

# **Assessment of Past Puntledge River Restoration Projects**

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*Prepared for:*

**Fish and Wildlife Compensation Program**

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## **EXECUTIVE SUMMARY**

A monitoring program was implemented to assess the physical and biological performance of past side-channel development and rehabilitation projects in the Puntledge River. The program focused on investigating juvenile use, adult spawning and incubation survival in Powerline, Forbidden, and Bull Island side-channels to determine whether they are continuing to provide stable and high quality spawning and rearing habitat for Puntledge River priority species. This project addresses ‘Research and Information Acquisition’ and ‘Habitat’ based priority actions in the Puntledge River Salmonid Action Plan (BC Hydro 2011) by assessing the efficacy of habitat enhancements undertaken by the FWCP program.

Coho salmon was observed spawning in all side-channels whereas Chinook were counted in Forbidden and Bull Island only, and chum and pink salmon in Powerline only. High discharges and poor visibility during peak spawning impeded surveys and collection of accurate data.

Hydraulic sampling methods were employed to evaluate incubation success in Bull Island and Powerline side-channels. Overall survival at Bull Island was 99% and consistent with expectations that the high quality screened spawning gravels would provide optimum incubation conditions as demonstrated in past studies at this site. Overall survival at Powerline side-channel was 51% possibly due to the greater incidence of fines at this location.

Mark-recapture surveys in the Forbidden (and Wong) side-channel complex were conducted during unseasonably cool conditions resulting in low population estimates compared to biostandards. Total coho population was estimated at 0.18 and 0.14 coho fry/m<sup>2</sup> in Forbidden and Wong side-channels, respectively. Routing monitoring in this side-channel complex is recommended to inspect intake function, beaver activity and fish access during the juvenile outmigration and adult spawning periods.

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## **1 INTRODUCTION**

Between 1984 and 2006, several side-channel development and rehabilitation projects were completed in the Puntledge River to provide stable summer rearing, overwintering and spawning habitat for a variety of salmonids. Although some of these projects pre-date the Fish and Wildlife Compensation Program (FWCP), they have all benefited from FWCP support over the past 15 years, and have had a positive influence on salmonid habitat in the Puntledge River. Several of these projects received additional modifications following their construction to address biological and/or performance issues that were identified through periodic monitoring.

Routine or project effectiveness monitoring is an integral and important component of habitat restoration, providing an evaluation of the overall success and benefit of the work, identify potential maintenance requirements or opportunities for improvement and provide direction for future projects.

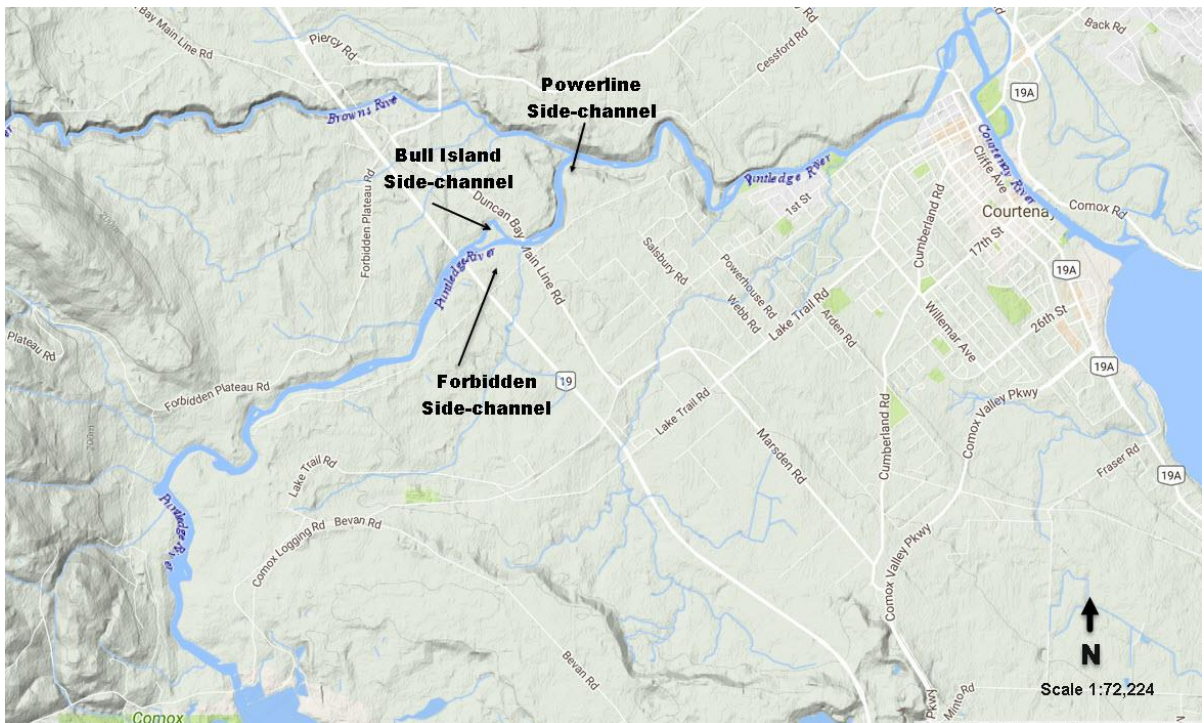
### **1.1 Goals and Objectives**

The goal of this project is to assess the physical and biological performance (juvenile use, adult spawning and incubation survival) of side-channels and restored habitat in the Puntledge River, to determine whether they are continuing to provide stable and high quality spawning and rearing habitat for Puntledge River priority species. The project examined three side-channels that were the focus of past FWCP projects in the watershed - Powerline, Forbidden, and Bull Island side-channels. This project addresses 'Research and Information Acquisition' and 'Habitat' based priority actions in the Puntledge River Salmonid Action Plan (BC Hydro 2011) by assessing the efficacy of habitat enhancements undertaken by the FWCP program.

A secondary objective of the project is to provide opportunity for the K'ómoks Guardian Watchmen program to develop and improve the technical skills in conducting stream monitoring and assessment of salmon populations in the Puntledge watershed, and build capacity within the K'ómoks First Nation for FWCP project management and delivery.

## 2 STUDY AREA

The Puntledge River Watershed encompasses a 600 km<sup>2</sup> area west of the city of Courtenay (**Error! Reference source not found.**). 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.



**Figure 1. Location map of the lower Puntledge River and the three side-channels assessed in 2016/2017.**

The Powerline side-channel is located approximately 8.6 km upstream of the estuary. The channel was originally constructed in 1991 primarily to provide rearing habitat for coho and trout, and limited spawning habitat for pink salmon. In 2003 and 2008, with FWCP support, the channel received improvements to address flow delivery and connectivity issues (Guimond 2004 and 2010). The channel is fed by a screened and open bank intake from the Puntledge River mainstem, and consists of alternating gravel beds

and rearing pools flowing through a mixed second growth forest. The channel is approximately 560 m in length with over 5000 m<sup>2</sup> of rearing and spawning habitat.

Bull Island side-channel is located in Reach C on the north side of the Puntledge River, approximately 9.6 km upstream of the estuary. In 2002-2003, this side-channel was enhanced through the construction of three Newbury-style rock weirs and the addition of 3700 cubic metres of spawning gravel (Guimond and Norgan 2003). The two year project resulted in the restoration of 2,165 m<sup>2</sup> of critical spawning habitat for Chinook (summer and fall run), coho and steelhead.

The Forbidden side-channel was constructed in 2006 to provide spawning and rearing habitat for coho and trout (Guimond 2007). The side-channel ties in with a smaller channel at the HWY 19 overpass on the Puntledge River and extends 550 m downstream discharging into Bevan Creek, at a location 100 m upstream of the confluence with the Puntledge River. Over the past decade, beaver activity converted much of the channel into a series of wetlands that currently provide rearing habitat for coho and trout and are also important for an assortment of other wildlife species.

### **3 METHODS**

#### **3.1 Spawning surveys**

Spawning channel counts started on September 15, 2017 and ran through to December 18, 2017. The method for each survey conducted was by walking the banks and counting the fish by visual confirmation. Many of the dates surveyed were unsuccessful due to very high water in the Puntledge River system and adjoining channels.

The Forbidden Channel had to be cleared of beaver activity on a weekly basis. Without this clearing activity fish would not have had access throughout the channel. Once the clearing was done Chinook and Coho started to enter the system. The salmon were observed by walking both sides of the channel to do the counts. Powerline Channel was difficult to get in and do counts until later in the season also due to the high flows in the Puntledge system. Also turbid water made counts in this channel difficult at times. This

channel was counted by walking one side of the channel as the other bank was to overgrown.

Bull Island held lower than average numbers of Chinook by counts, but this could be a result of high and turbid water making it difficult to get accurate counts. Also it is a small window during the day to get good counts due to glare off the water. It may be a plan for the future to count this channel by drone or swim counts. This channel was counted by taking the walking trail that parallels the channel from top to bottom. It made it difficult to get accurate counts as the channel was not always visible from the trail. Normally a person could walk the edges of the channel but due to inclement weather and high flows this was virtually impossible.

### **3.2 Hydraulic sampling to determine incubation survival**

Hydraulic sampling was conducted in the Bull Island side-channel on 6 January 2017 and in the Powerline side-channel on 2 February 2017. The hydraulic sampling method used to assess incubation survival was a venturi nozzle that injected an air/water mixture into the substrate to dislodge buried eggs/alevins (McNeil 1964). This is powered by a 3.5 hp water pump (Honda WB20XT) that is secured on a floating raft for easy transporting within the channel (Figure 2).



**Figure 2. Hydraulic sampling equipment transported on raft.**



The eggs/alevins are captured in a cylindrical fish screen/net and carefully transferred to trays where they are separated from the small gravel and debris, and the live/dead eggs and embryos from each redd are recorded (Figures 3 and 4).



**Figure 3. Displacement and capture of eggs/alevins from the gravel.**



**Figure 4. Sample of eggs and alevins displaced from a redd.**

A minimum of ~100 specimens should be collected from each redd. After sampling each redd, a hole approximately 30 cm deep was excavated with a shovel near to the site. A 1.2 m length of 50 mm diameter PVC pipe was placed vertically in the hole, and gravel was backfilled around the pipe by foot. The sampled eggs/alevins were returned to the

gravel through the pipe. The pipe was left to stand for a few minutes to allow alevins to settle back into the spaces between the gravel, before removal.

Bull Island was hydraulic sampled from the lowest weir at the confluence on the Puntledge River mainstem to approximately 120 m upstream at the second weir (Figure 5). Salmon redds were identified by areas of clean gravel (compared to surrounding areas) that was usually mounded as a result of the redd excavation activity). Over 30 potential redd sites were identified and sampled but only one third produced embryos (eggs/alevins). Powerline side channel was sampled in the upper 150 m from the outlet of the large settling pond downstream to the riffle/weir complex.

### **3.3 Juvenile overwintering Survey**

A mark-recapture survey was conducted between March 8-10, 2017 in the upper wetland of the Forbidden side-channel, to determine overwintering usage by coho and trout. Due to unseasonably cold temperatures throughout the month, much of the perimeter of the wetland was frozen solid and inaccessible. Fifteen Gee traps were baited with salmon roe and set for 24 hours throughout the upper 100 m of channel (Figure 5; Appendix 2). Gee traps consisted of ¼ inch galvanized mesh with cone shaped funnels on each end. Traps have two parts that hinge and connect together at the center. Traps were checked the following day and all species (salmonids and non-salmonids) were recorded. The salmonid catch from each trap was sedated with Alka-seltzer and fork length measurements were recorded to the nearest mm. Weights were not taken. All coho catches were fin clipped (upper lobe of caudal fin squared off using clipping scissors). After marking and sampling, the catches were released back to the site of capture and the traps were re-set in the same location. The traps were left to soak for another 24 hours. On the final day of recovery, all fish caught were recorded, noting the number of marked and unmarked coho in each trap.

A second mark-recapture survey was conducted in the adjacent side channel downstream of the HWY 19 overpass that was constructed during the highway

development project in 2001 (Figure 5). This channel is referred to as Wong channel (named after the biologist involved in its development). The second mark recapture study was conducted from March 20-22, 2017.



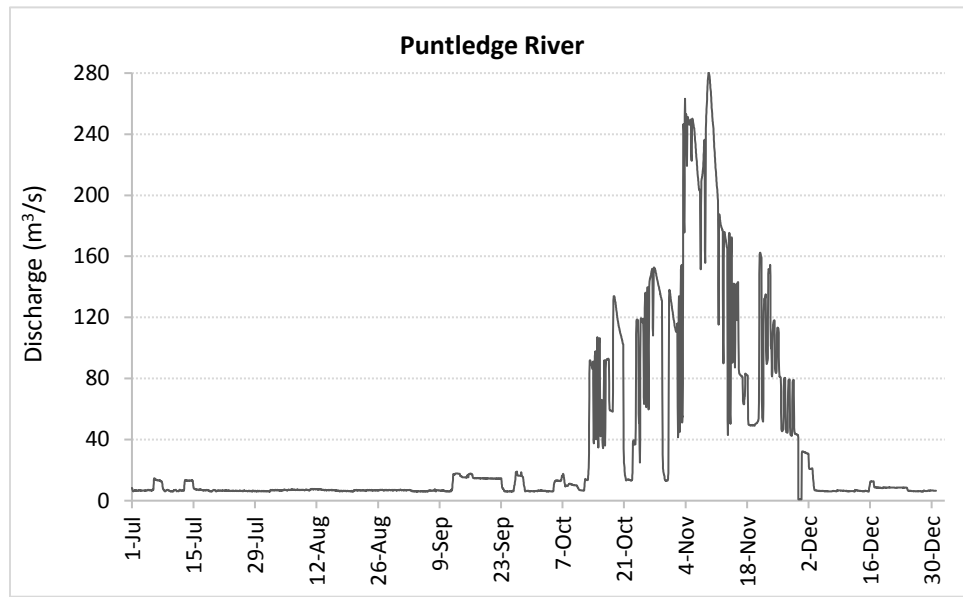
**Figure 5.** Location of Gee trapping (dashed polygons) in the Forbidden and Wong side-channels, and hydraulic sampling in Bull Island side-channel. Flow direction indicated by arrows.

## 4 RESULTS AND OUTCOMES

### 4.1 Spawning surveys

Mean hourly discharge for the Puntledge River Reach C from data records at WSC Gauge No. 08HB084 (BC Hydro Gauge 6) was obtained from BC Hydro Power Records for the period July – December 2016 (Figure 6). Between 1 October and 30 November,

flows in Reach C exceeded 100 m<sup>3</sup>/s 41% of the time, hampering the ability to conduct spawning assessments or obtain accurate data.



**Figure 6. Puntledge River mean hourly discharge for Reach C (WSC Gauge 6) from 1 July to 31 December 2016.**

Total numbers of salmon observed on each survey date are summarized in Table 1. The fish observed in the Forbidden side-channel during the counts were at bottom end of the channel where it enters the Bevan channel up to the wetland, from the wetland to the large pond (middle section), above and below the beaver dam located where the Wong channel starts and in the box culverts under Highway 19.

There were low numbers of Pinks in this channel in September. Once the water receded later in the fall there were large numbers of Chum spread throughout the channel and the forest. Also good numbers of Coho later in the fall after the water receded.

**Table 1. Summary of spawning counts in Powerline, Forbidden and Bull Island side-channels, 2016.**

Powerline Channel 2016					Totals		
Date	Pink	Coho	Chinook	Comments	Pink	Coho	Chinook
Sept 27/16	28	0	0	very few pinks this year	28	0	0
Oct 1/16	28	0	0		28	0	0
Oct 6/16	28	0	0		28	0	0
Oct 13/16	N/A	N/A	N/A	Due to high water unable to count			
Oct 19/16	N/A	N/A	N/A	Due to high water unable to count			
Oct 26/16	N/A	N/A	N/A	Due to high water unable to count			
Nov 3/16	N/A	N/A	N/A	Due to high water unable to count			
Nov 10/16	N/A	N/A	N/A	Due to high water unable to count			
Nov 21/16	N/A	N/A	N/A	Due to high water unable to count			
Nov 29/16	N/A	N/A	N/A	Due to high water unable to count			
Dec 3/16*	0	37	0		0	37	0
Dec 18/16	0	47	0		0	47	0
<b>Totals to year end</b>					<b>28</b>	<b>47</b>	<b>0</b>
Forbidden Channel 2016							
Date		Coho	Chinook	Comments	Coho	Chinook	
Sept 27/16		0	0	Clearing beaver dams for access	0	0	
Oct 1/16		0	4		0	4	
Oct 6/16		2	6	Chinook in Forbidden and Wong channel	2	6	
Oct 13/16		6	6	Coho starting to move but need to keep clearing beaver dams for access	6	6	
Oct 19/16		N/A	N/A				
Oct 26/16		4	14		12	14	
Nov 3/16		N/A	N/A	High water unsuccessful counts			
Nov 10/16		N/A	N/A	High water unsuccessful counts			
Nov 21/16		N/A	N/A	High water unsuccessful counts			
Nov 29/16		6	0	Coho moving into all areas of channel	18	14	
Dec 3/16		6	0		18	14	
Dec 10/16		6	0		18	14	
<b>Totals to year end</b>					<b>18</b>	<b>14</b>	
Bull Island Channel 2016							
Date		Coho	Chinook	Comments	Coho	Chinook	
Same as above dates		6	92	There were only 2 days where we could count fish due to turbid water in the Puntledge River. Oct 6 & 19 were dates that these counts come from.	6	92	

\*Could not get accurate count due to high flows, when water receded, there were large numbers of chum carcasses (>200).

## 4.2 Hydraulic sampling

Results from hydraulic sampling in the Bull Island and Powerline side-channel are detailed in Tables 2 and 3 respectively. Bull Island had an overall survival rate of 99 % whereas the overall survival in Powerline channel was 50%. Unfortunately, obtaining sufficient samples sizes of eggs/embryos (i.e. minimum of 100) from the redds sampled proved to be very challenging. For each redd recorded in Table 2, at least 3 other suspected redd sites were sampled with no or very few (1-2) embryos dislodged. Overall, only 32 eggs/alevins were collected per redd on average. However, very few dead eggs/alevins were displaced during the sampling procedure (Table 2). Conversely, sample collection in the Powerline side-channel was more successful with an average sample size of 128 specimens. Incubation survival in the Powerline side-channel was more variable at the individual redds, but was not correlated with higher fines and organics observed at individual redd sites. Overall average survival rate at Powerline side-channel was 51%. Gravel size/quality was fairly consistent at all sample sites in Bull Island, and highly variable at Powerline with a greater incidence of fines which likely accounted for the lower survival.

**Table 2. Results from hydraulic sampling in the Bull Island side-channel, 6 January 2017.**

Site #	Description	Alevins		Eggs		Total sample	% Live	% Dead
		Live	Dead	Live	Dead			
1	Mid-channel; immediately up/s of	12	0			12	100	0
2	Mid-channel, ~25 m up/s of Site 1	1		26		27	100	0
3	Mid-channel, ~30 m up/s of Site 1	28				28	100	0
4	Mid-channel, ~40 m up/s of Site 1	1		3		4	100	0
5	Mid-channel, ~55 m up/s of Site 1	2				2	100	0
6	Right side, ~55 m up/s of Site 1	9				9	100	0
7	Mid-channel, ~70 m up/s of Site 1	39			2	41	95.1	4.9
8	Left side, ~70 m up/s of Site 1	7		38	2	47	95.7	4.3
9	Mid-channel, ~100 m up/s of Site 1	13		165		178	100	0
10	Left side, ~110 m up/s of Site 1	6				6	100	0
11	Left side, ~just up/s of upper weir	6				6	100	0
	<b>Overall Average</b>					<b>32.7</b>	<b>99.17</b>	<b>0.83</b>

**Table 3. Results from hydraulic sampling in the Powerline side-channel, 2 February 2017.**

Site #	Description	Alevins		Eggs		Fry		Total sample	% Live	% Dead	Comments
		Live	Dead	Live	Dead	Live	Dead				
1	weir crest LB	27	0	81	47	1		156	69.9	30.1	Suspect alevins are CM, eggs are CO, larger alevins PK?
2	weir crest Centre-RB	4	1	29	1	2		37	94.6	5.4	Sm alevins CM, Larger (fry) PK
3	weir crest Centre of channel	8	1	11	9			29	65.5	34.5	Alevins Lg PK?
4	8 m up/s crest Centre-LB	20	1	0	75			96	20.8	79.2	1 alevin killed
5	~20 m up/s Centre channel	0	0	13	55			68	19.1	80.9	29 of the dead eggs were in stream; Higher sediments
6	~20 m up/s Centre-LB	304	7	0	7			318	95.6	4.4	Lots of fines and organics
									<b>60.9</b>	<b>39.1</b>	<b>Ave Survival Lower Section</b>
	<b>Upper Channel Section (UCS)</b>										
7	UCS LB	4	1	273	36			314	88.2	11.8	Better, larger gravel quality
8	Centre channel	30	4	0	140	1		175	17.7	82.3	
9	Centre channel	84	7	15	135			241	41.1	58.9	Low organics, smaller gravels
10	Centre-LB	0	0	0	5			5	0.0	100.0	Decent gravels, poor survival
11	Centre channel	0	0	0	2			2	0.0	100.0	
12	Centre channel ~15m downstream pond	0	0	165	3			168	98.2	1.8	slower V, deeper, higher fines & organics, sm – med gravels
13	Centre Channel furthest upstream	9	1	18	29			57	47.4	52.6	finer gravels, higher fines and organics
									<b>41.8</b>	<b>58.2</b>	<b>Ave Survival Upper Section</b>
	<b>Overall Average</b>							<b>128</b>	<b>50.6</b>	<b>49.4</b>	
<b>Comments:</b>											
Generally, spawning is limited to rehabilitated area at weir and in pockets upstream to outlet of settling pond. Thin layers of gravel over bedrock											
Difficult to identify species, but based on spawn timing and adult observations, eggs more likely Coho, smaller alevins Chum, larger alevins Pink											

### 4.3 Juvenile overwintering

Total catches for the three day mark-recapture survey in Forbidden side-channel are detailed in Table 4. Despite the icy conditions and cold temperatures (3.5 – 4 °C) during the study, a total of 42 coho smolts, and 1 rainbow trout were captured on the first day of recovery. Due to the small number of trout captured, only coho were marked. On the final recovery day 9 marked coho were captured plus an additional 23 unmarked coho, and 2 rainbow trout. Non-salmonid captures consisted of three-spine stickleback on the 2 capture days. Mean fork length (FL) of the coho was 80 mm (range 56 - 130 mm; Table 5).

**Table 4. Results from a Gee-trap mark-recapture survey in the Forbidden side-channel from 8 – 10 March 2017.**

Dates: March 8 - 10, 2017		Temp: 3.5 °C	Temp: 4 °C				Temp: 4 °C					
Day 1 - Set traps (8 Mar 2017)			Recovery - Day 2 Catch (9 Mar 2017)				Final Recovery - Day 3 Catch (10 Mar 2017)					
Forbidden Side-channel Gee Trap Site Description	Trap #	Chainage (approx) from Hwy	Coho		RB	TSSB	Total Catch	Coho				Total
			Coho	RB	TSSB		Mk	Unmk	RB	TSSB	Catch	
Approx. 20 m downstream from highway overpass	1	20	1			1	0	2			2	
Approx. 8 m d/s from Trap 1. Beside a big snag in the water.	2	28	0		1	1	0	0			0	
Approx. 10 m d/s. Just below beaver dam	3	38	0			0	0	0		3	3	
Approx. 10 m d/s. Beside large stump	4	48	0		1	1	0	0			0	
Approx. 10 m d/s. Beside large stump	5	58	1		3	4	0	0		3	3	
Approx. 10 m d/s. Beside large stump and fallen tree	6	68	2		4	6	0	1			1	
Approx. 10 m d/s. Logs in stream beside it	7	78	3		7	10	0	0		3	3	
Approx. 10 m d/s.	8	88	0			0	0	0			0	
Approx. 10 m d/s.	9	98	0		4	4	0	0		1	1	
Approx. 10 m d/s. By a large stump	10	108	5		1	6	1	0			1	
Approx. 10 m d/s. 4 m up/s of a beaver dam at base of dead tree	11	118	9			9	1	5		4	10	
Approx. 10 m d/s. 6 m below the beaver dam	12	128	1	1		2	0	0			0	
Approx. 10 m d/s. Beside a large tree and channel	13	138	5			5	1	2	2		5	
Approx. 10 m d/s. Beside a large stump	14	148	1		1	2	0	1			1	
Approx. 10 m d/s. Beside a large log across the channel	15	158	14			14	6	12			18	
<b>Total</b>			<b>42</b>	<b>1</b>	<b>22</b>	<b>65</b>	<b>9</b>	<b>23</b>	<b>2</b>	<b>14</b>	<b>48</b>	

**Table 5. Size (fork length) of coho salmon captured in Gee traps in the Forbidden and Wong side-channels in March 2017.**

	Forbidden SC		Wong SC	
	Coho	Rainbow trout	Coho	Rainbow trout
<b>Mean</b>	80	98	71	103
<b>Min</b>	56	84	49	67
<b>Max</b>	130	115	103	137
<b>StDev</b>	12.89	15.63	12.69	21.34
<b>Total # (n)</b>	65	3	103	10

A total of 102 coho were captured over the 3 day juvenile rearing survey in Wong side-channel and 23 recaptured (marked) coho (Table 6). Temperatures were slightly warmer than the previous survey (5°C). Mean fork length (FL) of the coho was 71 mm (range 49 - 103 mm; Table 5) and more smaller sized coho fry were caught in Wong



channel compared to Forbidden (Figure 7). Unlike Forbidden, traps were distributed more evenly throughout the channel (Appendix 2).

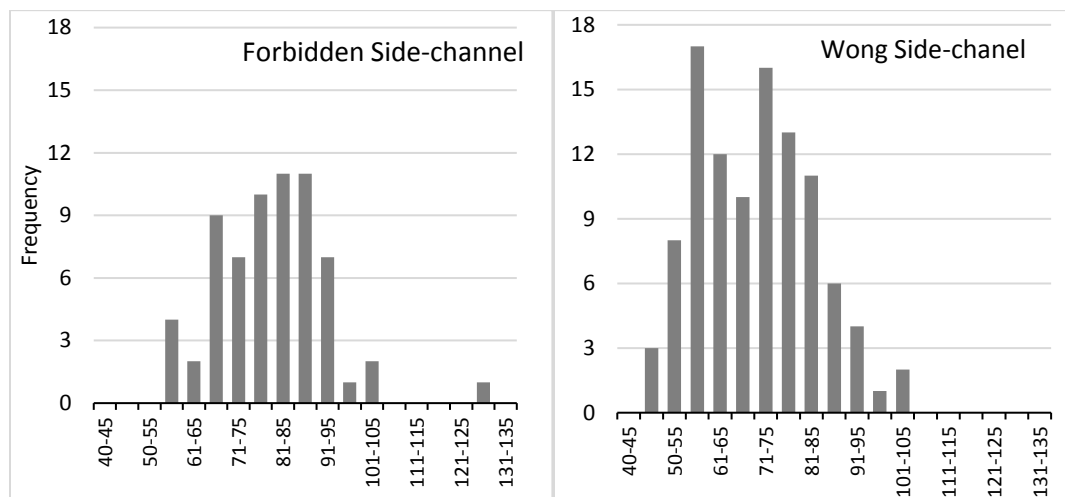


Figure 7. Length frequency histograms for sub-samples of coho salmon captured in the Forbidden and Wong side-channels between 8 -22 March 2017.

Table 6. Results from a Gee-trap mark-recapture survey in the Wong side-channel from 20 – 22 March 2017.

Dates: March 20 - 22, 2017		Temp: 5 °C		Temp: 5 °C		Temp: 6 °C		
Day 1 - Set traps (20 Mar 2017)		Recovery - Day 2 Catch 21 Mar 2017		Final Recovery - Day 3 Catch 22 Mar 2017				
Hwy 19 (Wong) Side-channel Gee Trap Site Description	Trap #	Coho	RB	Total Catch	Coho Mk	Unmk	RB	Total Catch
Approx 10 m up/s of Puntledge River confluence (channel outlet)	1	0		0	0	0		0
Approx. 10 m up/s from Trap 1	2	0		0	0	1		1
Approx 1.5m up/s from Trap 2 just above big log and rock to the right	3	1		1	0	1		1
Left bank where channel breaks into two	4	13		13	0	1		1
Approx 12 m up from Trap#4, left of beaver dam	5	5		5	4	4	1	9
Approx 12 m up just above old beaver dam	6	8		8	2	0		2
Approx 8 m up by a big stump	7	8		8	0	0		0
Approx 10 m up by alder tree	8	4		4	3	1		4
Approx 10 m up by small cedar tree	9	5		5	2	0		2
Approx 12 m up by big cedar tree	10	10		10	2	0		2
Start of the channel beside walk way	11	2	2	4	0	0	1	1
15 m d/s beside mini alder tree	12	0	2	2	0	1	2	3
10 m d/s of Trap 12 by two logs over the channel	13	6	1	7	5	5	2	12
Approx. 10 m d/s from Trap 13	14	15	1	16	1	0		1
Approx. 6m d/s of Trap 14 by big stump	15	10		10	4	1		5
<b>Total</b>		<b>87</b>	<b>6</b>	<b>93</b>	<b>23</b>	<b>15</b>	<b>6</b>	<b>44</b>

### **Coho Juvenile Population Estimate**

The Adjusted Petersen Method (single census) described in Ricker (1975) was used to estimate the population (N) of the channel using the formula:

$$N = \frac{(M+1)*(C+1)}{(R+1)}$$

Where:

N is the estimate of the total population

M is the number of fish marked

C is the catch or sample taken for census (marks + unmarked)

R is the number of recaptured marks in the sample

For the Forbidden side-channel, a total coho population was estimated at 142 individuals. Based on a rough calculation of the representative area that was surveyed (160 m long by 5 m wide), this estimate works out to ~0.18 coho (smolts and fry)/m<sup>2</sup>. For Wong channel, a similar result was obtained, or 143 coho. Expressing this number as fish/m<sup>2</sup> is more difficult due to the expansive habitat flooded by beaver dams. Using the original area of habitat downstream of the box culverts on HWY 19 that was constructed in 2001 (Van Osch and Wong 2001), this works out to 0.14 fish/m<sup>2</sup>.

## **5 DISCUSSION**

The high incubation survival result in Bull Island side-channel was not completely unexpected considering the introduction of high quality screened gravel at this site, and also agrees with previous incubation survival studies using in-situ incubators (Guimond 2006; Guimond and Burt 2007). The poor recovery (i.e. small sample size) of eggs/embryos at Bull Island from hydraulic sampling was also observed previously at this location (Guimond 2006) despite having redds visibly flagged, as well as in other channels where screened gravel has been introduced. The high porosity of the screened gravel may facilitate the dispersal of alevins after hatching. The injection of pressurized water into the gravel may also force the eggs/alevins further into the open crevices of the gravel rather than up to the surface compared to sites with native gravel. The absence of dead eggs,

alevins, yolk in the samples also leads to the conclusion that spawning habitat restoration in Bull Island continues to provide excellent conditions for incubation. Overall incubation survival in Powerline side-channel is slightly lower than the results obtained at this site in 2004 (67%; Guimond 2004), and lower than Bull Island which is expected based on the channel characteristics, discharges and sediment loads. The intake upgrades and large settling pond at the upper end of the Powerline side-channel constructed in 2009 has resolved the problems with sediment and flow delivery issues, and does not yet appear to require maintenance (excavation of settled material).

The estimated juvenile coho population in the two side-channel sites (Forbidden and Wong side-channels) was much lower than the biostandard of 0.67 smolts/m<sup>2</sup> (for side-channels and ponds published by Keeley et al. 1996). However our total coho population estimates are considered conservative due to several factors:

- i. A key assumption with mark-recapture studies is that the population must be closed; fish do not migrate into or out of the area sampled. Stop nets were not used to isolate the surveyed areas. For the most part, in Wong channel, many of the areas were delimited by beaver dams which may have impeded movement within the channel during the brief survey. In the Forbidden channel however, the wetland downstream of the end of the trapping site (~160 m downstream of the HWY 19 overpass) extended for another 150 m to a beaver dam at the former bridge crossing (Figure 2). The average width of the wetland was 35 m (or ~5250 m<sup>2</sup>). Therefore only a small section of the upper channel/wetland complex was surveyed (less than 15%). Much of the perimeter of the wetland was ice covered which may have also influenced fish movement and capture probability.
- ii. The number of traps set was insufficient, largely due to the conditions at the time of the survey (described above). Bryant (2000), found that minnow traps had the greatest effectiveness in mark-recapture population estimation when set at a radius of 2 m, and at higher densities in complex habitats (such as large debris jams) compared to open water.

- iii. Overwintering coho would typically be found in calmer, slower moving water, close to the banks, and/or in association with debris, compared to open channels with higher velocities. Due to the ice cover around much of the Forbidden side-channel wetlands, the majority of traps were placed in the more channelized section at the upstream end where the overwintering population would likely have been lower.

Despite these factors, the results are encouraging, and underscore the value and contribution of this man-made channel for coho production in the watershed. A more thorough and extensive mark-recapture survey using minnow traps under more ideal (i.e. ice-free) conditions would be valuable.

## **6 RECOMMENDATIONS**

A routine monitoring and maintenance schedule for the Forbidden side-channel should be implemented to inspect the intake, beaver control pipes and beaver activity during critical times of the year. The intake should be inspected following freshet flows, particularly when higher debris loads may be expected. If the intake appears to require more regular maintenance to address plugging issues, redesigning the intake with a self-cleaning (louvre style) screen, similar to the Powerline side-channel may be an option. Beaver control pipes and beaver activity should be inspected during the coho outmigration and adult spawning periods (April/May and October-December) to ensure access for juveniles and adults is not impeded. At the minimum, conducting annual spawning surveys in the 3 side-channels would be valuable for monitoring yearly variations in utilization, species diversity and distribution of spawners.

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**Appendix 1 - Photos**



**Photo 1. Forbidden side-channel intake at Puntledge River, upstream of HWY 19.**



**Photo 2. Beaver pipes installed at the upstream end of Forbidden side-channel to maintain flow.**





**Photo 3. One of several small beaver dam in Forbidden side-channel.**



**Photo 4. Opening beaver dam to provide temporary adult access upstream during spawning period.**





**Photo 5. Example of a beaver pond level control pipe for possible future installation at Forbidden side-channel (photo credit M. Sheng).**



**Photo 6. Lower section of Bull Island side-channel hydraulic sampled in January 2017. Note mounded gravel from Chinook spawning activity.**

**Appendix 2. Sketch of Gee trapping locations in Forbidden and Wong side-channels, 8-22 March 2017.**

