^3/s in August, it is expected that habitat conditions in the Middle and Upper Cowichan River study reach would provide near-optimal velocities and depths for ST, CO and CH fry and/or parr within the specific habitat type preferred by each species and life stage.*

LGL's results indicated that, *on average over the 52-year period of record*, flows in the upper and middle river had met minimum licensed criteria and supported the habitat conditions in riffles, glides and pools preferred by rearing coho, Chinook and steelhead. However, in at least 20% of the time upper and middle river flows in July, August and September did not meet minimum flow criteria. These instances would have been the result of drought scenarios similar to that of 2015 where Catalyst received approval for reduced releases to lower the risk of running out of storage before fall rains arrived.

The study did not examine the effect of flows on adult salmon migration or juvenile access to off-channel habitats, but did determine that maximum WUA for steelhead, Chinook and coho spawners occurred at flows of 14.7, >20 and 12 m^3/s, respectively (LGL Ltd. 2015).

Summary points and conclusions from the lower river study (LGL Ltd. 2014) were similar to those of the middle and upper river study. Lower Cowichan River historic median river flows from June to October (5.54-14.6 m^3/s) generally met preferred habitat conditions for coho, Chinook and steelhead rearing in riffles and glides. While median August-September flows were less than ideal for steelhead parr in glides, the discharge at maximum WUA for steelhead parr in riffles, the preferred habitat of parr, was determined to be 4.10 m^3/s. Analysis showed that August flows exceeded this discharge 90% of the time, and that habitat conditions in riffles and glides "*would provide near-optimal velocities and depths* *for steelhead, coho and Chinook fry and/or parr within the specific habitat type preferred by each species and life stage*" (LGL Ltd. 2014). In both studies, the author noted that effects of flow on mainstem temperature were not examined.

3.2 Water Quality

Though water quality is often described using a number of parameters, the CWB Flow Committee's terms of reference focused on temperature and dissolved oxygen levels through the study period.

3.2.1 Water Temperature

Cold Water Refugia – Lake Outlet

On August 5, 2015 between 1030h and 1145h, we measured surface and bottom temperatures in the deep water areas immediately downstream of the Catalyst weir, and in Hatchery Pool (aka Big Pool) 200 m downstream of South Shore Road bridge (Fig. 3). The purpose was to search for cold water refugia that might attract adult spring run Chinook to hold in these locations, or support these fish should their migration be delayed by the weir or the unusually low flows passing it. Hatchery Pool is situated immediately upstream of the Cowichan River's uppermost natural riffle. It is positioned at the downstream end of a stable, kilometre-long lake outlet reach characterized by deep pools and glides with hummocky spawning gravels. Catalyst's weir is at the upstream end of this reach – beyond are the natural depths of Cowichan Lake.

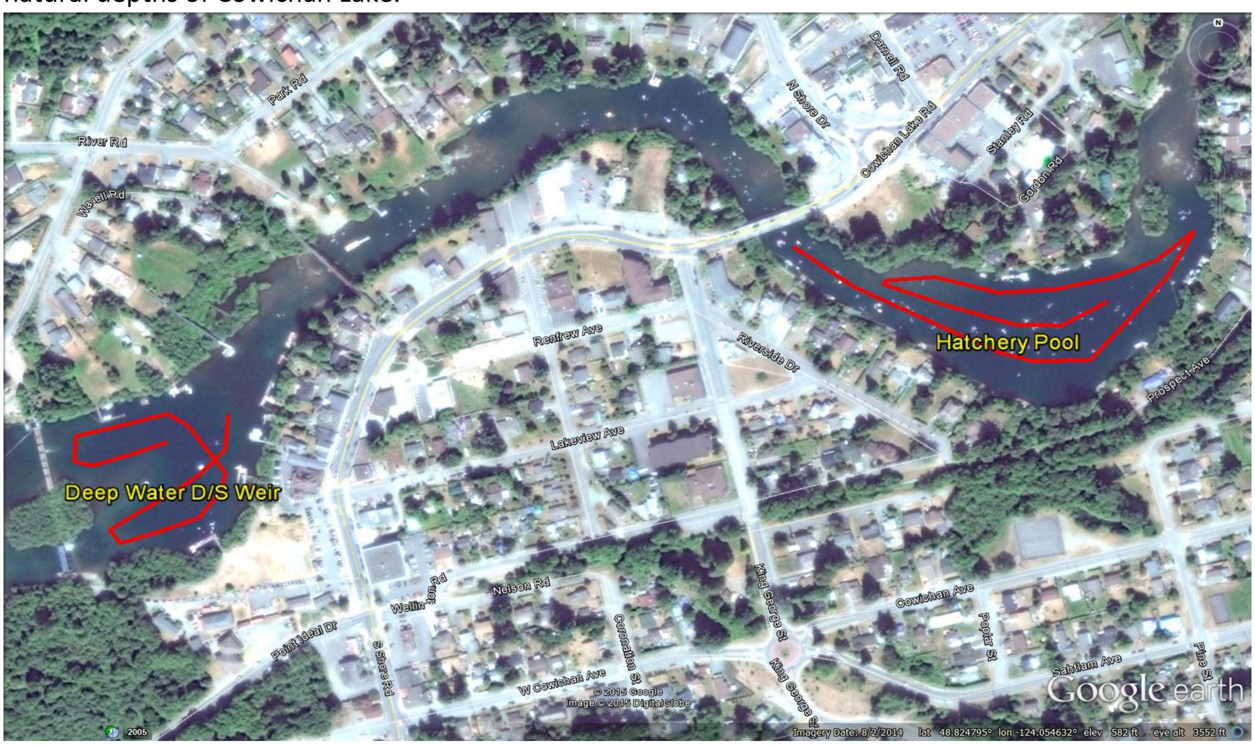


Figure 3. Google Earth image of water temperature survey routes (red lines) through deep water areas immediately downstream of the Catalyst weir and in Hatchery Pool, August 5, 2015. Photo taken August 2, 2014 - note the high number of "tubers" (white spots) floating the river.

Results indicated that, despite their large size and depths, both habitats investigated were completely isothermal, with water temperatures of 22.3 to 22.4°C from the surface to the bottom regardless of location. Technicians used detailed 0.5 m contour bathymetry of the outlet reach (UMA 2006) to plan routes (Fig. 3) and include the deepest zones in each area (below weir: 9.2 m, Hatchery Pool: 11 m) while surveying a representative mix of depths.

Consistently high water temperatures throughout the water column confirm these habitats offered no cold water refugia on the day of survey. In consideration of the lack of any usable cover (other than depth to ~10 m) and the high daytime use by recreationalists during the summer, these habitats appeared to be highly unsuitable for extended holding by adult Chinook.

Cold Water Refugia - River

Though no temperature refugia were identified in the lake outlet reach, several cold water inputs are known to exist on the Cowichan River, particularly the upper river above Skutz Falls. Using 2012-2015 data, Smith (2015) found that Cowichan River water temperatures correlated strongly with air temperature, and only moderately with discharge. He noted that summer water temperatures tended to decrease with distance downstream, and suggested cool water inputs could be partly responsible. The magnitude of temperature decline can be small to moderate depending on timing – 2015 data suggest a "crossover" occurred in May when mean daily temperatures at Greendale Trestle (rkm 47.8) were on average roughly the same as those reported at the lower river WSC Station 08HA011 (rkm 6.8). However, the same WSC Station's mean daily temperatures were on average 0.4, 1.1, 1.8 and 2.8°C lower than those of Greendale Trestle site in June, July, August and September, respectively (Stenhouse 2015). This confirmed that as the summer progressed, the decline in air temperatures and hours of sunlight after June and July have an increasingly significant impact on water temperatures over the river's length.

Based on existing reports/data and working downstream from the lake, Table 2 lists mainstem tributaries and known or suspected groundwater inputs that can affect Cowichan River water temperatures. The vast majority of the tributaries without groundwater dry or recede to very low discharges each summer. It is likely that all tributaries that continue to flow through the summer contribute water that is colder than the mainstem receiving it. The degree to which tributaries that lose surface flow continue to contribute subsurface intra-gravel water where they join the mainstem is not known. Based on local accounts, a number of additional discrete locations are thought to exist where mainstem streambed groundwater is used by resident trout and salmon through the summer. These areas need further investigation to confirm their existence and clarify their importance as thermal refugia.

Table 2. Preliminary known or suspected tributaries and groundwater sources with the potential to affect Cowichan River mainstem summer water temperatures.

Name	River Km	Watershed Code/UTM	Description
Stanley Creek	47.3	920-257700-58400	Tributary
Green Timbers Creek	45.1	920-257700-55800	Tributary

Name	River Km	Watershed Code/UTM	Description
Golding Brook	44.0	920-257700-54600	Tributary
Josiah Creek	43.7	920-257700-54500	Tributary
Watercress Creek	42.0	920-257700-52100	Tributary
Wrixon's Run	41.5	10U 426263mE 5406790mN	Groundwater & Tributary
Fairservice Creek	41.1	920-257700-51200	Tributary
Jungle Creek	40.1	920-257700-49800	Tributary
Breakfast Run	38.5	10U 427159mE 5404909mN	Groundwater from adj old channel
Double D (*aka Joe Ginders*) Creek	38.3	920-257700-47000	Tributary
Sawdust Pool	36.4	10U 428520mE 5404211mN	Groundwater & Tributary
Unnamed Creek at Cougar Run	35.7	920-257700-44100	Groundwater & Tributary?
Bear Creek	34.3	920-257700-42600	Tributary
Skutz Creek	33.6	920-257700-41700	Tributary
Mayo Lake Creek	29.3	920-257700-36600	Tributary
Bluff Creek	27.6	10U 433785mE 5403330mN	Tributary
Stoltz Pool (RB)	25.9	10U 434032mE 5402183mN	Groundwater
Stoltz Boat Launch (LB)	25.5	10U 434312mE 5402299mN	Groundwater from gravel bar
Dale's Creek	25.5	920-257700-32000	Tributary
Ernie's Gulch	24.5	920-257700-31000	Tributary
Dry Bend Creek	21.0	920-257700-27300	Tributary
Holt Creek	15.8	920-257700-20700	Tributary
Currie Creek	11.0	920-257700-14900	Tributary
Somenos Creek	3.0	920-257700-05700	Tributary

Note: tributary or location names from DFO's Mapster website, Province of BC's Habitat Wizard website, LGL (2005), HFFA (1987).

Cold Water Refugia – Wrixon's Run

Because Wrixon's Run (rkm 41.5) was accessible and known to contain one of the more significant cold water refugia in the upper river (Table 2), we surveyed the run in detail on August 13, 2015. Released from the lake, flow in the mainstem during the survey was 5.18 m^3/s (WSC Station 08HA002; provisional discharge), and weather during the survey was hot and dry.

The source of cold water was an adjacent historic pond and channel habitat fed by a nearby natural spring that runs year round. A very small tributary, locally known as Bernard Creek, contributes seasonally to the relic channel and pond network, increasing base spring flows by a factor of four during periods of heavy runoff (K. Cuthbert, landowner, pers. comm.). The complex was on the river's right (west) bank, connected at roughly 90^o to the mainstem by a short stable channel through a low elevation river bank vegetated with heavy grass and shrubs (Fig. 4). Mainstem configuration at this location was a smooth single thread channel bending slowly to the east (left bank), with the cold water input entering on the outside of this bend. Discharge on the day of survey was estimated at 50 L/s or 1% of mainstem flow, and temperatures of the mainstem and the cold water entering it were 22.1 and 9.9^oC, respectively, when the survey started at 1105h.

As a control just upstream of the cold water input, water temperature at the river's edge was measured at 22.0^{o}C. From that point outward into the river, temperature measurements just off the substrates at 1 m intervals across a 7 m transect from the bank yielded values from 22.2 to 22.5^{o}C. These control measurements were then repeated immediately opposite the input, and at 2, 5, 10 and 20 m intervals in a downstream direction from the input. Results showed that temperatures near the substrates in Wrixon's Run were cooled relative to the control for 107 m of stream length and up to 5.5 m of stream width (Appendix B).

Figure 4. Technician measuring water temperatures in Wrixon's Run in the Cowichan River (background, flowing left to right) where the cold water source (foreground, middle) enters the mainstem.

Using temperatures of up to, but not including, 22.0^{o}C (the coolest measurement in the control transect), we calculated that the area of stream bed positively affected by the input was 446 m^2. However, most of this area saw minimal temperature reductions - only 20% (89 m^2) offered temperatures of less than 20.0^{o}C (Appendix B). Area calculations should be considered conservative because daytime heating occurred during the 2.5 hours needed to complete the measurements. The mainstem and cold water inputs were re-measured at the end of the survey (1340h) and found to be 23.7 and 10.7^{o}C, respectively, up 1.6 and 0.8^{o}C from the morning's readings.

A brief snorkel survey of Wrixon's Run was conducted after the temperature measurements. At 2 m effective, visibility was poor to moderate. Approximately 95 adult fish were observed holding just above the substrates in the thermally influenced area. Twenty brown and rainbow trout were observed 82 m downstream of the input. A second school of 75 trout and one sockeye was counted 133 m below the input. The distribution of fish was almost certainly affected by the measurement activity, but greater depths near the downstream end of the cold water refugia may also have been attractive to fish. It should be noted that crews of a previous snorkel survey through this reach on August 4 (see Section 3.4.1.1 below) confirmed that little to no adult fish were observed immediately before or after Wrixon's Run.

Temperature Datalogger Network

Water temperature dataloggers from five key representative locations were downloaded weekly and results reported to a large stakeholder list same day by email (Appendix C).

When the Cowichan Low Flow Mitigation Strategy was formally initiated in late July 2015, a network of 17 temperature dataloggers through the length of the river had already been funded, installed and operating since 2014.   In early July 2015, initial network results to March 26, 2015 were reported (Stenhouse 2015).   Later in July 2015, Addendum 1 to the report was released and included network results to July 22, 2015 (Stenhouse 2015a). Most recently, Addendum 2 and appendices were circulated in late October 2015, summarizing network downloads to October 7 (Stenhouse 2015b).

The weekly download and reporting out to stakeholders provided an in-season, "real-time" update of hourly mainstem water temperatures at:

- Cowichan River at Lake Cowichan (*rkm 48; prelim data from WSC Station 08HA002*);
- Cowichan River at Wildwood BC Parks (*rkm 25; BCCF datalogger*);
- Cowichan River near Duncan (*rkm 7; prelim data WSC Station 08HA011*);
- Cowichan River North Arm, right-hand channel - North Arm Ramp (*rkm 0.7; BCCF datalogger*); and,
- Cowichan River South Arm - Metric Pool (*rkm 0.9; BCCF datalogger*).

A sixth datalogger was installed August 21 at North Arm Log Jam, as crews suspected temperatures at the North Arm Ramp site may have been unrepresentative (low, shallow flow).

Downloads and same-day reporting occurred August 21, 28 and September 4. The weekly communication briefed recipients on the Low Flow Mitigation Strategy and intentions to keep stakeholders advised, and provided the day's downloads graphically and in a spreadsheet. Cooler weather and precipitation in the first week of September led to reduced temperatures, and weekly updates were discontinued.

Results such as Figure 5 show diurnal temperature variations averaging 1.2°C for the lake outlet (range 0.4 to 2.0°C), and 2.7°C for a typical mid-river mainstem site such as BC Parks' Wildwood office at rkm 24.7 (range 1.0 to 4.1°C). Maximum variations occurred in late July and early August, at the same time that differences between lake outlet and river temperatures were lowest and even crossed over (i.e., river temperatures were higher than lake outlet temperatures).

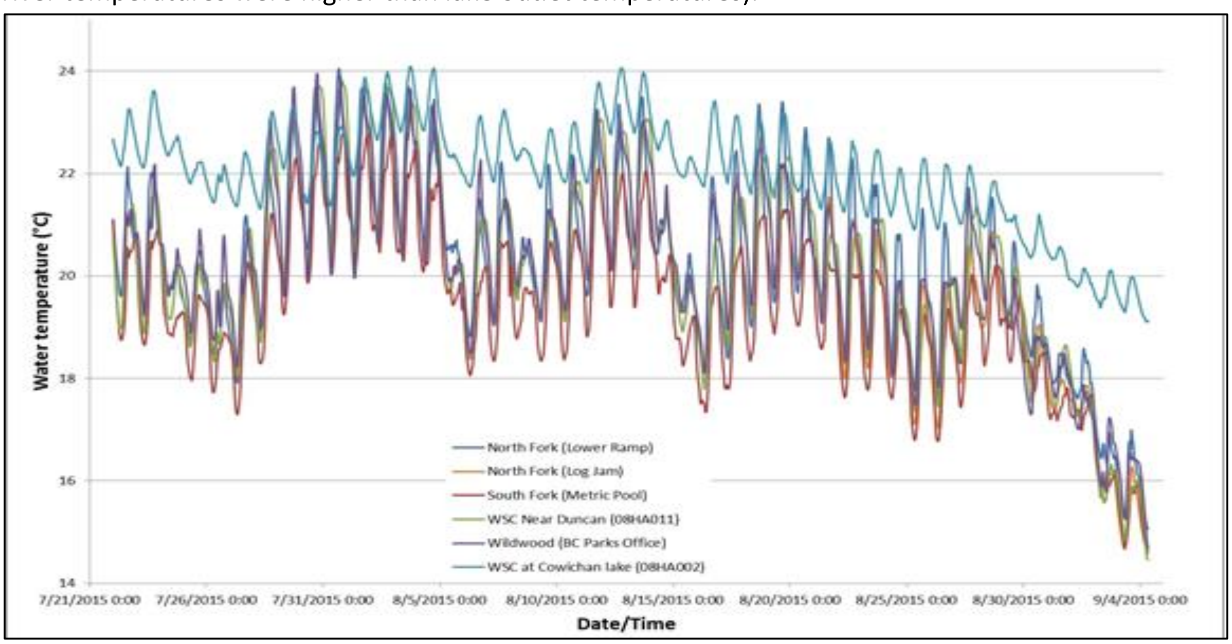


Figure 5. Example of Cowichan River hourly water temperature chart (July 21 to September 4) circulated to stakeholders weekly in late summer 2015.

In the lower river, water in the South Arm had consistently lower temperatures (~0.9°C lower on average) than water in the North Arm (either location), despite similar distances travelled from the bifurcation. Though aspect, groundwater and the degree of braiding may have an influence, shading from canopy and log jam cover in the South Arm were likely responsible for the cooler water – studies have shown that stream shading can significantly reduce maximum water temperatures (Johnson 2004). The North Arm channel is substantially more open and subject to solar energy inputs. The South Arm's lower temperatures may influence the proportion of returning Chinook that use it versus the North Arm.

In his analysis of potential effects of water temperature on adult Cowichan Chinook, Smith (2015) presented an overview of general, migration and spawning temperatures from past studies in the Pacific Northwest. References often cited 25.0°C as lethal, and temperatures below that down to approximately 14°C as stressful to varying extents. Smith noted that research suggested tolerance limits of adults are significantly lower than juveniles (McCullough 1999). With respect to the Cowichan and according to these criteria, 2015 data indicate that spring or early fall run adults that remained in the mainstem and found no thermal refuge would have been continually temperature stressed to some degree from May 12 when daily minimums began to exceed 14°C (Sandy Pool, rkm 19) to at least October 7 when dataloggers were last downloaded, a minimum of 149 days. Similarly, using 20°C as the point at which adult Chinook cease to migrate due to stress (McCullough 1999), Cowichan fish would have, in theory, stopped migrating through the river's upper reach altogether for 76 days (June 17-August 31), based on daily minimum temperatures recorded at Greendale Trestle (rkm 47.8). However, river corridor cooling of lake outflows allowed for sub 20°C minimums by mid-river (Sandy Pool) on 28 of 55 nights between June 27 and August 20, creating marginally more suitable conditions that may have supported some instances of migration. Despite these cooler nighttime windows, adults must still contend with the daytime heat, underscoring the likely value of point source or zonal cold water and the need for further investigation and protection of these natural refugia.

Spot measurements of water temperature taken during field work are summarized in Appendix D.

Given concerns about drought related water temperature extremes, the weekly download and communications were geared to inform stakeholders, improve decision-making with respect to flow and fisheries management, and potentially focus further research. Because real-time upper and lower river water temperatures are now available 24-7 via WSC's website (http://wateroffice.ec.gc.ca/), reporting weekly and exclusively on temperatures during future drought scenarios may not be required but could form part of a less frequent, more comprehensive update (e.g., latest fish counts, flows, storage, temperatures, etc.).

3.2.2 Dissolved Oxygen

During the upper river August 5 survey described above in Section 3.2.1, crews collected DO data in addition to temperature data. DOs in both the deep water areas just below Catalyst weir and in Hatchery Pool downstream of South Shore Road bridge varied little and ranged from 6.14 to 7.69 mg/L.

During the August 13 survey at Wrixon's Run (rkm 41.5), DO levels measured at 1105h in the mainstem and associated cold water input were 7.68 and 10.46 mg/L, respectively. The cold water input's relatively high DO was unexpected, as most groundwater sources are typically low in dissolved oxygen. However, a DO reading of 10.3 mg/L collected at this site by a DFO/BCCF crew on September 10, 2014 at 1430h suggests this cold water source's healthy level of dissolved oxygen is consistent.

DO levels taken during lower river discharge measurements or other investigations are listed in Appendix D. Based on limited data collected, mainstem DOs ranged from 5.47 to 8.46 mg/L in late July, above the provincial instantaneous minimum criterion of 5 mg/L for aquatic life stages other than buried embryos (Ministry of Environment 2015).

Independently, Cowichan Tribes also collected water quality data during summer 2015; a report was pending at time of writing. Staff expressed an interest in coordinating efforts in future years, and comparing real-time results of their equipment to that of BCCF's YSI meter.

3.3 Juvenile Monitoring and Salvage

While Gee-trapping in Cowichan Lake tributaries for DNA research commenced March 17, low water salvage on the tributaries and along Cowichan mainstem started as early as April 14 and late May, respectively. Several groups participated, and members of one group often worked with members of another. From records assembled, salvaging continued into the summer as late as August 20.

In summary, local stewards and First Nation members salvaged over 304,282 wild fish from the Cowichan watershed during the 2015 season, 14,802 from the Cowichan River mainstem and 289,480 from 12 sub-basins draining to Cowichan Lake (Appendix E). These numbers are conservative, as some data had yet to be received at time of writing, or may not have been recorded in the field. Earlier in the spring (March-April), another 264 fish (coho fry and parr, cutthroat and sculpin) were Gee-trapped as part of a research project targeting juvenile Chinook in lake tributaries.

Of fish salvaged from the mainstem, over 99% were coho fry with the balance being trout fry and parr (likely steelhead) and sculpins – no juvenile Chinook were encountered. Occurring from late May to the end of June, salvaged fish were mostly removed from drying braids or side-channels in the upper river and immediately released into the mainstem.

Of fish salvaged from Cowichan Lake's tributaries, 226,060 or 78% came from Robertson River. Large numbers also came from Ashburnham (20,387), Meades (14,902), Sutton (14,590), Nixon (6,600) and Shaw (5,386) creeks. Volunteers generally released salvaged fish at Cowichan Lake shorelines near the mouths of the respective tributaries. The exception was Robertson River where all fish were released into Bear Lake. Crews working Robertson would also temporarily stockpile fish in larger, more persistent pools before ultimately transferring them to Bear Lake. While coho fry comprised 95% of fish salvaged from Cowichan Lake tributaries, volunteers salvaged chum fry from Meades, Ashburnham and Sutton creeks, as well as Chinook fry from Robertson and Ashburnham creeks, and possibly Sutton

Creek[7]. Over 5,900 juvenile trout were salvaged; based on the 8% whose species were identified by salvage crews, 89% were rainbow/steelhead fry and parr, while 11% were cutthroat trout juveniles (Appendix E). Small numbers of sculpin and three-spine stickleback were also salvaged from most creeks.

3.4 Adult Monitoring

Adult Chinook monitoring was carried out using traditional snorkel surveys throughout the river, bank walks in the lower and tidal reaches, fence counts (DFO/CT) and sonar (DIDSON) surveys.

3.4.1 Snorkel Surveys

Snorkel surveys targeting spring run and fall run Chinook were completed in July/August in the upper river and in September in the lower river, respectively.

3.4.1.1 Spring Run Chinook

Prior to the low flow strategy being initiated, CT conducted preliminary surveys for spring run Chinook on July 6, 17 and 24, 2015. During the first survey with two 2-person crews, no Chinook were observed between the Greendale Trestle and Skutz Falls. On July 17 from Skutz Falls to Stoltz, a single 2-person crew observed two Chinook adults. Lastly on July 24, a 2-person crew again observed two Chinook over a 3.2 km section of the lower river, starting at rkm 4.5 and ending at the bifurcation.

One of the first field activities of the strategy, snorkel surveys targeting spring run Chinook were completed on August 4, 2015 by CT/BCCF crews (Appendix F). Three sections covering the uppermost 22.3 km of river (45% of total length) were swum:

- Greendale Trestle (rkm 47.8) to 70.2 Mile Trestle (rkm 40.6);
- 70.2 Mile Trestle to Skutz Falls (rkm 33.7); and,
- Skutz Falls to Stoltz Pool boat launch (rkm 25.5).

At least one member of each two-person team had experience snorkeling their respective sections. A total of <u>two adult Chinook were observed</u>, holding individually in pools 4.5 to 6 m deep in the middle survey section. The first was noted near the downstream end of the Block 51 meanders (~rkm 38.2), the second associated with a large log jam near the Sawdust Pool (~rkm 36.0). No Chinook adults or jacks were observed in the upper or lower sections.

Observation conditions were considered good over all. Discharge from Cowichan Lake at the start of the survey was 6.3 m^3/s (WSC website Stn 08HA002; provisional data) and mostly stable. Because the day was warm, clear and sunny, light streaming affected visibility at times, reducing observer efficiency temporarily. Crews' estimates of effective horizontal visibility were 5 to 8 m depending on lighting and aspect, with vertical visibility of up to 6 m in shaded pools in the lower section. Water temperature was

---

[7] Samples from Robertson and Ashburnham were confirmed by DNA testing to be Chinook (see section 3.4.1.1, *Spring Run Chinook*); test results from some Sutton Creek samples were outstanding at time of writing.

measured at 22.5°C at 0738h at Greendale Trestle, similar to the 22.8°C reported at 0800h at Cowichan Lake outlet (WSC website Stn 08HA002; provisional data).

In the upper two sections, the channel is irregular and wandering, with riffle-pool morphology and few instances of bedrock control. Deeper habitats were generally a result of local increases in gradient, focused scour on outside bends and occasional "hardpan" features, and scour associated with sporadic log jams. Surveyors encountered no scenarios where pools were too deep to survey. However, the log jams offered cover that may have prevented surveyors from seeing fish. As a result, survey confidence was thought to be high overall – crews agreed that groups of Chinook would not have been missed, but individuals could have been overlooked.

In the lowest snorkel section, over 3.4 km of the river (41%) flows through bedrock canyon and is moderately to highly confined with a high proportion of deep pool habitat. The other 59% is more typical alluvial channel similar to, but even less confined than that found in the upper two sections. The canyon habitat consists of Skutz and Marie canyons, 650 m and 2,750 m long, respectively. Using meso-habitat composition survey data collected during a 7.0 m^3/s flow scenario in October 2014 (LGL 2015), we calculated the proportions of riffle, pool, glide and cascade habitats in each canyon[8] (Table 3). Summarizing results from both canyons, 74% of their combined length was defined as pool habitat, followed by 15% riffle, 9% cascade and 2% glide. With such a large proportion of deep pool habitat per kilometre, traditional snorkel techniques to determine Chinook presence/abundance can be questionable in this section.

Table 3. Meso-habitat composition in the Cowichan River's Skutz and Marie canyons under a 7.0 m^3/s release scenario.

Meso-habitat Type	**Length of Channel (m)**		
	Skutz Canyon	**Marie Canyon**	**Aggregate**
Riffle	93 *(14.4%)*	409 *(14.9%)*	502 *(14.8%)*
Pool	454 *(70.3%)*	2,053 *(74.7%)*	2,507 *(73.9%)*
Glide	64 *(9.9%)*	13 *(0.5%)*	77 *(2.3%)*
Cascade	35 *(5.4%)*	273 *(9.9%)*	308 *(9.1%)*
Total	646 *(100%)*	2,748 *(100%)*	3,394 *(100%)*

Another factor affecting the suitability of the river's deep pool canyon habitat for holding Chinook is the temperature regimes in those habitats. Stakeholders have suggested that if groundwater inputs were present, even in small discrete zones, parts of the canyon may be suited to hold adults looking to avoid predators and withstand the summer's generally warm water. This may be a point of investigation in future years.

[8] Meso-habitat typing followed methods in Technical Circular No.8 (Johnston and Slaney 1996), and defined pools in the Cowichan River as having a minimum of 1.0 metres of residual depth.

Since the mid-1970s, the provincial Fish and Wildlife Branch (Nanaimo) has conducted spring and early summer snorkel surveys of the upper Cowichan River primarily to enumerate resident and/or adfluvial rainbow, brown and cutthroat trout, but all species are counted. Though surveys may not have occurred in some of the early years, annual July count data were found from 1990 onwards. In some years, surveys were also completed in April, May or June. Most of the annual surveys covered from the lake outlet (i.e., Oliver Creek, aka Hatchery Creek) to Sandy Pool, a distance of 29 km. Between 1990 and 2014, from zero to 38 Chinook have been counted during the provincial surveys (Fig. 6; Appendix G). We noted that over the period of record the numbers of adults and jacks observed – where they were broken down and reported – were 106 and 91, respectively. In 2015, the provincial survey occurred July 22 and covered Greendale Trestle (river km 47.8) just below Oliver Creek, to Skutz Falls, a distance of 14.1 km. With 5-7 m of visibility reported, fish viewing conditions were normal but no Chinook, adult or jack, were observed.

Summarizing the provincial records (Appendix G) we noted that July surveys were much more likely to report Chinook than surveys from April through June. Of 29 surveys taking place in July from 1976 to 2015, 22 (76%) contained reports of Chinook. Conversely, of 14 surveys conducted in the months of April, May or June in those same years, only one survey (7%) reported Chinook being observed. These numbers may partially be explained by conditions that would adversely affect observer efficiency in the wetter months with higher flows. But results may also support a general consensus among many stakeholders that the Cowichan's spring-run Chinook stock, if still distinct, is at extremely low levels of abundance.

Juvenile Chinook sampled from Cowichan Lake tributaries in 2015 were genetically compared to Cowichan fall run Chinook. Preliminary results from R. Withler, DFO, Nanaimo (Appendix H) were not definitive but suggest the juveniles were more closely related to fall run Chinook populations (such as Cowichan) of southeastern Vancouver Island, rather than Puntledge or Nanaimo spring run Chinook groups. Further analysis on "somewhat distinctive" groupings was required.

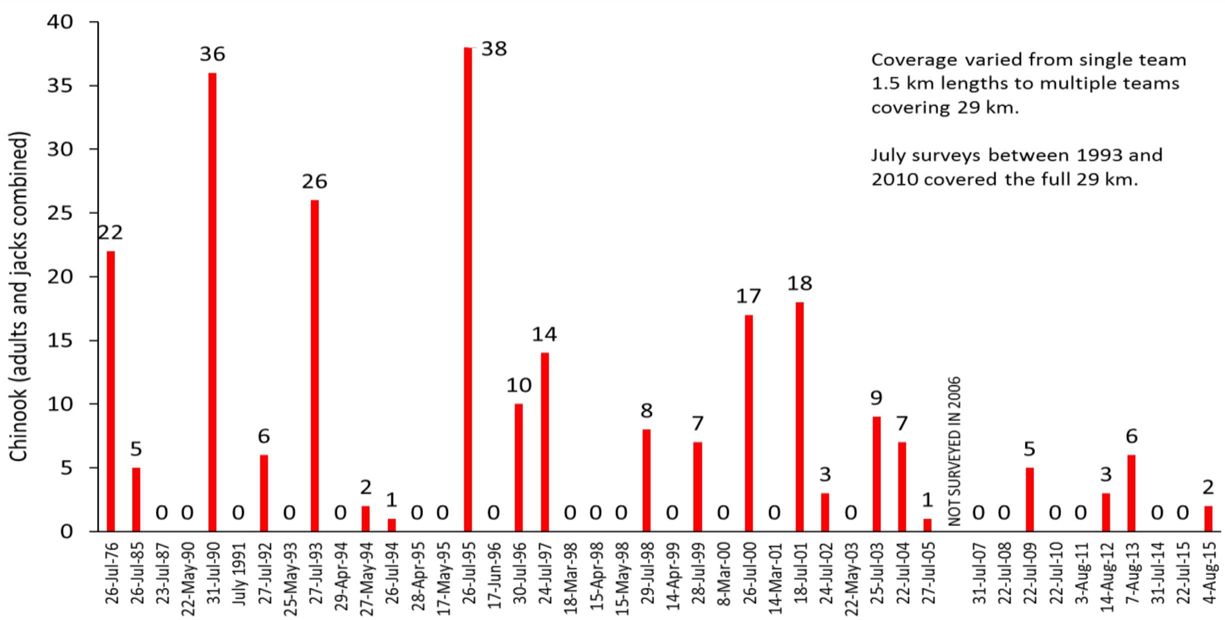


Figure 6. Cowichan Chinook counted during Provincial Fisheries snorkel surveys for resident trout and/or steelhead, 1976-2015.

Such results fuel the possibility that fall run Chinook, given improved access to the upper watershed via the Skutz Falls fishways, more favourable migration flows, less exposure to higher water temperatures, and decades of upper river out-planting of hatchery production, have come to dominate the upper watershed's suitable spawning and rearing habitats. They may have even interbred with ever declining numbers of earlier migrants, and genetically overwhelmed the migration timing characteristics of the original spring-run stock.

Even six and a half decades ago, Cowichan spring run Chinook according to Neave (1949) were believed to be "undoubtedly very scarce" with "only three or four unquestionable records of such fish having been obtained within the last few years…" It should be noted that Neave's account was based on an investigation of earlier information – no stock assessments appear to have been conducted by him for his report. Very few studies have documented migration timing for Vancouver Island spring run Chinook stocks, but general timing is thought to be May through July (Nagtegaal *et al.* 1994). Neave (1949) reported accounts of Cowichan spring run fish being caught or found dead in the river and lake between January and May.

3.4.1.2 Fall Run Chinook

Three lower river snorkel surveys for fall run Chinook were completed by CT fisheries staff in September. A fourth was planned for September 25 but cancelled when discharge from rain and lake releases during the preceding days increased discharge to over 25 m^3/s in the lower river (WSC station 08HA011 at rkm 6.9; provisional discharge). Additionally, DFO/CT's counting fence was installed September 17 and operational the next day, making further snorkel surveys less critical to understand fish presence and migration rates. For the rest of September and October, lower river discharge varied between 8 and 40 m^3/s (15 to 76% MAD), providing reasonable and regular adult upstream migration conditions. No further surveys were conducted.

The first survey occurred September 3 with a count of six Chinook adults and seven jacks (Fig. 7) over 2.7 km from "JC's Pool" (rkm 4.5) to "Powerline Pool" (rkm 1.8). Though conditions for the three-member team were good to begin with (3-5 m), transparency dropped substantially to less than 2 m downstream of the JUB outfall at rkm 3.8. Water temperature ranged from 15 to 15.8^{o}C during the survey. One adult Chinook appeared to have a significant laceration along its body length, possibly from a seal attack.

Numbers observed increased substantially on the second survey on September 10. River transparency (secchi=5.5 m) was similar or better than the first survey, and the three member crew counted 224 Chinook adults and 103 jacks over 5.4 km from the fence site (rkm 6.7; fence not yet installed) to the end of Quamichan Dike Road (rkm 1.3). One third of the Chinook were lightly coloured, and a small portion appeared "dark". Water temperature was 19^{o}C. Pink and sockeye salmon were also observed (Fig. 7).

On September 18, observers on the third and last snorkel survey counted 290 adult and 175 jack Chinook over 3.1 km from the DFO/CT counting fence (rkm 6.7) to the bottom of the JUB Pool (rkm 3.6).

Transparency had improved slightly (secchi=6.0 m) over the previous survey, and water temperatures were significantly lower at 15.5-16°C. Surveyors noted three Chinook mortalities at the counting fence, one adult and two jacks that had become stuck prior to final panel adjustments. Five injured Chinook were noted in the first segment surveyed, from the fence to "Black Bridge[9]" (rkm 5.8).

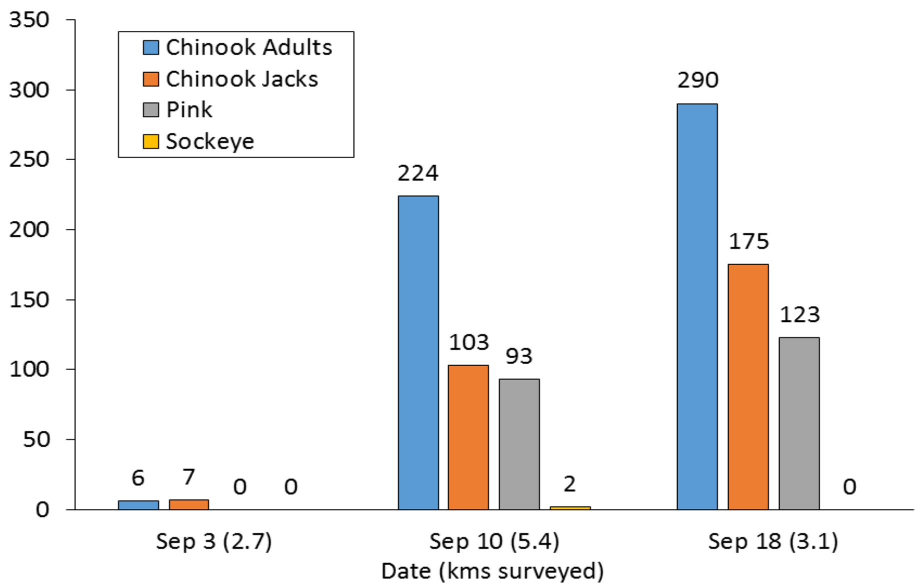


Figure 7. Cowichan River snorkel survey counts downstream of the counting fence below Allenby Road, Fall 2015.

All three surveys were conducted during the lowest flow regime that occurred in 2015, the period in which Catalyst's storage releases from Cowichan Lake were first reduced to 4.5 m^3/s (August 15), and subsequently varied from approximately 4.5 to 4.7 m^3/s until fall rains arrived in earnest (September 20; Fig. 8). Including natural inputs and losses between the lake and the survey sections, and withdrawals by Catalyst's Pumphouse at rkm 8.0, storage releases during this period translated roughly to discharges in the lower river of 3.0-3.8 m^3/s (Fig. 9), with the odd bump to 5 m^3/s when minor rains occurred (WSC station 08HA011; provisional discharge).

This range equates to between 5.7 and 7.2% MAD in the lower river, flows that allow fairly high observer efficiency during snorkel surveys but are less than desirable for fish and fish habitat, effluent dilution, recreation, etc.

Based on historic adult holding areas between the DFO/CT fence site and the tidal reach, CT snorkel crews established 15 segments (Appendix I) for which data were recorded on each swim. Assuming the snorkel program is repeated in future, this breakdown should help standardize the data, facilitate comparisons of year to year stock abundance by date and segment, identify problem areas (i.e., predation, de-watering, etc.), assist with brood collection, enable replicates to evaluate observer efficiency, and contribute to improved management and decision-making.

[9] Southern Railway of Vancouver Island bridge.

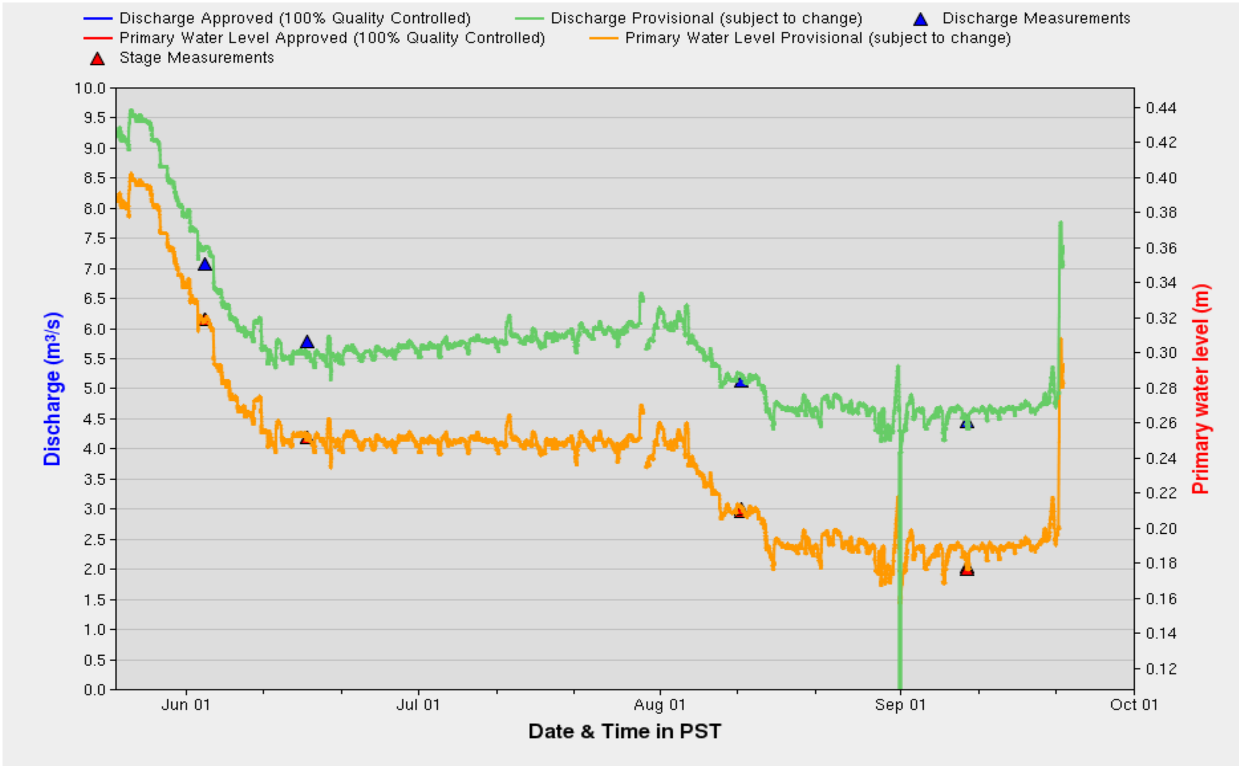


Figure 8. Discharge and stage at Cowichan Lake outlet, May 23-September 21, 2015 (WSC station 08HA002, provisional data and chart from http://wateroffice.ec.gc.ca/).

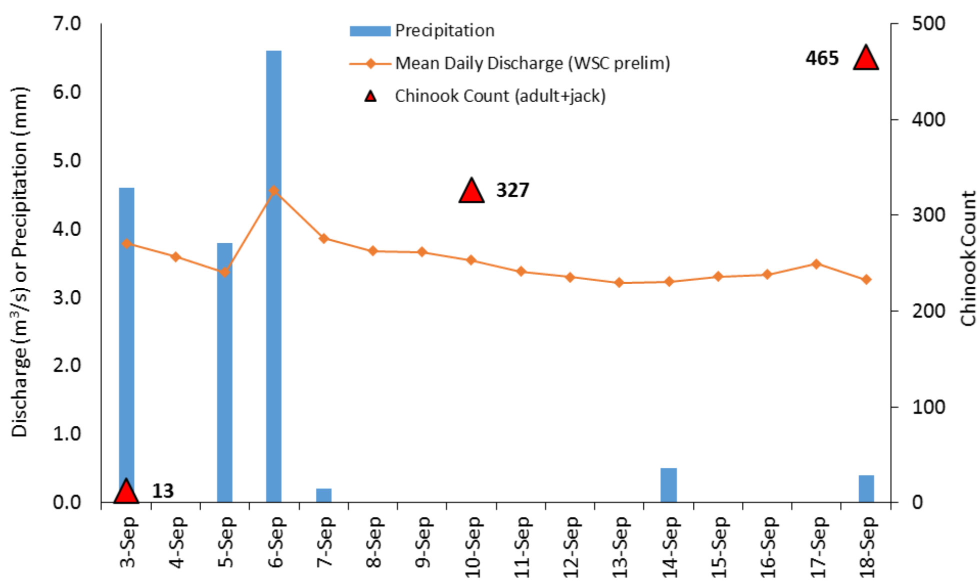


Figure 9. Lower Cowichan River daily discharge and precipitation versus fall Chinook snorkel counts below Allenby Road, September 3-18, 2015.

Independently in early August, CT crews completed a synoptic assessment of the North Arm's eastern channel log jams at rkm 0.7 (Photo Plates 7, 10) that may constitute migration impediments for returning Chinook. This review was particularly pertinent because of the complete lack of migration potential in the North Arm's western channel due to low flows. The investigation found no mortalities or unusual concentration of fish behind the jams and estimated that adult upstream passage was possible via a series of narrow pathways through the jams.

Investigations also highlighted the potential for gravel infilling to exacerbate passage issues at key log jams. The build-up of gravel in and around the front faces of log jams can have a distinct impact on water flow and therefore fish passage. CT crews know the long term history of specific log jams, and are familiar with the volume and recruitment of bedload from upstream, particularly recent gravel extraction zones (NHC 2009). The size of the jam can impact the ability to accurately assess fish passage potential - heavy duty dive lights with narrow beams are invaluable to assess dark overhanging sections of log jams. Long term knowledge and specific experience with these log jams was key in safely and accurately assessing fish passage.

3.4.2 Stream Walks

Completing surveys three days/week from September 8 to 30, 2015, the CRS observed a total of 538 adult Chinook, 288 Chinook jacks, 127 pink salmon and a total of 23 harbour seals (Appendix J). Fifty-six percent of Chinook observed were in the South Arm (538 vs. 408). The total number of survey days was 12; the South and then the North Arm were surveyed on each day, except days 8, 10, and 12 when the order was reversed. Survey effort was roughly the same in each arm.

The greatest number of seals observed during a single day was four (Appendix J). Seals were more commonly observed in the South Arm (15) than in the North Arm (8). Reviewing the data, there appeared to be no relationship between the number of seals observed and either the number of Chinook observed (adults and/or jacks), the tidal stage, or the time of day. Though nighttime surveys did not officially occur, the CRS made anecdotal note that more seal-related activity appeared to happen in the low light conditions of dawn and dusk.

Surveys did not cover early run Chinook timing (e.g., May-Aug), a period during which Chinook could be more sensitive to seal predation due to the low numbers returning and the seasonal low flows. At 83%, the proportion of days with seal sightings was high but it is unknown whether this was a population that was habitually predating on in-river salmon or simply a small representation of the overall population that frequents Cowichan Bay. A broader discussion is required to further develop a specific monitoring methodology that works for the Cowichan River seal population and includes early run Chinook.

3.4.3 Non-Stationary Sonar Surveys

No Chinook adults or jacks were observed during an August 27 portable DIDSON survey of the downstream end of the Skutz Falls canyon. A crew of DFO, CT and BCCF personnel covered approximately 100 m of stream canyon length, while an additional swimmer attempted to provide "containment" where possible, acting as a barrier and looking for any fish trying to avoid the DIDSON crew. The crew noted ledges and narrow portions of the canyon pool made for difficult surveying with the portable DIDSON, and an overly restricted view. They agreed that schools of adult-sized fish would likely have been detected if present, but that individuals could have easily been missed with the technique.

One adult Chinook was observed from the bank prior to the survey commencing. This fish was not observed again or recorded by the DIDSON.

Ultimately, the use of a hand held DIDSON in the Cowichan's deep pool canyon habitat was considered impractical due to incomplete coverage of the water column, limited viewing depth, issues with cable length, and other deployment limitations.

3.4.4 Other Adult Monitoring

At the time of writing, stationary DIDSON data collected by DFO at the Cowichan Lake weir and a mid-river location (rkm 24) were preliminary and under review (Table 4). This was a first year trial by DFO to employ DIDSON units in these locations targeting Chinook. Primary concerns with the resulting data were incomplete coverage of the likely migration period and performance shortfalls associated with the weir unit (I. Matthews, DFO, Nanaimo, pers. comm.). Numbers reported were for "large" targets interpreted to be ≥ 55 cm in length. While the weir DIDSON was removed August 9, the mid-river DIDSON ran into the fall; DFO arbitrarily assigned August 31 as the cutoff for "spring run" fish.

Table 4. Preliminary target counts at DFO stationary DIDSON stations located mid-river and at Cowichan Lake weir (unofficial data provided by I. Matthews, DFO, Nanaimo).

DIDSON Location	Start Date	End Date	Targets Counted	
			Moving Upstream	Moving Downstream
Catalyst Weir (rkm 49.3)	Jun 23	Aug 9	191	270
Mid-river (rkm 24)	Jun 12	Aug 31	419	183
Mid-river (rkm 24)	Sep 1	Oct 5	1315	283

Preliminary results suggest 236 targets migrated upstream past the mid-river DIDSON (Photo Plates 12-15) prior to August 31. Because species of each target cannot be verified, species composition of the results can only be estimated based on assumptions. Individual estimated lengths, behaviors and observation dates are the primary criteria by which species composition is approximated. Lengths in particular are most indicative of species. For example, a target that displayed typical fish swimming motion and was estimated to be 85 cm in length was almost certainly an adult Chinook. However smaller targets (i.e., 55-60 cm, est.) had the potential to be small Chinook, large brown or rainbow trout, or sockeye salmon (Appendix F).

Though preliminary weir DIDSON results were affected by the quality of the sonar data they did indicate that, during the period of operation, 79 more targets moved downstream towards the river than upstream into the lake. Like the mid-river results, smaller targets had the potential of being large trout or sockeye as much as small Chinook. Interestingly, a somewhat distinct migration of fish downstream through the weir occurred at the beginning of August (I. Matthews, DFO, Nanaimo, pers. comm.) – this corresponds with no known local stock behavior. Regardless, without “ground-truthing” or verification of results and given the relatively poor sonar data, it may be difficult to make definitive conclusions. Once data are finalized, further interpretation may be possible. At time of writing, a comparison of fall run results from the lower river counting fence and the mid-river DIDSON was planned to determine any correlations (I. Matthews, DFO, Nanaimo, pers. comm.).

Also at time of writing, the preliminary estimate of fall run Chinook passing the DFO/CT counting fence (rkm 6.7) was 6,800 fish, all ages. Mark recapture and scale/otolith data were being analyzed to determine the run’s age structure, etc. (S. Baillie, DFO, Nanaimo, pers. comm.).

Though they were last cleaned of debris in late August 2015 by DFO, the upstream ends of the Skutz Falls fishways were observed to be largely plugged with small debris during a site visit on November 13. It was not clear whether discharge and conditions at that time were allowing fish to bypass the fishways on their upstream migration.

4.0 Recommendations

1. Stream flow measurements were useful to help evaluate the accuracy of provisional real-time discharge reported by WSC's Cowichan River near Duncan hydrometric station (08HA011; Allenby Road bridge). Water levels at this station are affected by the cobble riffle ~150 m downstream and, at times, the DFO/CT fish fence (or its foundation sill) in that same location. The oscillating nature of flows below Catalyst's diversion also effects measurements done to improve the accuracy of the station's provisional data. Because of the license requirement to maintain at least 2.83 m^3/s below the pumphouse, Catalyst depends on this station's real-time reporting to manage storage releases from Cowichan Lake[10], particularly during drought scenarios when storage is limited and releases are reduced to avoid running out before fall rains return. Therefore, discharge measurements at the Allenby Road station are recommended every two weeks once flows leaving the lake have dropped below the 7.08 m^3/s target. This frequency is close to what occurred in 2015 when, according to the website, WSC technicians attended the station twice a month in June, August and September (no July visits occurred).

2. Coordination of measurements with periods of uniform diversion would reduce deviation from existing curves and improve station reporting. Should measurements be conducted by other than WSC staff, personnel should be qualified and use measurement equipment and methods that adhere to WSC standards. Results may then be used by WSC to immediately fine tune website reporting, as needed.

3. To eliminate the influence of DFO/CT's fish fence on local river height and therefore discharge at the Duncan WSC station, we recommend Catalyst continues to pursue an option to re-locate the station's levelogger upstream.

4. Flow monitoring and the associated habitat observations to determine conditions in the Cowichan's North and South arms were also valuable. In 2015, flows continued to be split evenly between the arms, a state that supported some degree of adult migration (as evidenced by field observations), as well as the greatest amount of rearing habitat with both channels largely wetted. 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.

5. Maintain a natural spring flow regime. A related issue not addressed during this project but flagged by the Flow Committee for 2016 was the degree of spring-time connectivity between side-channels and tributaries to the mainstem. 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. Two studies

---

[10] Catalyst also depends on real-time data from WSC station 08HA002 Cowichan River at Lake Cowichan to manage storage releases, but given this station's dependable invert control, deviation from the established curve rarely exceeds WSC's 5% guideline.

in the Cowichan were found that examined these issues. In a study of the influence of discharge on side-channel habitats, Burns *et al.* (1988) found a 28,008 m^2 reduction in active channel wetted area when flow was reduced from 20 to 7.08 m^3/s, and a further 17,897 m^2 loss when flow was reduced from 7.08 to 4.48 m^3/s. Monitoring side-channel connectivity at eight sites over spring flows of 50.5, 26.5, 21.5 and 15.8 m^3/s, Wright and Pellett (2006) found the most substantial changes occurred when flows were reduced from 50.5 to 26.5 m^3/s; side-channels lost an average of 78% of the discharge they had under the 50.5 m^3/s mainstem flow condition. Should further evidence or clarification of the value of adequate spring flows be required, the latter study could be repeated and/or extended in 2016.

Rearing area and off-channel connectivity are important and critically affected by spring flows. Possibly more important, studies have shown that juvenile salmonid growth peaks in spring when temperatures and natural flow rates are still moderate, typically tailing off by late summer (Sogard *et al.* 2009, Perrin 1990). From mid-summer to early fall, high temperatures can impart thermal stress, use lipid stores, limit growth and result in population declines (Wheeler 2009). Adequate spring flow can therefore 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**.

6. Water quality, particularly temperatures, should continue to be monitored. While WSC stations at rkm 6.9 and 48.5 now report close to real-time water temperatures (delayed by ~2 hours), dataloggers evenly located through the river corridor will help fill data gaps on the system's thermal regime and may highlight sites or zones needing further study or protection. Thermal refugia mapping conducted at Wrixon's Run could be repeated to confirm this site's size and level of use by fish. Other suspected key sites could be similarly mapped (e.g., Breakfast, Sawdust and Stoltz pools; Table 2), setting a foundation for a longer term, detailed evaluation of thermal refugia through the system.

7. Even from the incomplete information gathered, 2015 fry salvage efforts were significant throughout the watershed, particularly in Cowichan Lake tributaries. We recommend support be made available to group coordinators and that agency guidelines be re-stated or clarified to ensure the best possible outcome for salvaged fish. Data collection should be standardized to enable trend analysis. Because Cowichan Lake surface water temperatures peak from July to mid-August, consideration might be given during this period to off-shore releases using small boats, rather than releases at shorelines where temperatures can be extreme. Salvaged juveniles released off-shore have been shown to immediately seek the cooler water at depth (i.e., at or below the thermocline), likely increasing post-release survival rates (T. Rutherford, DFO, Nanaimo, pers. comm.).

8. Snorkel surveys to evaluate spring run Chinook returns were of limited effectiveness and should not be a high priority in future. At best, they served to re-confirm the very low Chinook abundance generally documented during the provincial July resident trout surveys since 1990.

Assuming the annual resident trout survey continues and covers at least Greendale Trestle (rkm 47.8) to Skutz Falls (rkm 33.7), further surveys may not be required. Working with FLNRO to extend this survey to Sandy Pool (rkm 19), as was normal practice prior to 2012, would generate more significant results. We recommend CT and FLNRO Fisheries staff annually coordinate to complete the full four section 29 km survey, collecting each other's data according to established protocols.

9. DFO's 2015 trial DIDSON operations mid-river and at the Catalyst weir showed good promise to generate abundance and timing data for early migrating Chinook. Other than widening the operation windows and site location improvements to optimize results, these operations may only need validation of species composition. With the Cowichan's significant numbers of large resident trout and the unusual July returns of sockeye seen in 2015, the species of smaller targets identified by the DIDSON will remain unconfirmed. Assuming DFO finds ways to address these issues, we recommend continuing to use this technology for early returns of Chinook.

10. Lower river snorkel surveys to enumerate and identify the distribution of fall run Chinook are recommended to continue. Conducted weekly until the counting fence is operational, these surveys from mid-August to mid-September give an early indication of return strength that stakeholders and managers can use in decision-making. They also provide close evaluation of holding and/or migration conditions as well as fish health that can lead to further monitoring, protection or drought mitigation activities, as needed.

11. Lower river bank surveys of seals and other predators by the Cowichan River Steward provided data that may serve as a baseline for comparable surveys in future. The CRS noted that feeding activity was not as readily encountered during the day, and suspected that greater activity may occur during low light scenarios or night time. Adjusting surveys to occur during low light hours could be evaluated but would need to consider additional safety issues. Bank surveys occurred exclusively in September; the practicality of conducting surveys earlier to cover early migrating fish in June and July could be examined. Methodology should be further defined to ensure repeatability, coordinated with other surveys by researchers and community stewards in Cowichan Bay, and reviewed by DFO marine mammal staff.

5.0 References

Burns, T., E.A. Harding and B.D. Tutty. 1988. Cowichan River assessment (1987): The influence of river discharge on side-channel fish habitats. Can. MS Rep. Aquat. Sci. No. 1999: v + 24p.

Chapman, A. 2011. A report on a statistical model to forecast seasonal inflows to Cowichan Lake. Prepared for BC Conservation Foundation (Nanaimo) by Chapman Geoscience Ltd., Victoria, BC. 7p.

Fleenor, W. 2014. Email to W. Jansen, DFO, Duncan. Cowichan Low Flow Update Graphs, September 11, 2014. Unpublished data.

Haig-Brown Fly Fishing Association. 1987. The Cowichan River map, from Lake Cowichan to the estuary.

Hop Wo, N. K., D. A. Nagtegaal and E. W. Carter. 2005. The effects of water release strategies on Chinook returning to the Cowichan River and the Nanaimo River. Can. Manuscr. Rep. Fish. Aquat. Sci. 2715:107 p.

Johnson, S. L. 2004. Factors influencing stream temperatures in small stream: substrate effects and a shading experiment. Can. J. Fish. Aquat. Sci. 61: 913-923.

LGL Ltd. 2015. Habitat-flow assessment for the middle and upper Cowichan River. Prepared for Ministry of Forests, Lands and Natural Resources, Nanaimo, BC. 56 p.

LGL Ltd. 2013. Habitat-flow assessment for the lower Cowichan River. Prepared for Ministry of Forests, Lands and Natural Resources, Nanaimo, BC. 34 p.

McCullough, D. A. 1999. A review and synthesis of effects of alterations to the water temperature regime on freshwater life stages of salmonids with special reference to Chinook salmon. U.S. Environmental Protection Agency. EPA-910-R-010, Seattle.

McHugh, D. and S. King. 2015. WCVI snorkel survey protocols for salmon enumeration in West Coast Vancouver Island streams. Fisheries and Oceans Canada, Nanaimo, BC. 48 p.

Ministry of Environment. 2015. British Columbia approved water quality guidelines: aquatic life, wildlife and agriculture. Water Protection and Sustainability Branch, May 2015. 36 p.

Ministry of Environment and Parks. 1986. Cowichan-Koksilah water management plan. Prepared by the Vancouver Island Region Planning and Assessment Branch. 273 p.

Nagtegaal, D. A., P. J. Starr, and B. Riddell. 1994. A preliminary report on the Chinook productivity study conducted on the Cowichan River, 1988 and 1989. Can. Manuscr. Rep. Fish. Aquat. Sci. 2233: 53 p.

Neave, F. 1949. Game fish populations of the Cowichan River. Fish Res. Bd. Can. Bull. 134: 32 p.

NHC Ltd. 2009. An integrated flood management plan for the lower Cowichan-Koksilah River floodplain. Prepared for Cowichan Valley Regional District in partnership with Cowichan Tribes, City of Duncan, District of North Cowichan. 261 p.

Pellett, K., J. Craig and C. Wightman. 2013. Preliminary investigation of habitat preferences and abundance of juvenile Chinook in the lower Cowichan River Floodplain (spring 2013), with reference to habitat compensation options. Prepared for CVRD, Duncan, BC, DFO, Nanaimo, BC, and Living Rivers – Georgia Basin/Vancouver Island, Surrey, BC. 40 p.

Perrin, C. 1990. Steelhead enhancement by nutrient addition to the Salmon River, Vancouver Island: first year assessment. Prepared by Limnotek Research and Development Inc. for BC Conservation Foundation, Surrey, BC. 54 p.

Province of BC. 2009. Manual of British Columbia Hydrometric Standards. Prepared by Ministry of Environment, Science and Information Branch for the Resources Information Standards Committee. Victoria, BC. 222 p.

Province of BC. 2010 (?). British Columbia's Water Act Modernization – Technical Background Report. Victoria, BC. 92 p.

Smith, J. J. 2015. An analysis of the effects of water temperature on adult Chinook salmon in the Cowichan River. Report prepared by LGL Limited, Sidney, BC, for Cowichan Tribes, Duncan, BC. 56 p.

Sogard, S. M., T. H. Williams, H. Fish. 2009. Seasonal Patterns of Abundance, Growth, and Site Fidelity of Juvenile Steelhead in a Small Coastal California Stream. Transactions of the American Fisheries Society. Vol. 138, Iss. 3.

Stenhouse, S. 2015. Cowichan River temperature monitoring 2014/15 summary report. Prepared for Cowichan Tribes, Cowichan Valley Regional District, and Fisheries and Oceans Canada. 13 p.

Stenhouse, S. 2015a. Cowichan River temperature monitoring 2014/15 summary report – Addendum 1, July 22, 2015 download. Prepared for Cowichan Tribes, Cowichan Valley Regional District, and Fisheries and Oceans Canada. 12 p. plus appendices.

Stenhouse, S. 2015b. Cowichan River temperature monitoring 2014/15 summary report – Addendum 2. October 7, 2015 download. Prepared for Cowichan Tribes, Cowichan Valley Regional District, and Fisheries and Oceans Canada. 14 p. plus appendices

UMA Engineering Ltd. 2006. Feasibility study for the lowering of Cowichan Lake outlet. Project E261-007. Prepared for Catalyst Paper Corporation, Crofton, BC. 66 p.

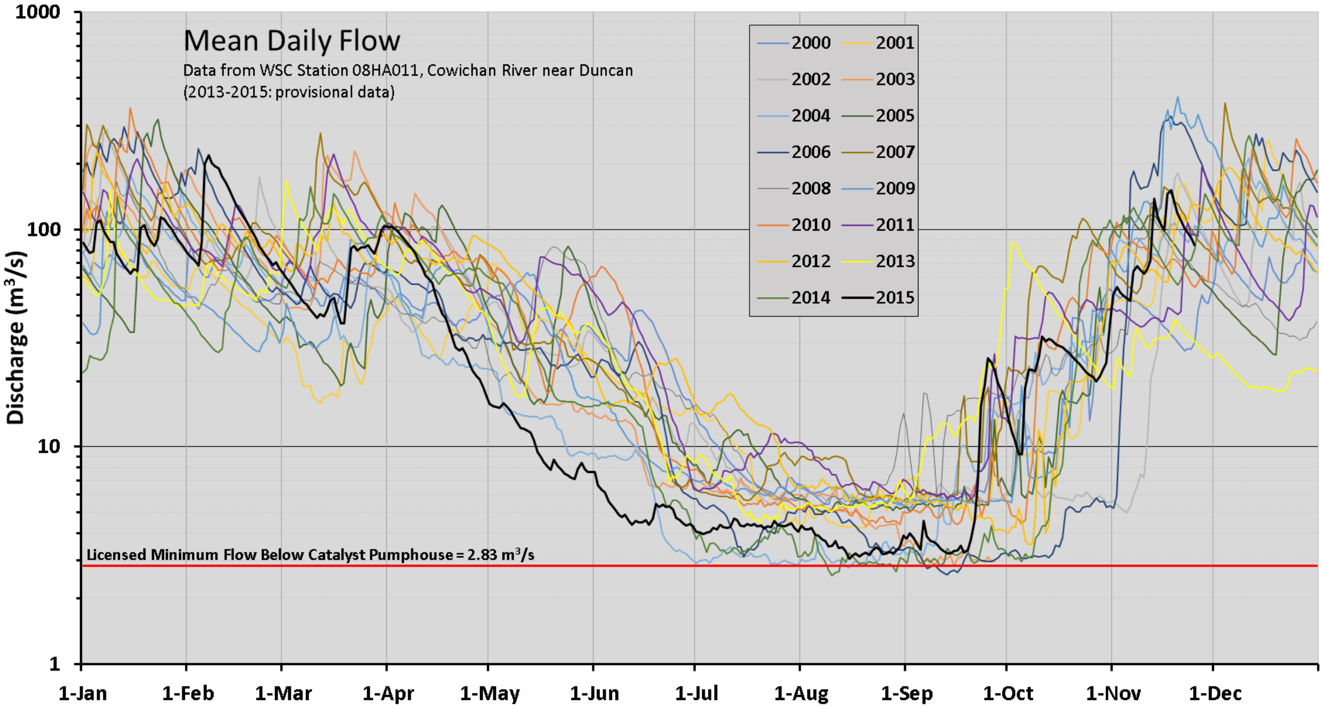
Vessey, M., B. Tutty, C. Wightman, J.R. Elliott, T. Rutherford and S. Baillie. 2008. Cowichan weir start-up, operational and seasonal protocols. Unpub. Rept. included as Appendix 'A' in Draft Tech. Memo. Cowichan Lake – Weir operation protocol assessment and review. Kerr, Wood Leidal Assoc. Ltd., Victoria, BC. 9p.

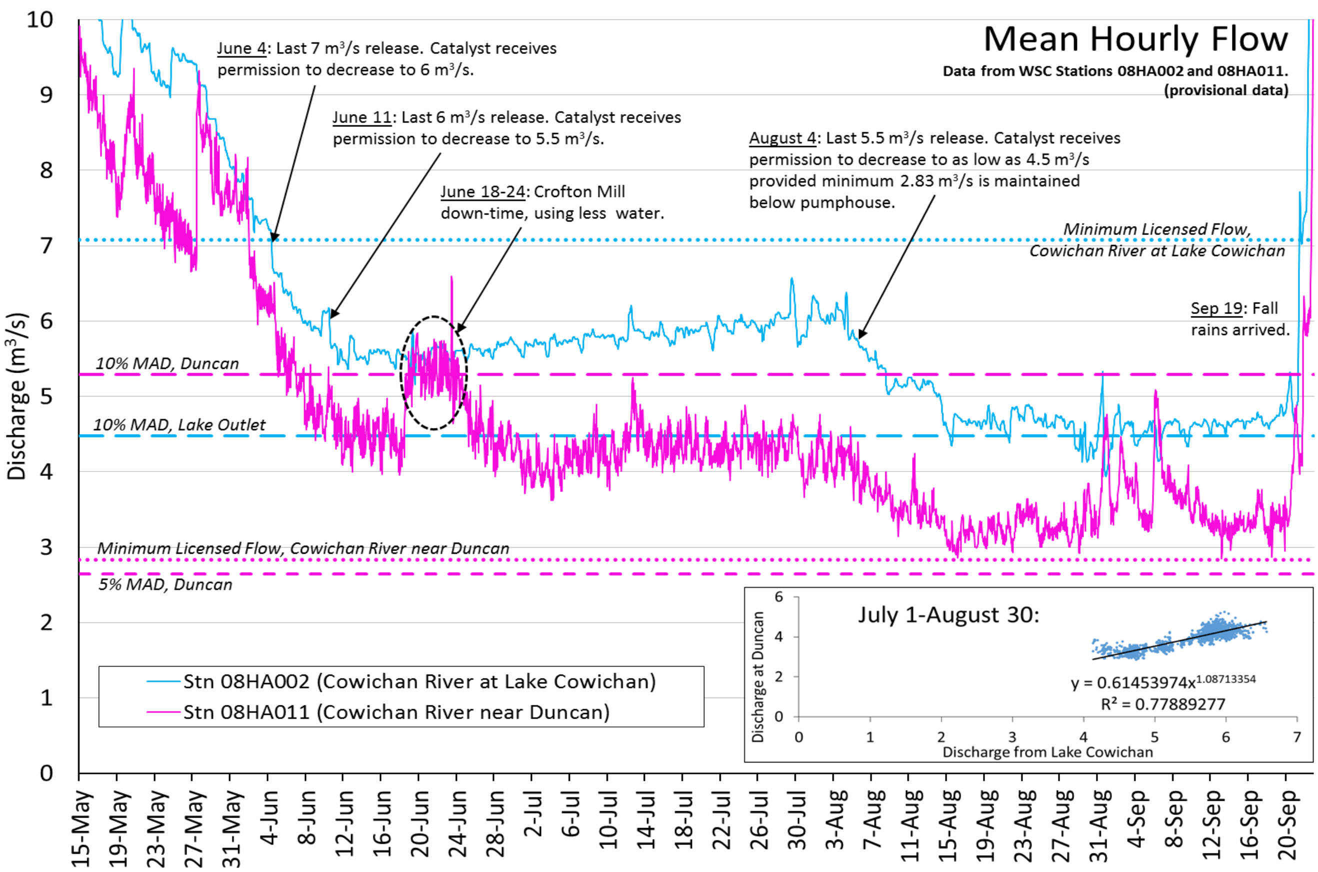
Wheeler, M. 2009. Seasonal patterns of anabolism and catabolism in juvenile steelhead: energy partitioning in growth. Thesis presented to the Faculty of Humboldt State University. 60 p.

Wightman, J. C. 2015. A science-based rationale for fisheries conservation flow targets in the Cowichan River. Prepared by BC Conservation Foundation and Living Rivers-Georgia Basin/Vancouver Island. 12 p.

Wright, H. and K. Pellett. 2006. Cowichan side channel and spawning platform monitoring 2006. Prepared for Ministry of Environment, Department of Fisheries and Oceans Canada, and Catalyst Paper. 23 p.

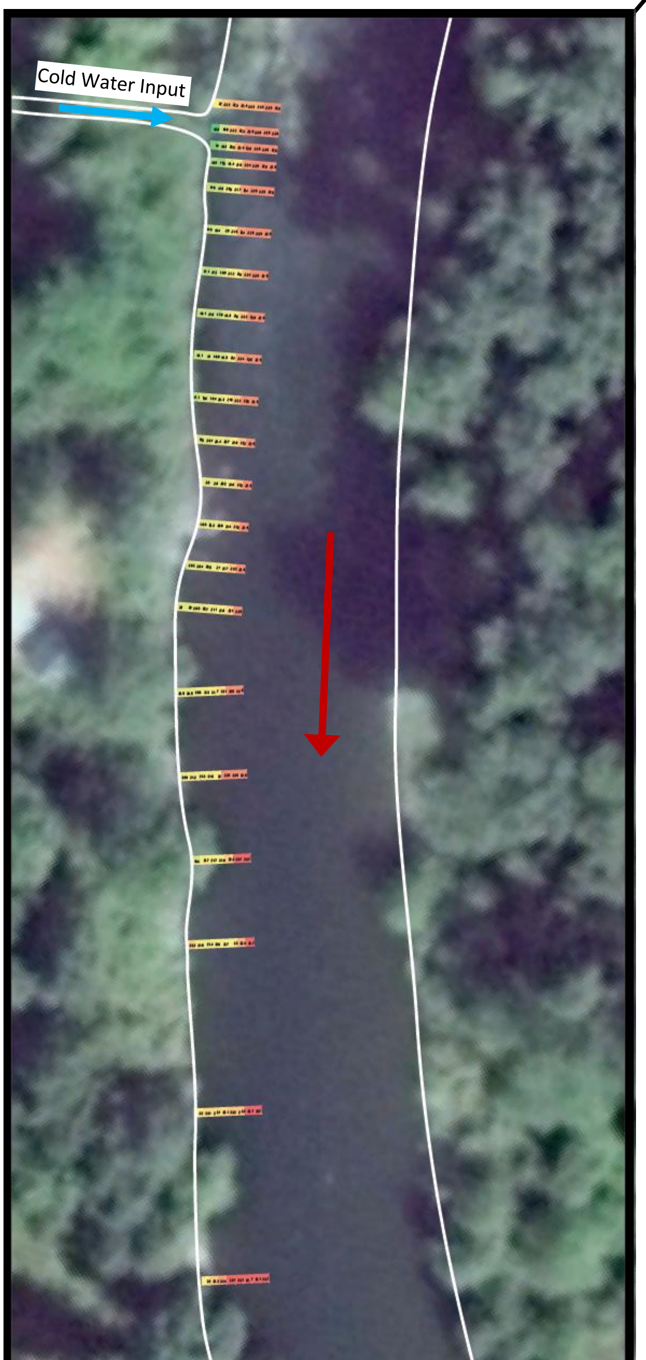
Appendix A. Cowichan River discharge at WSC's Cowichan River at Lake Cowichan (08HA002) and Cowichan River near Duncan (08HA011) stations, 2000 to 2015, and Summer 2015 relative to targets and key percentages of mean annual discharge.

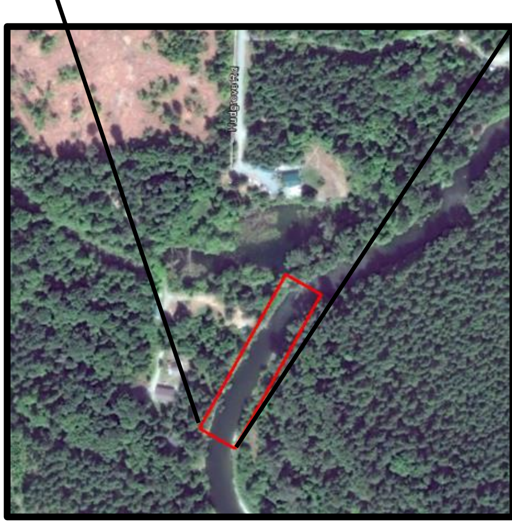




August 13, 2015 at 11:10 to 12:35 DST
UTM: 10U 426260 N, 5406783 E (River Km 41.5)

Cold water discharge: ~0.050 m^3/s
Mainstem discharge: ~5.2 m^3/s





Water temperature (°C) immediately above substrate at distance from right bank and downstream from cold water input confluence.

Distance (m)	Bank	1 m	2 m	3 m	4 m	5 m	6 m	7 m
0	22.0	22.2	22.3	22.3	22.3	22.3	22.5	22.5
1								
2								
3	10.8	18.8	22.2	22.3	22.5	22.5	22.5	22.5
4								
5	13.0	16.3	20.5	22.3	22.5	22.5	22.5	22.5
6								
7	16.5	15.3	19.4	21.9	22.4	22.5	22.5	22.5
8								
9								
10	17.6	17.8	20.8	21.7	22.4	22.5	22.5	22.5
11								
12								
13								
14								
15	17.9	19.4	20.0	21.5	22.4	22.5	22.5	22.5
16								
17								
18								
19								
20	17.1	17.2	18.9	21.2	21.8	22.3	22.5	22.5
21								
22								
23								
24								
25	18.1	17.8	17.6	19.9	21.6	22.2	22.5	22.5
26								
27								
28								
29								
30	18.1	19.0	18.8	19.5	21.7	22.4	22.5	22.5
31								
32								
33								
34								
35	17.1	19.6	19.4	20.3	21.6	22.2	22.5	22.5
36								
37								
38								
39								
40		19.3	20.1	20.4	20.7	21.6	22.2	22.5
41								
42								
43								
44								
45			20.0	20.0	20.2	21.6	22.2	22.5
46								
47								
48								
49								
50			19.9	20.3	20.8	21.4	22.2	22.5
51								
52								
53								
54								
55		20.2	20.4	20.5	21.0	21.7	22.2	22.5
56								
57								
58								
59								
60	20.0	20.0	20.5	20.7	21.1	21.6	22.1	22.5
61								
62								
63								
64								
65								
66								
67								
68								
69								
70	20.5	20.5	20.8	21.3	21.7	22.1	22.5	22.5
71								
72								
73								
74								
75								
76								
77								
78								
79								
80	20.9	21.2	21.3	21.6	22.0	22.5	22.5	22.5
81								
82								
83								
84								
85								
86								
87								
88								
89								
90		19.4	21.7	21.7	21.9	22.2	22.7	22.7
91								
92								
93								
94								
95								
96								
97								
98								
99								
100	22.2	21.5	21.4	21.6	21.7	22.0	22.3	22.7
101								
102								
103								
104								
105								
106								
107								
108								
109								
110								
111								
112								
113								
114								
115								
116								
117								
118								
119								
120	22.0	22.1	22.1	22.1	22.2	22.2	22.7	22.7
121								
122								
123								
124								
125								
126								
127								
128								
129								
130								
131								
132								
133								
134								
135								
136								
137								
138								
139								
140	22.0	22.2	22.4	22.7	22.7	22.7	22.7	22.7

Appendix C. Example of weekly water temperature update emailed to stakeholders.

From: *Tim Kulchyski [mailto:Tim.Kulchyski@cowichantribes.com]*
Sent: *Friday, August 28, 2015 4:13 PM*
To: *~60 recipients (representatives of DFO, FLNRO, Cowichan Tribes, Lake Cowichan First Nation, CVRD, City of Duncan, DNC, Town of Lake Cowichan, local streamkeepers and environmental stewards, environmental consultants, Cowichan River Hatchery)*
Cc: *~28 Crofton Mill recipients*
Subject: Cowichan Chinook Low Flow Mitigation Strategy – Weekly Temperature Monitoring, August 28

Good afternoon everyone,

Cowichan Tribes and BCCF continued the weekly download and compilation of key Cowichan River temperature loggers today (August 28, 2015). This is part of the Cowichan Chinook Low Flow Mitigation Strategy supported in part by Catalyst. The objective is to keep stakeholders regularly advised of peak period river temperatures from the lake outlet to the mouth. Attached is an excel file with today's data from:

- *Cowichan River at Lake Cowichan (river km 48; prelim data from WSC Station 08HA002)*
- *Cowichan River at Wildwood BC Parks (river km 25; BCCF datalogger)*
- *Cowichan River near Duncan (river km 7; prelim data WSC Station 08HA011)*
- *Cowichan River North Arm, right-hand channel - North Arm Ramp (river km 0.7; BCCF datalogger)*
- *Cowichan River North Arm, right-hand channel - Log Jam(river km 0.8; BCCF datalogger)*
- *Cowichan River South Arm - Metric Pool (river km 0.9; BCCF datalogger)*

Data sets presented here include temperature data from July 22 through to August 28, 2015 at 10:00 am.

A quick look at the data indicates that the temperature of the water leaving Cowichan Lake has dropped approximately one degree over the last week. The temperature throughout the rest of the system seems to have dropped over the last week and is slightly cooler as it reaches the lower end of the system. All lower temperatures seem to have increased yesterday with the warmer air temperature throughout the valley.

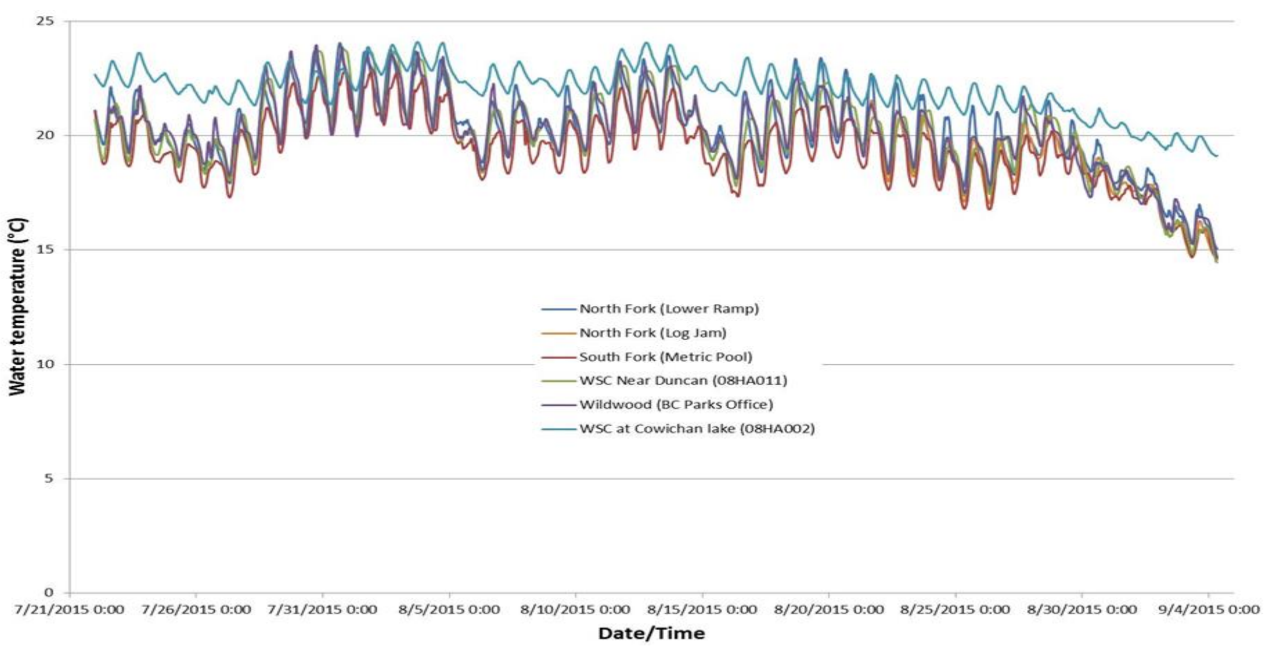


Figure 1: Hourly temperature data from five key locations throughout the Cowichan River Watershed.

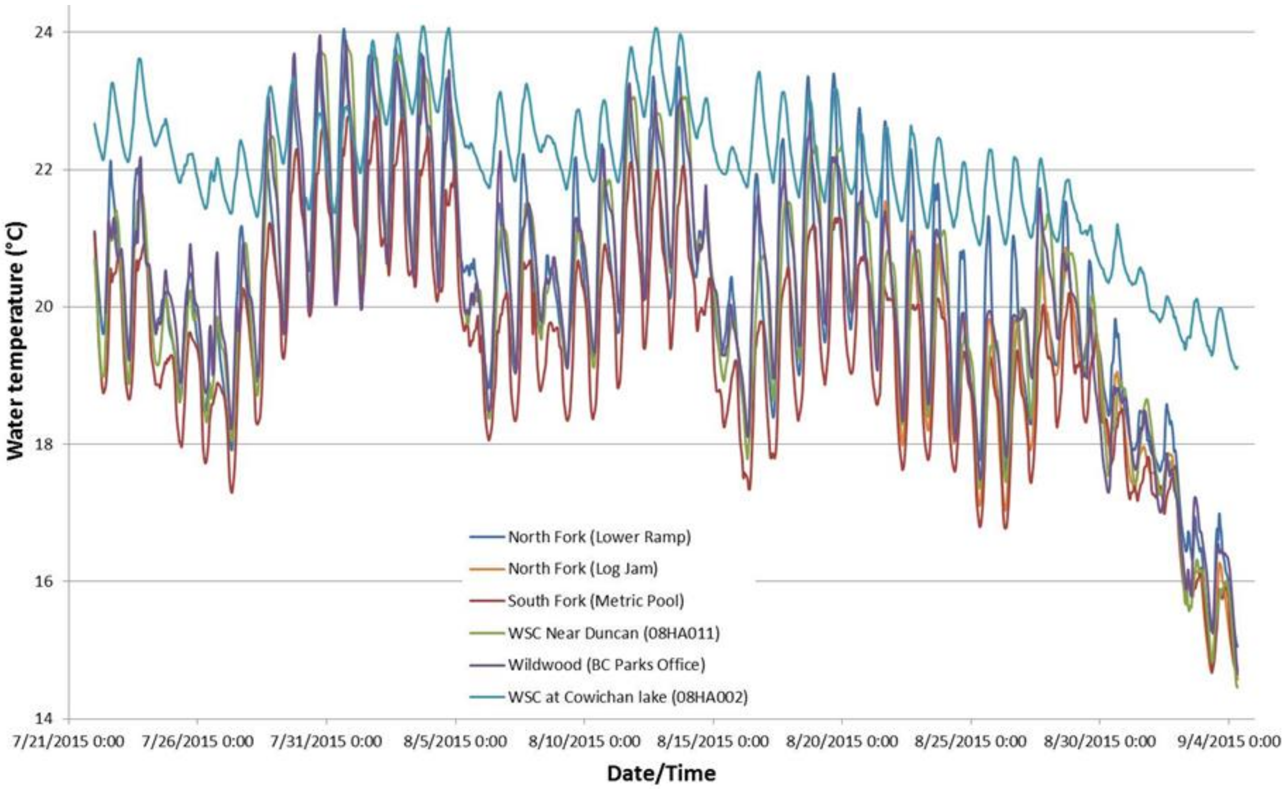


Figure 2: Hourly temperature data from five key locations throughout the Cowichan River Watershed (Temperature scale between 15 and 25^{o}C).

Huy tseep q'u siem

Tim Kulchyski

Cowichan Tribes

Appendix D. Spot measurements of water temperature and dissolved oxygen taken during field work.

Date	Location	Rkm	Time (PDT)	Water Temperature (°C)	Dissolved Oxygen (mg/l)
31 Jul	"Mainstem above Bifurcation" site	2.15	0931	21.3	5.82
	Mainstem riffle d/s of lower rive DFO DIDSON site	2.0	0938	22.5	6.6
	South Arm, ~100 m u/s of Hatchery Channel confluence	1.4	1012	20.8	5.47
	Hatchery Channel at CT smolt fence	~1.6	1116	17.9	4.9
	Hatchery Channel at CT smolt fence	~1.6	1118	17.9	4.73
	North Arm, western channel at CR6 access ramp	0.6	1235	22.5	7.61
	North Arm, riffle entering Log Jam	0.65	1337	22.9	8.46
Aug 5	Hatchery Pool (aka Big Pool), 200 m d/s of South Shore Road bridge	48.3	1030-1145	22.4	6.14-7.69
	Deep Water immediately downstream of Catalyst weir	49.3	1145-1230	22.4	~7
Aug 10	"Mainstem above Bifurcation" site	2.15	1045	19.5	-
	South Arm, ~100 m u/s of Hatchery Channel confluence	1.4	1143	19.9	-
	North Arm, western channel Q site	0.6	1200	19.9	-
	North Arm, western channel at CR6 access ramp	0.5	1215	20.7	-
	Mainstem, Allenby Road in Duncan/WSC (08HA011)	6.9	1350	20.5	-
	Mainstem, 300 m d/s of Catalyst Pumphouse	7.7	1340	20.1	-
Aug 13	Mainstem, at Wrixon's Run	41.5	See Section 3.2.1; App. B		7.68
Aug 13	Cold Water Input to Wrixon's Run	41.5			10.46
Aug 25	Mainstem, Allenby Road in Duncan/WSC (08HA011)	6.9	1125	17.9	-
Sep 2	"Mainstem above Bifurcation" site	2.15	1220	16.9	-
	South Arm, ~100 m u/s of Hatchery Channel confluence	1.4	1430	15.8	-
	North Arm ~40m downstream of last split to South Arm	1.2	1600	16.2	-
	North Arm, western channel Q site	0.6	1645	16.4	-
Sep 16	"Mainstem above Bifurcation" site	2.15	1045	15.2	-
	South Arm, ~100 m u/s of Hatchery Channel confluence	1.4	1143	15.3	-
	North Arm ~40m downstream of last split to South Arm	1.2	1340	15.9	-
	North Arm, western channel Q site	0.6	1440	16.2	-
	North Arm, western channel, end of glide d/s of ramp	0.45	1450	17.2	-

Appendix E. Cowichan River watershed fry salvage summary for 2015.

Key: CH=Chinook, CO=coho, CM=chum, PK=pink, SO=sockeye, RB/ST=rainbow/steelhead, CT=cutthroat.

	#	Location	CH Fry	CO Fry	CO Parr	CM	PK	SO	RB/ST	CT	Trout	Sculpin	Stickleback	Total Fish
Salvage (with some research)	1	**Meades Ck**		12502	27	2357				4	10	2		**14902**
	2	**Forestry Ck**		350	1						4			**355**
	3	**Utility Ck**												**0**
	4	**Shaw Ck**		5299	20					2	15	26	24	**5386**
	5	**Roberston Ck**	4906	216355	10				55	12	4722			**226060**
	6	**Oliver Ck**												**0**
	7	**Beaver Ck**												**0**
	8	**Halls Ck**		1200										**1200**
	9	**Nixon Ck**		6600										**6600**
	10	**Sutton Ck**	2	13927	4	1				6	650			**14590**
	11	**Ashburnham Ck**	644	19060	4	200			355	26	98			**20387**
	12	**Cottonwood Ck**												**0**
		Sub, Cow. Lake Tribs:	5552	275293	66	2558			410	50	5499	28	24	**289480**
	13	**Cowichan River**		14675							125	2		**14802**
Research, only	*1*	***Meades Ck***			*12*							*5*		***17***
	3	***Utility Ck***		*46*	*12*					*1*				***59***
	4	***Shaw Ck***		*27*						*2*		*49*		***78***
	5	***Roberston Ck***		*3*								*1*		***4***
	6	***Oliver Ck***		*22*								*1*		***23***
	7	***Beaver Ck***		*6*									*1*	***7***
	9	***Nixon Ck***		*58*	*1*					*1*		*2*		***62***
	11	***Ashburnham Ck***		*5*	*3*					*2*		*2*		***12***
	12	***Cottonwood Ck***										*2*		***2***
		Sub, Research only:		*167*	*28*					*6*		*62*	*1*	***264***
TOTALS (Research+Salvage)	1	**Meades Ck**		12502	39	2357				4	10	7		**14919**
	2	**Forestry Ck**		350	1						4			**355**
	3	**Utility Ck**		46	12					1				**59**
	4	**Shaw Ck**		5326	20					4	15	75	24	**5464**
	5	**Roberston Ck**	4906	216358					55	12	4722	1		**226054**
	6	**Oliver Ck**		22								1		**23**
	7	**Beaver Ck**		6									1	**7**
	8	**Halls Ck**		1200										**1200**
	9	**Nixon Ck**		6658	1					1		2		**6662**
	10	**Sutton Ck**	2	13927	4	1				6	650			**14590**
	11	**Ashburnham Ck**	644	19065	7	200			355	28	98	2		**20399**
	12	**Cottonwood Ck**										2		**2**
		Sub, Cow. Lake Tribs:	5552	275460	84	2558			410	56	5499	90	25	**289734**
	13	**Cowichan River**		14675							125	2		**14802**
		GRAND TOTAL:	**5552**	**290135**	**84**	**2558**	**0**	**0**	**410**	**56**	**5624**	**92**	**25**	**304536**

Notes:

Counts are conservative and were based on data made available from a number of groups by December 2015.

Where large numbers of fry were salvaged, volunteer crews often estimated counts to minimize handling stress.

For Sutton Creek Chinook, DNA tests for confirmation of species were pending at time of writing.

MEADES CREEK

Date	Crew	Salvage location	Temp (°C)	Gear	Release Location	Chinook #	Chinook mm	Coho fry #	Coho fry mm	Coho parr #	Coho parr mm	Chum #	Chum mm	Pink #	Pink mm	Sockeye #	Sockeye mm	RB/STHD #	RB/STHD mm	Cutthroat #	Cutthroat mm	Trout Other #	Trout Other mm	Sculpin #	Comments
17-Mar-15	*Bob, Harvey*	*Meades Bridge, N 48 50' 0.86" W 124 06' 33"*	*5*	*PS*						*12*	*55*														
17-Mar-15	*Parker, Cliff, Sandy*	*Meades Ck*	*5*	*G*																					
31-Mar-15	*Bob, Harvey*	*Meades Bridge*	*4.5*	*G*																				*2*	
7-Apr-15	*Bob, Harvey*	*Meades Ck*	*5*	*G*																				*3*	
					SUBTOTAL	*0*		*0*		*12*		*0*		*0*		*0*		*0*		*0*		*0*		*5*	
14-Apr-15	Bob	Meades Bridge	3	G				4	40			2	35							1	80			1	
21-Apr-15	Bob set, Parker & Sandy checked	Meades Ck	6	G				3	30-50																
21-Apr-15	Parker, Sandy	Meades Bridge	6	PS				500				2000													
28-Apr-15	Bob, Parker	Meades Ck	7	G				1	30-40	1	100													1	
28-Apr-15	Bob, Parker	Meades Bridge	7	PS				200				350													
5-May-15	Sandy, Parker, Nicki, Trish, Willa	Meades Ck	5	G				9	30-50											3	30-100				
5-May-15	Sandy, Parker, Nicki, Trish, Willa	Meades Bridge	5	PS				30				5													
12-May-15	Bob, Parker, Sandy, Trish	Meades Ck		G				10	30-50	1	80														
19-May-15	Bob	Meades Bridge	7	G				15	30-50																
1-Jun-15	Gary, Sam			PS				5000		15												10			
2-Jun-15	Bob, Parker	Meades Ck	11	PS	Marble Bay Govt Dock			1800																	
8-Jun-15	Ashley, Fern	Meades SC		PS	Cow Lake			130																	
8-Jun-15	Ashley, Fern	Meades mainstem		PS	Cow Lake			2100																	
8-Jun-15	Gary, Sam			PS				2000		10															
10-Jun-15	Parker, EDI crew	Meades Bridge		PS				500																	
6-Jul-15	Gary, Sam			PS				200																	
					SUBTOTAL	0		12502		27		2357		0		0		0		4		10		2	
					TOTALS	**0**		**12502**		**39**		**2357**		**0**		**0**		**0**		**4**		**10**		**7**	

FORESTRY CREEK

Date	Crew	Salvage location	Temp (°C)	Gear	Release Location	Chinook #	Chinook mm	Coho fry #	Coho fry mm	Coho parr #	Coho parr mm	Chum #	Chum mm	Pink #	Pink mm	Sockeye #	Sockeye mm	RB/STHD #	RB/STHD mm	Cutthroat #	Cutthroat mm	Trout Other #	Trout Other mm	Sculpin #	Comments
9-Jun-15	Ashley, Fern			PS	Cow Lake			350		1												4			
					TOTALS			**350**		**1**		**0**		**0**		**0**		**0**		**0**		**4**		**0**	

UTILITY CREEK

Date	Crew	Salvage location	Temp (°C)	Gear	Release Location	Chinook #	Chinook mm	Coho fry #	Coho fry mm	Coho parr #	Coho parr mm	Chum #	Chum mm	Pink #	Pink mm	Sockeye #	Sockeye mm	RB/STHD #	RB/STHD mm	Cutthroat #	Cutthroat mm	Trout Other #	Trout Other mm	Sculpin #	Comments
17-Mar-15	*Bob, Harvey*	*Between Bridges in Youbou off Bremner Rd N 48 52' 15" W 124 11' 40"*		*PS*						*12*	*55*														
17-Mar-15	*Bob, Harvey*	*Between Bridges*		*G*																					
17-Mar-15	*Parker, Cliff, Sandy*	*Between Bridges*		*G*																					
14-Apr-15	*Bob*	*Between Bridges*		*G*				*11*	*30-50*																
28-Apr-15	*Bob, Parker*	*Between Bridges*	*7*	*G*				*3*	*30-40*											*1*	*120*				
12-May-15	*Bob, Parker, Sandy, Trish*	*Between Bridges*	*7*	*G*				*7*	*30-40*																
19-May-15	*Bob*	*Between Bridges*	*7*	*G*				*25*	*30-50*																
						0		46		12		0		0		0		0		1		0		0	
					TOTALS	**0**		**46**		**12**		**0**		**0**		**0**		**0**		**1**		**0**		**0**	

GREY italics: Research sampling - fish released where caught.

Gear:	PS: Pole Seine
	G: Gee-trap
	BS: Beach seine

SHAW CREEK

Date	Crew	Salvage location	Temp (°C)	Gear	Release Location	Chinook #	Chinook mm	Coho fry #	Coho fry mm	Coho parr #	Coho parr mm	Chum #	Chum mm	Pink #	Pink mm	Sockeye #	Sockeye mm	RB/STHD #	RB/STHD mm	Cutthroat #	Cutthroat mm	Trout Other #	Trout Other mm	Sculp #	Comments
17-Mar-15	*Bob, Harvey*	*TS #1, below platform*	*6*	*G*				*2*	*70,80*															*7*	*Poss Chinook, DNA taken*
24-Mar-15	*Bob*	*TS2,3,4,5,6*	*3*	*G*																				*3*	
31-Mar-15	*Bob*		*4.5*	*G*																				*8*	
14-Apr-15	*Bob*		*3*	*G*				*2*	*70,40*															*6*	
21-Apr-15	*Bob set, Parker and sandy*		*6*	*G*				*15*	*30-40*															*11*	
28-Apr-15	*Bob, Parker*		*6*	*G*				*7*	*30-40*											*2*	*40,80*			*14*	
28-Apr-15	*Bob, Parker*		*6*	*PS*				*1*	*20-30*																
					SUBTOTAL	*0*		*27*		*0*		*0*		*0*		*0*		*0*		*2*		*0*		*49*	
5-May-15	Sandy, Parker, Nicki, Trish, Willa		6	PS				345																	
5-May-15	Sandy, Parker, Nicki, Trish, Willa		6	G				239	30-50	11	75-105									1	98			9	2 Chinook DNA taken
12-May-15	Bob, Parker, Sandy, Trish		7	G				12	30-50															3	
19-May-15	Bob			PS				2400																	
19-May-15				G				13	55	7	85-110									1	80			14	
26-May-15	Bob, Harvey		8	G				40	60-80	1	100														24 SB
10-Jun-15	Parker, EDI crew			PS				2000																	
15-Jul-15	Ashley, Fern	Shaw SC		PS	Mainstem			250		1												15			
					SUBTOTAL	0		5299		20		0		0		0		0		2		15		26	
					TOTALS	**0**		**5326**		**20**		**0**		**0**		**0**		**0**		**4**		**15**		**75**	

ROBERTSON RIVER

Date	Crew	Salvage location	Temp (°C)	Gear	Release Location	Chinook #	Chinook mm	Coho fry #	Coho fry mm	Coho pa #	Coho pa mm	Chum #	Chum mm	Pink #	Pink mm	Sockeye #	Sockeye mm	RB/STHD #	RB/STHD mm	Cutthroat #	Cutthroat mm	Trout Other #	Trout Other mm	Sculp #	Comments
18-Mar-15	*Bob, Harvey*	*TS#1, Renfrew Rd*	*4*	*G*																				*1*	
19-May-15	*Sandy*			*G*				*3*	*35*															*1*	*2 small CO fry*
					SUBTOTAL	*0*		*3*		*0*		*0*		*0*		*0*		*0*		*0*		*0*		*2*	
1-Jun-15	Gary, Sam			PS	Bear Lake			400																	
9-Jun-15	Gary, Sam			PS	Bear Lake			800		10												5			
17-Jun-15	Ashley, Fern	Robertson Mainstem		PS	Bear Lake	3500		1000														150			Trout: 10% pa
18-Jul-15	Ashley, Fern	Robertson Mainstem		PS	Bear Lake	900		1200														150			Trout: 10% pa
19-Jun-15	Ashley, Fern	Robertson SC		PS	Bear Lake			1600														15			Trout: 10% pa
22-Jun-15	Ashley, Fern	Robertson SC		PS	Bear Lake			26600														74			Trout: 10% pa
22-Jun-15	Gary, Sam			PS	Bear Lake			4000																	
23-Jun-15	Ashley, Fern	Robertson SC		PS	Bear Lake			6000														20			Trout: 10% pa
25-Jun-15	Bob							4000																	
25-Jun-15	Ashley, Fern	Robertson Mainstem		PS	Bear Lake			3500																	
29-Jun-15	Ashley, Fern	Robertson SC		PS	Bear Lake			9750														65			Trout: 10% pa
2-Jul-15	Ashley, Fern	Robertson Mainstem		PS	Bear Lake			650														20			
6-Jul-15	Ashley, Fern	Robertson Mainstem		PS	Bear Lake	2		150														25			
7-Jul-15	Bob	Renfrew bridge		PS		40		1900														100			
8-Jul-15	Ashley, Fern	Robertson Mainstem		PS	Bear Lake	25		900														30			
8-Jul-15	Gary, Sam			PS	Bear Lake			3000																	
13-Jul-15	Bob	Renfrew bridge		PS		35		4085														215			
14-Jul-15	Bob	Renfrew bridge		PS				1900														100			
14-Jul-15	Ashley, Fern	Robertson Mainstem		PS	Bear Lake	20		6000														180			
16-Jul-15	Bob	Renfrew bridge		PS				2850														150			
18-Jul-15	Bob	Renfrew bridge		PS		18		9935												10		10			
20-Jul-15	Ashley, Fern	Robertson Mainstem		PS	Bear Lake	28		12500														100			
20-Jul-15	Gary, Sam			PS	Bear Lake			700																	
21-Jul-15	Bob, Ashley	Renfrew bridge		PS		18		10										55							
29-Jul-15	Bob, Ashley	Upper river		PS		33		10925														575			
30-Jul-15	Ashley, Fern	Robertson Mainstem		PS	Bear Lake			13300														113			
31-Jul-15	Bob	Upper river		PS		5		1900														100			
31-Jul-15	Ashley, Fern	Robertson Mainstem		PS	Bear Lake	203		17000														135			
4-Aug-15	Ashley, Fern	Robertson Mainstem		PS	Bear Lake			6400														100			
5-Aug-15	Bob	Above Chanda Ck		PS				950														50			
7-Aug-15	Bob, Ashley	Renfrew bridge		PS		19		6650														350			
7-Aug-15	Ashley, Fern	Robertson Mainstem		PS	Bear Lake			6400														100			
7-Aug-15	Bob, Ashley	Renfrew bridge	19	PS		20		6300														700			
7-Aug-15	Bob																			2					
17-Aug-15	Ashley, Fern	Robertson Mainstem		PS	Bear Lake	7		10700														55			
18-Aug-15	Ashley, Fern	Chandra Ck		PS		3		11400														600			
24-Aug-15	Ashley, Fern	Robertson Mainstem		PS	Bear Lake	30		21000														435			
					SUBTOTAL	4906		216355		10		0		0		0		55		12		4722		0	
					TOTALS	**4906**		**216358**		**10**		**0**		**0**		**0**		**55**		**12**		**4722**		**2**	

GREY italics: Research sampling - fish released where caught.

Gear: PS: Pole Seine
G: Gee-trap
BS: Beach seine

OLIVER CREEK

Date	Crew	Salvage location	Temp	Gear	Release	Chinook		Coho fry		Coho parr		Chum		Pink		Sockeye		RB/STHD		Cutthroat		Trout Othe		Sculpin	Comments
			(°C)		Location	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	
8-Apr-15	*Bob*	*TS#1, Culver @ Klegg Way*	*4*	*G*				*22*																*1*	
					SUBTOTAL	0		22		0		0		0		0		0		0		0		1	
					TOTALS	**0**		**22**		**0**		**0**		**0**		**0**		**0**		**0**		**0**		**1**	

BEAVER CREEK

Date	Crew	Salvage	Temp	Gear	Release	Chinook		Coho fry		Coho parr		Chum		Pink		Sockeye		RB/STHD		Cutthroat		Trout Othe		Sculpin	Comments
		locatio	(°C)		Location	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	
21-Apr-15	*Robby, Bob*			*G*				*6*	*30*																*1 SB*
					SUBTOTAL	0		6		0		0		0		0		0		0		0		0	
					TOTALS	**0**		**6**		**0**		**0**		**0**		**0**		**0**		**0**		**0**		**0**	

HALLS CREEK

Date	Crew	Salvage	Temp	Gear	Release	Chinook		Coho fry		Coho parr		Chum		Pink		Sockeye		RB/STHD		Cutthroat		Trout Othe		Sculpin	Comments
		locatio	(°C)		Location	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	
12-May-15	Bob, Sandy, Trish		7	PS	Heather Beach			1200																	
					TOTALS	**0**		**1200**		**0**		**0**		**0**		**0**		**0**		**0**		**0**		**0**	

NIXON CREEK

Date	Crew	Salvage	Temp	Gear	Release	Chinook		Coho fry		Coho parr		Chum		Pink		Sockeye		RB/STHD		Cutthroat		Trout Othe		Sculpin	Comments
		locatio	(°C)		Location	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	
12-May-15	*Sandy*		*7*	*PS*				*50*																	
19-May-15	*Sandy*			*G*				*7*		*1*															
26-May-15	*Bob, Harvey*		*12*	*G*				*1*	*80*											*1*	*120*			*2*	
					SUBTOTAL	*0*		*58*		*1*		*0*		*0*		*0*		*0*		*1*		*0*		*2*	
8-Jun-15	Gary, Sam			PS				1000																	
25-Jun-15	Gary, Sam			PS				3500																	
29-Jun-15	Bob			PS				2100																	
					SUBTOTAL	0		6600		0		0		0		0		0		0		0		0	
					TOTALS	**0**		**6658**		**1**		**0**		**0**		**0**		**0**		**1**		**0**		**2**	

SUTTON CREEK

Date	Crew	Salvage	Temp	Gear	Release	Chinook		Coho fry		Coho parr		Chum		Pink		Sockeye		RB/STHD		Cutthroat		Trout Othe		Sculpin	Comments
		locatio	(°C)		Location	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	
12-May-15	Sandy		7	PS				250																	
19-May-15	Sandy			G				17		1															
				PS				200				1								6					
2-Jun-15	Bob, Parker			PS				50		1															
19-Jun-15	Ashley, Fern			PS	Pauls Rd boat launch			60		2															
20-Jul-15	Gary, Sam			PS				1000																	
21-Jul-15	Bob, Sandy, Trish, Perry, Kirk, Ashley		19	PS		2		12350														650			
					TOTALS	**2**		**13927**		**4**		**1**		**0**		**0**		**0**		**6**		**650**		**0**	

GREY italics: Research sampling - fish released where caught.

Gear: PS: Pole Seine
G: Gee-trap
BS: Beach seine

ASHBURNAM CREEK

Date	Crew	Salvage locatio	Temp	Gear	Release	Chinook		Coho fry		Coho parr		Chum		Pink		Sockeye		RB/STHD		Cutthroat		Trout Othe		Sculpin	Comments
			(°C)		Location	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	
19-May-15	*Sandy*			*G*	*Cowichan Lake?*			*5*		*3*										*2*	*150*			*2*	
					SUBTOTAL	*0*		*5*		*3*		*0*		*0*		*0*		*0*		*2*		*0*		*2*	
9-Jun-15	Bob			PS		201	60	800				200													DNA sampled
10-Jun-15	Parker, EDI crew			PS	Cowichan Lake?			1000																	mixed CH & CO
16-Jun-15	Ashley, Fern			PS	Pauls Rd boat launch	370		4000		2															mixed CH & CO
19-Jun-15	Ashley, Fern			PS	Pauls Rd boat launch	2		30																	mixed CH & CO
23-Jun-15	Ashley, Fern			PS	Pauls Rd boat launch	29		850		2												25			mixed CH & CO
29-Jun-15	Ashley, Fern			PS	Pauls Rd boat launch	1		900														20			mixed CH & CO
2-Jul-15	Bob			PS	Cowichan	17		1980										55		25					
13-Jul-15	Ashley, Fern			PS	Pauls Rd boat launch	24		4500														40			
14-Jul-15	Bob							1900										100							
16-Jul-15	Ashley, Fern			PS	Pauls Rd boat launch			1300														13			
20-Aug-15	Bob							1800										200		1					
					SUBTOTAL	644		19060		4		200		0		0		355		26		98		0	
					TOTALS	**644**		**19065**		**7**		**200**		**0**		**0**		**355**		**28**		**98**		**2**	

COTTONWOOD CREEK

Date	Crew	Salvage locatio	Temp	Gear	Release	Chinook		Coho fry		Coho parr		Chum		Pink		Sockeye		RB/STHD		Cutthroat		Trout Othe		Sculpin	Comments
			(°C)		Location	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	
26-May-15	*Sandy*			*G*																				*2*	
					TOTALS			**0**		**0**		**0**		**0**		**0**		**0**		**0**		**0**		**2**	

COWICHAN MAINSTEM

Date	Crew	Salvage locatio	Temp	Gear	Release	Chinook		Coho fry		Coho parr		Chum		Pink		Sockeye		RB/STHD		Cutthroat		Trout Othe		Sculpin	Comments
			(°C)		Location	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	mm	#	
Late May	Parker	upper			mainstem			3000																	
18-Jun-15	??	upper			mainstem			250																2	
28-Jun-15	Bob	upper			mainstem			300																	
30-Jun-15	Bob, Harvey, Vincent, Kirsten, Daphne, Loraine	upper			mainstem			1125														125			
May-June	Joe	upper			mainstem			10000																	Min. est.
					TOTALS			**14675**		**0**		**0**		**0**		**0**		**0**		**0**		**125**		**2**	

GREY italics: Research sampling - fish released where caught.

Gear:	PS: Pole Seine
	G: Gee-trap
	BS: Beach seine

Appendix F. Spring run Chinook snorkel survey completed August 4, 2015.

FILE NOTE

Date: August 31, 2015
File: 34560-27/COWI
XF: 34560-20/SNORK

SNORKEL SURVEY REPORT

Cowichan River

SURVEY DATE: August 4, 2015.
WEATHER: Clear, Sunny.
WATER TEMP: 22.5ºC at 0738h, Greendale Put-In.
DISCHARGE: 6.3 CMS or approximately 14% LT MAD.
VISIBILITY: 5-8 m horizontal (lower with occasional light streaming). 6 m vertical.
PERSONNEL: Section 1: Greendale Trestle to 70.2 Mile Trestle (7.2 km; Wightman, Stenhouse)
Section 2: 70.2 Mile Trestle to Skutz Falls (6.9 km; Pellett, Atkinson)
Section 3: Stutz Falls to Stoltz Pool Boat Launch (8.2 km; Kulchyski, Craig)
Total Km Surveyed: 16.3 km

1) Adult Fish observed

Section 1: Greendale Trestle to 70.2 Mile Trestle

Species	Small 20-35 cm	Medium 35-50 cm	Large 50+ cm	Total
Chinook Salmon	-	0	0	0
Sockeye Salmon	-	-	4	4
Rainbow Trout	167	59	-	226
Cutthroat Trout	0	0	0	0
Brown Trout	122	172	13	307

Section 2: 70.2 Mile Trestle to Skutz Falls

Species	Small 20-35 cm	Medium 35-50 cm	Large 50+ cm	Total
Chinook Salmon	-	0	2	2
Sockeye Salmon	-	-	4	4
Rainbow Trout	206	178	27	411
Cutthroat Trout	0	0	0	0
Brown Trout	83	347	128	558

Section 3: Skutz Falls to Stoltz Pool Boat Launch

Species	Small 20-35 cm	Medium 35-50 cm	Large 50+ cm	Total
Chinook Salmon	-	0	0	0
Sockeye Salmon	-	-	1	1
Rainbow Trout	75	70	5	150
Cutthroat Trout	0	0	0	0
Brown Trout	40	72	28	140

Summary over 16.3 km surveyed:

Species	Small 20-35 cm	Medium 35-50 cm	Large 50+ cm	Total
Chinook Salmon	0	0	2	2
Sockeye Salmon	0	0	9	9
Rainbow Trout	448	307	32	787
Cutthroat Trout	0	0	0	0
Brown Trout	245	591	169	1005

Comments:

- The main purpose of the survey was to enumerate spring run Chinook salmon in the upper Cowichan mainstem (Fig. 1).
- Surveyors focused on seeing adult or jack Chinook – less attention was paid to trout counts (i.e., trout counts are conservative).
- Overall, observer visibility was good and confidence was high with the exception of deep water canyon habitats in the 3rd section. In these locations, the bottom was often unobservable. One of the snorkelers performed free dives in key spots in an effort to observe any fish that may have been holding deep. While far from making the crew 100% efficient, this technique increased the diver's confidence in these canyon habitats.
- The only Chinook observed were two single fish in the middle section (estimated weights: 6-12 kg). The first was observed near the downstream end of the Block 51 meanders (~rkm 38.2); the second was associated with a large log jam near the Sawdust Pool (~rkm 36.0). Both fish appeared to be bright and in good shape, and were on the bottom of large pool habitat 4.5-6 m in depth. Origins were not confirmed. No features that might indicate any sort of cold water influence were noted in the immediate areas.
- Sockeye were dusky and generally mixed in with larger trout (mostly browns).
- Trout counts in Sections 1 and 2 were similar to those of a Provincial survey on July 22, 2015. The 3rd section was not surveyed by the Province. No Chinook adults or jacks were observed during the July survey.
- Brown trout were often observed in schools of 20-30, mixed with smaller numbers of rainbow or sockeye. Larger groupings of trout were often associated with cold water inputs (e.g. Wrixon's, Stoltz Pool, etc.).
- In the middle section, observers judged steelhead parr densities to be low to moderate. Several dead crayfish were noted. Four cold water tributaries were noted in the section contributing varying amounts of surface water. Near Stoltz, coho fry were observed holding off a very small tributary (cold water refugia). No submerged cold ground water inputs were noted, though snorkelers could not survey the bottom of pools.
- In the lower section, snorkelers observed moderate numbers of juveniles including steelhead parr in the canyon reaches. In the alluvial reach below the canyons, observers noted low to moderate parr numbers moderate to good numbers of steelhead fry in suitable habitats.

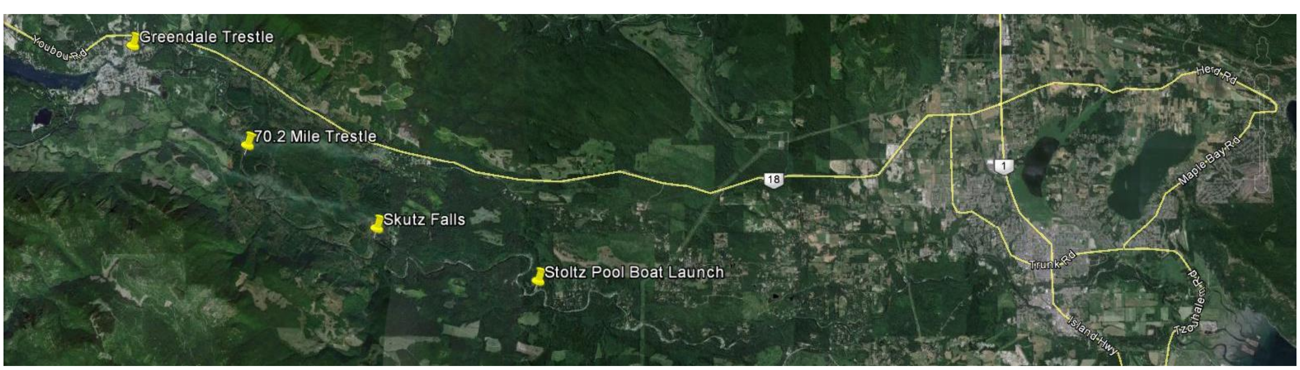


Figure 1. Google Earth image showing Lake Cowichan at left, locations of the three survey sections, and Cowichan Bay at right.

Appendix G. Summary of adult and jack Chinook observed during Provincial Fisheries snorkel surveys of the Cowichan River for resident trout and/or steelhead, 1976 – 2015.

Year	Date	Chinook Counted	Location	Comments	Primary Purpose
1976	26-Jul-76	22	"Upper River" & Riverbottom to Allenby	Upper: 15; Riverbottom-Allenby: 2adt, 5J.	Resident Trout
1985	26-Jul-85	11	Palmer's to Skutz	Road Pool to Blk51: 1J, 4adt; Blk51-Skutz: 6 size unspecified.	Resident Trout
1987	23-Jul-87	0	Road Pool to Skutz		Resident Trout
1990	22-May-90	0	Hatchery Creek to Block 51		Resident Trout
1990	31-Jul-90	36	Hatchery Creek to Skutz	to Blk51: 5 size not mentioned; Blk51-Skutz: 20J, 11adt	Resident Trout
1991	July 1991	0	Road Pool to Skutz	Results not found - only a reference to this swim.	Resident Trout
1992	27-Jul-92	6	Hatchery Creek to Stoltz	70.2-Skutz: 5adt; Skutz-Stoltz: 1adt	Resident Trout
1993	25-May-93	0	Lake Cow Village to Block 51		Resident Trout
1993	27-Jul-93	26	Lake Cow Village to Sandy Pool	to Blk51: 5 (jack+adult); Blk51-Skutz: 21adt	Resident Trout
1994	29-Apr-94	0	Lake Cow Village to Block 51		Resident Trout/Steelhead
1994	27-May-94	2	Lake Cow Village to Block 51		Resident Trout
1994	26-Jul-94	1	Lake Cow Village to Sandy Pool	Skutz to Stoltz: 1J	Resident Trout
1995	28-Apr-95	0	Lake Cow Village to Block 51		Steelhead
1995	17-May-95	0	Lake Cow Village to Block 51		Resident Trout
1995	26-Jul-95	38	Lake Cow Village to Sandy Pool	to Blk 51: 1J; Blk51-Skutz: 1J,2adt; Skutz-Stoltz: 27J; Stoltz-Sandy: 7J	Resident Trout
1996	17-Jun-96	0	Lake Cow Village to Block 51		Resident Trout
1996	30-Jul-96	10	Lake Cow Village to Sandy Pool	Blk51-Skutz: 2adt; Skutz-Sandy: 8J	Resident Trout
1997	24-Jul-97	14	Lake Cow Village to Sandy Pool	Blk51-Skutz: 9J,2adt; Stoltz-Sandy: 1J, 1adt	Resident Trout
1998	18-Mar-98	0	Hatchery Creek to Spring Pool		Steelhead
1998	15-Apr-98	0	Lake Cow Village to Block 51		Steelhead/Resident Trout
1998	15-May-98	0	Road Pool to Spring Pool (1.5 km)		Steelhead Redds
1998	29-Jul-98	8	Lake Cow Village to Sandy Pool	Blk51-Skutz: 1adt; Stoltz-Sandy: 5J, 2adt	Resident Trout
1999	14-Apr-99	0	Hatchery Creek to Spring Pool		Steelhead
1999	28-Jul-99	7	Lake Cow Village to Sandy Pool	to Blk51: 1adt; Blk51-Skutz: 6adt	Resident Trout
2000	8-Mar-00	0	Skutz-Stoltz, less canyon reaches		Steelhead
2000	26-Jul-00	17	Lake Cow Village to Sandy Pool	to Blk51: 3adt; Blk51-Skutz: 3J,4adt; Skutz-Stoltz: 5J,2adt	Resident Trout
2001	14-Mar-01	0	Lake Cow Village to Block 51		Resident Trout/Steelhead
2001	18-Jul-01	18	Lake Cow Village to Sandy Pool	Blk51-Skutz: 15adt; Skutz-Stoltz: 1J,1adt; Stoltz-Sandy: 1adt	Resident Trout
2002	24-Jul-02	3	Lake Cow Village to Sandy Pool	to Blk51: 1adt, Skutz-Stoltz: 2adt	Resident Trout
2003	22-May-03	0	Lake Cow Village to Block 51		Resident Trout/Steelhead
2003	25-Jul-03	9	Lake Cow Village to Sandy Pool	Blk51-Skutz: 8adt; Skutz-Stoltz: 1adt	Resident Trout
2004	22-Jul-04	7	Lake Cow Village to Sandy Pool	to Blk51: 6adt; Stoltz-Sandy: 1J	Resident Trout
2005	27-Jul-05	1	Lake Cow Village to Sandy Pool	to Blk51: 1adt	Resident Trout
2006			**NOT SURVEYED**		
2007	31-Jul-07	0	Lake Cow Village to Sandy Pool		Resident Trout
2008	22-Jul-08	0	Lake Cow Village to Sandy Pool		Resident Trout
2009	22-Jul-09	5	Lake Cow Village to Sandy Pool	70.2 to Skutz: 5 size unspecified	Resident Trout
2010	22-Jul-10	0	Stanley Creek to Sandy Pool		Resident Trout
2011	3-Aug-11	0	Stanley Cr-Skutz, plus Stoltz-Sandy Pool		Resident Trout
2012	14-Aug-12	3	Lake Cow Village to Skutz Falls	70.2-Skutz: 3 size unspecified	Resident Trout
2013	7-Aug-13	6	Greendale to Skutz	70.2-Skutz: 6 size unspecified	Resident Trout
2014	31-Jul-14	0	Greendale to Skutz		Resident Trout
2015	22-Jul-15	0	Greendale to Skutz		Resident Trout
2015	4-Aug-15	2	Greendale to Stoltz	70.2-Skutz: 2adt	Spring Run Chinook

Key: adt = adult Chinook; J = jack Chinook.

Appendix H. DFO preliminary genetic analysis of juvenile salmon collected in Cowichan Lake tributaries, 2015 (R. Withler, DFO, Nanaimo, email to B. Crandall, CLSES, October 17, 2015).

We analyzed the following juveniles collected in the Cowichan system in 2015:

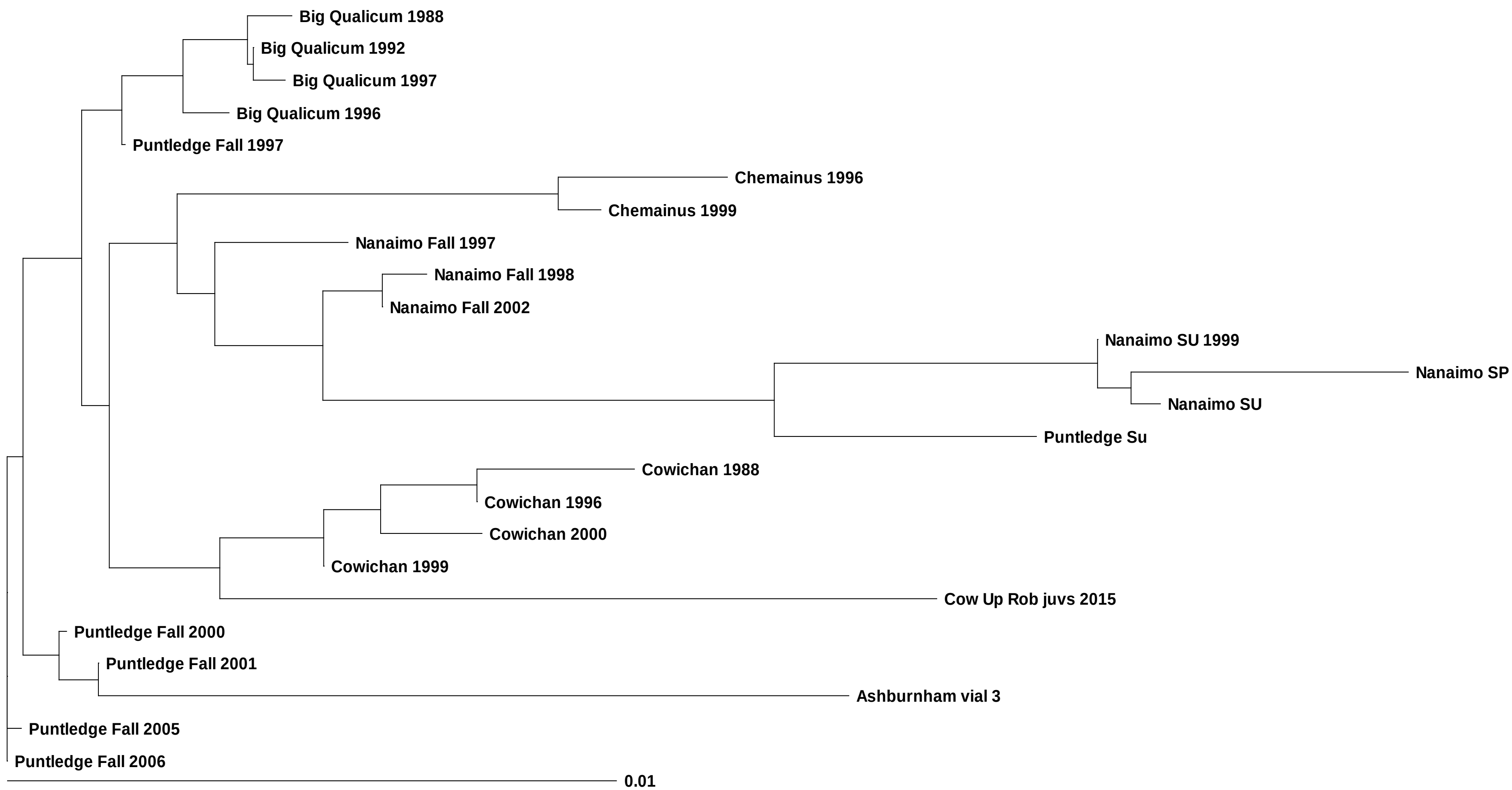
Ashburnham Creek Vial 2:	4 Chinook	
Ashburnham Creek Vial 3:	16 Chinook	
Sutton Creek Vial 6:	0 Chinook	4 Coho
Upper Robertson River Vial 4:	17 Chinook	1 Coho
Upper Robertson River Vial 5:	16 Chinook	2 Coho
Upper Robertson River Vial 8:	17 Chinook	1 Coho

Thus, in total, we obtained genotypes for 70 Chinook juveniles (no data for Coho). All samples showed statistical signs of 'family structure' meaning that they were composed of multiple samples from several families. The family structure will have to be analyzed and removed from the samples before a final analysis is completed but the current interpretation of the data indicates that:

- The Chinook from vials 2 (Asburnham), 4, 5, and 8 (Robertson River) were all very similar
- The Chinook from vial 3 (Ashburham) were distinctive, although the difference may be due simply to the presence of different families within the population, not necessarily a different population

Combining the similar samples of vials 2, 4, 5, and 8 provides a better (less family-structured) sample of those fish. In the attached 'tree diagram' showing the Cowichan juveniles in relation to other Southeast Coast Vancouver Island Fall and Summer Chinook:

- the combined juvenile samples (labelled Cow Up Rob juvs 2015) cluster with the Cowichan adult samples from our database (fall run fish)
- however, they are somewhat distinctive, which may simply reflect the remaining family structure or may indicate they are a separate population (but one very similr to the adult samples)
- further analysis to remove multiple samples belonging to the same families must be carried out before their distinctive nature can be confirmed/refuted
- even if they are a separate spawning group from those spawned each year in the Cowichan hatchery, the Upper Robertson fish genetically resemble the Fall Chinook populations more than the Puntledge/Nanaimo Spring/Summer group
- Similarly, the Chinook in the Ashburnham vial 3 sample also cluster with fall samples (in this case, Puntledge fall samples)
- Taken together, the data indicate that there may be two or more related, but differentiated by restricted gene flow among them, spawning populations of Chinook in the Cowichan system
- However, none of the Cowichan juveniles sampled to date are as distinctive as the summer Chinook of the Nanaimo and Puntledge rivers, nor do they share any genetic similarity with them. All the Cowichan fish appear more closely related to the Fall run Chinook populations of southeastern Vancouver Island.


Big Qualicum 1988
Big Qualicum 1992
Big Qualicum 1997
Big Qualicum 1996
Puntledge Fall 1997
Chemainus 1996
Chemainus 1999
Nanaimo Fall 1997
Nanaimo Fall 1998
Nanaimo Fall 2002
Nanaimo SU 1999
Nanaimo SP
Nanaimo SU
Puntledge Su
Cowichan 1988
Cowichan 1996
Cowichan 2000
Cowichan 1999
Cow Up Rob juvs 2015
Puntledge Fall 2000
Puntledge Fall 2001
Ashburnham vial 3
Puntledge Fall 2005
Puntledge Fall 2006
0.01

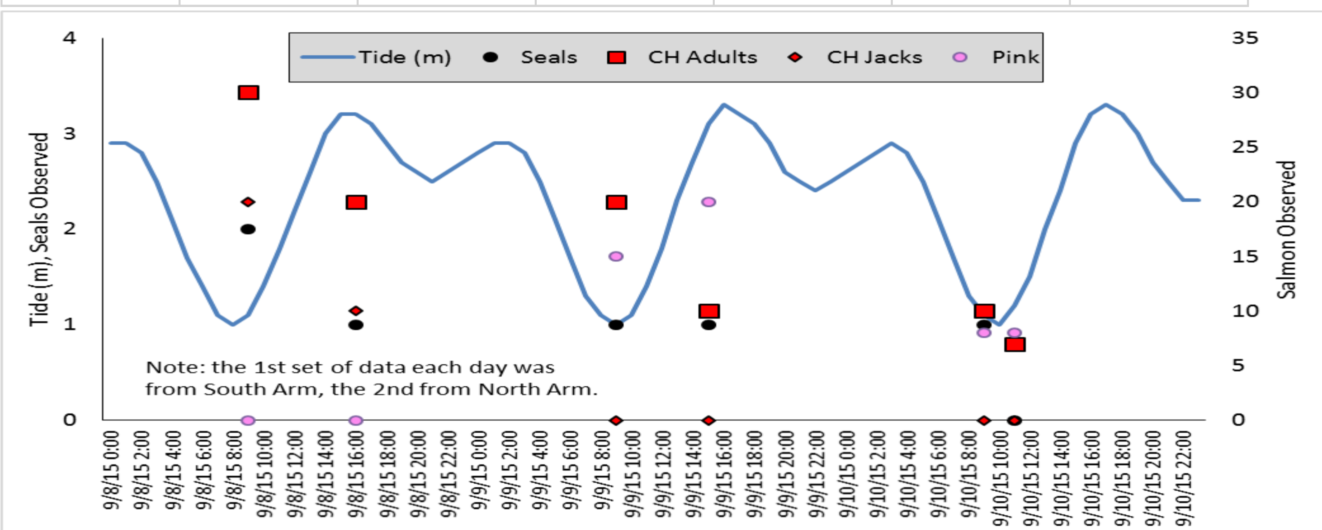
Appendix I. Lower Cowichan River snorkel survey segments established in 2015 identifying adult holding areas between the DFO/CT fence site and tidal reaches.

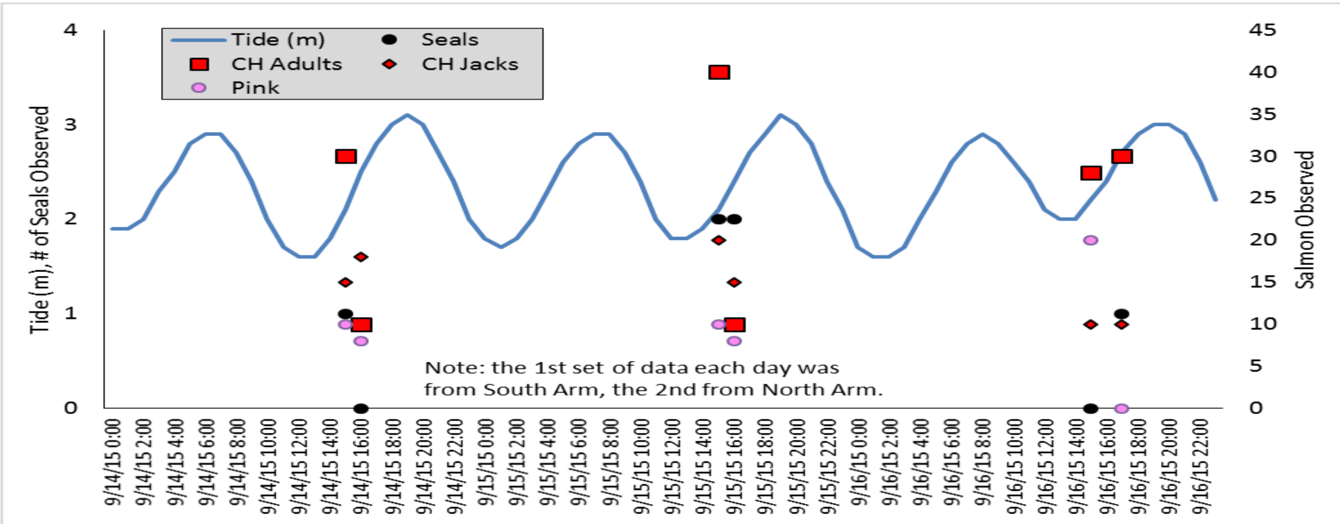
SEGMENT	DESCRIPTION	RIVER KM* FROM	RIVER KM* TO	LENGTH (m)
1	DFO Fence to Black Bridge (Railway)	6.7	5.8	900
2	Black Bridge to Silver Bridge (Hwy 1)	5.8	5.3	500
3	Silver Bridge to Toilet Bowl	5.3	4.8	500
4	Toilet Bowl to JC's Pool	4.8	4.5	300
5	JC's Pool to start of JUB Outfall	4.5	3.7	800
6	JUB Outfall to Upper Quamichan Jam	3.7	3.2	500
7	Upper Quamichan Jam tailout to Quamichan Pool tailout	3.2	2.7	500
8	Quamichan Pool tailout to Black Creek (Jane's SC conf)	2.7	2.2	500
9	Black Creek to DIDSON tailout	2.2	2.0	200
10	DIDSON tailout to Powerline tailout	2.0	1.8	200
11	Powerline tailout to End of Quamichan Road Dike	1.8	1.3	500
12	End of Quamichan Road Dike to Irve's Corner	1.3	0.7	600
13	Irve's Corner to Monica's Pool tailout	0.7	0.3	400
14	Monica's Pool tailout to Pembury Bridge tailout	0.3	-0.1	400
15	Pembury Bridge tailout to right bank Take Out	-0.1	-0.3	200

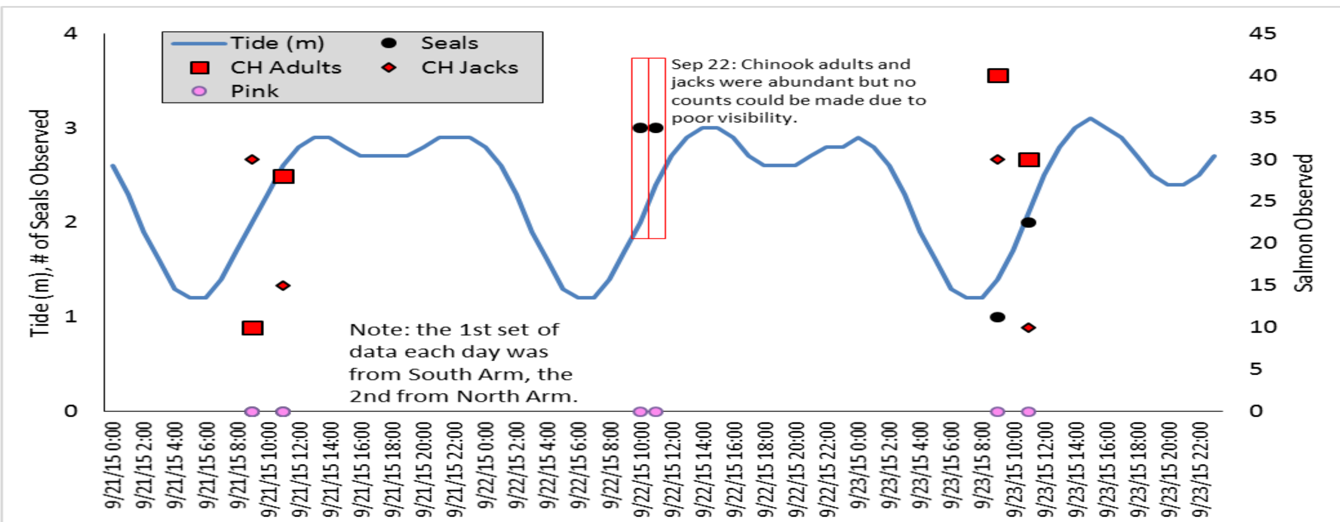
* Assumes Pembury (Tzouhalem Road) Bridge = river kilometre 0.0.

Appendix J. Bank survey results from the Cowichan River Steward of seals, Chinook adults and jacks, and pink salmon observed in the Cowichan's South and North Arms relative to hourly tides. Weekly charts of Sep 8-10, Sep 14-16, Sep 21-23, and Sep 28-30.

Date	Time	Location	CH Adults	CH Jacks	Pinks	Seals
8-Sep	09:00:00	Clemclem	30	20	0	2
	16:00:00	Pembury	20	10	0	1
9-Sep	09:00:00	Clemclem	20	0	15	1
	03:00:00	Pembury	10	0	20	1
10-Sep	09:30:00	Clemclem	10	0	8	1
	11:00:00	Pembury	7	0	8	0
14-Sep	15:00:00	Clemclem	20	15	10	1
	16:00:00	Pembury	10	18	8	0
15-Sep	15:00:00	Clemclem	40	20	10	2
	16:30:00	Pembury	10	15	8	2
16-Sep	15:00:00	Clemclem	28	10	20	0
	17:30:00	Pembury	30	10	0	1
21-Sep	09:00:00	Clemclem	10	30	0	0
	10:30:00	Pembury	28	15	0	0
22-Sep	10:00:00	Pembury	abundant	abundant	0	0
		Clemclem	abundant	abundant	0	3
23-Sep	09:00:00	Clemclem	40	30	0	1
		Pembury	30	10	0	2
28-Sep	09:00:00	Pembury	30	10	10	0
	11:00:00	Clemclem	40	20	10	0
29-Sep	15:00:00	Clemclem	30	15	0	2
	16:30:00	Pembury	25	20	0	0
30-Sep	15:00:00	Pembury	30	10	0	1
	17:30:00	Clemclem	40	10	0	2
		Totals	**538**	**288**	**127**	**23**




Tide (m)
Seals
CH Adults
CH Jacks
Pink
Tide (m), # of Seals Observed
Salmon Observed
Note: the 1st set of data each day was from South Arm, the 2nd from North Arm.


Tide (m)
Seals
CH Adults
CH Jacks
Pink
Tide (m), # of Seals Observed
Salmon Observed
Sep 22: Chinook adults and jacks were abundant but no counts could be made due to poor visibility.
Note: the 1st set of data each day was from South Arm, the 2nd from North Arm.

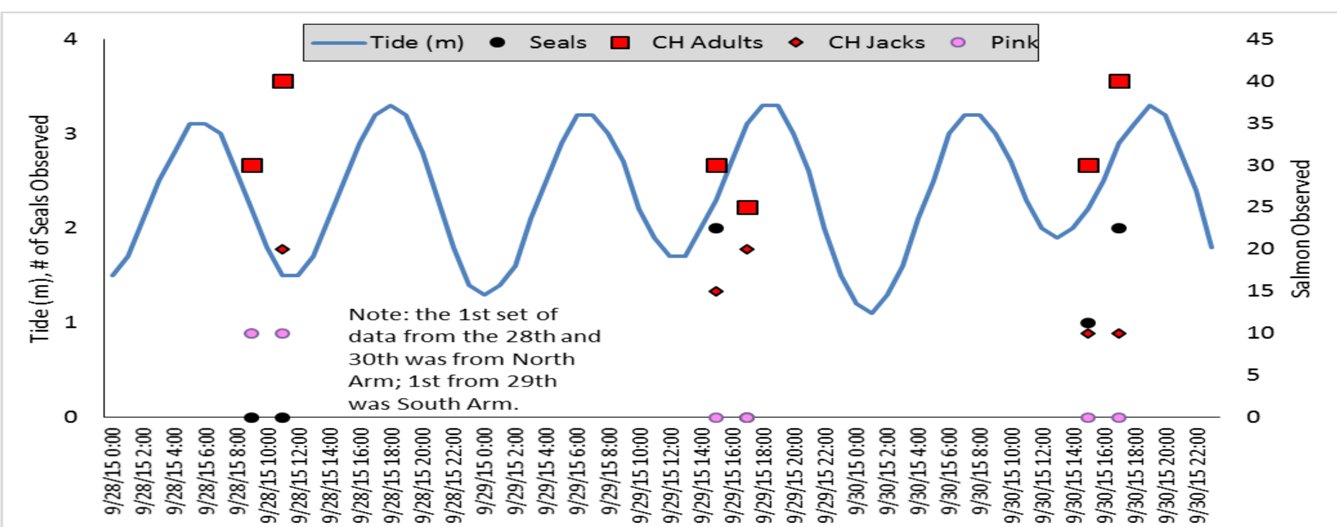

Tide (m)
Seals
CH Adults
CH Jacks
Pink
Tide (m), # of Seals Observed
Salmon Observed
Note: the 1st set of data from the 28th and 30th was from North Arm; 1st from 29th was South Arm.

Photo Plates.

Photo 1. Cross-stream view of "Mainstem above Bifurcation" flow site, Jul 31, 2015. Q=3.619 m^3/s.

Photo 2. Downstream view of "Mainstem above Bifurcation" flow site, Jul 31, 2015. Q=3.619 m^3/s

Photo 3. Cross-stream view of North Arm flow site, 40 m downstream of bifurcation, Jul 31, 2015. Q=3.619 m^3/s.

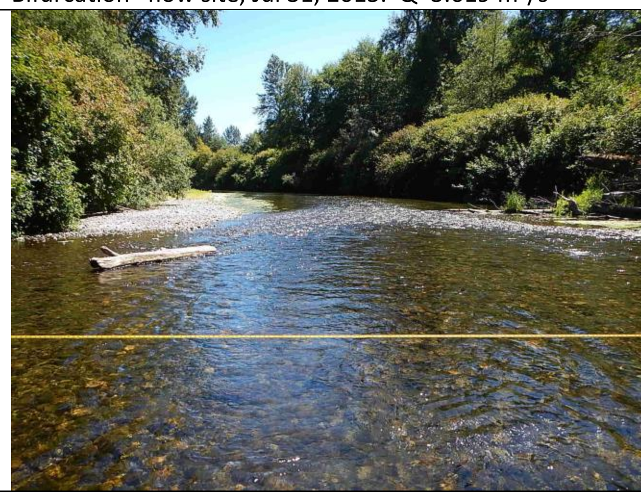


Photo 4. Downstream view of North Arm flow site, 40 m downstream of bifurcation, Jul 31, 2015. Q=3.619 m^3/s.

Photo 5. Cross-stream view of South Arm flow site just above Hatchery Channel, Aug 10, 2015. Q=1.664 m^3/s

Photo 6. Downstream view of South Arm flow site just above Hatchery Channel, Aug 10, 2015. Q=1.664 m^3/s

Photo 7. Panorama looking downstream (SE) of main North Arm log jam, Jul 31, 2015. North Arm flow (1.811 m^3/s) enters from far left, and 93% (1.69 m^3/s est.) flowed through the log jam towards the North Arm's east channel, leaving 0.121 m^3/s (7%) in the west channel at far right. These proportions remained roughly consistent through the summer base flow period.

Photo 8. Downstream view of North Arm flowing to the main log jam (behind tech.) in Photo 7. Jul 31, 2015.

Photo 9. Downstream view of North Arm's west channel with a flow of 0.121 m^3/s. Jul 31, 2015

Photo 10. Downstream view of North Arm east channel between log jams, Jul 31, 2015. Q=1.69 m^3/s est.

Photo 11. Downstream view of North Arm east channel, below secondary log jam, Jul 31, 2015. Q=1.69 m^3/s est.

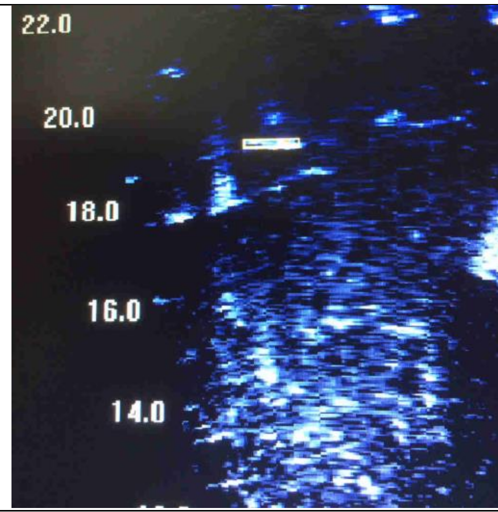
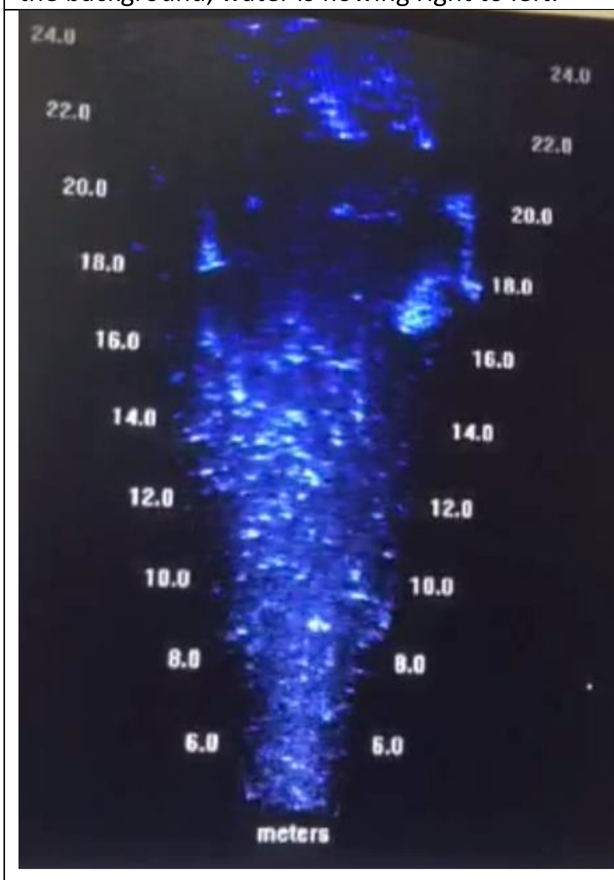
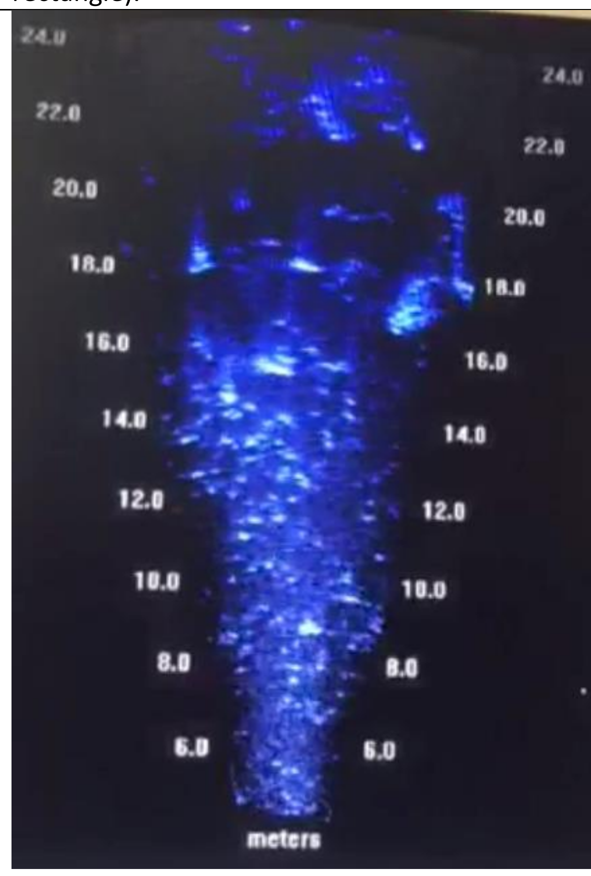


Photo 12. Cross-stream view of mid-river DIDSON set up. Unit is sounding towards the boulder in the background; water is flowing right to left.

Photo 13. Close-up of DIDSON sonar data screen showing target and length measuring tool (white rectangle).





Photos 14, 15. Typical mid-river DIDSON sonar data screen showing plan view of the Cowichan River bed, with no fish in the left image and two large targets (likely Chinook adults) in the right image just seconds later. Numbers are horizontal distance (metres) across the channel from the DIDSON unit attached to the ladder. Photos with permission from I. Matthews, DFO, Nanaimo.