Small Woody Debris Restoration in the Puntledge River Headpond

COA-F17-F-1199

Prepared for:

Fish and Wildlife Compensation Program

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On behalf of:

Courtenay and District Fish and Game Protective Association

November 2016

Prepared with financial support of the Fish and Wildlife Compensation Program on behalf of its program partners BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations and public stakeholders.

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EXECUTIVE SUMMARY

With support from the Courtenay and District Fish and Game Protective Association (CFGA) Conservation Committee and Fisheries and Oceans Canada (DFO), a habitat enhancement project was completed in the Puntledge River headpond in January/February 2016 using recycled Christmas trees. This pilot project will determine whether the addition of strategically placed small woody debris (SWD) in the headpond could potentially reduce summer Chinook fry entrainment at the hydro facility by providing a safer and more complex corridor for migration away from the hydro penstock intakes, and whether it will enhance rearing habitat, allowing fry to remain in the headpond longer, growing to a preferable larger size before they migrate past the hydro facility, with a higher diversion rate at the Eicher fish screens. These project objectives address 'Research and Information Acquisition' and 'Habitat' based priority actions in the Puntledge River Salmonid Action Plan (BC Hydro 2011) by providing further insight on downstream fish passage limitations of emergent Chinook fry and their behaviour/response to habitat enhancement activities in the lower Puntledge River mainstem.

The SWD installations were assessed during 5 snorkel surveys between March and April to determine utilization of the SWD by wild Chinook fry. In addition, releases of marked fry and minnow trapping was conducted to assess fry distribution and longevity of use. Overall, the sites that were treated with SWD bundles had slightly higher densities of fry compared to untreated sites, suggesting that Chinook fry were attracted to the SWD. However the total number of fry observed during all surveys was low (maximum 1.2 fry/m^2, average 0.5 fry/m^2). Results from marked fry releases and minnow trapping were inconclusive.

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1 INTRODUCTION

In 1965 summer-run Chinook salmon were restricted from accessing their historical spawning habitat upstream of the Puntledge diversion dam (PUN diversion dam) due to the impairment of their principal spawning area upstream of the dam, and entrainment mortality on out-migrating juveniles (BC Hydro 2011). This restriction was finally lifted following the installation of Eicher fish screens at the PUN diversion dam in 1993 to address juvenile entrainment issues, and the restoration of over 4500 m^2 of spawning habitat above the dam in 2005. The majority (>75%) of juvenile summer Chinook from natural spawning above the diversion dam migrate from the spawning grounds between February and April as newly emerged fry (average 38 mm fork length), while a second group migrates from May to July at 60-80 mm (Guimond et al. 2014). Recent investigations have indicated that the overall performance of the Eicher fish screens to effectively divert juveniles during their seaward migration is influenced by fish size as well as penstock discharge and screen cleanliness (Guimond and Taylor 2014). This can result in lower than acceptable survival rates on out-migrating juveniles, particularly on the smaller fry. Concerns regarding fish entrainment and Eicher screen performance/operation are currently being investigated under the Puntledge Fish Entrainment Strategy (PUNFES).

Complementing the efforts of the PUNFES, and in partnership with Fisheries and Oceans Canada (DFO) and the Fish and Wildlife Compensation Program (FWCP), the Courtenay and District Fish and Game Protective Association (CFGA) engaged in a pilot study in 2016 to investigate whether habitat enhancement/restoration activities upstream of the PUN diversion dam could further mitigate summer Chinook fry mortality and entrainment at the hydro facility. Increasing juvenile survival during their seaward migration is an important step in maintaining the genetic integrity of the summer run, and necessary for their long-term adaptation and conservation.

1.1 Goals and Objectives

The goal of this project is to determine whether the placement of small woody debris (SWD) bundles along the river margins will be utilized by emergent summer Chinook fry during their downstream migration through the Puntledge River headpond. Utilization of similar SWD complexing has been observed in Cowichan and Englishman Rivers. Attraction of fry to SWD bundles on the left side of the river could potentially reduce the proportion of fry encountering the Hydro facility intakes by creating a more secure fry migration corridor along the left bank and safer passage past the diversion dam. Secondly, SWD complexing along river margins and in a backwater area upstream of the diversion dam may provide sufficient habitat and cover for fry to reside in the headpond longer and grow to a larger size before continuing their downstream migration. Larger fry (> 55 mm) have a much higher survival past the diversion dam.

These project objectives address 'Research and Information Acquisition' and 'Habitat' based priority actions in the Puntledge River Salmonid Action Plan (BC Hydro 2011) by providing further insight on downstream fish passage limitations of emergent Chinook fry and their behaviour/response to habitat enhancement activities in the lower Puntledge River mainstem.

2 STUDY AREA

The Puntledge River Watershed encompasses a 600 km^2 area west of the city of Courtenay on Vancouver Island (Figure 1). The lower Puntledge River flows from Comox Lake in a north-easterly direction for 14 km where it joins with the Tsolum River. From this point downstream the river is called the Courtenay River, and flows for another 2.9 km into the Strait of Georgia. The lower Puntledge River below Comox Lake is divided into 3 distinct reaches that are influenced by BC Hydro operations. The project area is located in the headpond reach, also referred to as Reach B (BC Hydro 2003), delineated by the Comox impoundment dam at the outlet of Comox Lake and the Puntledge diversion dam,

approximately 3.7 km downstream. This is a low gradient reach (<0.01%) characterized by deep, slow moving water, a result of backflooding from the diversion dam. The average channel width is about 60 m (range: 35 and 105 m; Bengeyfield and McLaren, 1994). Discharge through the reach is controlled by releases at the Comox impoundment dam sluice gates. Normal operations target a discharge of 33 m^3/s in this reach to maintain a power output of 24 MW at the Puntledge Generating Station, and provide a minimum instream flow of 5.7 m^3/s below the diversion dam for fish, however flows vary throughout the year to meet specific requirements under the Puntledge River Water Use Plan and to manage reservoir levels.

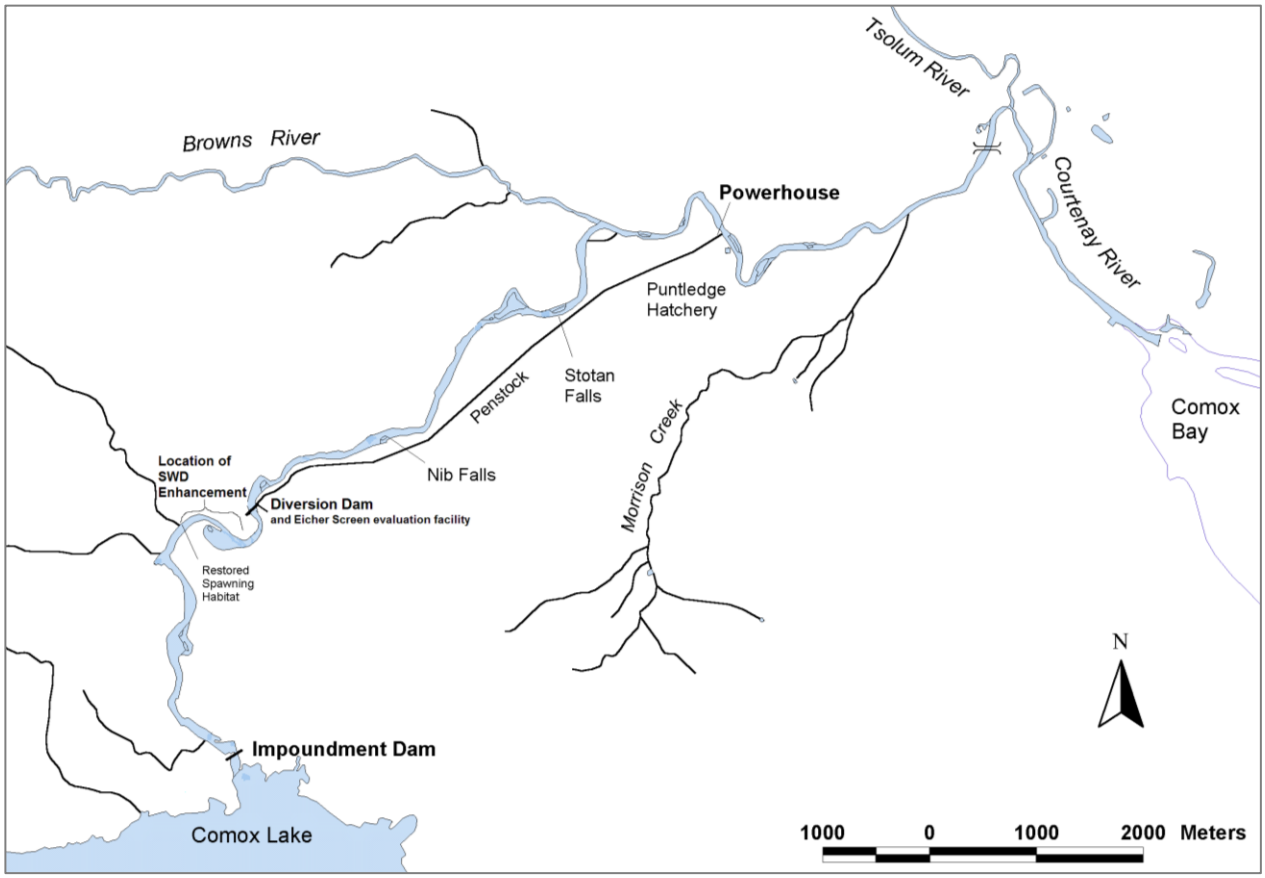

Figure 1. Location map of the lower Puntledge River and study area.

3 METHODS

3.1 SWD Site selection

In December 2015, DFO conducted a reconnaissance survey in the lower headpond reach by boat to identify suitable sites for SWD installations based on depth and velocity characteristics of submerged SWD sites in other watersheds (i.e. Cowichan) where Chinook fry use was observed. A total of 11 SWD placement sites were selected on the left bank and one site was selected in the extensive backwater 'slough' on river right (Figure 2). On a subsequent reconnaissance survey in March 2016, the 11 SWD sites were measured and adequately flagged to be easily located by the assessment crew. During this survey 7 "Untreated" sites were also established to provide a comparison of fry use in adjacent untreated areas of the river margin. Five sites were located on river left, 1 on river right and 1 in the slough (Figure 2). An 8th untreated site was also included in the snorkel surveys, but results are mainly for qualitative observations and not used in comparisons or analysis. This site is located on the right bank, directly across the boat launch beside the spawning platform, and represents a more natural complexed habitat with large woody debris (LWD) from blowdown providing significant cover.

3.2 SWD Installation

Recycled Christmas trees were used to construct the small woody debris (SWD) complexing bundles in the Puntledge River headpond. Trees were collected in the local community in early January 2016, and stored at the CFGA clubhouse until required. On the day of installation, the trees were transported to the Puntledge River headpond boat launch adjacent the spawning platform, approximately 1 km upstream of the diversion dam. Trees were assembled into small bundles on shore, which consisted of 8-10 large

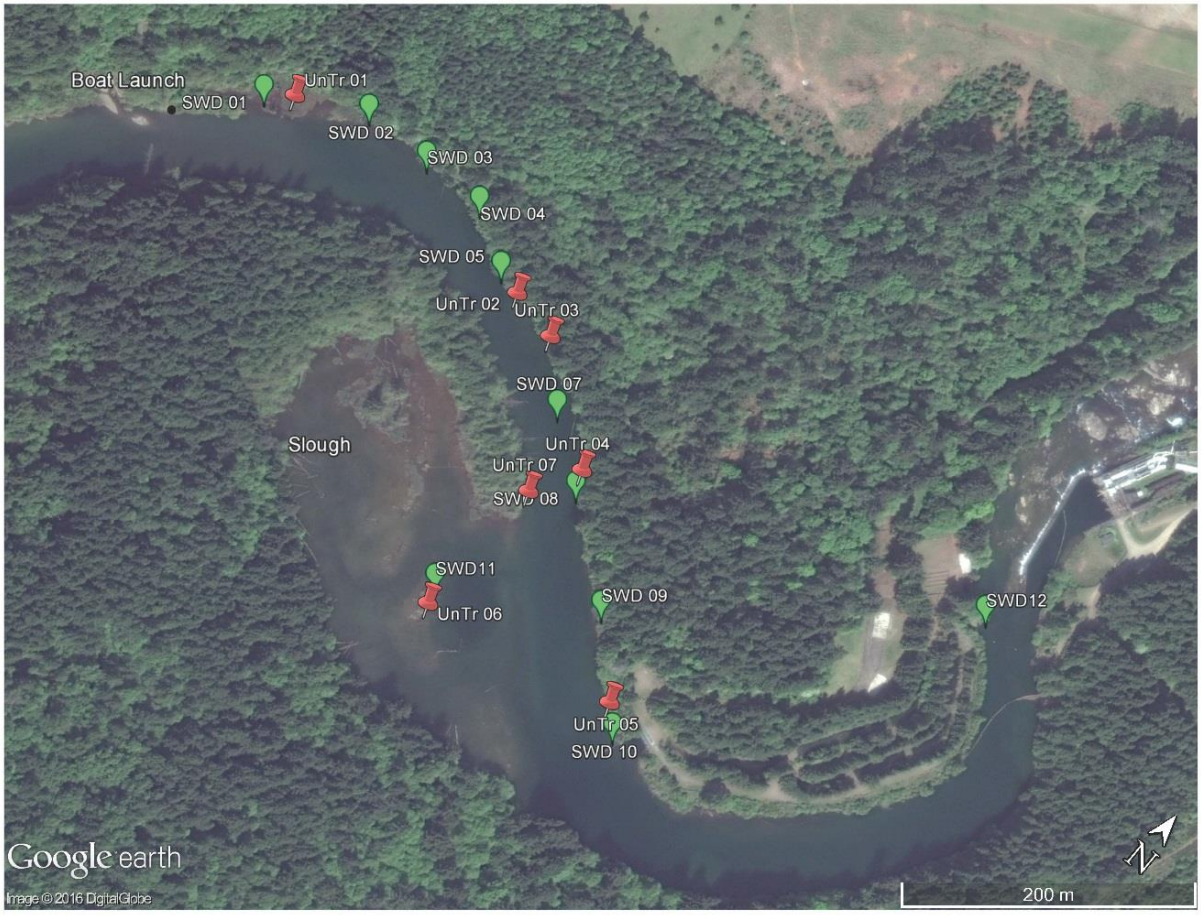

Figure 2. Location of small woody debris (SWD) and untreated (UnTr) sites in the Puntledge River headpond upstream of the diversion dam.

(8-10 ft) trees (typically Douglas fir) that were cabled and clamped together at their trunks in sequence (Figure 2). The tree bundle was then towed to the receiving site in the river by boat and anchored to healthy trees along the bank (Figure 3). Ten of the 12 SWD sites identified during the reconnaissance survey were supplied with a SWD bundle.

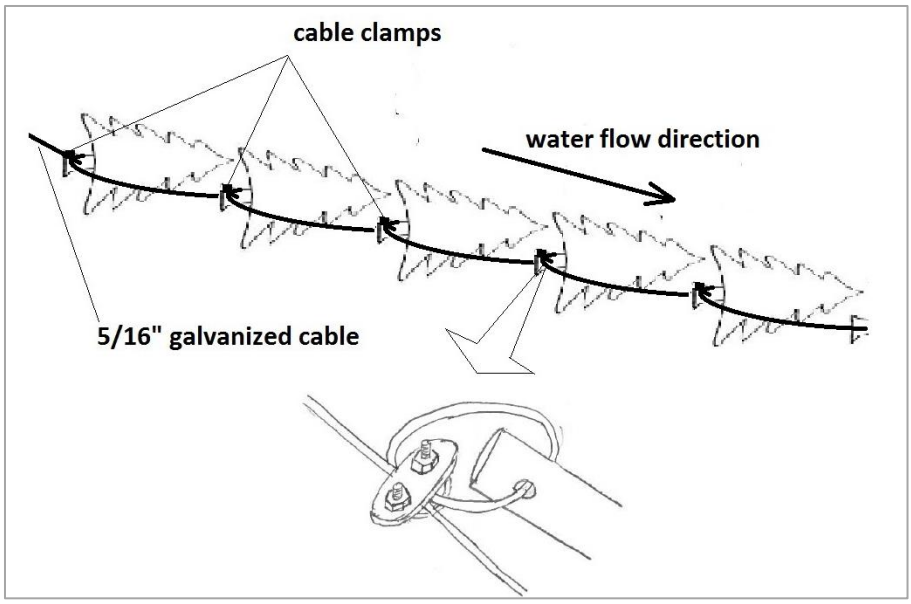

Figure 3. Cabling and clamping design for the SWD Christmas tree bundles in the Puntledge River.

3.3 Assessment of fish utilization

Chinook fry utilization of the SWD complexing sites was assessed by a snorkel survey crew from the BC Conservation Foundation, and field support team comprised of a DFO boat and operator, and at least one spotter and data recorder. Snorkel surveys were conducted at a river discharge <40 m^3/s. On the first scheduled survey, the crew conducted one swim during daylight and a second after dark in order to determine the best opportunity to observe fry distribution at the SWD and untreated sites. All successive surveys were conducted during the night, commencing approximately 1 hour after sunset. Between 21 March and 25 April, five nighttime snorkel surveys were completed at the 10 SWD and 7 Untreated sites. Each survey was completed by 2 snorkelers moving downstream and counting all individual fish of each species observed at each site.

For the last 2 surveys (April 5 and 25), marked hatchery Chinook fry stained in a Bismarck Brown dye immersion bath, were released on the left bank at the upstream most SWD site prior to the swim, to monitor the distribution of marked fry at the SWD and untreated sites and observe their migration from upstream to downstream SWD locations

on river left, and at bundles placed on the opposite bank. Approximately 4000 fry were released, 24 hours and 2 hours prior to the two surveys.

On April 4, minnow traps were set at 3 of the SWD sites to assess fry utilization and longevity of use at the sites. Sites were selected based on utilization by fry observed during previous snorkel swims, and on their accessibility by foot from a recreational trail which parallels the river. Traps were baited with salmon roe and either placed within or adjacent to the tree bundle and allowed to fish overnight.

4 RESULTS AND OUTCOMES

4.1 Environmental conditions

Mean hourly discharge for the Puntledge River (Reach B), represented by Comox impoundment dam (CMC) sluice gate releases, and the Puntledge Generating Station (turbine flow), for the study period were obtained from BC Hydro Power Records (**Figure 4**). Snorkel surveys commenced following a period of high flow events from 1- 18 March (> 180 m^3/s). Reach B discharge ranged from 9 to 15 m^3/s for the first 2 swims, and 27 to 35 m^3/s for the remaining 3 swims. River temperature over the assessment period (21 March – 25 April) recorded from a Tidbit temperature data logger (Onset Computer Corp.) in the headpond averaged 8.37 ^oC, increasing from 6.7 ^oC to 10.2 ^oC over the five snorkel surveys (Figure 4). Other environmental conditions recorded during the 5 surveys are summarized in Table 1.

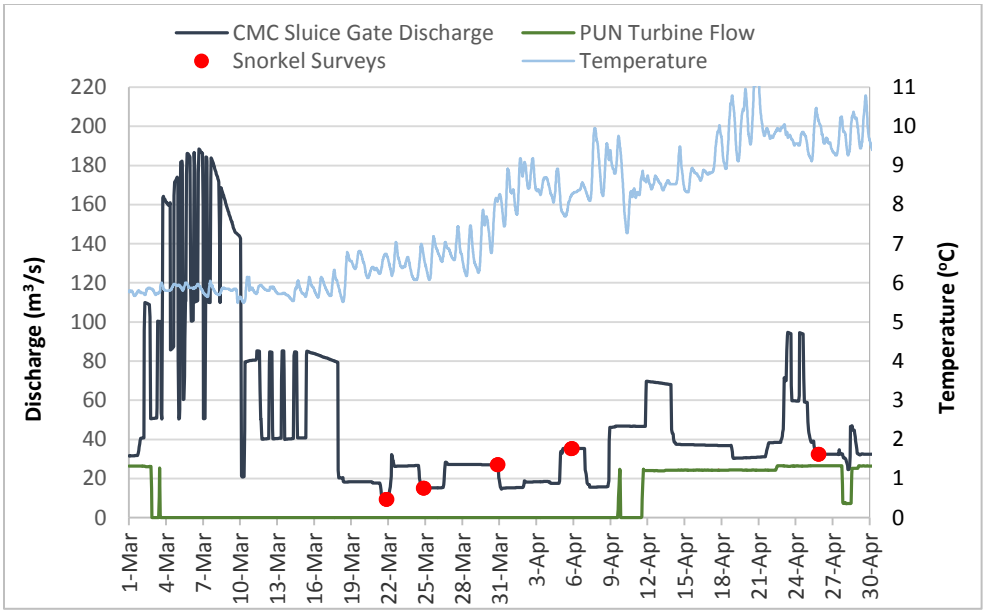

Figure 4. Puntledge River mean hourly discharge for Reach B (CMC sluice gate discharge), penstock discharge (Turbine Flow), and river temperature from 1 March to 30 April 2016, showing snorkel surveys.

Table 1. Environmental conditions observed during five snorkel surveys in the Puntledge River headpond.

Survey Date	Survey Start Time	Sunset	Moonrise	Illumination (%)	Sky Cover	Reach B Discharge (m^3/s)	Water Temp (°C)
21-Mar-16	17:00	-	-	-	showers	9.3	6.5
21-Mar-16	20:50	19:35	18:04	97	cloudy	9.3	6.5
24-Mar-16	20:45	19:40	21:08	99.3	cloudy	15.2	6.5
30-Mar-16	21:00	19:49	2:00	60.8	clear	27.1	7.5
5-Apr-16	21:00	19:59	6:03	4.3	cloudy, showers	35.3	8
25-Apr-16	21:15	20:29	23:55	90.6	clear	32.5	10

4.2 SWD Installation

SWD Site 12 at the entrance to the fishway was not complexed due to an existing accumulation of sand and debris and the concern of further passage restrictions with SWD additions. A second site (Site 6, Figure 2) was also not treated due to a lack of solid anchor points (riparian trees), and was used as an Untreated site instead. The receiving sites for the

SWD bundles varied in depth, velocity and habitat characteristics. There was also significant variation in velocity between and within sites after the SWD placement (Table 2). The average length of the SWD treatment sites was 11.7 m, and 15.6 m for the untreated sites, average velocities ranged from 0 to 0.35 m/s, and depths from 0.2 to 2.5 m.

Table 2. Location and description of small woody debris (SWD) and Untreated (UnTr) sites in the Puntledge River headpond.

Site Name	X	Y	Site Description	Velocity* (m/s)	Length (m)	Avg. depth* (m)
SWD 01	-125.10263	49.66348	adjacent spawning platform, shallow, marshy area	0.07	15	0.5
UnTr 01	-125.10231	49.66363	Contiguous and downstream of SWD 01	0.3	18	0.5
SWD 02	-125.10170	49.66383	circular arrangement of SWD	0.08	9	0.5
SWD 03	-125.10100	49.66381	Some overhanging cover	0.18	11	1
SWD 04	-125.10031	49.66381	extensive overhanging cedar	0.35	12	1.5
SWD 05	-125.09978	49.66358	overhanging cedars	0.35	7.5	1.5
UnTr 02	-125.09947	49.66360	Contiguous and downstream of SWD 05	0.12	15	1.5
UnTr 03 (SWD 06)	-125.09903	49.66343	No SWD installed here. Used as an untreated site.	0.15	15	0.8
SWD 07	-125.09853	49.66313	SWD along log; deep water; trees on bottom	0.13	11	2.5
UnTr 04	-125.09797	49.66296	contiguous and upstream of SWD 8	n/a	15	n/a
SWD 08	-125.09787	49.66283	Overhanging coniefrs	0.18	13	1
SWD 09	-125.09696	49.66238	No overhanging cover	0.07	13.4	1.8
UnTr 05	-125.09623	49.66194	contiguous and upstream of SWD 10	0.02	15	0.2
SWD10	-125.09601	49.66182	Upper hatchery intake log boom	0.03	13	1.8
SWD 11	-125.09846	49.66196	lagoon at small island	0	12	0.8
UnTr 06	-125.09826	49.66172	contiguous and downstream of SWD 10	0	16	0.8
SWD 12	-125.09407	49.66378	fishway inlet	n/a	n/a	n/a
UnTr 07	-125.0982	49.66267	Right bank near lagoon; shallow	0.09	15	1

*Average velocity and depth measured at river discharge of ~33 m^3/s

4.3 Assessment of fish utilization

For the most part, visibility during the snorkel surveys was good (5-6 m) and juvenile salmonids were fairly approachable and could easily be distinguished by species within the first 1-2 m of depth. Species confirmation was more difficult at greater distances, and were identified as "unknown fry" (J. Craig personal communication, April 6, 2016). No fish

were observed at any site during the first (daytime) snorkel survey. During the nighttime surveys, the density of Chinook fry ranged from 0 to 1.22 fry/m^2 at the SWD sites for all swims, with the highest densities observed during the 21 March survey (Figure 5).

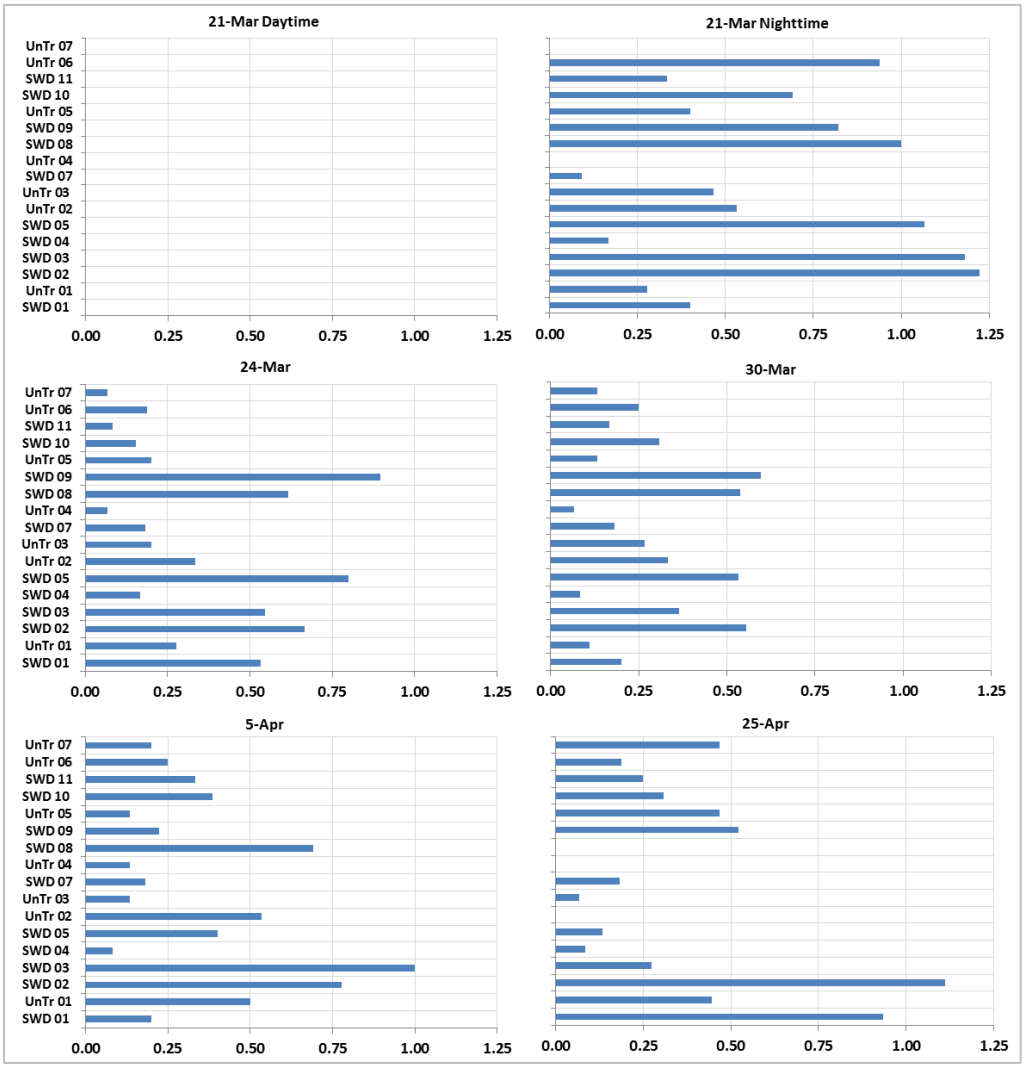

Figure 5. Density (fry/m^2) of summer Chinook fry at SWD treated and Untreated sites in the Puntledge River headpond during one daytime and five nighttime snorkel surveys in March/April 2016.

Fry densities at the untreated sites were similar in their variability, ranging from 0 to 0.94 fry/m^2. On average, the SWD treated sites had higher densities of fry than the untreated sites on each survey (Figure 6), but only results for the 24 March survey were statistically different ($p=0.0342$; one-way ANOVA comparison at $\alpha=0.05$).

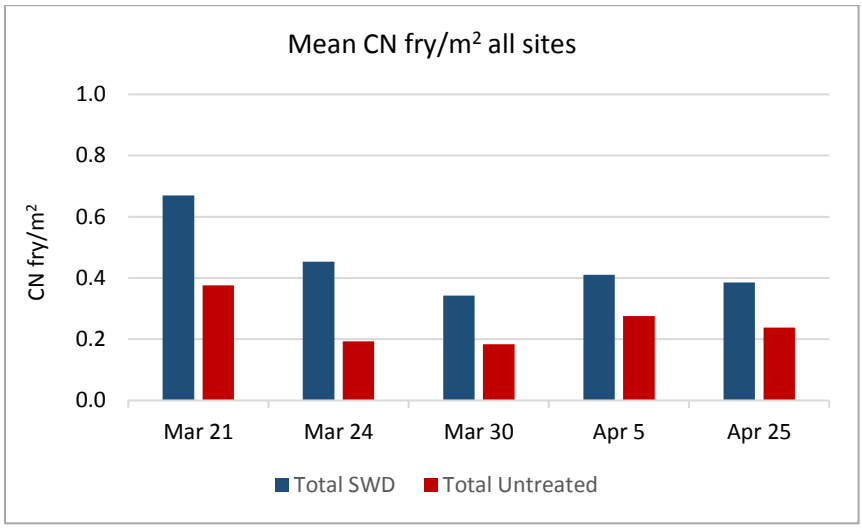

Figure 6. Mean CN fry density (fry/m^2) for all SWD and Untreated sites observed for each snorkel survey.

The following is a summary of observations reported by one of the snorkel survey crew following the 5 April survey (notes included in Appendix B). Overall, Chinook fry were more often observed in moving water (< 0.1 m/s), and commonly within or below trees, but occasionally above (<15 cm) or adjacent the bundles within 1 m. The more consistent and higher fry densities (0.5 – 1 fry/m^2) were observed at shallow (0.25-1.5 m) sites over gradual slopes (<4H:1V) of silty loam, and associated with small detritus with budding but sparse aquatic, grass-like vegetation, 5-20 cm in height. Sites in which the SWD bundles were deeper, associated with steep banks, higher velocities, or muddy bottoms with no vegetation appeared to have lower fry densities. This is reflected to some degree in Figure 3 for the 5 April survey where densities at sites with ≥ 1.5 m depth (SWD Sites 4, 5, 7, 9 & 10) had lower fry densities (<0.5 fry/m^2) than shallower sites (SWD Sites 2, 3 & 8). Over all surveys, Sites 2, 3, 5, 8 & 9 had the highest fry densities (≥0.5 fry/m^2; Figure 7). Due to the variability in velocities within the SWD sites, a correlation between specific site velocity characteristics and fish presence or behavior is difficult.

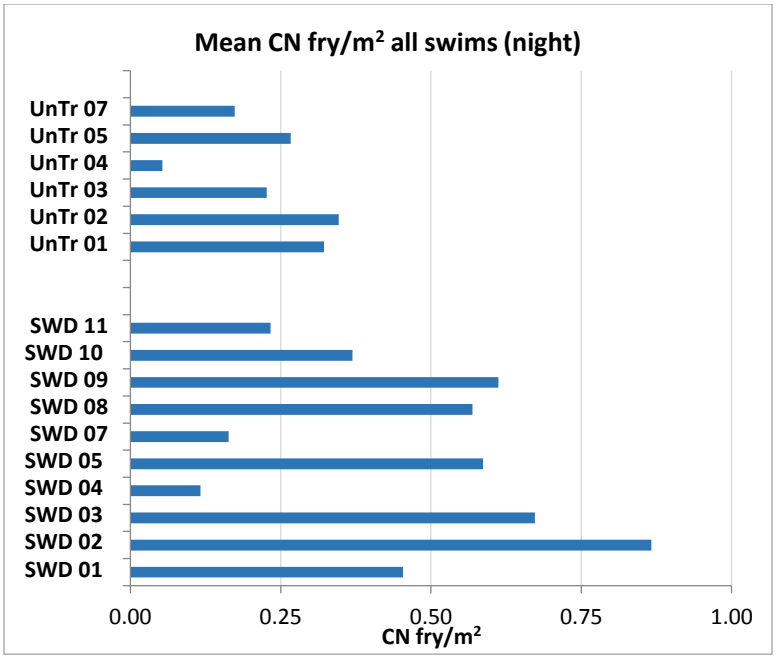

Figure 7. Mean CN fry density (fry/m^2) at each site for all nighttime swims.

As indicated in comments from the survey crew (Appendix 2) there was considerable variation in habitat characteristics (depth, velocity, overhead and existing instream cover, substrate, orientation of SWD and proximity to bank, etc.) at both the SWD and untreated sites, making a comparison of fry attraction to SWD versus untreated sites more challenging. Overall however, on the basis of the presence/absence of SWD, a comparison of mean fry density results over all surveys showed a marginal significant difference ($F = 4.68$, $p = 0.047$), even though there is sufficient variability in the two data sets to overlap the confidence intervals (Figure 8).

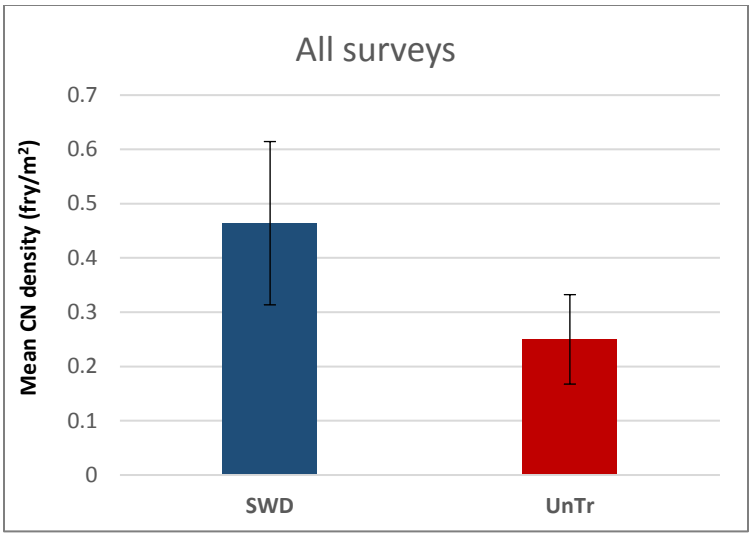

Figure 8. Mean CN fry density (fry/m^2) at all SWD treated and Untreated sites for all surveys with 95% confidence limits.

Other species observed at the SWD and Untreated sites, in addition to Chinook fry, are summarized in Table 3.

Table 3. All fish observations at SWD and Untreated sites.

Survey Date	Wild Chinook	Dyed Chinook	Coho Smolt	Coho Fry	Trout sp.	TSSB	Unknown fry	Total All Species
21-Mar-16	119	-	1	3	3	42	-	168
24-Mar-16	74	-	9	7	4	41	-	135
30-Mar-16	60	-	1	5	5	31	-	102
5-Apr-16	78	4	2	13	2	47	14	160
25-Apr-16	71	41	5	61	1	74	26	279

Fry catches from 6 minnow traps was very poor with a total catch of 1 wild Chinook fry, 2 coho fry and 5 threespine stickleback, thus precluding further assessment using this method.

Similarly, the two releases of marked hatchery fry failed to provide any insight into fry use and/or residency at the SWD sites. Although the fry stained with the Bismarck Brown dye showed up well relative to unmarked (wild) fry, the marked fry releases seemed to spend little time in the headpond. Only 4 marked fry from the first release (4 April) were observed at the SWD sites approximately 24 hours later (Appendix 3). Three of these fry were observed at untreated sites, one of which was on river right. The second marked fry release on 25 April was surveyed approximately 2 hours post release, and, as expected, a greater number of marked fry were observed at the SWD and untreated sites. The fry were dispersing downstream with the upstream sites (SWD 01, SWD 02 and UnTr 01) having the greatest number of fry (between 6 and 17 fry) and only 1 or 2 fry observed at a few of the lower sites on both river left and river right, and in the lagoon. The paucity of marked fry observations may be due to an inclination for hatchery fry to migrate downstream immediately following their release in the headpond, as evidenced by the large numbers of marked fry captured at the Eicher evaluation facility on 26 April. Smaller numbers of marked fry were also observed at this facility on April 5, however the Puntledge Generating Station was offline at the time (Figure 4) compared to maximum generation on 25 April. Therefore most of the fry would have passed over the diversion dam.

5 DISCUSSION

The low densities of fry observed at the SWD treated sites overall was much less than anticipated, particularly when compared to observations in other watersheds (Cowichan and Englishman rivers). The snorkel crew commented on a potential bias in fry visibility between trees that had shed their needles, compared to fully needled trees (Appendix 2). A greater preference of fry for the latter may account for some fry being missed during surveys. The ‘headpond’ is an atypical river channel compared to the above systems, with lower velocities, finer substrates and variable benthic vegetation, which may influence rearing behaviour/strategies in this system. A low fry abundance in the headpond may also account for fewer observations. Based on the estimate of brood year 2015 summer

Chinook adults above the diversion dam (from Puntledge Hatchery's trap and transport records to the lake and video counts of natural migrants at the fishway), there were ~40 females that spawned above the dam, either in the headpond or in tributaries to Comox Lake. The estimated fry production from this population is <70,000. Furthermore, snorkel surveys were conducted following an extended period of high river discharge which may have moved large numbers of emergent fry downstream.

However, the fry density results between SWD and untreated sites overall, indicates that the addition of SWD may be beneficial and may warrant further investigation.

6 RECOMMENDATIONS

Despite the low densities of fry observed at the SWD bundles in 2016, routine monitoring of the existing installations should be conducted over the 2016/17 fall/winter season to determine their functionality, stability and condition, and continued into early spring during the emergent Chinook migration. Additional activities may be incorporated into the program, including the following:

1. Thin out branches in some of the SWD installations to compare fish use to trees with more dense cover.
2. Re-position some of the bundles closer to the banks and/or increase the number of trees at some sites.
3. Install more SWD on the right bank just upstream of the slough where the banks are more shallow and assess to determine if this location results in greater use and longer residence time for Chinook juveniles.
4. Install different types of SWD along river left or river right including different species of Christmas tree, or bundles of riparian shrubs such as red osier dogwood (*Cornus stolonifera)* or willow (*Salix sp*.).
5. Install more SWD along the left-bank at the fishway (following removal of the sediment wedge) and upstream beside the former upper hatchery site. This section

of the river is on an inside bend and shallower than many of the existing SWD sites upstream, and may be a preferable rearing area. It should be noted that activities at this location may confound other studies in the river (i.e. 2017 left back light attraction study), and should be deferred until after completion of the study.

6. Existing LWD (blowdown) along the banks should be secured, and may be enhanced through falling of additional large conifers, for long term habitat complexing, due to the limited contributions in this reach from upstream sources.

7 ACKNOWLEDGEMENTS

We are grateful for the financial support for this study from Fisheries and Oceans Canada (DFO) Ecosystem Management and the Fish and Wildlife Compensation Program (FWCP), on behalf of its program partners BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations and public stakeholders. This pilot project was made possible by the commitment and contributions of various DFO personnel from South Coast SEP and Puntledge River Hatchery, and volunteers with the Courtenay and District Fish and Game Protective Association Conservation Committee (CFGA). In particular, we wish to acknowledge M. Sheng, D. Davies, D. Poole, D. Miller, D. Campbell, and L. Terry (DFO), and W. White, P. Savin, R. Roberts, R. Rogers, G. Sawchuck, R. Tickell, F. Clifford, O. Winnig, B. Bell, S. Eggiman, N. Swan, F. Leigh, N. Emory, and M. Graham (CFGA). We would also like to thank Murray's Christmas Tree Farm, the Comox Fire Department and the Courtenay Fire Department for Christmas tree donations, the snorkel survey crew J. Craig, S. Stenhouse and J. Atkinson (BCCF) for collecting data and observations on fry utilization, and to D. Annand (Smit Field Aerodrome) and BC Hydro for providing access to the boat launch site at the river.

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Personal Communication

James Craig, AScT BC Conservation Foundation April 6, 2016.

Appendix 1. Photos

Photo 1. SWD Site #01.

Photo 4. SWD Site #03.

Photo 2. Untreated Site #01 downstream of SWD 01.

Photo 5. SWD Site #04.

Photo 3. SWD Site #02.

Photo 6. SWD Site #05.

Photo 7. SWD Site #07.

Photo 10. SWD Site #10.

Photo 8. SWD Site #08.

Photo 11. Untreated Site #08 upstream of SWD 11.

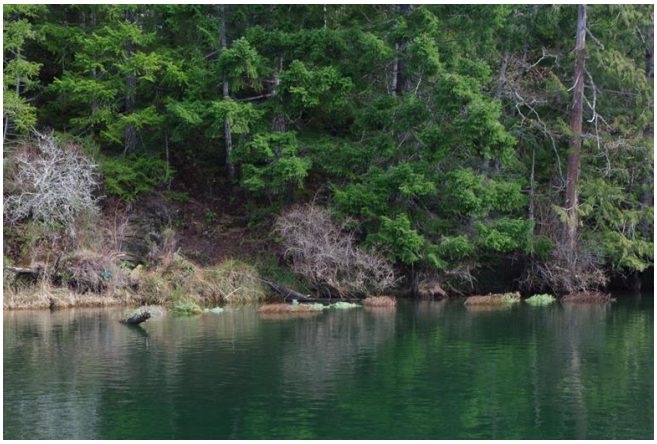


Photo 9. SWD Site #09.

Photo 12. SWD Site #11 in slough on river right.

Photo 13. Volunteers with the CFGA preparing SWD bundles on shore.

Photo 14. Towing completed SWD bundle to receiving site downstream.

Photo 15. Swimmers with BC Conservation Foundation (BCCF) conducting initial daytime snorkel survey at SWD and Untreated sites, 21 Mar 2016.

Appendix 2. Snorkel swim observations in the Puntledge River headpond, 5 April 2016. J Craig (BCCF) email correspondence.

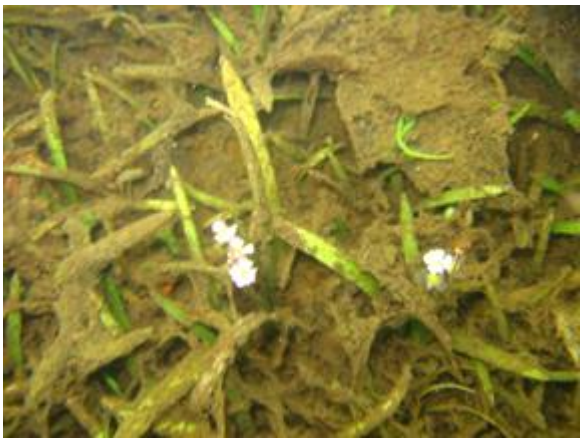
Hi All…some notes from our survey last night (SS and JA should chime in when they get a chance – my observations may not be representative of theirs...):

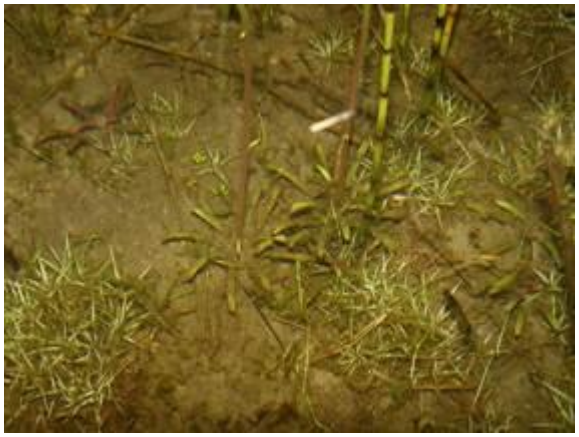
Visibility was good overall, estimated at 5-6 m. Therefore speciation was limited only by the distance that fish could be approached. In general, all species were very approachable, as good or maybe better than any river or estuarine setting I've surveyed. With patience, one could pinch caudal fins and catch individual fry. Approachability allowed for high confidence in picking out coho fry – generally the less abundant species, from Chinook – the more abundant fry. This was true in the first 1 to 2 m of depth – fish observed deeper than 2 m could usually not be identified and were called "unknown fry". Occasionally, a deeper fry would turn and give us a "broadside", allowing a confirmation but this was rare. Snorkelers could easily work together to minimize double-counting.

Access to sites was somewhat challenging at times, depending on the night's discharge and the "stiffness" of overhead cover. Some of the larger and older overhanging veg was pretty solid and did not want to move especially in light of our inability to push hard against water. Makes me wonder about repeatability night to night.

As you're aware, velocities varied significantly from site to site, and even from one "portion" of a site to the "remainder". It was difficult to make detailed conclusions about fish presence or behavior relative to sites and velocities. But on a "macro scale", I observed that Chinook tended to be more commonly in moving water while coho were commonly on the "inside" and particularly against banks (when they were steep or vertical). Chinook were occasionally observed above the bundles (<15 cm from the surface) but more commonly within or below the trees. They were also commonly adjacent to the trees within 1 m. Keep in mind that seeing any fry beyond 3 m straight down was very tough unless they darted (uncommon) – and only then could you possibly distinguish salmon fry swimming behavior at depth from that of TSB.

The most consistent densities of Chinook (up to 1.0/m^2, often 0.5/m^2) that I observed occurred over shallow (0.25-1.5 m), gradual slopes (to 100%, but mostly <1V:4H) of silty loam and small detritus with budding but sparse aquatic vegetation (similar to water lobelia? Photos of similar plants below). This grass-like veg appeared to be in an early grow out stage and ranged from 5 to 20 cm in height. The veg and substrates appeared to have an abundance of aquatic nymphs (mostly Ephemeroptera?) that likely provided a food source (no direct feeding noted but did not have a lot of time to observe). Velocities in these relatively high density areas were lower than I would have expected…<<10 cm/s, but maybe that's the norm in this Headpond reach.. It's so different than a typical river channel as far as microhabitats for early rearing. If the substrate had no veg and was comprised of just mud and sticks, densities were much lower. The right bank slough also had these budding out aquatic plants, and fry were observed there as well but in lower densities than along the left bank.





Overall, the habitat available looked pretty nice and offered an excellent diversity. Because of that diversity, I would not be surprised if it turns out to be difficult to detect significant differences around our "added" habitat. As mentioned above, the treated sites appeared to very "noisy" from a habitat classification perspective…i.e., so many differences in site depth, position, angle front-to-back, substrates beneath, proximity to bank, influence of existing cover, and velocities. Comparing those to the varied characteristics of the Control sites is challenging from the habitat quality perspective.

We also wondered if fish preferred needle-less trees, as opposed to needled. Some of the trees had shed their needles, and we thought we might have observed more numbers there…possibly a preference of being in cover, while at the same time being able to see what's coming?? It may however just be related to the viewability of fish in the 2 types of trees – perhaps we are just seeing fewer in the more dense, needled trees.

Bismarcks showed up well relative to non-marked fry. It would be interesting in following them on the night of release.

In the **middle** sites along left bank (sorry- I don't know site #s), we noted that most of the trees are deeper, associated banks are steeper, thalwegs might be closer to the bank, and velocities were higher. These sites obviously held fewer fish, which I'm guessing the data will show.

The population of freshwater mussels was interesting to see – I'm cc'ing Greg Wilson here in case it's of interest to him.

Amphibs were quite abundant too – we saw lots while we moved from site to site. Definitely *Taricha granulosa*, and at least one *Aneides vagrans*. I think the other guys have seen *Ambystoma gracile* as well.

Probably forgetting a few things but hope this helps. Kevin wouldn't forgive me if I failed to mention PIT tags – there may be an application for them in future in a modified study….

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Appendix 3. Observations from 5 nighttime snorkel surveys in the Puntledge River headpond, 21 March - 25 April 2016.

	Survey 1								Survey 2							Survey 3						
Survey Date/Time:		**3/21/2016 20:50**							**3/24/2016 20:50**							**3/30/2016 20:50**						
Weather:		**Rain/overcast**							**partly cloudy, windy**							**clear**						
Boat Crew:		**DM, PS**							**MS, DD, WW**							**MS, DC, PS**						
Swim Crew:		**SS, JA**							**SS, JA**							**SS, JA**						
Temp:		**6.6**							**6**							**7**						
Site	**Length (m)**	**Wild Chinook**	**Coho Sm**	**Coho Fry**	**Trout**	**TSSB**	**Comments**	**CN Fry/m**	**Wild Chinook**	**Coho Sm**	**Coho Fry**	**Trout**	**TSSB**	**Other**	**CN Fry/m**	**Wild Chinook**	**Coho Sm**	**Coho Fry**	**Trout**	**TSSB**	**Other**	**CN Fry/m**
SWD 01	15	6			20 cm	1		0.40	8		2	1 RBparr; 1 CT		1 sculpin	0.53	3						0.20
UnTr 01	18	5			1 CT parr	1		0.28	5	5	2		3	2 amphib	0.28	2						0.11
SWD 02	9	11					8 CN 3' away added to total	1.22	6		1	1 RB parr	2		0.67	5				1		0.56
SWD 03	11	13				3	8 CN close to bank	1.18	6	2	1		7		0.55	4		2	1 30 cm		1 amphib	0.36
SWD 04	12	2						0.17	2						0.17	1						0.08
SWD 05	7.5	8				2	4 CN near bank	1.07	6						0.80	4						0.53
UnTr 02	15	8						0.53	5						0.33	5		3			1 amphib	0.33
UnTr 03	15	7				1	Originally site SWD 06	0.47	3				2		0.20	4				1		0.27
SWD 07	11	1				1		0.09	2				2		0.18	2				2		0.18
UnTr 04	15	0		1	1 fry	4		0.00	1						0.07	1				1		0.07
SWD 08	13	13				5	1 CN near bank	1.00	8				2		0.62	7				2		0.54
SWD 09	13.4	11		1		1		0.82	12						0.90	8				2		0.60
UnTr 05	15	6	1			6		0.40	3	2	1	1 adult ST	4		0.20	2	1		3 RB parr	10	40 cm CT	0.13
SWD 10	13	9		1				0.69	2				2		0.15	4						0.31
SWD 11	12	4				7		0.33	1				1		0.08	2				1		0.17
UnTr 06	16	15				8		0.94	3				9		0.19	4				3	2 amphib	0.25
UnTr 07	15	0				2		0.00	1				7		0.07	2				8		0.13
TOTAL	**226**	**119**	**1**	**3**		**42**		**0.53**	**74**	**9**	**7**		**41**		**0.33**	**60**	**1**	**5**		**31**		**0.27**
Total SWD	117	78	0	2				0.67	53	2	4				0.45	40	0	2				0.34
Total Untreated	109	41	1	1				0.38	21	7	3				0.19	20	1	3				0.18

Appendix 3 cont'd.

	Survey 4									Survey 5								
Survey Date/Time:	**4/5/2016 21:00**				BB fry released Apr 4, 16:00					**4/25/2016 21:15**				BB fry released Apr 25, 20:00				
Weather:	**Rain/overcast**									**clear**								
Boat Crew:	**DM, WW**									**DM, EG**								
Swim Crew:	**SS, JC**									**SS, JC**								
Temp:	8									10								
Site	**Wild Chinook**	**Dyed CN**	**Coho Sm**	**Coho Fry**	**Trout**	**TSSB**	**Other**	**CN Fry/m**	**Comments**	**Wild Chinook**	**Dyed CN**	**Coho Sm**	**Coho Fry**	**Trout**	**TSSB**	**Other**	**W CN Fry/m**	**Comments**
SWD 01	3	0		1		2		0.20		14	12		6	1 RB ad	1	6	0.93	cottids
UnTr 01	9	0		1		1		0.50		8	17	1	17		1		0.44	
SWD 02	7	0		1		1		0.78		10	6	3	1		4	1	1.11	unknown fry
SWD 03	11	0		3	1 RB, 1 DV 25cm		3	1.00	unknown fry	3	1		4		4	2	0.27	unknown fry
SWD 04	1	0						0.08		1		1				3	0.08	unknown fry
SWD 05	3	1						0.40		1					1	1	0.13	unknown fry
UnTr 02	8	1		2		4	1	0.53	unknown fry				16			3	0.00	unknown fry
UnTr 03	2	0		1				0.13		1			10		1	3	0.07	unknown fry
SWD 07	2	0					1	0.18	unknown fry	2	1				2	3	0.18	unknown fry
UnTr 04	2	0		2		1		0.13					2				0.00	
SWD 08	9	0		1		4	2	0.69	unknown fry						3	1	0.00	unknown fry
SWD 09	3	0				6		0.22		7					1	2	0.52	unknown fry
UnTr 05	2	1	2	1		11	2	0.13	unknown fry	7	1		4		13		0.47	3 amphib
SWD 10	5	0				1	3	0.38	unknown fry	4			1		4		0.31	2 amphib
SWD 11	4	0				3	1	0.33	unknown fry	3					1		0.25	
UnTr 06	4	0				6		0.25		3	1				21		0.19	1 amphib
UnTr 07	3	1				7	1	0.20	unknown fry	7	2				17	1	0.47	unknown fry
TOTAL	**78**	**4**	**2**	**13**		**47**	**14**	**0.35**		**71**	**41**	**5**	**61**		**74**	**26**	**0.31**	
Total SWD	48	1	0	6				0.41		45	20	4	12				0.38	
Total Untreated	30	3	2	7				0.28		26	21	1	49				0.24	

Appendix 4. Confirmation of FWCP Recognition (article in the Comox Valley Record, January 28, 2016).

Conservationists use discarded Christmas trees to help protect fry

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Finding a second use for Christmas trees, a group from the Courtenay and District Fish & Game Protective Association along with members from the Department of Fisheries and Oceans put leftover trees to use Tuesday morning along the banks of the Puntledge River.

Large trees donated from tree recycling programs earlier this month were strung together in groups of around 10 and pulled into the water and tied to nearby trees to provide small woody debris for chinook fry, explained Wayne White, chairman of the conservation committee for the fish and game association.

"The idea is that the fish tend to like hiding in all these little nooks and crannies, especially when the flow is up. We're hoping when they come up out of the gravel they're quite small, and they'll hang out in these trees and grow a bit bigger."

The idea is to attract the fish to the side of the river opposite of where BC Hydro takes its water off into the penstock so they don't enter and get caught on screens, he added.

"The concern is that we would like to get those guys out and grow to big fish," said White. "That's why we're bringing them over to this side but also that it holds them for a little while and they'll get bigger. When they're bigger they'll have enough strength to swim off the screen (if they do get caught)."

The idea was presented by DFO, and the idea to use debris came from other river systems on Vancouver Island such as the Englishman and Cowichan rivers.

The fish are expected to come into the river in February, and White said the group will be monitoring the more than 120 trees in the water.

Strings of Christmas trees were tied to nearby trees along the banks of the Puntledge River, to give the chinook fry a safe haven.

PHOTO BY ERIN HALUSCHAK

While similar projects have worked on other rivers, the idea to use Christmas trees is unique, explained Mel Sheng from the Salmon Enhancement Program of the DFO.

"When the fry emerge out of the gravel, what we think they do naturally is they go to the banks and start migrating downstream looking for habitat to seek cover and potentially rear in those areas before they migrate down to the ocean. We're doing a little test to see if we use Christmas trees if the fish are attracted to them."

He said he hopes the fish will be attracted to the migration corridor and not the penstock, but if they do get diverted into the intake, they will hopefully grow bigger thanks to the woody debris cover to have no problems surviving the screen.

Spots to tie the rows of trees to the banks were chosen based on water velocity.

While the trees ultimately will lose their needles, the group hopes the string of branches can stay in the water providing habitat for the fish up to 10 years.