Wahleach Project Water Use Plan

Channel Stability Assessment

Implementation Year 07

Reference: WAHMON-1

Lower Jones Creek Fish Productivity Monitoring

Study Period: 2011-2012

Greenbank Environmental Services
Living Resources Environmental Services

October 2012

Lower Jones Creek Fish Productivity Monitoring
WAHMON#1 Year 7 2011-2012

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Executive Summary

As required by the Wahleach Water License, BC Hydro has been overseeing a fish productivity monitoring program in Lower Jones Creek since 2005. The objectives of the monitoring program are outlined by the Consultative Committee (CC) of the Wahleach Water Use Plan (WUP).

The primary focus of the monitoring program is to examine the impacts of WUP CC recommended CC minimum flow release targets on Lower Jones Creek fish productivity. Specifically, in the Fall of 2005 new minimum flow targets were implemented requiring maintenance of fall spawning, and incubation/rearing flows of 1.1 m3/s (September 15 to November 30) and 0.6 m3s for the remainder of year. The fish productivity monitoring program has focused on the central question to be addressed as outlined in the approved terms of reference*:*

Will the operational changes to the flow regime of Lower Jones Creek improve fish productivity as defined by the productivity indices outlined in the WUP.

This document examines all data collected during year 7 of the projected 10-year monitoring program. The goal of this interim report will be to summarize data collected during the fall adult escapement period for pink, chum and coho salmon as well as salmon fry outmigration data gathered from March – May. Adult escapement and spawning was monitored from September 5, 2011 to December 12, 2011. Other factors were examined such as; flow, temperature, substrate, water quality and channel morphology in an effort to determine which most influence spawning success and egg-to-fry survival.

For the 2011-2012 survey period the escapement estimate for adult pink salmon was 7569, chum escapement for the 2011 survey period was 92 and coho escapement was estimated at 2.

A total of 20,149 pink fry were captured during the trapping period, which translates to an out-migration population estimate of 119.249 (these results represent the largest capture and population estimate for pink salmon fry to date). A total of 368 chum fry were captured during the trapping period, which translates to an out-migration population estimate of 2301. The preliminary egg-to-fry survival estimate for pink salmon is 2.24% and for chum salmon 1.98%. This compares to a post-WUP mean 2.25% for pink salmon and 1.59% for chum.

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1.0 Introduction

The Wahleach Water Use Plan (WUP) submitted to the Provincial Comptroller of Water Rights in December of 2004 was implemented by BC Hydro in January of 2005. The conditions of the WUP defined minimum flow targets (1.1 $m^{3}s$ from September 15 to November 30 and 0.6 $m^{3}s$ during the rest of the year), physical works and monitoring programs.

The component of the monitoring program examined in this report is fish productivity within the anadromous section of Lower Jones Creek. Specifically, this program has monitored annual escapement and egg-to-fry survival of pink and chum salmon. Coho and steelhead escapement and smolt production were also included in this monitoring program, however their use of Lower Jones Creek is very limited and they are only briefly discussed in this report.

The monitoring program is expected to run for 10 years and the results have been reported annually since 2005. There was also four years of baseline data gathered from 1999- 2004 (pre-WUP). This report is the Year 7 interim review and a final review will take place in Year 10 (2014). Both reviews will examine annual fish productivity and trends over the duration of the monitoring period that will help to answer the key management question.

The study area includes the lower 1.2 km of Jones Creek from its confluence with the Fraser River upstream to the cascade above the Laidlaw Road Bridge, which is a barrier to upstream fish passage. (Figure 1) The key management question as outlined in the fish productivity monitoring Terms of Reference (TOR) is:

Will the operational changes outlined in the amended Wahleach Water License result in increased productivity for anadromous and resident fish populations in Lower Jones Creek?

With respect to this question, the main objective of the fish productivity monitoring study, as presented in this report, are:

Adult Escapement:

1. To provide an accurate estimate of returning adults to Lower Jones Creek.

2. To determine the distribution and density of spawning salmon within Lower Jones Creek.

3. To monitor stream discharge and document the effects of the variable discharge on channel morphology and the potential implications to spawning success.

4. To monitor water quality and water temperature to determine if these factors may influence spawning success.

Fry Outmigration:

1. To provide annual estimates of the out-migrating fry population from lower Jones Creek.

2. To provide annual estimates of egg-to-fry survival based on potential egg deposition estimates from each years escapement and total fry out-migration estimates.

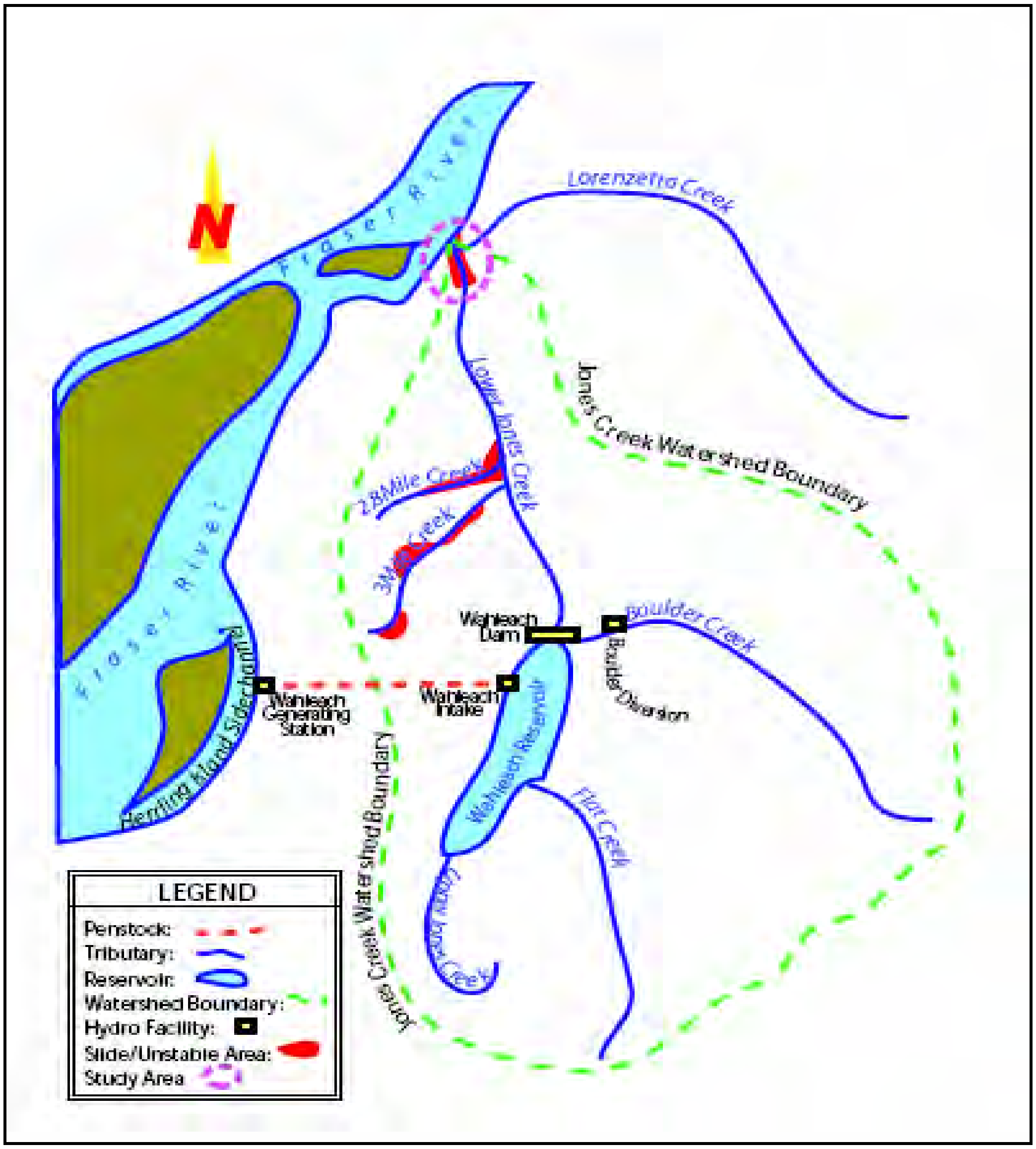

Figure 1 Map showing Wahleach system and Lower Jones Creek location

1.1 Site description

Jones Creek is located 30 km west of Hope, British Columbia. The Wahleach Dam is located on Jones Creek approximately 8.5 km upstream of its confluence with the Fraser River. The Wahleach Dam impounds Jones (Wahleach) Lake reservoir which receives water from upper Jones Creek and a number of other inflow sources. The reservoir provides flow to the Wahleach Generating Station (WAH GS) which is located on the Fraser River downstream of the Jones Creek confluence (Figure 1). Lower Jones creek flows are provided mainly from tributary inflow and surficial runoff from areas downstream of the Wahleach Dam, although additional flows can be provided via a siphon from the Wahleach Reservoir as well as a water diversion structure at Boulder Creek. Both of these sources are used by BC Hydro to meet the lower Jones Creek minimum flow targets during low flow periods.

The lower Jones Creek area is characterized as a highly mobile gravel fan which is unstable and prone to regular shifts in channel location (Hartman, G.F. and M. Miles. 1997). In addition, significant amounts of fine materials are mobilised from upstream areas and are deposited in the lower Jones Creek area. This leads to gravel compaction and channel instability. The channel instability and stream bed scour are thought to be major factors in low egg-to-fry survival in Lower Jones Creek.

An artificial spawning channel for pink and chum salmon was constructed at the lower end of Jones Creek in 1953-54 (Figure 2). Pink and chum salmon fry out-migration studies conducted between 1954-1981 during the operation of the spawning channel, estimated mean annual chum fry production at 71,100 (range 1,700 to 253,600) while odd-year pink salmon fry production from the channel was estimated at 747,000 (range 145,000 to 1,500,000). The average egg-to-fry survival for chum over the same period was estimated at 34.6% (range 13.5% to 85.0%) while the average for pink was 37.7% (range 8.5% to 79.1%) (Fraser and Fedorenko 1983). The spawning channel was decommissioned after it was severely damaged by two landslides in 1993 and 1995. Historical information regarding spawning in Jones Creek prior to spawning channel construction is summarized in Hartman and Miles (1997).

A large bin-wall weir, located 300 m upstream of the Fraser River was constructed to divert returning spawners into the artificial spawning channel during its operation. The diversion weir remained in place after the channel was decommissioned and prohibited fish passage into upstream areas until 1998, when a small channel was excavated around the downstream diversion dam. This allowed fish to access an additional 650 m of linear habitat (or approximately 6000 m_2 of spawning habitat) in lower Jones Creek to the location of the upstream weir which was constructed to provide intake water for the spawning channel. Both of the weirs were removed by BC Hydro in August 2004, extending access to the remaining accessible anadromous habitat in Lower Jones Creek (an additional 500-600 square metres of spawning habitat, identified as Section 4 in this report, see Figure 2).

The study area includes the lower 1.2 km of Jones Creek from its confluence with the Fraser River to the natural barrier to anadromous fish located just above the Laidlaw Road Bridge (Figure 2). The study area also includes a portion Lorenzetta Creek which is a low gradient tributary to Jones Creek with slough-type characteristics in most areas. Recent enhancements have provided suitable spawning habitat in the lower 100 m of Lorenzetta Creek which is the most productive area for pink and chum salmon. Coho salmon also spawn in the lower area but utilize intermittent spawning habitat in upstream areas. Most of Lorenzetta Creek provides good rearing habitat for coho and resident trout species.

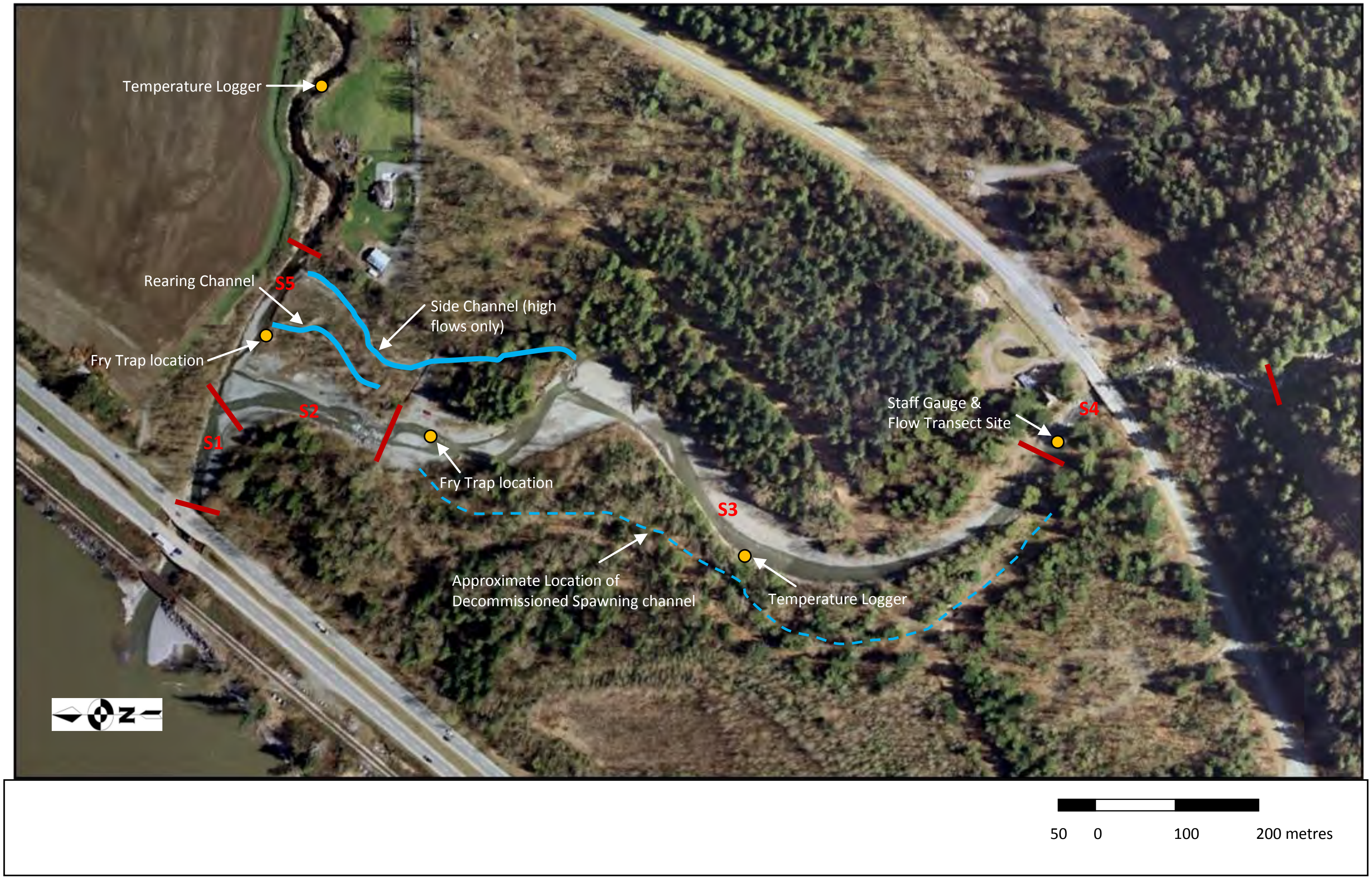

Figure 2 Lower Jones Creek study area

Figure 3 Lower Jones Creek. Showing the location of all transect cross sections.

2.0 Methods

2.1. Adult Enumeration

Ground surveys were undertaken by a crew of two people walking in an upstream direction. The survey was started at the Fraser River confluence and extended up to the barrier to fish migration. Lower Jones Creek was divided into 4 sections (Figure 2) and counts were maintained separately for each section. The four survey sections are:

- Section 1: Fraser River confluence to Lorenzetta Confluence (80m)
- Section 2: Lorenzetta confluence to boulder riffle (110m)
- Section 3: Boulder riffle to hydrometric station (565m)
- Section 4: Hydrometric station to barrier (180m)

The lower section Lorenzetta Creek, from its confluence with Lower Jones Creek to the DFO spawning platform approximately 190 m upstream (Section 5) was also surveyed.

The crew members were on opposite sides of the creek and remained in continuous communication with each other to ensure as many fish as possible were observed and to avoid duplicate counts of individual fish. Fish were identified to species and live fish were counted as either holding or actively spawning. Carcasses were identified to species, enumerated and above the high water mark to avoid counting more than once. Counts were conducted once or twice weekly from September 5, 2009 to December 15, 2009.

An observer efficiency was estimated for each of the ground surveys. The observer efficiency is a qualitative assessment based on flow conditions and water clarity and provides an estimated efficiency for the days count. For example, an observer efficiency of 75% estimates that 75 % of the fish present on that day are counted and the count is expanded by that fraction in the AUC method.

Section 5 (Lorenzetta Creek) was extended significantly during the coho migration and spawning period. This was to better estimate the actual number of coho migrating through Lower Jones Creek and to determine the total distribution of this coho population.

2.2 Adult Enumeration Data Analysis and Escapement Estimates

The escapement model consists of two main elements: i) a simple process model predicts the number of fish present on each day of the run and the departure schedule based on the total escapement and parametric relationships simulating arrival timing and survey life, and ii) an observation model simulates the number of fish counted on each survey based on the predicted numbers present and detection probabilities. With the AUC method, uncertainty (i.e., 95% confidence intervals) in escapement estimates is not generally quantified (English etal. 1992). Methods for doing so have been suggested in cases where estimates of survey life and observer efficiency are obtained in addition to count data (Korman et al. 2002), but since these data were not collected in Jones Creek, we do not report 95% confidence intervals for escapement estimates.

2.2.1 Process Model

To estimate total escapement from repeat count data, the proportion of the total run present on each survey day must be determined. This can be calculated by estimating run timing parameters that describe the cumulative proportion that has arrived and departed for each model day, which forms the process model. In the description that follows, note that lower case Arabic letters denote either model array indices (subscripts) or data, upper case Arabic letters denote state variables (variables predicted by the model), and Greek letters denote variables that are estimated (parameters).

The proportion of the total escapement entering the survey area on day 't' (PA_t) of the run is predicted by a beta distribution,

(2.1) $PA_t = \phi_t^{\tau-1}(1-\phi_t)^{\beta-1}$

where, τ and β are parameters of the beta distribution and ϕ_t represents the proportional day of the run for day *i*, ranging from 0 to 1, on the assumed first (*t*=1) and last (*t*=*T*) day, respectively. τ is the precision of run timing with smaller values representing a low and constant rate of arrival over the duration of the run, and larger values representing a shorter and more concentrated arrival timing. The maximum length of the spawning period for chum and pink was constrained to 66 days (September 1- November 5) and 92 days (September 5- December 5), respectively. The beta distribution is reparameterized so that β is calculated based on estimates of the day when the peak arrival rate occurs (μ) and the precision of arrival timing, using the transformation:

$$\beta = \frac{\tau - 1}{\frac{\mu}{T}} + 2 - \tau$$

For Pacific salmon, survey life, the number of days a fish spends in the survey area, is normally longer for fish that arrive earlier in the spawning period (Perrin and Irvine 1990; Su *et al.* 2001). Survey life was modeled such that it varied with day of entry into the spawning area, but did not vary among years. Survey life was predicted using a decaying exponential relationship,

$$SL_t = \lambda_c e^{-\lambda_s t}$$

where SL_t is the mean survey life for a fish entering on day t, λ_c is the maximum mean survey life, and λ_s is the slope of the relationship. The mean departure day for a fish arriving on day t is simply $d_t = t + SL_t$. Constants of 15 days were used for λ_c, and 0.006 for λ_s for both pink and chum salmon.

The proportion of fish that arrive on day t and depart on day tt is predicted from a normal distribution with mean d_t and standard deviation σ_t,

$$PAD_{t,tt} \sim Normal(tt, d_t, \sigma_t) \quad (2.4)$$

It was assumed that error around the date of entry-mean survey life relationship is lognormally distributed, thus $\sigma_t = \lambda_v * SL_t$, where λ_v is the coefficient of variation in mean survey life. PAD values are standardized so that proportions across all departure days for each arrival day sum to 1, that is, all fish must exit the survey area by the assumed last day of the run. As a fish can obviously not depart before it arrives, $PAD_{t,tt} = 0$ for tt < t. The proportion of fish departing on each day (PD_t) is computed from,

$$PD_t = \sum_t PA_t * PAD_{t,tt} \quad (2.5)$$

Note that departure timing depends on both arrival timing and the survey life relationship that defines PAD. Finally, the number of fish present in the survey area on each day (U_t) is the product of the total escapement (E) and the difference between the cumulative arrivals and departures on that day,

$$U_t = E\left[\int_1^t PA - \int_1^t PD\right] \quad (2.6)$$

The difference between the cumulative values of PA and PD on any date represents the proportion of the total run that is present.

2.2.2 Observation model and estimation of model parameters

Escapement (E) and arrival timing parameters (μ, σ), and those defining observation process are jointly estimated by assuming that the count data arise from an overdispersed Poisson distribution with accounts for the extra variation associated with the nonrandom distribution of fish on any survey (e.g., clumping),

$$n_t \sim Poisson(N_t \theta_t e^{\varepsilon_t})$$

where, n_t is the total number of fish counted on day t, θ_t is an estimate of the survey-specific detection probability (i.e., uncorrected guess made by the surveyor), and ε_t ⍰$_t$ is a survey-specific deviate used to model overdispersion in the data (McCarthy 2007, Royle and Dorazio 2008)). ε_t ⍰$_t$ is drawn from a normal distribution with a mean of 0 and a precision τ.o (i.e., ε_t~dnorm(0,⍰τ.o) where σ.o=τ.o$^{-0.5}$). The term "~" denotes that the value to the left of the term is a random variable sampled from the probability distribution defined on the right. This equation is often referred to as the likelihood component of the model because it describes the likelihood of the data given the parameter values.

2.3 Channel Morphology and Spawner Density

Channel morphology was monitored during all post-WUP study years. Channel width measurements were taken at a number of established transect locations in each study section. Multiplying the average wetted channel width by the length of the section allowed us to estimate wetted area for each study section. This assessment was completed a minimum of five times over each spawning and incubation period. The average total area by section during the spawning period was used to estimate spawner density. This procedure also allowed us to determine if channels were shifting location or if wetted area was changing over time. Although the channel measurements were influenced by different flows on each measurement day, this procedure allowed a rough assessment of spawning area availability over time and channel shifting. The wetted area calculations were also used to estimate spawner density within each study section. Spawner density was calculated by applying the percent distribution of total live counts for each section to the estimate of total escapement for each species. This was considered a better approach than calculating escapement estimates for each section due to the uncertainty in fish movement during the spawning period. Other environmental information collected during each of the surveys included:

- Staff gauge reading and discharge measurements at the upstream weir (Discharge was directly measured with a flow-transect)
- Water visibility/clarity was visually estimated and recorded as an observer efficiency during each ground survey.
- Current weather conditions were recorded.
- Hourly water temperature was collected continuously at two locations (Jones Creek at the upstream weir and Lorenzetta Creek) with Onset TidBit thermistors.

Additional fluvial geomorphologic data is collected in odd (pink) years by Northwest Hydraulic Consultants (NHC 2008, 2010). This data is used to further investigate the potential impact of channel migration, scour and sedimentation on fish productivity.

2.4 Fry Trapping

Annual fry trapping was undertaken using a modified fyke-net and live-box downstream migrant trap. This work was completed under a DFO scientific fish collection permit (Licence No. XR 40 2012). The trap consists of a 6mm mesh fyke-net with 7 m wing panels funneling to a 1 m^2 opening at the cod end (See Appendix 6 for trap images). Additional panels were added or removed during the course of the studies to improve trap efficiency when possible or to prevent damage to the trap during high flow events. The net panels were anchored to the substrate using 5/8 inch rebar secured via cedar bracing poles. The cod end funneled to an 8 inch diameter PVC pipe attached by two steel pipe clamps. The 7.4 m PVC pipe discharged directly into a 0.75 x 1.4 x 1.0 m welded aluminum livebox.

A mesh baffle served to reduce turbulence in the box and also provided the fry with separation from predators that may have also been captured. Fry trapping was not possible at the furthest downstream extent of Lower Jones Creek due to inundation of the Fraser River, which generally occurs about half way through the outmigration period. To avoid inundation of the trap, it was installed at the downstream end of Section 3 (Figure 2) at a level higher than the Fraser River local flood elevation.

A single-trap configuration was used and efficiencies under all trap configurations were tested with mark-recapture tests. The trap fished continually for the entire migration period with the exception of 5 days when high water levels damaged the traps or clogged the intake. The traps were cleaned of debris several times daily. Fish were generally counted once in the morning and again at the end of the day.

All efforts were made to keep the traps fishing as efficiently as possible, with slight adjustments sometimes necessary to ensure that maximum efficiency was maintained. An additional trap was employed in Lorenzetta Creek to capture additional fry for use in the mark-recapture tests at the Jones Creek trap. This trap was similar in design to Lower Jones. It employed the same PVC pipe, though shorter at 4.5 m in length, with a cod end of 0.5 m^2. The wings were also smaller, extending only 5m from the conduit opening. This trap operated from the middle of March to when the Fraser River inundated the area (April 20 this year). Mark-recapture experiments were not undertaken on Lorenzetta Creek since it is not possible to trap the entire outmigration period and it is outside of the influence of the Jones Creek flow regime. No fry from Lorenzetta were used in mark-recapture tests this year as sufficient numbers were available from Lower Jones Creek.

Fry were transferred from the traps to plastic buckets and moved streamside for processing. Fry were identified to species and enumerated while ensuring that marked fry were identified and enumerated separately. Unmarked fry were often held in covered 20 L buckets until they were required for a mark-recapture test. All adults and smolts captured were transferred to buckets, measured and immediately released downstream.

In 2012, 11 marked releases were undertaken during the out-migration to determine catch efficiencies. Fry were marked by immersion in a dilute solution of Bismarck Brown Y dye (concentration 1:100,000) for approximately 90 minutes. Marked fish were held for a minimum of 4 hours prior to release to ensure survival and good condition. The condition of all batches of marked fry was assessed before being released and those dead or moribund were removed from the calculation. Fry were released between 19:00 and 22:00 hours, at a location approximately 600 m upstream of the trap (Figure 2). Fry were released at dusk or in the dark to mimic natural emergence and migration behaviour and to provide maximum cover from predators during migration.

2.5 Fry Population Estimates

Numbers of chum and pink smolts passing the downstream trapping site were estimated using a maximum likelihood (ML) model developed by Darroch (1961) and modified by Plante (1990) for stratified, mark-recapture data. Smolts captured at downstream traps in either Jones Creek or Lorenzetta Creek, marked with Bismark Brown Y dye, and then released upstream of the Jones Creek trap (Figure 2), constituted "marked populations", and smolts recovered at the Jones Creek trap represented the "recovery sample". With stratified mark-recapture methodology, both the marking and recovery samples are stratified. All smolt population estimates and 95% confidence intervals were computed from the collected, mark-recapture data using the software package, Stratified Population Analysis System (SPAS) (http//www.cs.umanitoba.ca/~popan/). A description of the ML estimator and the use of the SPAS software is provided by Arnason *et al.* (1996).

The number of marking and recovery periods was set to equal the number of marked batches released. The midpoint for each recovery period was defined as the date when the mark group was released. It was necessary to pool strata (mark and recovery periods) to avoid small sample and numeric problems that may prevent the maximum likelihood iterations from converging. When pooling strata, we followed the recommendations of Arnason *et al.* (1996). If numbers of marked and recaptured smolts in the majority of strata were too low to use the stratified estimator, data from all marking and recovery periods were pooled and the standard, pooled Petersen estimator for unstratified data were used (see Arnason *et al.* 1996 and for a discussion of the problems associated with pooling sparse data).

The stratified mark-recapture model used to estimate fry abundance allows for the proportion of marked fish and trapping efficiency to vary over time, but assumes the population is closed (i.e., the trapping period overlaps the entire migration period) and that capture efficiency is equal for marked and unmarked fish. The number of pink and chum fry captured at the beginning and end of the trapping period was either zero or very low relative to numbers captured during the peak of migration, suggesting that the assumption of population closure was reasonably well met. We assumed 100% mark retention and 0% marking-induced mortality, but we did not attempt to evaluate this. With respect to the assumption of equal capture efficiency for marked and unmarked fry, we assumed marking did not change CE at the trap, but we did not test this directly.

Fry have been taken from Lorenzetta Creek in most years to augment fry numbers from Jones Creek for the mark-recapture tests, however, in 2012 this was not required as there were sufficient numbers of fry captured in Lower Jones Creek to provide for all mark recapture tests.

2.6 Egg-to-fry survival

For egg-to-fry survival estimates we divided the total fry production by the potential egg deposition for each species. Potential egg deposition was calculated multiplying the number of females spawning above the trap site by their fecundity. The number of females was estimated based on the assumption of a 1:1 sex ratio while we used a literature based fecundity estimate for both species. An average fecundity of 1,600 eggs per female for pink and 2,765 eggs per female for chum was taken from Banford and Baily (1979).

3.0 Results Adult Escapement

3.1 **Pink Salmon Adult Escapement**

The first observation of pink salmon was on September 8, 2011 when 3 fish were observed (Table 1). Numbers increased throughout September until the peak count of 5946 adult pink salmon was observed on September 24, 2011. The last observation of pink salmon was on October 23, 2011 when a total of 26 were counted. Carcass recovery was completed during each of the field surveys. Excluding Lorenzetta, a total of 3397 carcasses (1051 male, 2346 female) were recovered throughout the escapement period (Appendix A). The peak carcass count of 2559 occurred on October 8, 2011, which was fourteen days following the peak live count. The peak count in Lorenzetta was 157 adults on September 24, 2011.

Table 1 Daily adult pink observations in Lower Jones and Lorenzetta Creek by survey date and section.

	Lower Jones Creek				Jones	Lorenzetta
Date	**S1**	**S2**	**S3**	**S4**	**Total**	**S5**
8-Sep-11	0	0	3	0	3	0
14-Sep-11	5	3	464	212	684	11
18-Sep-11	27	224	3026	262	3539	22
24-Sep-11	81	284	4924	500	5789	157
30-Sep-11	156	704	4525	274	5659	98
4-Oct-11	40	337	2981	375	3733	11
8-Oct-11	64	219	1313	194	1790	38
13-Oct-11	2	30	233	29	294	9
18-Oct-11	1	9	48	5	63	9
23-Oct-11	0	4	17	2	23	3
Distribution	**1.7%**	**8.4%**	**81.3%**	**8.6%**	**100%**	

For the estimate of total escapement we have excluded the counts from Lorenzetta since those fish are not directly subjected to the flow regime of Jones Creek. Applying the day specific counts to the model described above (Section 2.2) results in an escapement estimate of 7569 pink salmon. This assumes a maximum survey life of 24 days, with the mean observer efficiency assumed to be 0.80 and the slope of survey life relationship = 0.018, CV = 0.65; (see Decker et al. 2011). The escapement estimate of 7569 pink salmon is the second highest since surveys were initiated by BC hydro in 1999 (Table 2).

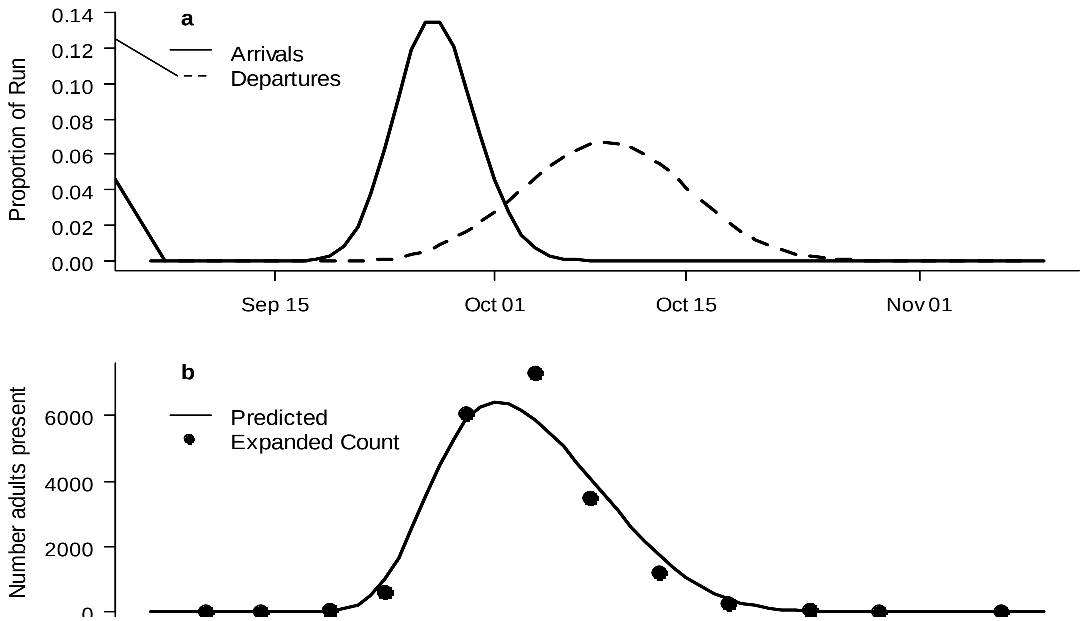

Figure 4 Predicted 2011 pink salmon arrival and departure timing (A), predicted numbers present and observer counts expanded by observer efficiency (B).

Table 2 Pink spawning distribution by section and escapement 1999-2011. Section 1 and 2 were combined from 2001-2004, section 4 was made accessible in 2004. Percentages in S5 are presented for information only and reflect the share of total adult spawners *if*, S5 counts were included with Lower Jones escapement.

Year	S1	S2	S3	S4	S5	Esc. Est.
1999	n/s		n/s	n/s	n/s	1380
2001	15%		85%	n/a	n/s	4432
2003	10%		90%	n/a	n/s	2489
2005	4.5%	15.4%	27.7%	52.4%	*(26.7%)*	212
2007	0.8%	3.3%	78.2%	17.7%	*(1.8%)*	3167
2009	0.6%	4.2%	85.0%	10.0%	*(2.2%)*	7820
2011	**1.7%**	**8.4%**	**81.3%**	**8.6%**	***(1.6%)***	**7569**

n/a = not accesible n/s = not surveyed

The majority of pink spawning activity in Lower Jones Creek (81.3%) was observed in Section 3, which holds approximately 75% of all the available spawning area in Lower Jones Creek, (Table 7 & 2). Sections S4 (8.6%) and S2 (8.4%) had the next highest levels of activity (Table 2).

An index of adult spawning density in Lower Jones Creek was calculated by applying the percent distribution (Table 2) for each section to the estimate of total escapement (7569 pink), and comparing it to the average area of available spawning habitat throughout the escapement period (Table 7). Within Lower Jones Creek, Section 4 had the highest spawner density with 1.22 fish/m2 (Table 3). The density for all of the Lower Jones Creek survey area was 0.89 fish/m2, nearly one fish per square metre.

Table 3 Lower Jones Creek adult pink spawning density by section 2011

Year	s1	s2	s3	s4	Total
2005	0.01	0.04	0.01	0.27	0.04
2007	0.03	0.11	0.30	0.89	0.29
2009	0.13	0.43	1.05	1.45	0.96
2011	0.16	0.85	0.96	1.22	0.89
Mean	0.08	0.36	0.58	0.96	0.55

3.2 Chum Salmon Adult Escapement

The first observation of chum salmon was on September 18, 2011 when 1 fish was observed (Table 4). Numbers continued to increase slowly throughout October until the peak count was observed on November 2, 2011 with a total of 35 adult chum. Three chum were observed in Lower Jones Creek on November 25, 2011 and none were observed on subsequent surveys. Carcass recovery was minimal as a grand total of only 13 were recovered. Lorenzetta Creek was accessible to chum salmon during the entire escapement period. The peak count in Lorenzetta was 18 chum adults on November 2, 2011.

For the estimate of total escapement we have excluded the counts from Lorenzetta since those fish are not directly subjected to the flow regime of Jones Creek. Applying the day specific counts to the model described above (Section 2.2) results in an escapement estimate of 92 chum salmon. This assumes a maximum survey life of 18 days, with the mean observer efficiency assumed to be 0.80 and the slope of survey life relationship = 0.006, CV = 0.65; see Decker et al. 2011). The escapement estimate of 92 chum salmon is the second smallest since surveys were initiated by BC hydro in 1999 (Table 5).

Table 4 Daily chum observations by section. Distribution by percent is calculated using Lower Jones Creek numbers only.

	Lower Jones Creek				Jones	Lorenzetta
Date	**S1**	**S2**	**S3**	**S4**	**Total**	**S5**
18-Sep-11	0	0	1	0	1	0
24-Sep-11	0	0	3	0	3	0
30-Sep-11	0	0	2	0	2	0
4-Oct-11	0	1	3	0	4	0
8-Oct-11	0	1	4	0	5	2
13-Oct-11	0	0	4	1	5	1
18-Oct-11	2	3	15	2	22	2
23-Oct-11	0	5	16	6	27	7
27-Oct-11	2	5	13	3	23	15
2-Nov-11	2	7	17	9	35	18
9-Nov-11	0	3	4	4	11	9
18-Nov-11	0	2	6	1	9	3
25-Nov-11	0	2	0	1	3	3
Distribution	**4.0%**	**19.3%**	**58.7%**	**18.0%**	**100%**	

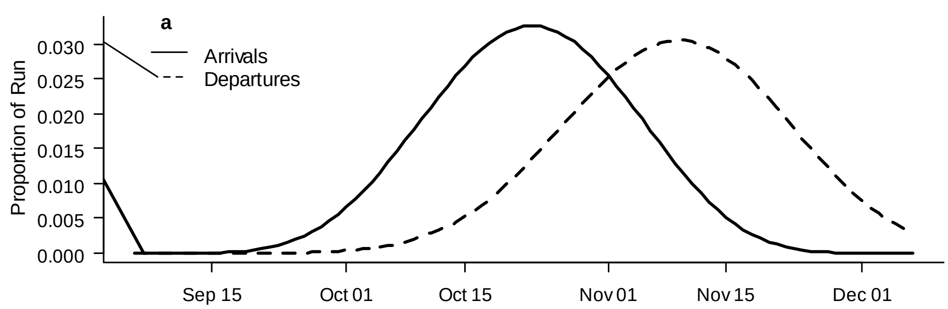

Figure 5 Predicted 2011 chum salmon arrival and departure timing (A), predicted numbers present and observer counts expanded by observer efficiency (B).

The majority of chum spawning activity in Lower Jones Creek (58.7%) was observed in Section 3, which holds approximately 75-80% of all the available spawning area in Lower Jones Creek, (Table 7 & 5). Sections S2 (19.3%) and S4 (18.4%) had the next highest levels of activity (Table 5). Chum spawning distribution, though more variable than pink, is typically concentrated in the upper two sites (Tables 2 &5).

Table 5 Chum spawning distribution by section 2001-2011. Section 1 and 2 were combined from 2001-2004, section 4 was made accessible in 2004.

Year	S1	S2	S3	S4	S5	Escapement Est.
1999						989
2001	11%		89%	n/a	n/s	182
2003	18%		82%	n/a	n/s	555
2004	67%		32%	1%	n/s	571
2005	6.2%	31.0%	27.4%	35.4%	*(36.9%)*	104
2006	4.6%	9.6%	64.8%	21.1%	*(3.9%)*	1311
2007	3.8%	15.6%	65.6%	15.0%	*(39.3%)*	124
2008	70.5%	2.3%	16.6%	4.9%	*(10.2%)*	543
2009	3.8%	4.9%	70.1%	21.1%	*(4.3%)*	423
2010	n/s	n/s	n/s	n/s	n/s	5
2011	**4.0%**	**19.3%**	**58.7%**	**18.0%**	*(28.6%)*	92

n/a = not accessible n/s = not surveyed

An index of adult spawning density in Lower Jones Creek was calculated by applying the percent distribution for each section to the estimate of total escapement (92 chum), and comparing it to the average area of available spawning habitat throughout the escapement period (Table 7). For chum, as with pink salmon, Section 4 had the highest spawner density with 0.03 fish/m2 (Table 3). The density for all of the Lower Jones Creek survey area was 0.02 fish/m2.

Table 6 Chum salmon spawning density by section in Lower Jones Creek 2005-2011. Values shown are spawners per m^2.

Year	s1	s2	s3	s4	Total
2005	0.01	0.03	0.00	0.08	0.03
2006	0.08	0.09	0.10	0.44	0.18
2007	0.01	0.02	0.01	0.03	0.02
2008	0.43	0.02	0.01	0.05	0.13
2009	0.03	0.03	0.05	0.16	0.07
2011	0.01	0.02	0.01	0.03	0.02
Mean	0.10	0.04	0.03	0.13	0.07

3.3 Coho Salmon Adult Escapement

Two adult coho were observed during the escapement period in Lower Jones Creek. On November 18, 2011 two were observed holding in a pool in S3. No coho redds were identified in Lower Jones creek and no more coho were observed. Two coho were observed spawning in Lorenzetta Creek in S5 on October 18, 2011. This was the peak count in that section. A total of 19 coho were observed upstream in Lorenzetta Creek out of the survey area.

4.0 Results Fry Outmigration

4.1 Fry Outmigration

Of the 77 trapping days completed on Lower Jones Creek (March 19 – June 3, 20012), a total of 6 days were lost due to high flows resulting in a total of 71 operational trapping days. The trap remained fishing in the same location in Reach 3 until there were 3 consecutive days of 0 captures. Pink and/or chum fry were captured on 62 of the 71 days that the trap was operating.

A total of 5 fish species were captured in Lower Jones Creek, with pink fry representing 98.2% of all fish captured (Table 7). The total of 20149 pink fry is the largest amount of fry captured since this project was initiated in 1999, and is more than twice the number of fry ever captured in Lower Jones Creek during outmigration monitoring (Appendix A). The 71 days of trapping also represents the most protracted out-migration period yet observed for pink salmon fry. Over the previous 7 years the mean out-migration period for pink fry is 57 days, with the longest trapping period 61days in 2010. Chum fry comprised the next largest proportion of the catch at 1.8%. Together, salmonids comprised virtually 100% of the total catch in Lower Jones creek (Table 7).

Table 7. Species composition of fish captured in the Lower Jones Creek and Lorenzetta trap 2012.

Jones Creek

Common Name	Taxonomic Name	Total Catch	% Composition
Salmonids			
Pink Salmon	*Oncorhynchus gorbuscha*	20149	98.2%
Chum Salmon	*Oncorhynchus keta*	368	1.8%
Coho Salmon (Age 0)	*Oncorhynchus kisutch*	6	<0.1%
Rainbow Trout	*Salmo mykiss*	1	<0.1%
Non-salmonids			
Sculpins	*Cottus (sp)*	2	<0.1%
Total		**20526**	

Lorenzetta Creek

Common Name	Taxonomic Name	Total Catch	% Composition
Salmonids			
Pink Salmon	*Oncorhynchus gorbuscha*	1843	79.9%
Coho Salmon (Age 1+)	*Oncorhynchus kisutch*	351	15.2%
Rainbow Trout	*Salmo mykiss*	9	0.4%
Cutthroat Trout	*Oncorhynchus clarki*	1	<0.1%
Non-salmonids			
Lamprey	*lampreta (sp)*	19	0.8%
Sculpins	*Cottus (sp)*	85	3.7%
Total		**2308**	

The first pink fry was captured on March 19 and the last on May 28, the peak single day count was April 16 with 1563 fry captured, this is the largest single day capture total for Lower Jones Creek. The first chum fry was captured on May 2 and the last on June 1, the peak single day count was May 17 with 45 chum fry captured. The May 2 date for the first capture of chum fry was very late in the out-migration period compared to previous years. Chum fry normally begin to enter the trap in the last week of March and the previous, latest date of first capture for chum fry was April 8 (in 2008). Chum fry were captured on 30 of the 71 days that the trap was operating for a total of 368 fry.

The trap on Lorenzetta Creek operated for a total of 33 days (March 19 - April 20, 2012), there were no lost trapping day due to high flow. A total of 6 fish species were captured in Lorenzetta Creek, with pink fry representing 79.9%% of all fish captured (Table 7). Coho smolts (Age 1+) represented the next largest capture group at 351, this represents the largest number of coho smolts captured on Lorenzetta creek to date and is more than double the previous high

(Appendix A). No chum fry were captured on Lorenzetta during the capture period, this is the first time this has occurred.

A total of eleven mark-recapture tests were carried out on lower Jones Creek throughout the migration period. Mark-recaptures were performed at early, peak and late out-migration timing and at a variety of flows (Table 8). Capture efficiencies ranged from a low of 0.07 to a high of 0.38, the pooled total was 0.20.

Table 8 Mark recapture results Lower Jones Creek.

Release Date	Marked	Recaptured	Capture Efficiency	Staff Gauge
31-Mar	100	7	0.07	0.54
5-Apr	200	18	0.09	0.48
9-Apr	500	72	0.14	0.46
15-Apr	1000	377	0.38	0.48
18-Apr	1000	266	0.27	0.52
1-May	850	74	0.09	0.65
3-May	500	94	0.19	0.55
8-May	1000	138	0.14	0.56
13-May	1000	239	0.24	0.56
21-May	1000	192	0.19	0.54
25-May	1000	117	0.12	0.55
Total	**8150**	**1594**	**0.20**	

Results indicate that successful coho spawning did occur in Lower Jones Creek during the 2011 brood year. Although no adult coho were observed spawning in Lower Jones Creek in 2011, two coho adults were observed holding in a pool in the creek on November 18, 2012. Despite the small total of 6 coho fry captured during the 2012 out-migration period, the presence of coho adults and fry (with egg sacs partially visible according to field notes, indicating they had not migrated from Lorenzetta Creek) would indicate successful spawning.

4.2 Egg-to-fry Survival Estimates

Pink escapement to lower Jones Creek was estimated at 7569 in 2011. It was estimated that 88% of the pink (6661 fish) spawned upstream of the trap site. Assuming the ratio of males to females is 1:1, the number of effective females is 3330. An average fecundity of 1600 eggs per female was taken from Banford and Baily (1979) and used as a surrogate to calculate potential egg deposition (PED) since no direct estimates of pink or chum fecundity in Jones Creek are available. The PED (effective females x average fecundity) was estimated at 5,328,576 eggs upstream of the trap location. Based on the total out-migrating population estimate of 119,249 pink fry, the egg-to-fry survival rate for lower Jones Creek is estimated at 2.24 %, (Table 9 & 10). This result is nearly equivalent to the post-WUP mean for pink salmon fry of 2.25% .

Table 9 Lower Jones Creek Fry Production with upper and lower confidence limits

Brood Year	Number mark groups	Mean CE	*N*	lower 95% CI	upper 95% CI	CI (± *N* as %)
1999	3	5.7%	5,049	2,105	7,992	58%
2003	3	8.3%	1,901	960	2,843	50%
2004	4	18.0%	1,027	598	1,456	42%
2005	5	13.0%	1,055	828	1,282	22%
2006	5	11.1%	16,733	13,535	19,930	19%
2007	8	n/a		too few fish		
2008	5	24.1%	1,567	1,071	2,062	32%
2009	10	27.8%	16,711	15,293	18,130	8%
2011	5	17.3%	2,301	2,003	2,599	13%
1999	3	7.4%	7,160	3,928	10,392	45%
2003	3	8.3%	5,702	3,575	7,829	37%
2005	5	15.5%	3,570	2,884	4,257	19%
2007	8	9.1%	86,442	56,744	116,140	34%
2009	12	22.9%	39,315	37,240	41,390	5%
2011	11	19.6%	119,249	110,905	127,593	7%

Chum escapement to lower Jones Creek was estimated at 92 in 2011. It was estimated that 91% of the chum (84 fish) spawned upstream of the trap site. Assuming the ratio of males to females is 1:1, the number of effective females is 42. An average fecundity of 2765 eggs per female was used as a surrogate to calculate potential egg deposition. The PED (effective females x average fecundity) was estimated at 115,997 eggs upstream of the trap location. Based on the total out-migrating population estimate of 2301 chum fry, the egg-to-fry survival rate for Lower Jones Creek is estimated at 1.98 %. (Tables 9 & 10). This result is also nearly equivalent to the post-WUP mean for chum salmon fry of 1.59%.

Table 10 Lower Jones Creek fry population and egg-to-fry estimates for chum and pink salmon. * No population estimate due to low chum escapement and fry capture.

	Chum			Pink		
Brood Year	Fry Capture	Pop. Est	Egg-to-Fry	Fry Capture	Pop. Est	Egg-to-Fry
1999	170	5,049	0.37%	396	7,160	0.36%
2003	164	1,901	0.30%	470	5,702	0.32%
2004	108	1,027	0.39%			
2005	161	1,055	1.17%	493	3,570	2.56%
2006	1,572	16,733	1.07%			
2007	11	11*	n/a	5,377	86,442	3.54%
2008	231	1,567	0.97%			
2009	3,965	16,711	3.13%	9,085	39,315	0.66%
2011	368	2,301	1.98%	20,149	119,249	2.24%

4.3 Flow and Channel Stability

Detectable channel shift affecting an active spawning area in Lower Jones Creek was observed in Section 2 early in the spawning period. Following high inflow from September 26-28, the entire area of this section was altered. Figures 7 and 8 visually demonstrate the dramatic change in creek morphology following the high flows, which had a maximum instantaneous flow of approximately 15.5 m^3sec. As the images show, the entire area was significantly widened and deepened, increasing from an average channel width of 5.38m prior to the high flow, to 13.03 metres after (Table 11). The wetted area also rose, increasing from 484m^2 to 1172m^2 in this section. The photos show evidence of a large area of recent (Summer 2011) fluvial deposits completely washed away, scouring up to a depth of just over 2 metres along this channel.

Pink spawning was active at this time, and it is assumed that any redds constructed in this area prior to September 28 were washed away. In the last survey prior to the channel shifting (Sept 24, 2011), a total of 284 pink salmon were counted. Following the channel shift, a peak of 704 pink salmon were observed on Sept, 30, 2011 (Table 1). The newly expanded area available for spawning was densely redded by pink salmon (Table 3). Transects and photos taken during the remainder of the spawning and incubation period indicate that no other channel movement or scour occurred (Table 11).

BC Hydro is required to deliver a minimum of 1.1cms to Lower Jones Creek throughout the pink and chum salmon spawning period (September 15 to November 30). Flow throughout the entire pink and chum migration and spawning period was at or above compliance.

Table 11 Lower Jones Creek average wetted width (ww) and available spawning area by reach Sept 2011-March 2012

Date	4-Sep		18-Sep		30-Sep		25-Nov		1-Jan		15-Mar	
Stage	0.43m		0.455m		0.465		0.51		0.46		0.475	
Flow	0.80cms		1.02cms		1.19cms		1.74cms		1.07cms		1.39	
Reach	Avg WW(m)	Reach area m^2	Avg WW(m)	Reach area m^2	Avg WW(m)	Reach area m^2	Avg WW(m)	Reach area m^2	Avg WW(m)	Reach area m^2	Avg WW(m)	Reach area m^2
S-1	13.3	999	13.53	1015	10.27	770	9.73	730	11.20	840	11.20	840
S-2	5.6	500	5.38	484	13.03	1172	11.10	1148	13.58	1148	13.58	1206
S3-1	12.3	1166	12.45	1183	12.93	1228	14.08	1337	12.50	1188	12.50	1153
S3-2	11.6	2545	11.49	2528	11.48	2526	11.20	2464	11.66	2565	11.66	2741
S3-3	12.0	3651	12.19	3717	12.56	3830	13.06	3983	11.00	3355	11.00	3351
S4	13.1	588	13.03	587	13.38	602	13.73	618	13.60	612	13.60	618
Total		**9449**		**9513**		**10128**		**10280**		**9708**		**9909**
Spawnable Area		**8268**		**8324**		**8862**		**8995**		**8494**		**8670**

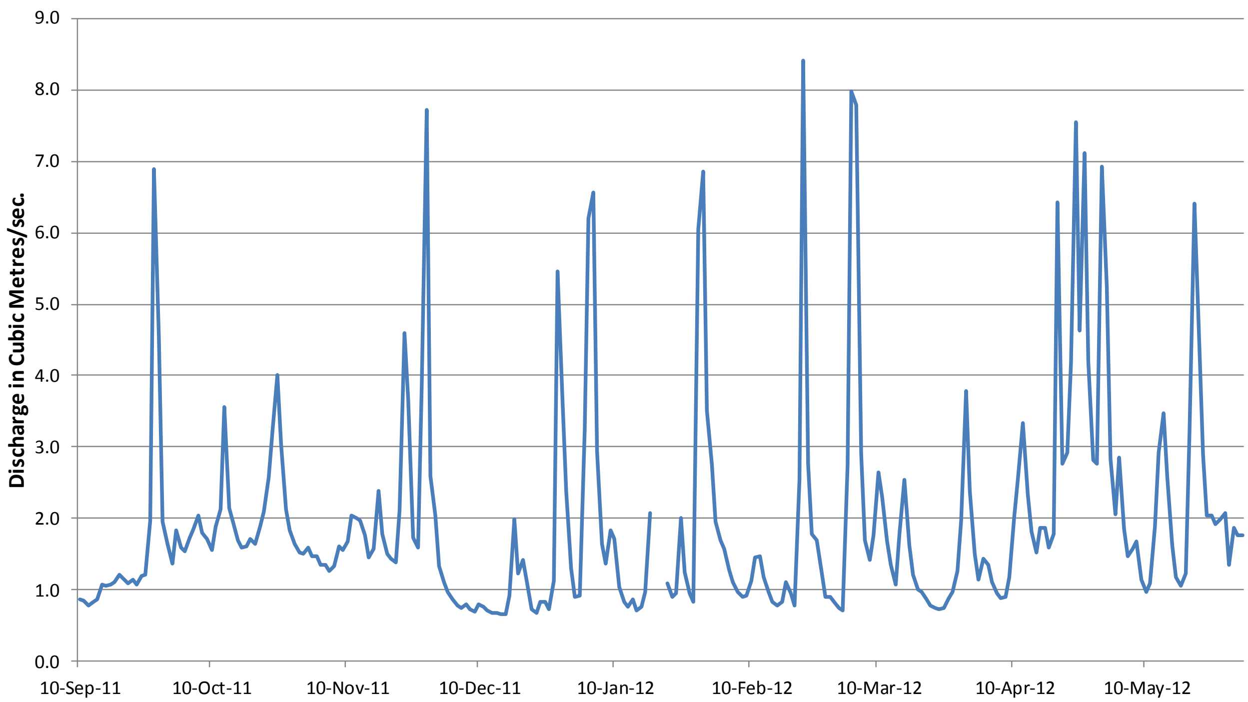

Figure 6 Daily mean Lower Jones Creek Discharge November 2011 - June 2012. The peak instantaneous discharge occurred Sept 27, 2011 with an estimate of 15.5 m^3sec.

Figure 7 Section 2 Sept 18, 2011, average channel width 5.38 metres, area 484m^2. Observe the expansive area of recently deposited fluvial sediment at the centre and right of the photo.

Figure 8 Section 2 September 30, 2011, following high flows. Note the majority of the fluvial material has been washed away and the channel greatly widened as well as deepened.

4.3 Water Temperature and Accumulated Thermal Units

Mean daily water temperature and accumulated thermal units (ATUs) from September 15, 2011 (start of pink spawning) to June 1, 2012 (end of emergence) are shown in Figure 6. ATU for the duration of the trapping program for pink salmon ranged from 896 to 1254 (ATU calculated from the beginning of active pink spawning, September 15, 2011). The predicted peak emergence period for pink fry using the range 900-1100 ATU was from March 22 – May 6. This roughly matched the observed peak, which was April 8 - May 13. For chum salmon fry, which used ATU calculated from the beginning of active chum spawning, October 15, 2011, the predicted peak emergence (using the same range 900-1100 ATU) was from May 27 – June 15, 2012. This does not correspond to the observed emergence pattern for chum fry which ran from May 2- June 1, 2012. Chum were first captured on May 2 which corresponds to approximately 730 ATU according to our temperature data. According to literature on the subject this would be early timing for chum fry emergence (Pauley 1988, Hard, 1996). In addition, chum fry migration was over by June 1, which, according to our ATU estimate, should have been the peak of emergence and migration.

During the incubation period water column temperatures ranged from a high of 15.4 Celsius to 0.0 Celsius. This temperature range is considered ideal for salmonid incubation (Pauley, 1988).

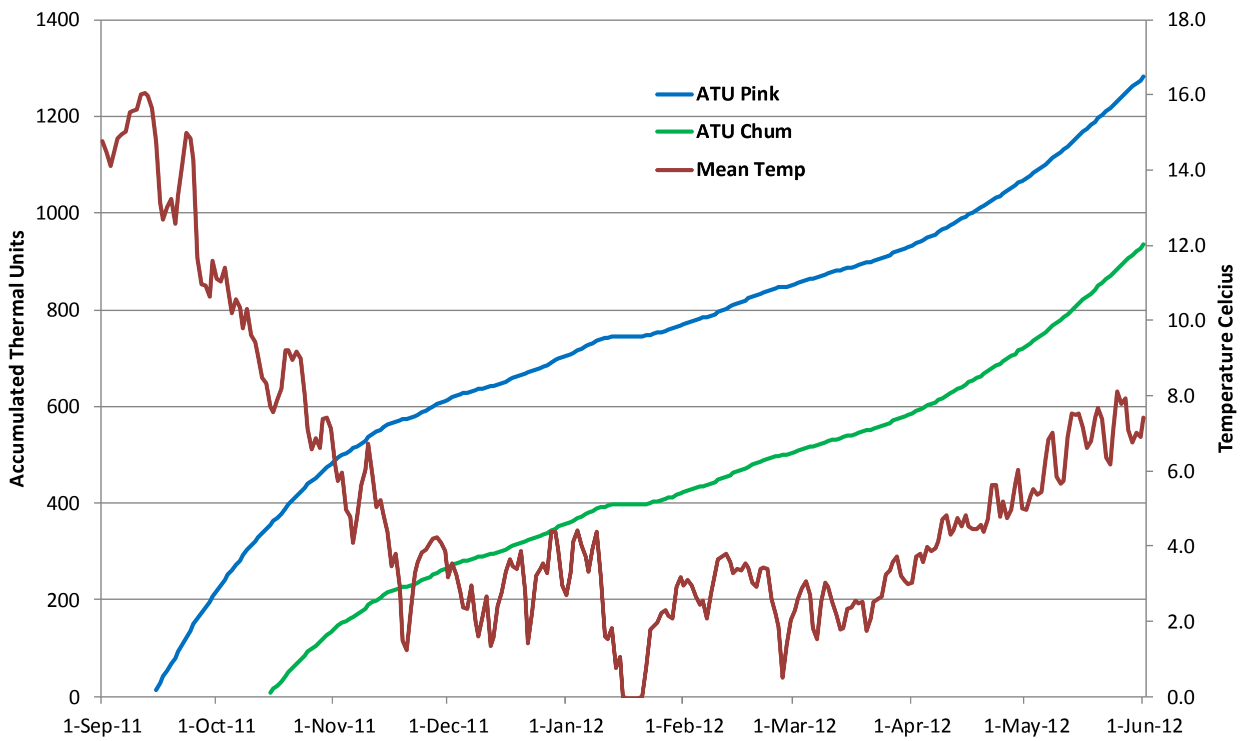

Figure 9 Lower Jones Creek Temperature and Accumulated Thermal Units

5.0 Discussion

The adult pink escapement estimate of 7569 is the second highest since surveys were initiated by BC Hydro in 1999 and is above the Post-WUP average of 4692 (Appendix A). Pink migration and spawning timing was typical of what has been witnessed in previous years with the first entrants to the system arriving in the first week of September, and peak spawning occurring a few weeks later (the peak count of September 24, 2011 was the earliest to date). The last pink spawners were observed on October 23, 2011, which is also typical end of run timing for Lower Jones Creek (Appendix A).

The adult chum escapement estimate of 92 is below average escapement based on surveys implemented by BC Hydro since 1999 (Table 4). Chum migration and spawning timing was typical of what has been witnessed in previous years with the first entrants to the system arriving in mid to late September (September 18, 2011) and peak spawning occurring approximately a month later (November 2, 2009, Table 4). The last chum spawners were observed on November 25, 2011, which is also typical end of run timing for Lower Jones Creek. Chum spawning distribution was typical of Lower Jones Creek in previous years, with the majority (75.7%) of all fish spawning in section 3 and 4 (Table 5).

The high flow in Lower Jones Creek at the end of September likely had an impact on the success of spawning pink adults in section 2. Assuming that all redds in this section were lost, the peak count (prior to the channel shifting) of 284 pink salmon on September 24 can help to give an indication of the overall impact. Although unknowns such as: how many redds had been created in this section? how many of the fish in this section were spawning as opposed to migrating through? preclude an accurate assessment of loss. Although these questions cannot be answered with any confidence, the impact of losing the spawn of 284 fish would be small considering the total escapement estimate of 7569, of which 284 represents less than 4%.

The heavy concentration of spawners in S4 (1.22 per m^2) and S3 (0.96 per m^2) has been observed in all survey years across both species (pink and chum). The density of 1.22 pink spawners per square metre in 2011 is the second highest yet recorded as is the overall density of 0.89 spawners per m^2. Redd superimposition leading to spawning failure is a concern in water courses where spawning density is high (McNeil 1964, Fukushima et. al, 1998).
It is reported in Heard (1975) that instantaneous densities (instantaneous density is defined as "the density of spawners on the spawning ground at any given time") of over .80 spawners per square metre can influence spawning behavior and potentially lead to redd superimposition. The value of 1.22 spawners per m^2 for pink salmon in section 4 is the density estimate using the total escapement over the spawning period. The maximum instantaneous density (MID) for section 4 would be 0.85 spawners per m^2 (calculated using the peak count of 500 on Sept. 24 divided by the available spawning habitat at that flow level, 587m^2). Using the same method the MID for section 3 would be 0.66spawners per m^2. These results, coupled with field observations that recorded signs of egg wash in all areas of the creek, supports the possibility that redd superimposition may have been an issue effecting low egg-to-fry survival in Lower

Jones Creek in 2011. This phenomenon was also noted in the 2009 brood year which had MID of over .80m^2 in section 4 and a value near .80m^2 in section 3 (0.78m^2). Egg-to-fry survival of the 2009 pink brood year was a post WUP low of 0.66%.

In 2012 egg-to-fry survival for both pink and chum fry was typical of what has been observed since the initiation of the new flow regime in 2005. Preliminary egg-to-fry estimates for both species are close to the mean for the post-WUP period. Estimates are still low relative to salmonid enhancement program biostandards for pink and chum in the Lower Fraser River (6% and 9% respectively) as well as other values reported in literature for this species (Appendix C). However, comparisons with other systems are problematic as they all have their own unique biophysical properties and geographical/morphological characteristics. Within the context of Lower Jones Creek, the 2012 out-migration appears to have been productive for the system based on our observations to date. The record pink fry population estimate is encouraging, as is the fact that coho appear to have again successfully spawned and their eggs incubated in Lower Jones Creek. In addition, both estimates of egg-to-fry survival are above pre WUP means, which may indicate improved fish productivity as a result of the new flow regime.

6.0 Conclusions and Recommendations

Although egg-to-fry survival has improved slightly for both chum and pink salmon post WUP, egg-to-fry survival continues to be low. Based on our observation to date, the reasons for this appear to be centered around three main issues:

1. High flow events causing scour and channel movement.
2. Density dependent factors, eg. redd superimposition.
3. Poor substrate quality due to high density of fines.

The first two are variable events depending on: magnitude of flow during spawning and incubation, and the number of returning salmon. Both are only notable in some years, whereas poor substrate quality appears to be a constant. Substrate quality is not analysed in our assessment, though NHC reports sedimentation related to accumulation of fines throughout the 2005-2010 period in several of their transect locations. Concentrations of fines in excess of 25% have been regularly recorded at monitoring stations located in the high density spawning areas of Lower Jones Creek (Section 3). The impact of sedimentation, (ie. fine sediment < 10 mm) in spawning gravels has been shown to decrease survival of salmonid eggs to emergence in many studies (Bjornn and Reiser, 1991; Everest et al., 1987; Greig et al., 2005, 200, Jensen et. al., 2009).

The impacts of these high concentrations of fine material can be severe, for example, findings in Jensen et. al. (2009) indicated that at concentrations of fines (defined in their study as grain size of less than 0.85 mm) greater than 10%, threshold effects were observed and embryo survival dropped rapidly. This 10% threshold was surpassed in all years examined by NHC in most transects (NHC, 2006, 2008, 2010).

- Improve techniques aimed at analyzing channel realignment and actual loss of spawned habitat over the spawning and incubation period. NHC recommends expansion of the number of transects they use to analyze channel realignment, this recommendation should be incorporated in future years.
- Investigate coho resurgence by increasing efforts to include more adult surveys through the winter months, although difficulties due to turbid water and low returns will likely be encountered. Investigate late spring and summer rearing populations of coho in Lower Jones Creek.
- Continue to use the Darroch stratified mark-recapture estimator and the most recent version of the Coquitlam River AUC model, described in this report, to generate estimates of fry abundance and escapement, respectively, in future analyses.
- Ensure that periods of interrupted flow data do not extend over long periods of time. Expedient maintenance of hydrometric data station should be a priority.

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Appendix A List of Chum and Pink Escapement estimates 1999-2011 and species list of all trap captures in Lower Jones Creek 2000, 2004-2012.

Pink Salmon Escapement

Date	1999	Date	2001	Date	2003	Date	2005	Date	2007	Date	2009	Date	2011
			0	sept. 5	0			Sept. 9	11	Sept. 5	3	4-Sep	0
		Sept. 11	1	sept. 11	4	14-Sep	20	Sept. 12	11	Sept. 9	10	8-Sep	3
		Sept. 18	49	sept. 18	32	19-Sep	21	Sept. 17	583	Sept. 14	69	14-Sep	695
		Sept. 23	863	sept. 21	156	22-Sep	11	Sept. 18	875	Sept. 18	484	18-Sep	3561
Oct. 5	1125	Oct. 1	3662	sept. 25	523	27-Sep	10	Sept. 21	1098	Sept. 24	4854	24-Sep	5946
Oct. 12	1261	Oct. 9	1193	sept. 29	1603	3-Oct	115	Sept. 23	1292	Sept. 29	5824	30-Sep	5757
Oct. 13	46	Oct. 15	521	Oct. 1	1989	6-Oct	135	Sept. 25	1438	Oct. 3	2772	4-Oct	3744
Oct. 20	559	Oct. 22	21	Oct. 2	1561	11-Oct	97	Sept. 27	1752	Oct. 8	977	8-Oct	1828
Oct. 29	0	Oct. 29	0	Oct. 6	1114	21-Oct	39	Oct. 5	758	Oct. 13	224	13-Oct	303
				Oct. 9	290	25-Oct	5	Oct. 10	279	Oct. 19	33	18-Oct	72
				Oct. 16	3			Oct. 14	169	Oct. 24	2	23-Oct	26
	1380		**4432**		**2489**		**212**		**3167**		**7820**		**7569**

Escapement Estimates		
	1999-2004	**2767**
	2005-2011	**4692**

Chum Salmon Escapement

Date	1999	Date	2001	Date	2003	Date	2004	Date	2005	Date	2006	Date	2007
		Sept. 11	0	sept. 11	0			14-Sep	1				
		Sept. 18	4	sept. 18	1			19-Sep	0			Sept. 23	1
		Sept. 23	3	sept. 21	4			22-Sep	5	25-Sep	50	Sept. 25	2
Oct. 5	375	Oct. 1	32	sept. 25	2	Oct. 3	3	27-Sep	4	29-Sep	60	Sept. 27	10
Oct. 12	223	Oct. 9	43	sept. 29	25	Oct. 8	25	3-Oct	2	6-Oct	97	Oct. 5	14
Oct. 13	19	Oct. 15	76	Oct. 1	21	Oct. 12	47	6-Oct	14	13-Oct	276	Oct. 10	12
Oct. 20	239	Oct. 22	16	Oct. 2	33	Oct. 19	89	11-Oct	28	16-Oct	399	Oct. 14	23
Oct. 29	46	Oct. 29	9	Oct. 6	110	Oct. 24	107	21-Oct	37	22-Oct	504	Oct. 20	42
Nov. 4	13	Nov. 6	0	Oct. 9	196	Oct. 30	102	25-Oct	16	27-Oct	209	Oct. 23	37
Nov. 10	12			Oct. 16	38	Nov. 6	72	28-Oct	0	2-Nov	219	Oct. 30	13
Nov. 18	5			Oct. 27	70	Nov. 10	82	3-Nov	4	9-Nov	57	Nov. 5	10
Nov. 24	2			Nov. 4	45	Nov. 16	124	9-Nov	2	16-Nov	21	Nov. 8	4
Dec. 1	0			Nov. 12	13	Nov. 22	47			22-Nov	12	Nov. 15	0
				Nov. 23	27	Nov. 27	14					Nov. 21	0
				Nov. 27	4	Dec. 3	3						
	989		**182**		**555**		**571**		**104**		**1311**		**124**

Escapement Estimates		
	1999-2004	**372**
	2005-2011	**574**

Chum Salmon Escapement

Date	2008	Date	2009	Date	2010	Date	2011
						14-Sep	0
Sept. 22	7	24-Sep	24	Sept. 27	0	18-Sep	1
Sept. 27	50	29-Sep	17	Oct. 8	0	24-Sep	3
Oct. 1	94	3-Oct	61	16-Oct	2	30-Sep	2
Oct. 6	132	8-Oct	124	25-Oct	5	4-Oct	4
Oct. 8	123	13-Oct	110	2-Nov	2	8-Oct	7
Oct. 12	114	19-Oct	138	22-Nov	0	13-Oct	6
Oct. 19	78	24-Oct	99			18-Oct	24
Oct. 22	99	2-Nov	42			23-Oct	34
Oct. 27	20	11-Nov	11			27-Oct	38
Oct. 30	21	14-Nov	3			2-Nov	53
Nov. 2	21	20-Nov	0			9-Nov	20
Nov. 9	15					18-Nov	12
Nov. 16	7					25-Nov	6
Nov. 18	2					5-Dec	0
	543		**423**		**5**		**92**

Lower Jones Creek

Common Name	2012	2010	2009	2008	2007	2006	2005	2004	2000	Total	% Comp
Salmonids											
Pink Salmon	20149	9105		5377		493		470	396	35990	83.0%
Chum Salmon	368	3965	231	11	1556	161	108	164	170	6734	15.5%
Coho Salmon (smolt)		2		4	2	1	15	3		27	0.1%
Coho Salmon (fry)	6	164					15	2		187	0.4%
Rainbow Trout	1	3	2	24	23	14	6	23	19	115	0.3%
Non-salmonids											
Sculpins	2	2	8	128	61	3	63			267	0.6%
Longnose Dace		2	1	3	5		3	1	1	16	0.0%
Bridgelip Sucker				2	2		1			5	<0.01%
Peamouth Chub				1						1	<0.01%
Mountain Whitfish				1	2					3	<0.01%
Lamprey					8					8	<0.01%
Northern Pike Minnow					4				1	5	<0.01%
Threespine Stickleback					2			2	3	7	<0.01%
	20526	**13243**	**242**	**5551**	**1665**	**672**	**211**	**665**	**590**	**43365**	**100%**

Lorenzetta Creek

Common Name	2012	2010	2009	2008	2007	2006	2005	Total	% Comp
Salmonids									
Pink Salmon	1843	7288		5327		3702		18160	48.6%
Chum Salmon		4674	2061	1034	7	3022	309	11107	29.7%
Coho Salmon (smolt)	351	63	123	75	101	154		867	2.3%
Coho Salmon (fry)		5897						5897	15.8%
Rainbow Trout	9	13	21	29	14	40	2	128	0.3%
Cutthroat Trout	1			1		2		4	<0.01%
Dolly Varden		1		1				2	<0.01%
Non-salmonids									
Sculpins	85	217	41	79	35	164	17	638	1.7%
Longnose Dace						2		2	<0.01%
Bridgelip Sucker						1		1	<0.01%
Peamouth Chub								0	<0.01%
Mountain Whitfish			2			3		5	<0.01%
Lamprey	19	102	53	97	25	259		555	1.5%
Northern Pike Minnow		4	1	8				13	<0.01%
Threespine Stickleback				1		1		2	<0.01%
	2308	**18259**	**2302**	**6652**	**182**	**7350**	**328**	**37381**	**100%**

Appendix B Lower Jones Creek trap at varying flow levels.

Figure 10 Lower Jones Creek Trap April 16, 2012 discharge at approximately 1.45 m^3sec.

Figure 11 Lower Jones Creek Trap April 26, 2012 discharge at approximately 9.0 m^3sec.

Appendix C Comparison of egg-to-fry survival for selected coastal streams.

Pink Salmon, *Oncorynchus gorbuscha*

Egg- Fry survival rates Population	years of data	Egg - Fry Mean Survival	Egg - Fry Std Dev. Survival	Reference
McClinton Cr	6	14.40%	6.9-23.88	Prichard 1948
Nile Ck	3	13.40%	0.4-32.3	Wickett 1962
Morrison Cr.	2	7.83%	0.68	
Nile Ck	5	7.75%	4.79	Wickett 1951
Hooknose Creek	14	6.96%	2.67	Parker 1962
Vedder R	5	6.91%	0.98	Chapman 1970
Harrison R.	5	6.42%	1.77	IPSFC 1967
Lyutoga R	7	6.39%	2.56	
Lesnaya R	7	6.26%	2.18	Kanid'yev et al. 1970
Lakelse Lk.	8	6.20%	1.20	Harding 1970
Fraser R.	15	6.01%	1.14	Pac. Sal. Comm. 1988
Hooknose Cr.	10	5.60%	0.9-16.5	Hunter 1959
McLinton Cr.	6	5.52%	1.31	Neave 1953
Auke Cr.	11	4.30%	0.2-12.3	Taylor 1983
Unweighted Average		**7.43%**		

Chum Salmon, *Oncorynchus keta*

Egg- Fry survival rates Population	years of data	Egg - Fry Mean Survival	Egg - Fry Std Dev. Survival	Reference
Qualikum	10	26.69%	8.90%	
Disappearance Cr. Alaska	2	12.80%		Wright (1964)
Qualicum R.	4	12.11%	3.44%	Fraser et al. 1983
Big Qualicum R.,, BC	4	11.20%		Lister and Walker (1966)
Barnes Ck.	4	10.63%	3.08%	Fedorenko and Bailey 1980
Minter Cr., Wash.	10	9.10%		
Hooknose Ck.	14	7.64%	2.91%	Parker 1962
Nile Ck.	4	6.51%	1.29%	
Inch Ck	4	4.54%	1.15%	Fedorenko and Bailey 1980
Nile Ck.	6	1.12%	0.46%	Wickett 1952
Unweighted Average		**10.23%**		