Gates Creek Salmon Project

Adult Escapement Assessment

Project # 12.SON.01(Part 2)

Prepared for:

Lillooet Tribal Council

By

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1.0 Introduction

Gates Creek, a tributary of the Seton- Anderson Watershed, is located in the Southern Interior of British Columbia (Figure 1). The watershed drains approximately 34,000 hectares. Gates Lake and Anderson Lake provide the only storage in the watershed as the basin contains no glaciers. Gates Creek runs 12 kilometres from Gates Lake in Birken to Anderson Lake in D'arcy (Figure 1) and supports several species of pacific salmon and trout: including sockeye (*Oncorhynchus nerka*), coho (*O. kisutch*) and pink (*O. gorbushca*) salmon, as well as rainbow trout and steelhead (*O. mykiss*), and bull trout (*Salvelinus confluentus*).

Of all the salmonid species supported by Gates Creek, sockeye are the most abundant. Gates Creek sockeye fall into the early summer run classification which includes sockeye populations in seven geographical locations (the North Thompson, South Thompson, Chilcotin, Nechako, Lower and Upper Fraser) in addition to the Seton-Anderson populations. Historical annual adult sockeye escapement to Gates Creek are estimated to have been as high as 150,000 to 200,000 individuals (Hruska 2010). However, the 1913 and 1914 slides of Hell's Gate as well as the construction of the Seton Dam in the 1950's reduced sockeye escapement to as little as a few thousand sockeye in the 1950's (Andrew and Green 1958). In 1968, with the intention of increasing sockeye escapement in the Seton- Anderson watershed, Gates Creek spawning channel was constructed by the International Pacific Salmon Fisheries Commission (IPSFC). From 1968 to 1984 the channel was operated by the IPSFC. Briefly, between 1985 and 1987, channel operations were handled by the Department of Fisheries and Oceans Canada (DFO). In 1987, the N'Quatqua First Nation (NFN) assumed responsibility for the channel; the channel continues to be operated by NFN into the present time.

In the summer of 2008, substantial restoration work funded by BC Hydro's Fish and Wild Life Compensation Program (FWCP) was undertaken on the spawning channel with the goal of increasing egg to fry survival. These improvements included gravel replacement, gradient changes and structural modifications to the channel (Anon. 2009). While juvenile migration and adult escapement data exists as far back as the 1980s for Gates Creek spawning channel, annual estimates of fecundity and egg deposition which are required to estimate egg to fry survival, have not been undertaken in quite some time. The last available fecundity estimates for Gates Creek spawning channel were obtained in 1988 by D. Hickey (DFO unpublished data, in O'Donaghey *et al.* 1999). Age class and size of sockeye females fluctuate between years (Larkin and McDonald 1968; Bigler *et al.* 1996); therefore fecundity is likely varied among years. Without egg to fry survival rates DFO scientific advisors and funding agencies cannot accurately monitor changes in channel productivity.

In the spring of 2012 the spawning channel monitoring program was expanded to include estimates of sockeye fry production and egg to fry survival from both Gates Creek and Gates Creek spawning channel (Lingard *et al.* 2012). The primary objective of the program is to accurately estimate egg to fry survival from both Gates Creek and the spawning channel. Accurate fecundity and percent spawn data is necessary to link the existing adult escapement program to the spring juvenile program. The first fecundity and percent spawn estimates were collected in the fall of 2011 (data on file) and used in conjunction with juvenile migration data collected in spring 2012 to derive egg to fry survivals for Gates Creek and spawning channel (Lingard *et al.* 2012). This interim report summarizes the results of sockeye adult sampling on Gates Creek in the fall of 2012, this data will be utilized in conjunction with Spring 2013 juvenile data to calculate egg to fry survival rates.

2.0 Methods

2.1 Spawning Channel Loading

The spawning channel and Gates Creek are loaded with a known number of adults using a full channel weir and mechanical counters. Fish are excluded from Gates Creek by a full span **diversion** fence installed on the creek adjacent to the spawning channel out-flow (Figure 2). A second **exclusion fence** which houses the mechanical counters is installed on the spawning channel (Figure 2). The mechanical counters are similar to those used on subway entry gates which count a single up count as the gate is pushed past a trigger point. There are two counters on the **exclusion fence** with openings large enough for a single sockeye salmon to enter at a time. A tunnel with a separate (third) mechanical counter is located adjacent to and below the **exclusion fence**. Fish are either allowed into the spawning channel through the gates on the **exclusion fence**, or are routed through the tunnel into Gates Creek above the **diversion** fence (Figure 2). Counter gates are lockable allowing fish to be directed into either the spawning channel or the creek based on a management strategy directed by DFO advisory staff. Ideally, the channel and creek are loaded so fish from each portion of the run are present in equal proportions in each environment.

The spawning channel is reputed to have high rates of pre-spawn mortality (PSM). In comparison, the PSM rate for Gates Creek has not been observed to be as high as the channel (DFO unpublished data). It is unknown as to whether the high levels of PSM in the channel are a particular trait of the early component of the population, a uniform occurrence over the duration of the run, or a result of loading the spawning channel too densely. In an attempt to assess this question, DFO scientific advisors decided to

direct the first ~7,000 fish into Gates Creek in 2012. In theory if the early part of the run is more susceptible to pre-spawn mortality Gates Creek assessments of PSM would be higher than the spawning channel.

2.2 Visual Survey Validation of Counter(s)

Visual surveys of adult sockeye, consisting of removal and enumeration of carcasses, are conducted on the spawning channel annually. Sockeye salmon carcasses are removed from the water and placed on the channel bank. The carcasses are separated as males, females, and jacks (precocious males) prior to enumeration. Females are classified as 0%, 50% or 100% spawned, which refers to the number of eggs retained in the carcass (see section 2.3 for further discussion of percent spawn criteria). Carcasses are cut in half as they are counted and loaded into a dump truck. Generally, two people work together to process the carcasses. One technician either uses a field book or hand tally to keep count while the second technician cuts the fish. Cutting of carcasses serves to both expose the egg cavity of females which allowes evaluation of percent spawn as well as prevents double counting of carcasses. The enumerated carcasses are then removed to Anderson Lake to prevent bears from becoming habituated to the channel property. Comparisons of mechanical counter generated data to channel visual enumeration data are then undertaken. Validation of counter estimates of creek loading are not presented here as escapement data are provided as final estimates by DFO.

2.3 Classification of Female Percent Spawn

In 2011 inconsistencies were identified in survey methods employed by N'Quatqua technicians on the channel and the criteria used to estimate percent spawn of female carcasses on the creek by DFO stock assessment personnel. In an effort to eliminate these inconsistencies the N'Quatqua technicians accompanied DFO stock assessment staff during weekly Gates Creek enumeration activities from August 31st to September 18th, 2012. In general, the method of estimating female percent spawn is highly subjective and requires technicians to classify female mortalities as 0%, 50%, or 100% spawned. By stock assessments definitions a female sockeye is categorized as:

- 100% spawned if only a handful of loose eggs remain in the fish (which equates to approximately 500 or less eggs).
- 50% spawned if roughly two handfuls or more loose eggs remain in the fish (greater than a few hundred eggs, but skeins not intact). *DFO advises this criteria to be rare among the Gates Creek sockeye population.
- 0% spawned if there are intact skeins remaining in the fish.

To allow continuity of data collection between DFO and N'Quatqua Fisheries technicians, the above listed criteria were used for assessment of percent spawn in sockeye females on Gates Creek and spawning channel in 2012.

2.4 Fecundity Sampling

Mean fecundity for the 2012 escapement of sockeye to Gates Creek spawning channel was estimated using intact egg skeins from 45 un-spawned (0%) females spread over the duration of the sampling period August 26th to September 23rd. All sampled individuals were natural pre-spawn mortalities. Post orbital-hypural (POH) lengths were taken for each fish. The eggs were boiled to preserve individual egg integrity for counting at a later time.

2.5 Egg Retention

A total of 85 spawned females were sampled for egg retention in the spawning channel over the sampling period (August 26th to September 23rd). No egg retention samples were obtained in the first week of observations as no spawned carcasses were available. All samples were collected over the remaining three week period, September 2nd to September 23rd to ensure representation of egg retention over the duration of the spawning period.

2.6 Percent Spawn and Total Egg Deposition

Percent spawn refers to the proportion that effective females (100% spawned) represent of the total annual female escapement. To estimate total effective females and percent spawn the total number of spawned females must be adjusted for females which only spawned partially (the 50% category). While 50% spawn is an arbitrary and subjective figure applied to a wide range of partially spawned sockeye salmon, it was advised that standard DFO protocol for using this category in estimates of percent spawn and PSM is to split the 50% category total equally between the 0% and 100% categories (S. LePage, pers.comm.). In essence it is assumed a 50% spawned fish represents half a fully spawned fish (100%) and half an un-spawned fish (0%). The following equations were used to estimate percent spawn and pre-spawn mortality rates.

$$PS = (S+0.5*P)/ TF$$

$$PSM = (U+0.5*P)/ TF$$

Where:

PS= Percent spawn
PSM= Pre-spawn mortality
S= Spawned females (100%)

U= Un-spawned females (0%)

P= Partial spawned females

TF = Total number of females (summed 0%, 50% and 100% categories)

Egg deposition was estimated by multiplying the number of effective (100% spawned) females by the estimated mean fecundity.

ED= EF*MF

Where:

ED= Estimated egg deposition

EF= Number of effective females given by (S +0.5*P)

MF= Mean fecundity

2.7 Comparison to 2011 Fecundity and Retention Data

Differences in mean fecundity, egg retention and POH length data for 2011 and 2012 data were analyzed using single factor one way ANOVA and either Welch's or Student's t-test.

3.0 RESULTS

3.1 Spawning Channel and Gates Creek Loading

Loading of the spawning channel commenced on August 10th and finished on August 31st, 2012. Between August 10th and August 21st a total of 354 fish were let into the channel, as the majority of fish during this period (7,281) were diverted into Gates Creek. Between August 21st and August 31st a total of 17,234 sockeye were loaded into the spawning channel (Table 1). Overall, the total number of sockeye loaded into the spawning channel was 17,598 of which there were: 5,882 males, 1,572 jacks, and 9,514 females (Table 2). Male (including jacks) to female ratio was 1:1.3 for the fall of 2012.

The total estimated sockeye escapement into Gates Creek in 2012 was 13,576. Of this total 976 were jacks 4,264 were males and 8,336 females giving a male to female ratio of 1:1.6 (including jacks)[1] (Table 3) (DFO, unpublished data).

[1] All Gates Creek escapement data are provided by DFO Stock Assessment Department

3.2 Visual Survey Validation of Channel Counter

A 3% difference was observed between the total estimated sockeye escapement to the spawning channel from the visual survey (17,079) and the channel mechanical counters (17,598).

3.3 Mean Fecundity and Egg Retention

Mean POH length and estimated fecundity for females in the spawning channel in the fall of 2012 was 46.5 cm (SD 2.4) and 3,119 eggs (SD 517), respectively. The linear relationship between POH length and fecundity for Gates Creek spawning channel sockeye in 2012 was explained by the equation:

y= 110.43x-2012.1 (R2=0.27) where

y= the number of eggs, and

w= POH length in cm

This regression analysis of POH length and egg number shows a weak relationship (R^2 0.27) with only 27% of variability in egg number being predicted by POH length (Figure 2).

No significant difference in mean fecundity between 2011 (3,260 eggs) and 2012 (3,119 eggs) was observed (Table 4) using single factor one way ANOVA (F (86) = 1.44, *P* =0.233), or student's t-test (P = 1.988). However, a significant difference was found in mean POH length in females sampled for fecundity between years (48.0 cm in 2012 vs. 46.5 cm in 2011) using single factor ANOVA (F (87) = 8.665, *P* = 0.00417), and Welch's t-test (*P*= 0.00417).

Mean egg retention was 248 (SD 391) for sockeye sampled in the spawning channel. The mean POH length for sampled 100% females was 45.9 cm (SD 2.3). The relationship between POH length and number of eggs retained was y= 11.643x-249.9 (R^2= 0.0035) (Figure 3). The low R^2 value indicates POH length is a poor predictor of egg retention.

Estimated mean egg retention in 2012 was 3.7 times 2011's mean egg retention of 68 (SD 153) (Table 5). A significant result was obtained by both single factor ANOVA (F (142) = 12.15, *P* = 0.000654) and Welch's t-test (*P* = 0.000255) when comparing mean egg retention in 2011 and 2012. No significant difference was seen in mean POH length among egg retention samples between 2011 (46.1 cm, SD 6.9) and 2012 (46.0 cm, SD 5.3) from Student's t-test (*P*= 0.848) or single factor ANOVA.

3.4 Percent Spawn and Egg Deposition

Spawning Channel

A total of 9,514 females were loaded into the spawning channel. Partial (50%) spawners totalled 163 individuals representing 1.7% of total female escapement. Partial spawners were divided equally among

the 0% and 100% categories for calculation of pre- spawn mortality and effective females. Effective females (including half of the 50% spawned category) totalled 2,518 giving an estimate of 27.3% percent spawn, for 2012. Pre-spawn mortalities (0% spawners) (with half of the 50% spawners included) totalled 6,997 or 74.3% of total female escapement (Table 6).

Estimated egg deposition for 2012 was 7,853,642, which is 47.3% lower than the estimated egg deposition of 14,911,240 in 2011 (Table 7).

Gates Creek

An equivalent of 4,311 effective females was estimated to have spawned in Gates Creek, in 2012, from a total estimated female escapement of 8,336. Percent spawn was estimated by DFO to be 51.7%; almost double the estimated percent spawn for the spawning channel. Egg deposition for the 2012 brood year is estimated to have been 13,446,009 and is 81.0% lower than the estimated egg deposition of 69,428,220 in 2011 for Gates Creek (Table 7).

4.0 Discussion

4.1 Counter Operations and Visual Survey Validation

This year's data show a small difference (3.5%) between the counter estimated escapement (17,588) and visual survey estimates (17,079) into the channel. Historic visual observations of fish passing through the mechanical counters revealed a potential 10% over estimate of escapement into either the channel or the creek (Matthew Foy, pers. comm.). Some of the inconsistencies observed during counter operations include:

- Double counting of fish as they move back and forth through a partially opened gate, as well as sensitivity to flooding,
- The ability for a fish to not be counted if one fish is swimming directly behind another and counter gates are not permitted to close between fish.
- Counters cease to operate if the counter gates are clogged with debris or a build up of fish carcases on the fence causes back watering.
- Multiple triggering of the creek counter by one fish due to the flapping of fish tails on the trigger mechanism.

Improvements have been made to counter operation to circumvent flooding of the counters through the installation of small debris excluding devices and routine cleaning of debris and fish off the fence (Matthew Foy, pers. comm.).

An additional factor which contributes to the over estimation of escapement by the mechanical counter is that the counter does not differentiate between species. Bull trout are known to be present and migrating up river in August along with sockeye (Morris *et al.* 2003), and were indeed visually observed both above the diversion fence in Gates Creek as well as in the upper pools of the spawning channel in 2012. Closed Circuit video validation could be installed on the counter(s) in 2013 to allow for more thorough validation of counter estimates as well as allow estimation of error margins with greater precision.

4.2 Fecundity, Egg Retention, Percent Spawn and Egg Deposition

Liaison with stock assessment staff during creek enumeration activities in the fall of 2012 greatly improved the consistency of percent spawn estimation. Prior to 2012, channel staff understood females with as little as a few hundred eggs could be classified as 0% spawn, this would potentially overestimate PSM rates in past years. In 2012 after working more closely with DFO stock assessment personnel and applying consistent classification between creek and channel PSM rates greater confidence may be placed on estimated PSM values for 2012 than previous years. Consistency and communication between various agencies (BC Hydro WUP monitors, DFO, LTC etc) in data collection techniques and sharing of information is improving and should be continued. This will assist in answering the questions regarding the high PSM rates observed in this stock.

Total egg deposition was reduced by 47.3% in the spawning channel and 81.0% in Gates Creek from 2011 to 2012. However, mean fecundity per female did not change between 2012 (3,119) and 2011 (3,260).

The reduction in egg deposition in the spawning channel in 2012 was a result of increased PSM year to year (47.5% vs. 74.3%). The percent spawn was reduced in 2012 by 48.0% to 27.3% from 2011 when it was 52.5%. This difference between years may be greater than estimated here, as the PSM rate in 2011 may have been inflated due to the previously mentioned misclassification of spawned (100%) females as un-spawned (0%).

In Gates Creek, the 81.0% reduction in egg deposition was a result of both a lower percentage of effective spawners and reduced escapement from 2011 to 2012. The high rate of PSM was not limited to the Gates Creek population; early summer sockeye stocks province wide experienced the highest mean rate of PSM on record 56.9% (DFO, unpublished data). A bevy of factors could have played a roll in increased PSM in 2012 including: discharge, water temperature and disease. Increases in pre-spawn mortality and egg retention have been correlated to increased physiological stress (Hruska 2010) and may be an indicator

that Gates Creek fish faced adverse migration conditions in 2012. Tissue samples taken by the DFO Fish Health Lab indicated Infectious Haematopoietic Necrosis Virus (IHNV) was present in high percentages in Gates Creek sockeye; however, there was no indication fish were developing the IHN disease (DFO unpublished data).

Some ancillary observations were also made in 2012 which could be of interest to management personnel. Fish were delayed at the Seton Dam fish way due to operational issues (Don McCubbing pers. comm.), which may have contributed to elevated migration stress. Additionally, senior N'Quatqua fisheries personnel noted a number of fish with an abnormal scale pattern which they feel indicates straying of sockeye from another population mixed with the Gates population (Harry O'Donaghey, pers. comm.). Scale and operculum punches were taken and passed on to DFO personnel for genetic analysis however, results are not yet available for confirmation.

4.3 Potential Factors Influencing PSM

Allowing the first 7,000 fish into Gates Creek appears to have had no effect on reducing pre-spawn mortality in the spawning channel, as the percent spawn was nearly twice the rate in Gates Creek (51.7%) as was observed in the spawning channel (27.3%), in 2012. Percent spawn was also higher in 2011 in Gates Creek (82.2%) than the channel (52.5 %) despite the channel being entirely loaded with the early portion of the run before any sockeye were allowed into Gates Creek. As sockeye in both the spawning channel and Gates Creek are assumed to have experienced the same migration conditions and exposure to pathogens, pre-spawn mortality may also be expected to be similar between the two areas.

Although total escapement to the watershed was 44% lower in 2012 (30,644) than in 2011 (54,565), the channel was loaded to relatively similar densities (10% variance) in 2012 (17,068) as compared to 2011 (15,484). This small inter-annual loading variance was also observed if we only consider the number of females entering the channel which increased from 8,302 in 2011 to 9,456 in 2012. Thus, in this case, a relatively small increase in spawner density in the channel was associated with doubling of PSM between years. The trigger points that may relate density of spawners to PSM are not well understood. In Alaska high spawner densities and temperature have both been shown to reduce percent effective spawn (Quinn *et al.* 2007). However, another study at Weaver Creek spawning channel, did not demonstrate that density has a significant effect on percent spawn in sockeye, but did show an effect on the number of progeny produced per deposited eggs (Essington *et al.* 2000). Given these observations, further years of data from Gates Creek are yet required to establish if spawner density is an important factor in PSM in this population.

Note: Due to the once weekly frequency of sampling on Gates Creek as well as the more challenging environment with which carcasses must be recovered, a smaller proportion of the total population is sampled to estimate sex ratio and percent spawn during visual surveys than in the channel. As such total PSM numbers for Gates Creek are estimated by applying ratios from a sub sample to the estimated spawner abundance total for Gates Creek while in the spawning channel all carcasses which enter the channel are enumerated (minus a small number carcasses removed by wildlife). These factors may affect PSM calculations.

5.0 Summary and Recommendations

In 2012 continued improvements were made to data collection methods at Gates Creek spawning channel. Technical field skills of the N'Quatqua technicians as well as consistency in data collection methods between DFO and channel staff were improved through working with DFO stock assessment staff. A second year of fecundity data which will compliment juvenile out migration data to be collected in spring 2013 was collected. This will allow for further assessment of egg to fry survival for both Gates Creek and the spawning channel.

Deleted:

Further improvements to data collection methods and in comparative analysis should yet improve the precision of egg to fry survival estimates, assist in assessing the causes of high PSM experienced by Gates Creek sockeye and provide further skill building opportunities for N'Quatqua technicians. Linkage with fish passage studies at Seton dam (WUP Bridge Mon 14, Hinch 2012) may also assist in PSM evaluations. A key recommendation is that video validation be added to the mechanical counters to allow for a more precise estimate of counter error. Furthermore, analysis of video validation data would provide additional employment for channel staff in the off season. Further training of N'Quatqua staff by working with DFO technicians will build technical skills for channel staff as well as ensure consistency in scientific methods between the two organizations.

6.0 Tables

Table 1. Cumulative estimated escapement of sockeye adults into Gates Creek spawning channel, collected via counter, Fall 2012.

Date	Cumulative Total
10/08/2012	5
09/08/2012	15
10/08/2012	364
11/08/2012	2,001
12/08/2012	2,976
13/08/2012	4844
14/08/2012	7,201
15/08/2012	9,982
16/08/2012	13,072
17/08/2012	14,607
18/08/2012	15,223
19/08/2012	16,400
20/08/2012	17,226
21/08/2012	17,598

Table 2. Summary of 2011 and 2012 escapement estimates for adult sockeye to Gates Creek spawning channel collected via visual surveys.

	2011	2012
Males	6,631	5,882
Jacks	551	1,672
Females	8,302	9,514
Total	**15,484**	**17,068**

Table 3. Summary of 2011 and 2012 estimates for adult sockeye escapement to Gates Creek collected via visual surveys.

	2011	2012
Males	950	4,264
Jacks	12,224	976
Females	25,907	8,336
Total	**39,081**	**13,576**

Table 4. Mean fecundity and POH length (cm) in Gates Creek spawning channel females sockeye for 2011 and 2012

	Sample size	Mean POH in cm (SD)	Mean Fecundity (SD)
2011	48	48.0 (2.2)	3,260 (571)
2012	40	46.5 (2.4)	3,119 (516)

Table 5. Mean egg retention and POH in Gates Creek spawning channel female sockeye for 2011 and 2012

	Sample size	Mean POH in cm (SD)	Mean egg retention (SD)
2011	64	46.1 (2.6)	68 (153)
2012	80	45.9 (2.3)	248 (391)

Table 6. Break down of female percent spawn from visual counts, to Gates Creek spawning channel, Fall 2012.

Percent spawn	2011		2012	
	Number	% of total	Number	% of total
0%	3,647	43.9%	6,915	72.6%
50%	588	7.1%	163	1.7%
100%	4,067	49.0%	2,436	25.6%
Total	**8,302**	**100.0%**	**9,514**	**100.0%**

Table 7. Estimated effective females, mean fecundity and egg deposition for the 2011 and 2012 brood years of Gates Creek spawning channel sockeye population.

	2011	2012
Effective females	4,574	2,518
Mean fecundity	3,260	3,119
Egg deposition	**14,911,240**	**7,853,642**

Table 8. Estimated effective females, mean fecundity and egg deposition for Gates Creek sockeye population in 2011 and 2012. (Estimated effective females was provided by DFO (DFO, unpublished data))

	2011	2012
Effective Females	21,297	4,311
Mean fecundity	3,260	3,119
Egg deposition	**69,428,220**	**13,446,009**

7.0 Figures

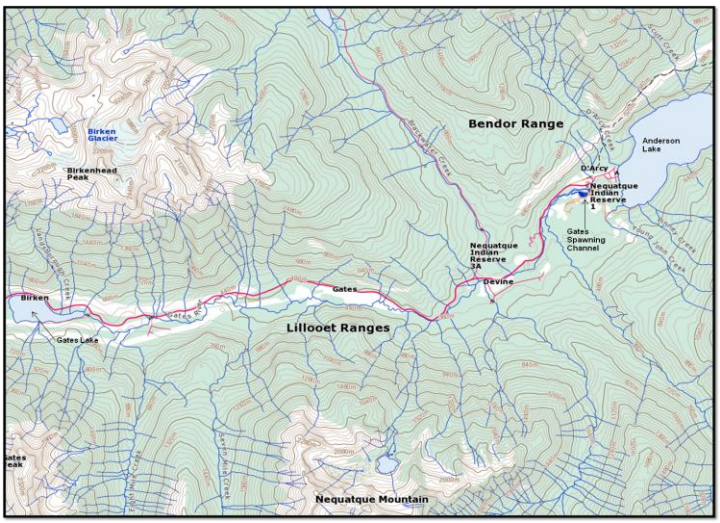

Figure 2. Map of study area show the Gates Creek and Gates Creek spawning channel.

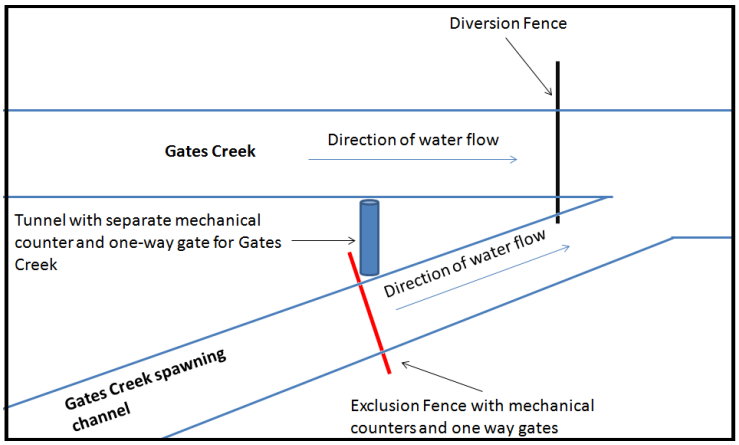

Figure 1. Schematic diagram of enumeration equipment at confluence of Gates Creek and spawning channel.

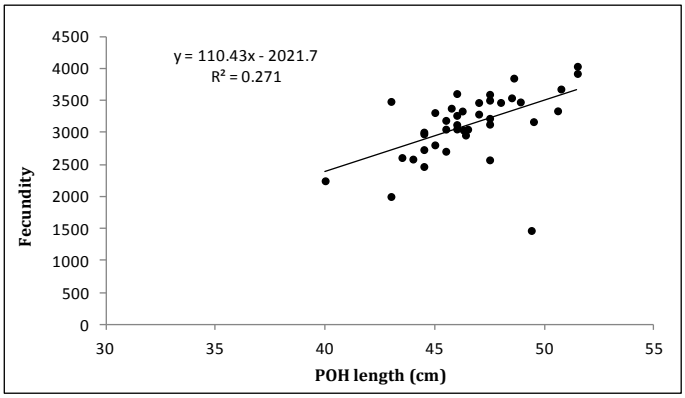

Figure 3. Scatter plot with fitted regression line of POH length (in cm) and total fecundity of female sockeye sampled at Gates Creek spawning channel, fall 2012.

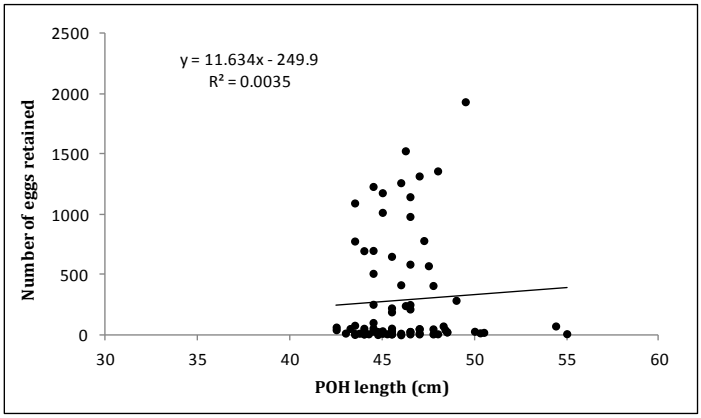

Figure 4. Scatter plot with fitted regression line of POH length (in cm) and number of eggs retained per female sockeye at Gates Creek spawning channel, fall 2012

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