Jordan Project Water Use Plan

Lower Jordan River Salmon Spawning Assessment and Enumeration

Implementation Year 5

Reference: JORMON-3

Jordan Salmon Spawning Assessment/Enumeration

Study Period: September 2009 – May 2010

Cascadia Biological Services
1442 White Pine Terrace
Victoria, BC
V9B 6J3

September 16, 2010

Executive Summary

The purpose of this study is to evaluate spawning success of anadromous salmon in Jordan River as part of the Jordan River Water Use Plan Monitoring Program. This report represents Year 5 of the planned 6-year study period. The study area encompassed both Reach 1 and Reach 2 of the lower Jordan River between the tailrace of the powerhouse and an impassable barrier located approximately 590m upstream.

The overall goal of this study was to evaluate spawning success focusing on two different anadromous salmon runs in the Lower Jordan River:

- Coho salmon from September 21st to December 21st 2009; and
- Steelhead from March 15th to May 31st 2010.

In addition to escapement monitoring for the periods above, five incubation tests in areas of high spawning suitability within the defined study area were conducted to determine potential incubation success of each developmental stage.

The results of the enumeration study show that only 4 adult (coho salmon) were observed during both sets of fall and spring assessments. Upon comparison to results obtained during the 2005/2006, 2006/2007, 2007/2008 and 2008/2009 seasons, overall numbers of adult fish have decreased from Year 1, Year 2, Year 3 and Year 4 which saw 4, 14, 3 and 1 adult salmon respectively compared to 4 individuals in Year 5. When considering individual species, returning coho remained steady from 4 individuals in Year 1, 1 individual in Year 2 to no individuals in both the 3rd and 4th years. This compares to 4 individuals in Year 5. Chum salmon both increased and decreased dramatically from 0 in Year 1 to 13 in Year 2 compared with 0 in years 3, 4 and 5. Steelhead increased from 0 in Year 1 to 2 individuals both in Year 2 and 3 of the study to 0 individuals in Year 4 and Year 5. Although the adult salmon population has decreased considerably from Year 2 of the study, the juvenile (0+) rainbow trout as well as the 1+ cohorts appear to have increased dramatically over the same study period. This is most evident when grouping all the cohorts together as Year 4 of the study shows 131 individuals compared to 57 individuals in Year 3 and 13 individuals in Year 2. Year 5 of the study shows an increase over Year 4 with a total of 171 individuals. The Year 1 results were not included in the comparisons, as it appears that the study did not include rainbow trout observations.

The results of our incubation assessments were all very successful through all three stages of development. In Year 5 of our study, all five incubation sites averaged survival rates over 97.6%. All three stages of egg development saw high survival rates. Comparing these results to Years 1, 2, 3 (data limited to hatch phases for Year 2) and 4 of the study suggests that overall; incubation success is very high at all sites except Site 3, which consistently produces lower survival rates although in the latter years of this study, they remain high at over 85%. Located next to a copper mine tailings slag pile, Site 3 Year 1 results showed 0% survival through all three stages of development. Year 2 at this site was limited to only the first stage of development due to extreme weather (cassettes lost). Survival at this stage in the second year was 87.5%. Two potential reasons for increased survival at Site 3 through the five years of the study are:

- the location of the cassettes was moved in Year 3 approximately 15m upstream of a small tributary entering the river through the tailings pile to avoid confounding siltation effects.
- approximately 40 cubic materials of potentially toxic material was removed in association with high flow events in the winter of 2006/2007.

Year 3, Year 4 and Year 5 survival rates have been shown to continuously improve from Year 1 and 2 results, which show high survival rates through all three stages of development (>84%, >91.5% and 97.5 survival respectively).

Results to date show potential limits to spawning success in the Lower Jordan River remain consistent over all five years of this study. The results show an absence of adequate spawning habitat (flow, gravel quality and quantity) as well as potential water quality issues from historic mine abandonment discussed above. Other potentially limiting factors to spawning success include predation in the lower reaches by eagles and a seal, a lack of freshwater attraction flows from the Lower Jordan River and confounding effects of generation which may attract fish to the tailrace rather than to the Lower Jordan River mainstem. As monitoring predation and attraction flow issues are not part of this study scope, it is recommended that future studies review these issues if salmon spawning success becomes an objective for fisheries management in the watershed

The effect of the initiation of the 0.25cms minimum flow release on spawning success was not measurable in terms of providing additional access to spawning habitat, or providing more stable incubation habitat. It may, however, have improved the water quality adjacent to Site 3 as egg survival was higher in Year 5 than in all previous assessments.

Overall, the data and conclusions to date are preliminary and will be summarized in the final year of monitoring.

Table of Contents

List of Figures

List of Tables

1.0 Introduction

BC Hydro initiated the Water Use Plan (WUP) process for the Jordan River watershed in April 2000 and concluded it in November 2001. From this WUP, a minimum flow was ordered for fisheries benefits, and a 6-year monitoring plan was established to evaluate the effectiveness of the ordered flow regime. The Lower Jordan River Spawning Assessment and Enumeration study program is one component of the monitoring plan. Initiated in 2005, this report focuses on Year 5 of the 6 year monitoring plan.

The overall objective of the study program is to assess the effectiveness of the minimum flow order for Lower Jordan River using spawning success as a key indicator. Spawning success is defined as the number of recruits per spawner within the anadromous reaches (approximately 590m in length) (refer to Figure 1). Target species were coho salmon (surveyed September 21st to December 21st 2009) and steelhead trout (surveyed March 15th to May 31st 2010). Study methods included snorkel surveys and incubation assessments within the anadromous section of river (Reaches 1 and 2).

1.1 Project Area

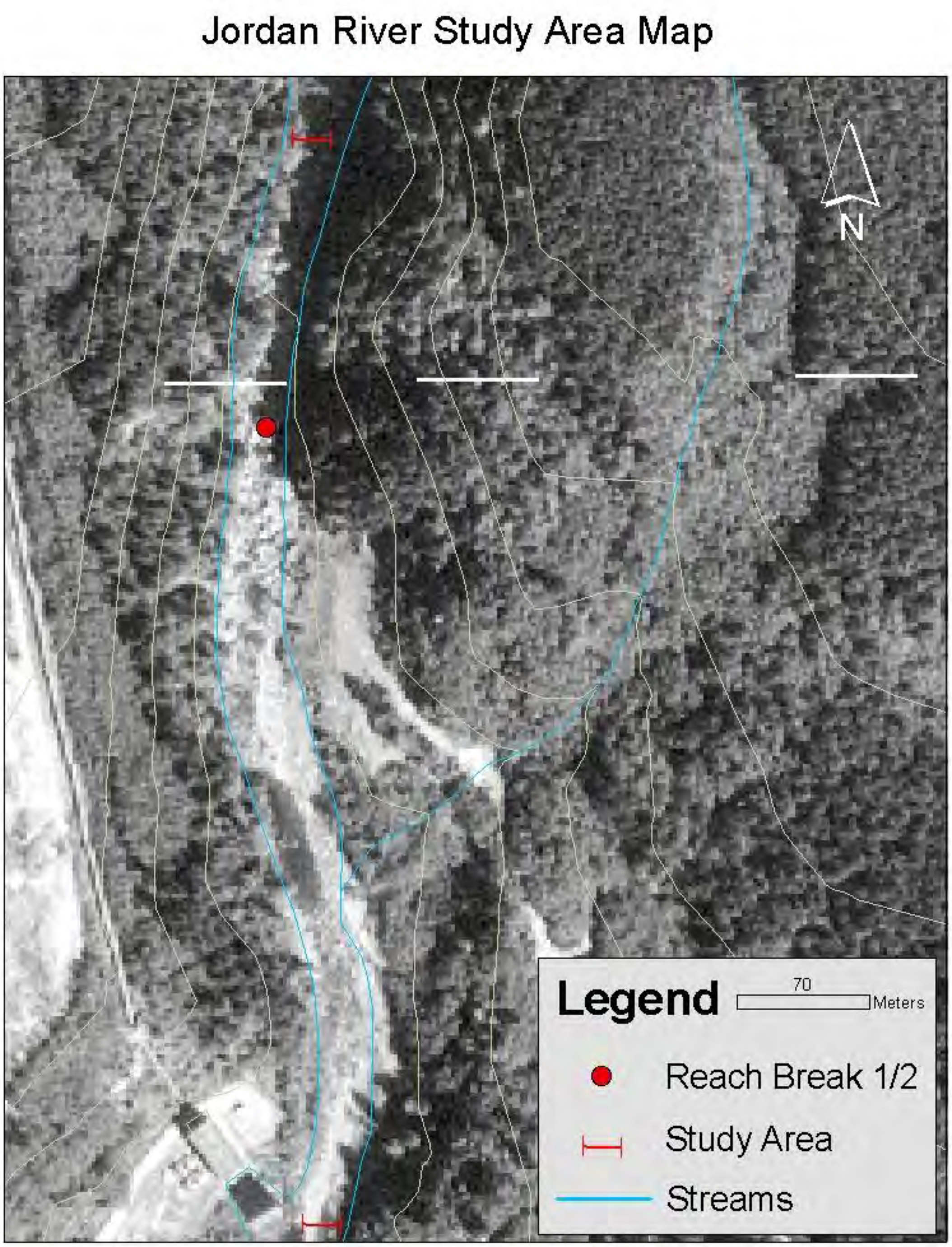
The study area (Reaches 1 and 2 from Figure 1) encompasses the mainstem of Jordan River (WSC- 930-037300) between the powerhouse tailrace and an impassable barrier to upstream fish migration located approximately 590m upstream.

The Jordan River drainage is located on the west coast of southern Vancouver Island, approximately 60 km west of Victoria. The river empties into the Juan de Fuca Strait. The existing river habitat is approximately 25 km long (excluding two reservoirs: Diversion and Elliot), of which approximately 7.4 km is between Elliott Dam and the powerhouse tailrace. The Lower Jordan River downstream of the powerhouse tailrace is tidally influenced and is not part of the study area.

The drainage area of Jordan River is approximately 184 km^2, of which 80% (147 km^2) is captured at the power intake at Elliott Dam. Under normal operating conditions, inflows and storage at Elliott Reservoir are diverted to the Jordan River powerhouse via a tunnel and penstock. Flows in the lower Jordan River channel below Elliott Dam are derived from local input from the residual 37 km^2 of the watershed as well as the 0.25 cms currently being released from the dam.

Where projected inflows to the Elliott Reservoir exceed its storage, BC Hydro will release flows from Elliott Dam to avoid uncontrolled spill events.

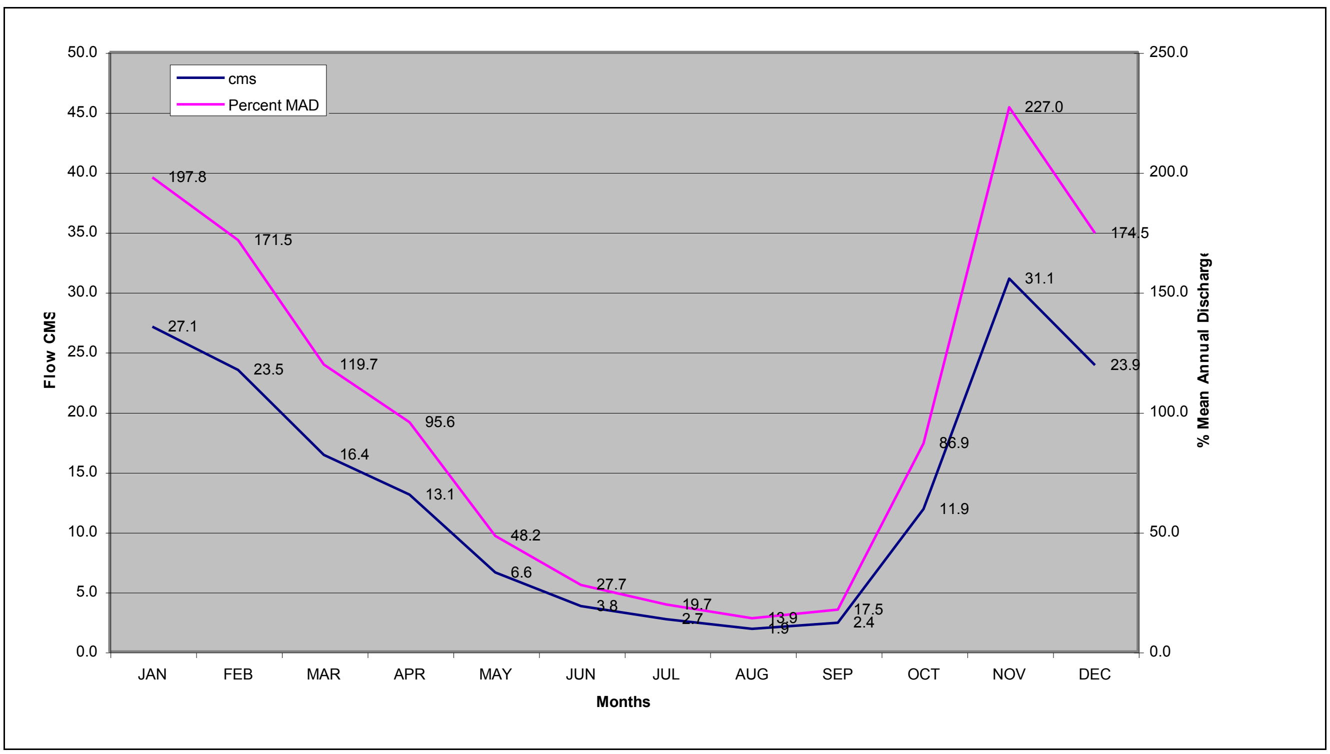
Figure 1 Jordan River Study Area



The mean annual precipitation within the watershed is 2,830 mm. The heavy precipitation events are usually limited to the winter period (October- March). Active logging within the watershed has reduced its capacity to attenuate precipitation events. Consequently peak flows during the winter have been more severe, while in the summer months periods with reduced or no inflow are frequent. Other factors affecting fish spawning activities within the study area include construction of the new tailrace and generating facility, past mining operations and a historical log sort at the Jordan River confluence.

Based on daily Lower Jordan River inflows calculated for the 1984-1999 period, the mean annual discharge is 13.7 cubic meters per second (cms) (BC Hydro 2001) measured at a gauging station located approximately 125 m upstream of the tailrace. The mean monthly discharge calculated using this data set is shown in Figure 2.

Figure 2 Mean Monthly Discharge for Jordan River (1984-1999).



A Fish Information Summary System (FISS) report generated June 13, 2007 indicated the presence of anadromous cutthroat trout, chum salmon, coho salmon, cutthroat trout, rainbow trout, and steelhead.

1.2 Objectives of the Work

The following objectives were initially identified (BC Hydro 2005):

The overall objective of this monitoring program was to assess the performance of the key WUP decision to increase flows in the lower Jordan River from leakage/local inflows to >0.25 cms using spawning success (number of returns to outmigrants) as the performance measure. As a requirement for establishing baseline performance measures, specific objectives related to our monitoring program included the following;

- Evaluate incubation success (Coho salmon) at five specific sites within the delineated study area; and
- Determine the number of spawning adults within the study area during specific timing/spawning windows for both Coho salmon (September 21st – December 21st) and for Steelhead (March 15th – May31st).

2 Methodology

2.1 Survey Preparation

Survey preparation for the project included the following;

- A detailed review of past projects on the lower Jordan River including the 2005/2006 report and associated recommendations.
- Assess safety concerns/site conditions with BC Hydro staff prior to the initiation of snorkel surveys.
- Produce a detailed safety plan and have it reviewed by BC Hydro staff.
- Review issues documented in Year(s) 1-4 of the project and prepare changes if any, to the new sampling and study program.

2.2 Fall and Spring Surveys

A total of eight fall and spring snorkeling surveys were completed during both the Coho spawning period (September 21st 2009 to December 21st 2009 – 5 surveys) and the Steelhead spawning period (March 15th 2010 to May 31st 2010 – 3 surveys). Due to safety concerns, a crew of three was utilized, whereby two snorkelers were in the water at all times and the third crewmember traveled onshore parallel to the two swimmers. The onshore crewmember maintained constant contact via two-way radios to the powerhouse and was equipped with various flotation devices as well as towropes. Where possible, the river was snorkeled/assessed twice from top (start point) to bottom. An underwater camera was used to photograph spawners. Staff gauge and water temperature measurements were also taken during each survey as well as select photographs documenting river conditions at the time of survey.

2.3 Winter/Spring Incubation Tests

Eyed coho salmon eggs (*Oncorhynchus kisutch*) were obtained from the Jack Brooks Hatchery in Sooke, BC, at approximately 265 ATU (accumulated thermal units) and transported to Jordan River on January 7th, 2010 following procedures detailed in Attachment I (Incubation Summary Protocol). Prior to transportation, staff at the hatchery sanitized all equipment including a 15-gallon tote with a diluted iodine solution. Eggs were then placed in the tote with water from the hatchery and covered with a sterilized cloth to reduce impacts associated with travel. The total time elapsed between the hatchery and insertion into the cassettes ranged from 2-3 hours. Once at the incubation site locations, eggs were manually inserted into the cassettes (200/cassette - Jordan-Scotty incubation cassettes). The cassettes were zip tied together forming three cassettes (600 eggs) per site. Cassettes were then planted in the gravel (holes dug one week prior to insertion), at five different sites in the river. Once planted, the cassettes were covered with gravel/cobble and tied to a piece of rebar vertically implanted into the streambed. Four out of the five sites (Sites 1, 2, 4 and 5) replicated incubation sites utilized in Year 1 of the program except for Site 3 which was placed approximately 15m upstream of the original site due to possible contamination issues associated with an unnamed tributary that flows through the copper tailing deposit. Sites for Year(s) 2-5 remained the same. The locations and biophysical summaries of the incubation sites are summarized in Figure 3 as well as in Table 1 below.

Egg survival was assessed at hatch, emergence as well as at post emergence at all five incubation sites and are discussed further in the results section. After each assessment and where possible, eggs/alevins were buried in the gravel once assessed for stage and health.

Water temperature was monitored at each visit to the assessment area using a handheld mercury thermometer.

Discharge was monitored by BC Hydro's gauging station located approximately 125 m upstream of the tailrace and correlated to flow using the stage-discharge relationship for the station generated by Dave Burt & Associates Ltd. River discharge data for the study period between September 15th 2009 and May 10th 2010 ranged from 0.441 cubic meters per second (cms) on October 12th 2009 to 22.569 cms on November 20th 2009. Please refer to Figure 3 below for discharge data at the hydrological station located within our study approximately 200m upstream of the tailrace along the right bank of the river. The graph also shows the installation date of the cassettes (first white triangle) as well as the incubation cassette sample dates for all three phases of development (white triangles following in order). The yellow line represents the lowest observable flows during our incubation assessment period.

Figure 3 Jordan River Discharge Curve (October 2009 – May 2010)

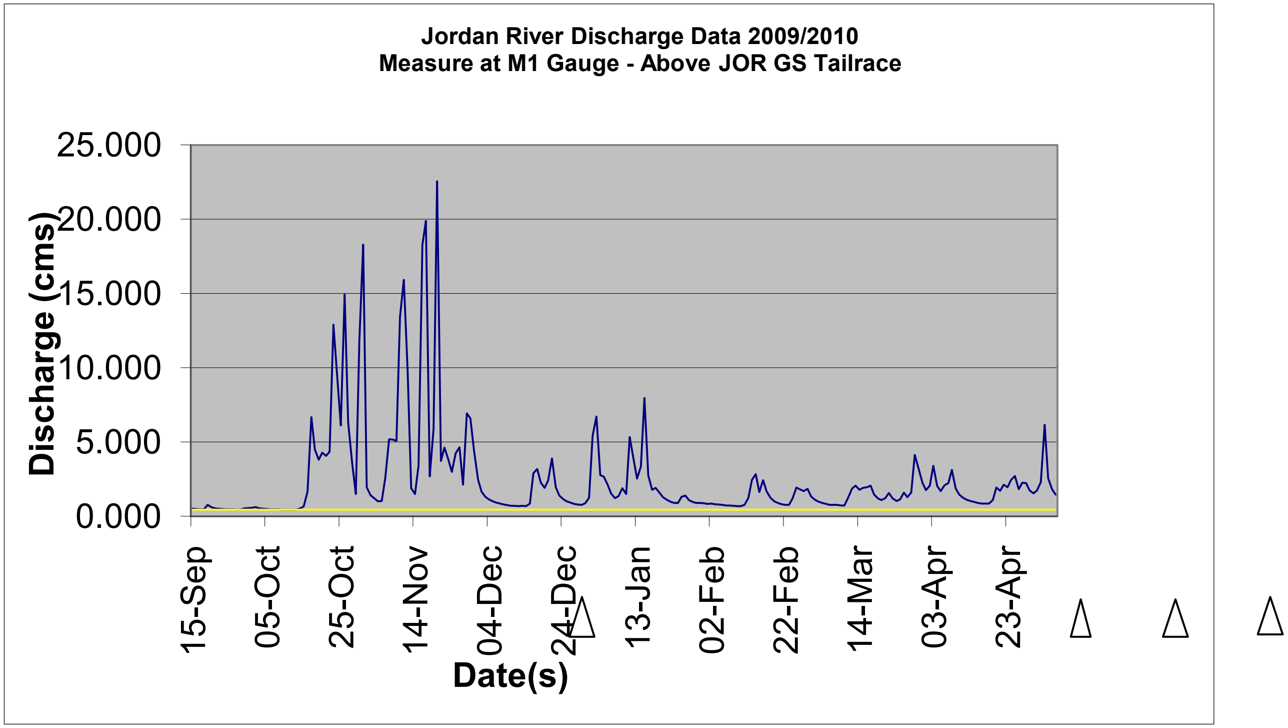
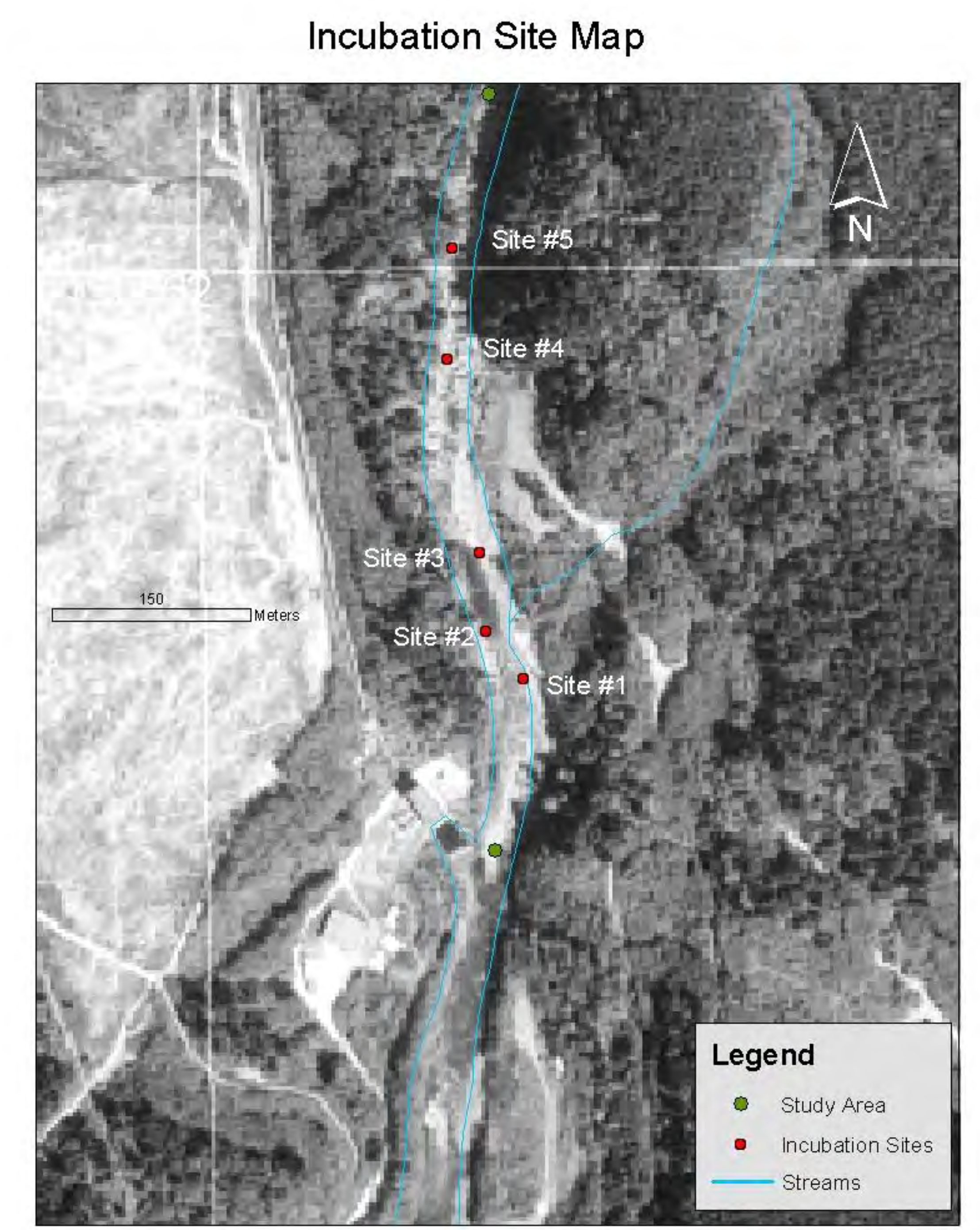


Table 1. Incubation Site Summary at Time of Placement

Incubation Site #	Water Depth Over Cassettes	Water Velocity at 60% Depth	Temp.	Substrate	Total Dissolved Oxygen (Time of Placement) (mg/l)	Silt Content In Cassettes When Sampled
1	0.28m	0.09m/s	1^{o}C	Gravel (50-80mm)	10.34	No Silt
2	0.30m	0.06m/s	1^{o}C	Gravel (25-45mm)	10.41	No Silt
3	0.25m	0.08m/s	1^{o}C	Gravel (25-50mm)	10.46	No Silt
4	0.28m	0.12im/s	1^{o}C	Gravel (25-40mm)	10.43	No Silt
5	0.21m	0.11m/s	1^{o}C	Gravel (25-50mm)	10.33	No Silt

Figure 4 Incubation Site Map



The following photographs present typical river conditions at time of egg placement into gravel. Where possible, views of upstream/downstream conditions as well as substrate composition at each incubation site were photographed. Photos were taken on January 7th 2010.

Site #1 – Glide section of last riffle before tidal influence (Plates #1 and 2)

Plate 1. Typical view of Site #1 facing downstream.

Plate #2. View of substrate (Site 1)

Site #2 – Tailout of large pool opposite mine tailings (Plates 3 and 4)

Plate #3. Side view of Site #2.

Plate #4. View of substrate (Site #2)

Site #3 – At outflow (20m upstream) of large tributary coming from tailings (Plates 5 and 6)

Plate #5. Side view of Site #3.

Plate #6. View of substrate (Site #3)

Site #4 – 40m downstream of cascade reach (Plates 7 and 8)

Plate #7. Upstream view of Site #4.

Plate #8. View of substrate (Site #4)

Site #5 – 75m u/s of Site #4 in cascade habitat (Plate 9 and 10)

Plate #9. View of substrate (Site #5)

Plate #10. Downstream view of substrate and habitat (Site #5)

3 Results

3.1 Study Area Delineation and Description

Reach 1

General channel characteristics of Reach 1 included an average channel width of 43.20 m and average gradient of 3%. The stream morphology most common within Reach 1 consists of riffle-pools with large boulders being the dominant substrate and a mix of small and large cobble sub-dominant. Remnants of an abandoned mine lie on the left bank of the river. Seepage from the mine contributes to elevated levels of toxic heavy metals (Griffith 1996). Refer to Figure 1 for reach delineation. Sub-delineation of Reach 1 into smaller biophysical units is presented below in Table 2. General biophysical changes observed over Year(s) 1-5 of the project are limited to undercutting of the mine tailings along the left bank of the river. Over the five years of this study, the tailings pile has been reduced in volume by approximately 77 cubic meters of material. This is primarily due to bank undercutting as a result of extremely high flows. Other noted changes over the five years include a reduction in spawning gravel volume over the length of the reach. This is primarily attributed to near record flows in the fall of 2006 associated with 3 weeks of storms and overflow conditions. During this time, record river discharges removed the overall depth of gravel through surface scour. Although the gravel areas generally remained the same, significant volumes were lost as the overall gravel depth and volume were reduced. The total gravel area and any changes noted are based on observations from year to year and are not the result of physical measurements.

Table 2. Reach 1 Biophysical Delineation

Section	Location	Dominant Substrate	*Spawning Area (m^2)	Primary Cover
1	0-171m	boulders/cobble	44	boulders
2	171-249	cobble/gravel	30	deep pool
3	249-419	boulders	45	boulders

* - Note: Spawning gravel distribution has remained the same over the five-year study period. Spawning gravel volume however, has been reduced by almost ¼ from Year 1 to Year 5 observations.

Fish habitat characteristics of Reach 1 include good deep pool and boulder cover. LWD cover within the reach is considered poor. Pockets of spawning gravel exist intermittently throughout the reach and consist of large gravel/small cobble sized substrate. A typical view of the habitat within the reach is shown in photographs below.

Reach 2

General channel characteristics of Reach 2 included an average channel width of 31.80m and average gradient of 18%. The reach extends up from Reach 1 into higher gradient cascades to an impassable barrier located approximately 590m upstream of the tailrace. Refer to Figure 1 for reach delineation. Sub-delineation of Reach 2 into smaller biophysical units is presented below in Table 3. Changes observed over Year 1, 2, 3, 4 and 5 of the project are limited to a reduction in spawning gravel volume over the length of the reach. Although no changes to gravel area were noted, gravel volume appears to have been reduced significantly over the five years of the study. This is primarily attributed to near record flows in the fall of 2006 associated with 3 weeks of storms and overflow conditions.

Table 3. Reach 2 Biophysical Delineation

Section	Location	Dominant Substrate	*Spawning Area (m^2)	Primary Cover
1	419-435m	boulders/cobble	20	deep pool
2	439-590	boulders/cobble	5	boulders

* - Note: Spawning gravel distribution has remained the same over the five-year study period. Spawning gravel volume however, has been reduced by almost 1/3 from Year 1 to Year 5 observations.

Fish habitat characteristics of Reach 2 include good deep pool and boulder cover. LWD cover within the reach is considered poor/non-existent. Small pockets of spawning substrate exist occasionally throughout the reach and are generally located at pool tailouts and consist of small cobble sized substrate. A typical view of the habitat within the reach is shown in photographs below.

3.2 Spawning Assessment Results 2009/2010

Escapement results from the 5 coho surveys and 3 steelhead surveys are summarized in Table 4 below. Overall, only four observations were made over the course of the study. The observations were of coho salmon on October 21st 2009 (2) and November 19th 2009 (2). The four individuals were observed on the left bank of the river adjacent to the mine tailings approximately 40m upstream of the largest pool within the study area. No other observations were made including BC Hydro staff observations of the tailrace, which has in previous years added to the overall numbers as it is checked regularly throughout the fall and winter. The 4 individuals observed during the fifth year of the study compares well to the previous four years of the study, which saw a total of 3, 16, 4 and 1 for years 1 through 4 respectively. When directly comparing species to the previous study years, the 4 coho salmon observed were equal the 2005/2006-study year however, more than the 1, 0 and 0 individuals in Year (s) 2 through 4 respectively . When comparing other species of salmon, the absence of steelhead observations in 2009/2010 are comparable to Year(s) 1 through 4 were 0, 2, 2 and 0 steelhead individuals were recorded respectively. During the course of our snorkel surveys, crews paid special attention to dug up gravels, which may have been an indication of spawning activity. From our assessments, no redds were observed during the course of both coho and steelhead surveys. Conditions during both surveys were favorable as visibility was moderate to high during the majority of our snorkel assessments. Throughout the surveys, numerous rainbow trout (o+ cohorts) were observed (approximately 99 individuals) ranging in length from 40 to 90mm as well as larger individual (approximately 72 individuals - 1+ cohorts) ranging in length from 90-160mm. Overall, the results (salmon enumeration) are quite poor compared to previous years as well as when comparing to nearby indicator streams such as Kirby Creek with coho returns averaging 225 individuals (range 146-323 between 1995-2002) over 6.4 km of river (35 individuals/km). Table 4 below presents a summary of the enumeration results and biophysical data for Year 5 of this program. Please refer to Figure 4 (Spawning Assessment Location Map) and Figure 5 (Adult Salmon Spawner Enumeration) for graphical displays of the enumeration results.

Table 4 Spawning Assessment Summary

Task/Date	Target	Location	**Staff Gauge (m)	Water Visibility/Stage	Fish Observed Juveniles	Fish Observed Adults	Other Comments
Coho Survey 1 30/09/09	CO	Reach 1	1.28m	Good/Low	31 0+ RBT	9 1+ RBT	No eagles/seals Observed
Coho Survey 2 21/10/09	CO	Reach 1	1.77m	Moderate/Moderate	22 0+ RBT	13 1+ RBT 2 Coho	I Eagle Observed/No seals
Coho Survey 3 19/11/09	CO	Reach 1	1.66m	Moderate/Moderate	10 0+ RBT	3 1+ RBT 2 Coho	No eagles/seals observed
Coho Survey 4 26/11/09	CO	Reach 1	1.56m	Moderate/Moderate	27 0+ RBT	20 1+ RBT	I Eagle Observed/No seals
Coho Survey 5 05/12/09	CO	Reach 1	1.43m	Good/Low	No fish	No fish	No eagles/seals observed
Steelhead Survey 1 20/03/10	ST	Reach 1	1.45m	Good/Low	No fish	No fish	No eagles/seals observed
Steelhead Survey 2 01/05/10	ST	Reach 1	1.36m	0ood/Low	3 0+ RBT	6 RBT 1+	No eagles/seals observed
Steelhead Survey 3 10/05/10	ST	Reach 1	1.41m	Good/Low	6 0+ RBT	11 RBT 1+	No eagles/seals observed

** - Note: The Inflow Monitoring study will attempt to extrapolate discharge measurements based on inflow records at the end of the study.

Figure 4 Spawning Assessment Map

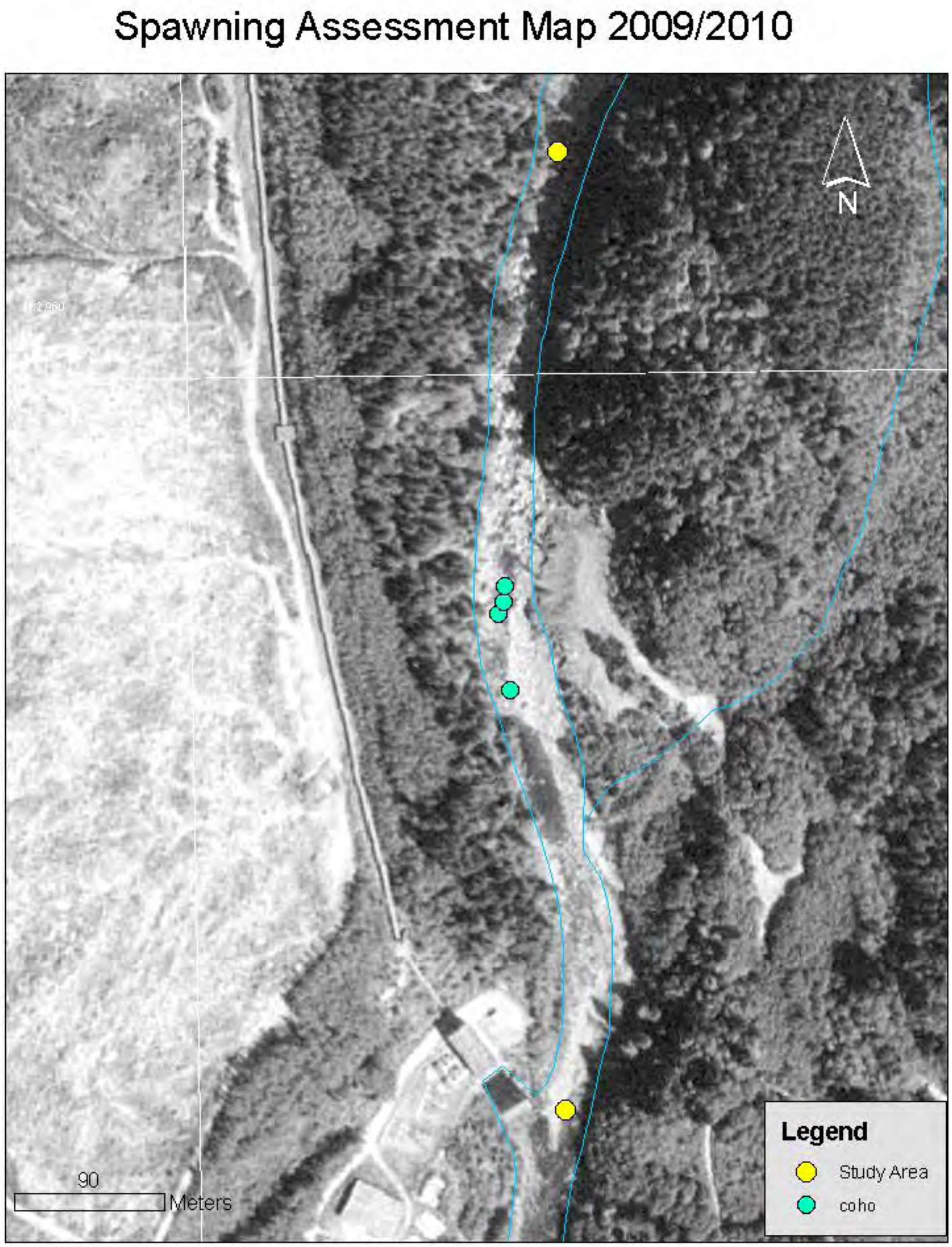
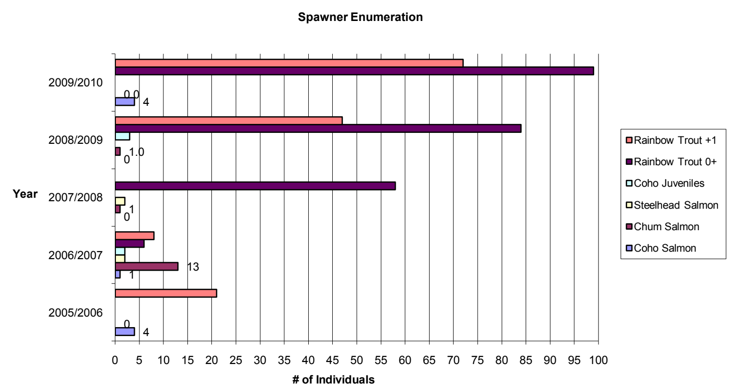


Figure 5 Adult Salmon Spawner Enumeration Including Rainbow Trout Cohorts (2005-2010)



3.3 Incubation Assessment

The 2009/2010 incubation assessments represents the fifth year of monitoring incubation success at five different incubation sites within reaches 1 and 2 of the Jordan River mainstem. To ensure consistency in our results, the incubation sites have remained at the same locations over the five-year study period and have used the same equipment and configuration of cassettes from year to year. This includes retaining the initial incubation site characteristics including depth of cassettes in the substrate, water level at time of burial, rebar configuration etc. The incubation assessment period for all five sites was from early January 2010 to the end of April 2010 and included sampling one of the three cassettes at each site representing one of the three incubation phases (hatch, emergence and post emergence). From our assessments, the average survival to stage sampled at sites 1 through 5 was 97.6% (range 97%-98.5%), 97.4% (range 97%-98%) and 97.8% (range 97%-99.5%) for hatch, emergence and post-emergence phases respectively. Mean survival to stage sampled for all five incubation sites was 97.6%. Refer to Table 5 below for individual plate summaries as well as Tables 6-10 for incubation site characteristics and comparisons from year to year. Overall, water depth over the incubation cassettes as well as velocities remained within acceptable ranges at all five sites during each site visit sampling stage development. Water temperature readings through the incubation period (January 7th 2010 – April 29th 2010) ranged from 1.23 °C to 9.08 °C averaging 5.16 °C. The discharge for the same period ranged from 0.680 cms to 4.124 cms (D. Burt. in prep, 2010). To ensure the cassettes were covered at all times during the study period, the cassettes were visited at various dates during extended dry spells and low flow conditions. These assessments were correlated to the staff gauge height so that comparisons could be made to the discharge curve. From this correlation, we have determined that the cassettes had appropriate flows as well as remained submerged during the entire study period. This was also confirmed with flow/discharge records showing that the lowest flows during our incubation assessment period was on February 10th 2010 when we visited the site to confirm extreme low flow conditions observed at Kirby Creek approximately 18 km to the southeast. As all five sites had adequate flows and water depths at that time, we can deduct adequate flows were present throughout the survey period.

3.3.1 Incubation Site Summary

The following incubation sites descriptions and summary are detailed below and in Table 5 titled Incubation Assessment Summary 2010. In summary, all five sites were sampled at three specific stages of development including the hatch stage, followed by the emergence stage, and finally, the post emergence stage. These stages were sampled at all five sites on March 18th 2010 (hatch), April 8th 2010 (emergence stage) as well as on April 29th 2010 (post emergence stage). The sample dates were based on expected ATU's based on water temperature data from a neighboring stream (Kirby Creek) located between the Sooke River and Jordan River. The target ATU's for our assessment were 450, 750 and 900 based on the stages identified above for sampling. Actual ATU's at the time of sampling based on temperature data received after the completion of our assessment was 413 (hatch stage), 532 (emergence) and 685 (post emergence). The expected ATU's versus the actual ATU's are off as a result of differences between are neighboring stream and Jordan River. Overall, our assessments resulted in high survival rates at all five sites through all three stages of development. Please refer to select photographs below as well as Tables 5-10 and Figures 6-11 for a detailed breakdown of the 2009/2010 assessment as well as comparison tables for Years 1-5. Figure 6 (Overall Incubation Success Comparisons) represents the overall incubation success over the four-year study period as well as a comparison to the 2003 incubation assessment by Wright and Guimond. The Wright and Guimond incubation results are shown for the sake of comparing overall survival. However, it should be noted that the species used (Pink Salmon) differed from that used in this study (Coho Salmon) as well as a few other key differences. These include the sites used for incubation (+-5m difference in location), depth of cartridges and configuration, substrate used to cover the cassettes etc. Figures 7-11 represent the incubation success at each of the three developmental stages for each of the five sites.

Typical view of hatch stage.

Typical view of emergence stage of development

Typical view of cassette at post emergence stage of development

Table 5. Incubation Assessment Summary 2009/2010 (Year 5)

Site	Plate #1 (P1) Sampled March 18th 2010	Plate #2 (P2) Sampled April 8th 2010	Plate #3 (P3) Sampled April 29th 2010	% Survival P1/P2/P3
1	160 hatched (80%) 5 morts (2.5%) 5 unhatched (2.5%) 30 emerged (15%)	189 alevins (94.5%) 6 morts (3%) 5 emerged (2.5%) 0 unhatched (0%)	0 alevins (0%) 4 morts (2%) 196 emerged (98%)	97.5%/97%/98%
2	91 hatched (45.5%) 6 morts (3%) 3 unhatched (1.5%) 100 emerged (50%)	189 alevins (94.5%) 4 morts (2%) 7 emerged (3.5%) 0 unhatched (0%)	0 alevins (0%) 6 morts (3%) 194 emerged (97%)	97%/98%/97%
3	111 hatched (55.5%) 5 morts (2.5%) 0 unhatched (0%) 84 emerged (42%)	186 alevins (93%) 7 mort (3.5%) 7 emerged (3.5%)	0 alevins (5.5%) 5 morts (2.5%) 195 emerged (97.5%)	97.5%/97.5%/97.5%
4	107 hatched (53.5%) 5 mort (2.5%) 7 unhatched (3.5%) 81 emerged (40.5%)	184 alevins (92%) 6 mort (3%) 10 emerged (5%)	0 alevins (5.5%) 6 morts (3%) 194 emerged (97%)	97.5%/97%/97%
5	108 hatched (54%) 3 morts (1.5%) 6 unhatched (3%) 83 emerged (41.5%)	187 alevins (93.5%) 5 mort (2.5%) 8 emerged (4%)	1 alevins (0.5%) 1 mort (0.5%) 198 emerged (99%)	98.5%/97.5%/99.5%

Table 6. Incubation Assessment Summary 2008/2009 (Year 4)

Site	Plate #1 (P1) Sampled April 1st 2009	Plate #2 (P2) Sampled April 9th 2009	Plate #3 (P3) Sampled May 1st 2009	% Survival P1/P2/P3
1	76 hatched (38%) 3 mort (1.5%) 2 unhatched (1%) 119 emerged (59.5%)	8 alevins (4%) 10 morts (5%) 180 emerged (90%) 2 unhatched (1%)	0 alevins (0%) 7 morts (3.5%) 193 emerged (22.5%)	98.5%/95%/96.5%
2	28 hatched (14%) 5 morts (2.5%) 2 unhatched (1%) 165 emerged (82.5%)	40 alevins (20%) 3 morts (1.5%) 155 emerged (77.5%) 2 unhatched (1%)	10 alevins (5%) 10 morts (5%) 180 emerged (90%)	97.5%/98.5%/95%
3	4 hatched (2%) 4 morts (2%) 1 unhatched (0.5%) 191 emerged (95.5%)	3 alevins (1.5%) 7 mort (3.5%) 190 emerged (95%)	11 alevins (5.5%) 17 morts (8.5%) 172 emerged (86%)	98%/96.5%/91.5%
4	50 hatched (25%) 6 mort (3%) 10 unhatched (5%) 134 emerged (67%)	Lost Cassette	Lost Cassette	97%/NA/NA
5	66 hatched (33%) 9 morts (4.5%) 4 unhatched (2%) 121 emerged (60.5%)	1 alevins (0.5%) 5 mort (2.5%) 194 emerged (97%)	0 alevins (0%) 8 mort (4%) 192 emerged (96%)	95.5%/97.5%/96%

Table 7. Incubation Assessment Summary 2007/2008 (Year 3)

Site	Plate #1 (P1) Sampled February 29th 2008	Plate #2 (P2) Sampled April 9th 2008	Plate #3 (P3) Sampled May 9th 2008	% Survival P1/P2/P3
1	155 hatched (77.5%) 6 mort (3%) 1 unhatched (0.5%) 38 emerged (19%)	160 alevins (80%) 6 mort (3%) 34 emerged (17%)	146 alevins (73%) 9 mort (4.5%) 45 emerged (22.5%)	97%/97%/95.5%
2	178 hatched (89%) 1 mort (0.5%) 11 unhatched (5.5%) 10 emerged (5%)	175 alevins (87.5%) 4mort (2%) 21 emerged (10.5%)	90 alevins (45%) 4 mort (2%) 106 emerged (53%)	99.5%/98%/98%
3	181 hatched (90.5%) 1 mort (0.5%) 11 unhatched (5.5%) 7 emerged (3.5%)	165 alevins (82.5%) 16 mort (8%) 19 emerged (9.5%)	144 alevins (72%) 31 mort (15.5%) 25 emerged (12.5%)	99.5%/92%/84.5%
4	184 hatched (92%) 3 mort (1.5%) 10 unhatched (5%) 3 emerged (1.5%)	165 alevins (82.5%) 7 mort (3.5%) 28 emerged (14%)	148 alevins (74%) 11 mort (5.5%) 41 emerged (20.5%)	98.5%/96.5%/94.5%
5	150 hatched (75%) 3 mort (1.5%) 19 unhatched (9.5%) 28 emerged (14%)	163 alevins (81.5%) 6 mort (3%) 31 emerged (15.5%)	85 alevins (42.5%) 12 mort (6%) 103 emerged (51.5%)	98.5%/97%/94%

Table 8. Incubation Assessment Summary 2006/2007 (Year 2)

Site	Plate #1 Sampled February 14th 2007	Plate #2	Plate #3	% Survival P1/P2/P3
1	28 hatched (14%) 4 mort (2%) 168 unhatched (84%)	Lost	Lost	98%/0%/0%
2	23 hatched (11.5%) 7 mort (3.5%) 170 unhatched (85%)	Lost	Lost	96.5%/0%/0%
3	59 hatched (29.5%) 25 mort (12.5%) 116 unhatched (58%)	Lost	Lost	87.5%/0%/0%
4	4 hatched (2%) 4 mort (2%) 192 unhatched (96%)	Lost	Lost	98%/0%/0%
5	9 hatched (4.5%) 14 mort (7%) 177 unhatched (88.5%)	Lost	Lost	93%/0%/0%

Table 9. Incubation Assessment Summary 2005/2006 (Year 1)

Site	*Date Sampled	Plate #1	Plate #2	Plate #3	% Survival P1/P2/P3
1	03/03/06	6 alevins (3%) 1 mort (0.5%) 193 unhatched (96.5%)	6 alevins (3%) 10 morts (5%) 184 unhatched (92%)	9 alevins (4.5%) 6 morts (3%) 185 unhatched (92.5%)	97%/95%97%
2	02/05/06	161 emerged (80.5%) 20 unhatched (10%) 3 morts at egg stage (1.5%) 16 morts (8%)	183 emerged (91.5%) 4 unhatched (2%) 2 morts at egg stage (1%) 11 morts (5.5%)	184 emerged (92%) 8 unhatched (4%) 3 morts at egg stage (1.5%) 5 morts (2.5%)	90.5%/93.5%/96 %
3	13/04/06	200 morts (100%)	200 morts (100%)	200 morts (100%)	0%/0%/0%
4	13/04/06	180 at emergence (90%) 10 emerged (5%) 6 morts at egg stage (3%) 4 morts (2%)	171 at emergence (85.5%) 25 emerged (12.5%) 4 morts at egg stage (2%)	182 at emergence (91%) 15 emerged (7.5%) 2 morts at egg stage (1%) 1 mort (0.5%)	95%/98%/98.5%
5	10/03/06	190 alevins (95%) 6 morts (3%) 4 unhatched (2%)	189 alevins (95%) 8 morts (4%) 3 unhatched (1%)	188 alevins (94%) 6 morts (3%) 6 unhatched (3%)	97%/96%/97%

Table 10. Incubation Assessment Summary (Pink Salmon) – Years 2003, 2006-2009

Site # (2003)	Site # in 2006-2008 assessments	Overall Site Survival % 2003	Overall Site Survival % 2005/2006	*Overall Site Survival % 2006/2007	**Overall Site Survival % 2007/2008	**Overall Site Survival % 2008/2009	**Overall Site Survival % 2009/2010
	1	N/A	97	98	96.5	96.5	97.5
1	2	14.7	93	96.5	98.5%	97%	97.3
2	3	7.7	0	87.5	92%	95%	97.5
3	4	86.7	97	98	96.5	*97	97.2
	5	N/A	97	93	96.5	96	98.5

* - Site survival based on only one stage/cassette sampled (200 individuals)

** - Site survival based on an average of all three cassettes/stages of development

(Note: 2003 data is from Wright and Guimond 2003

Figure 6 Overall Incubation Success Comparisons

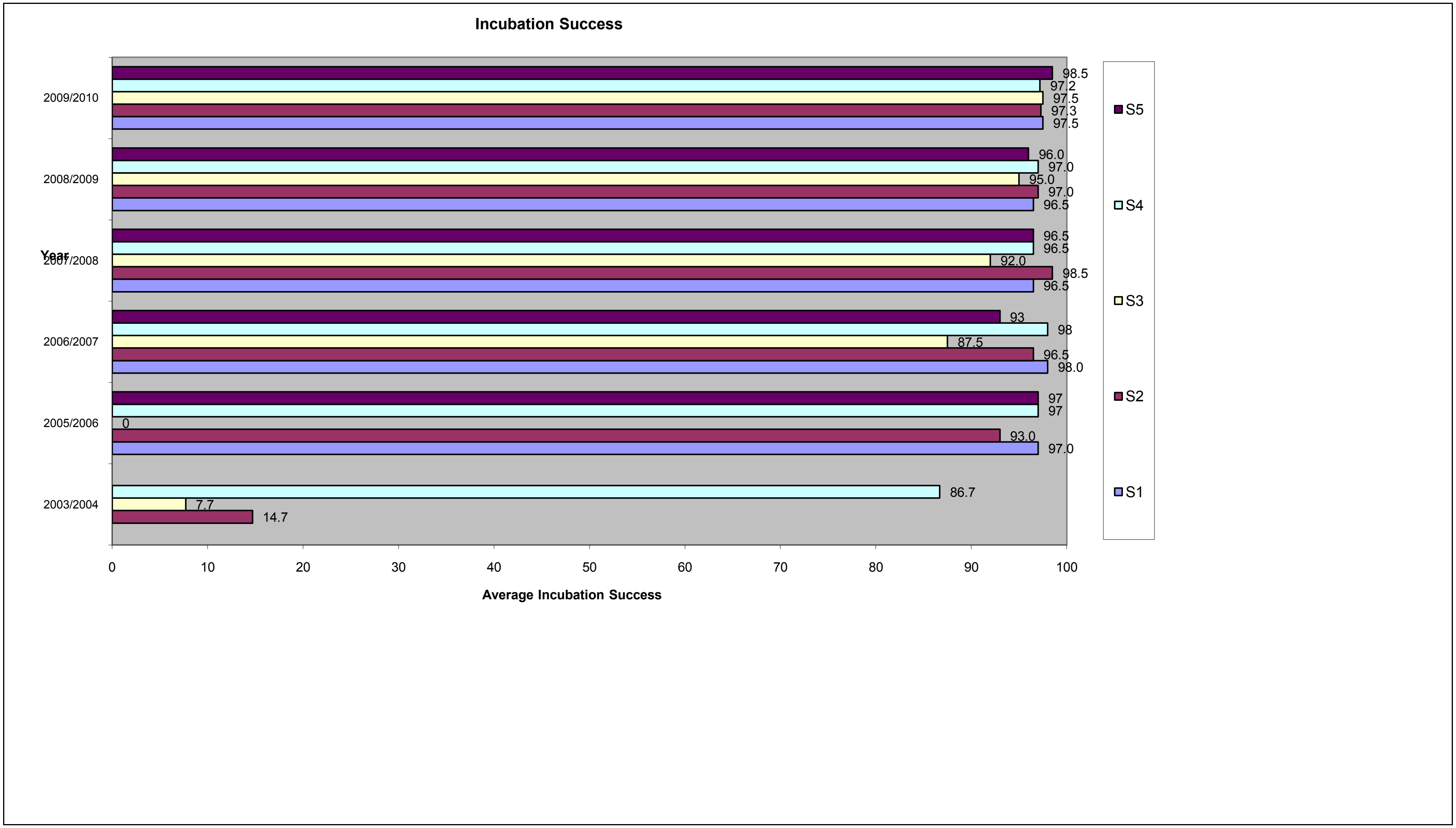


Figure 7 Incubation Success – Hatch, Emergence and Post Emergence Stages (Site 1)

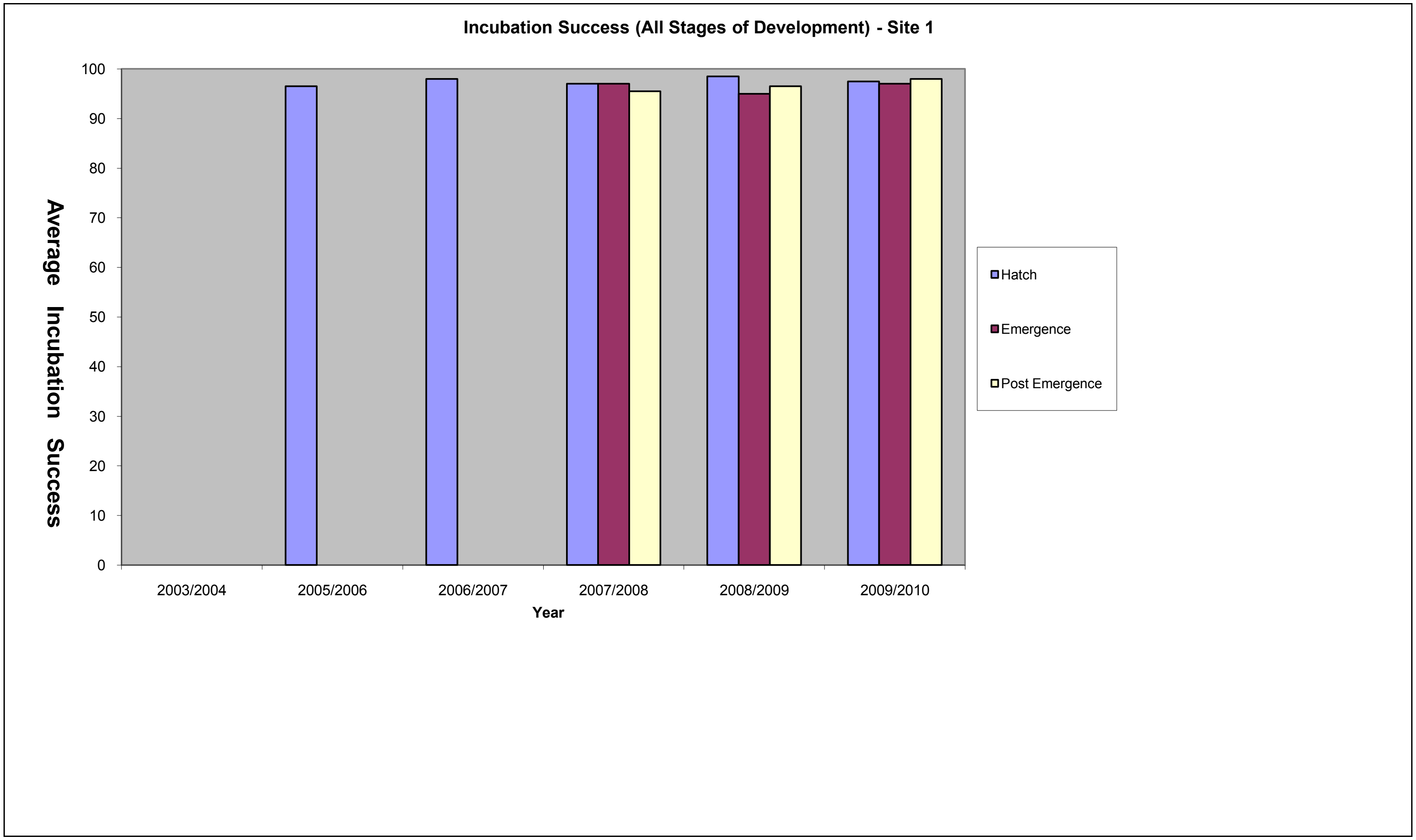


Figure 8 Incubation Success – Hatch, Emergence and Post Emergence Stages (Site 2)

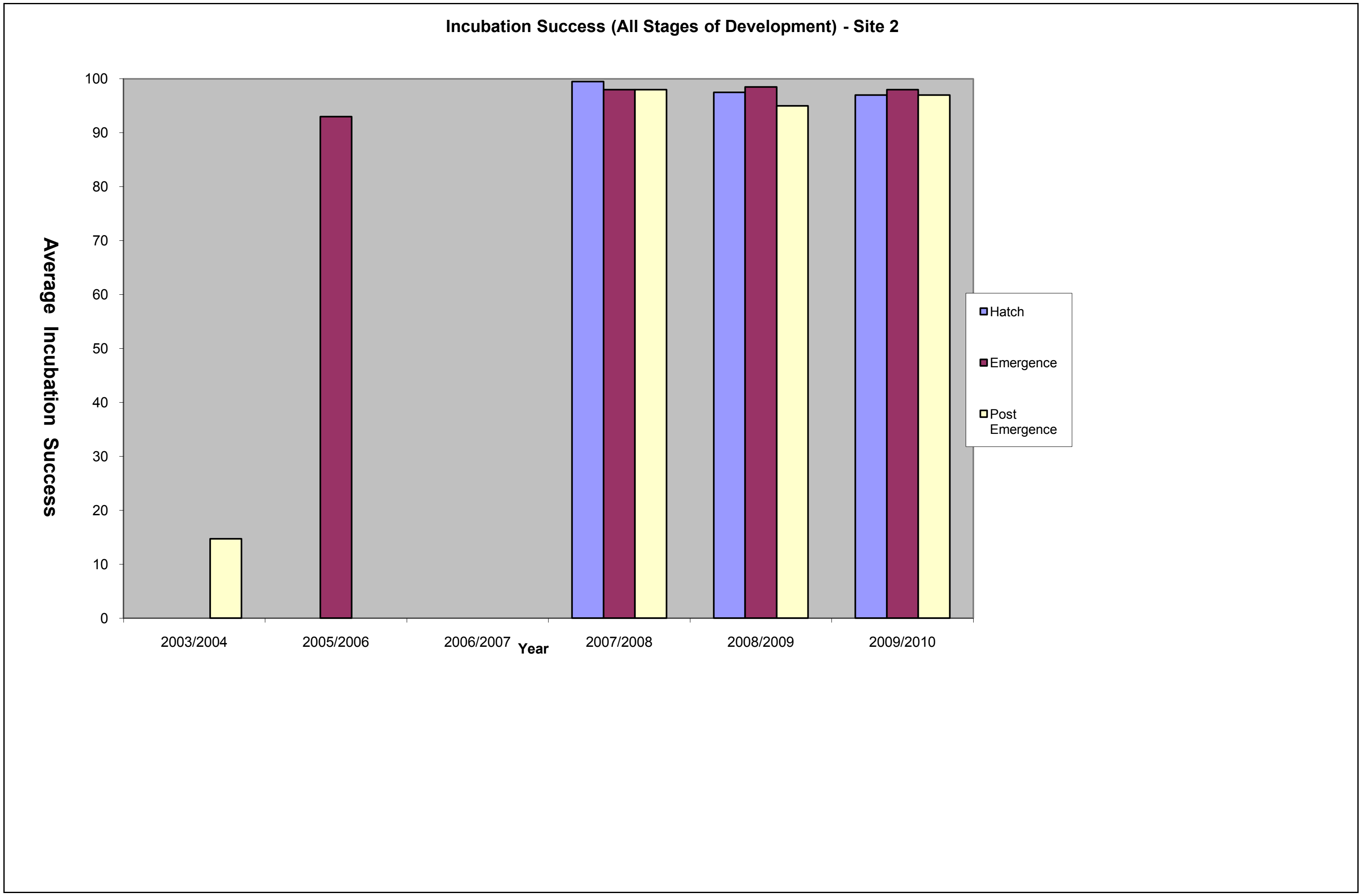


Figure 9 Incubation Success – Hatch, Emergence and Post Emergence Stages (Site 3)

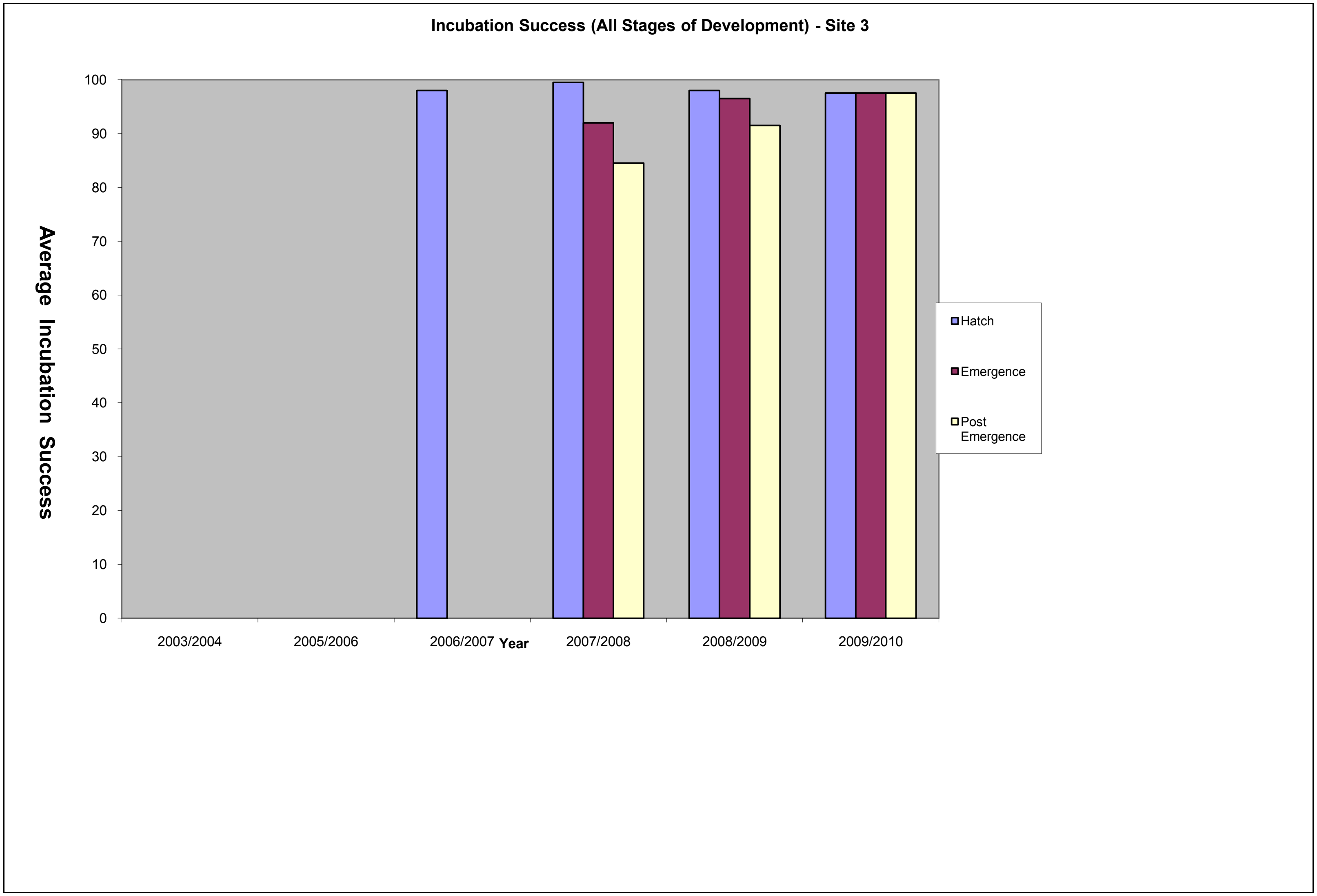


Figure 10 Incubation Success – Hatch, Emergence and Post Emergence Stages (Site 4)

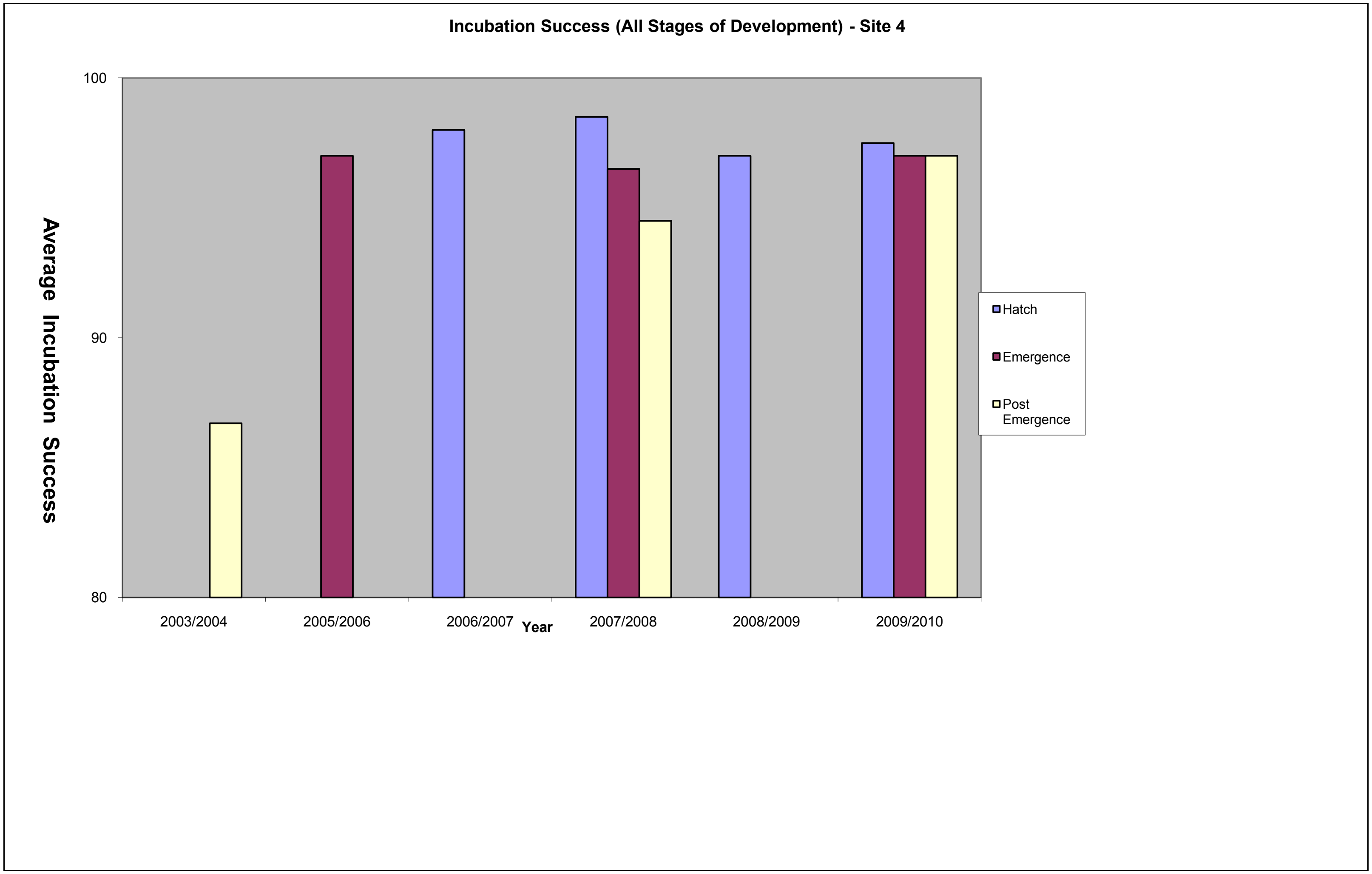
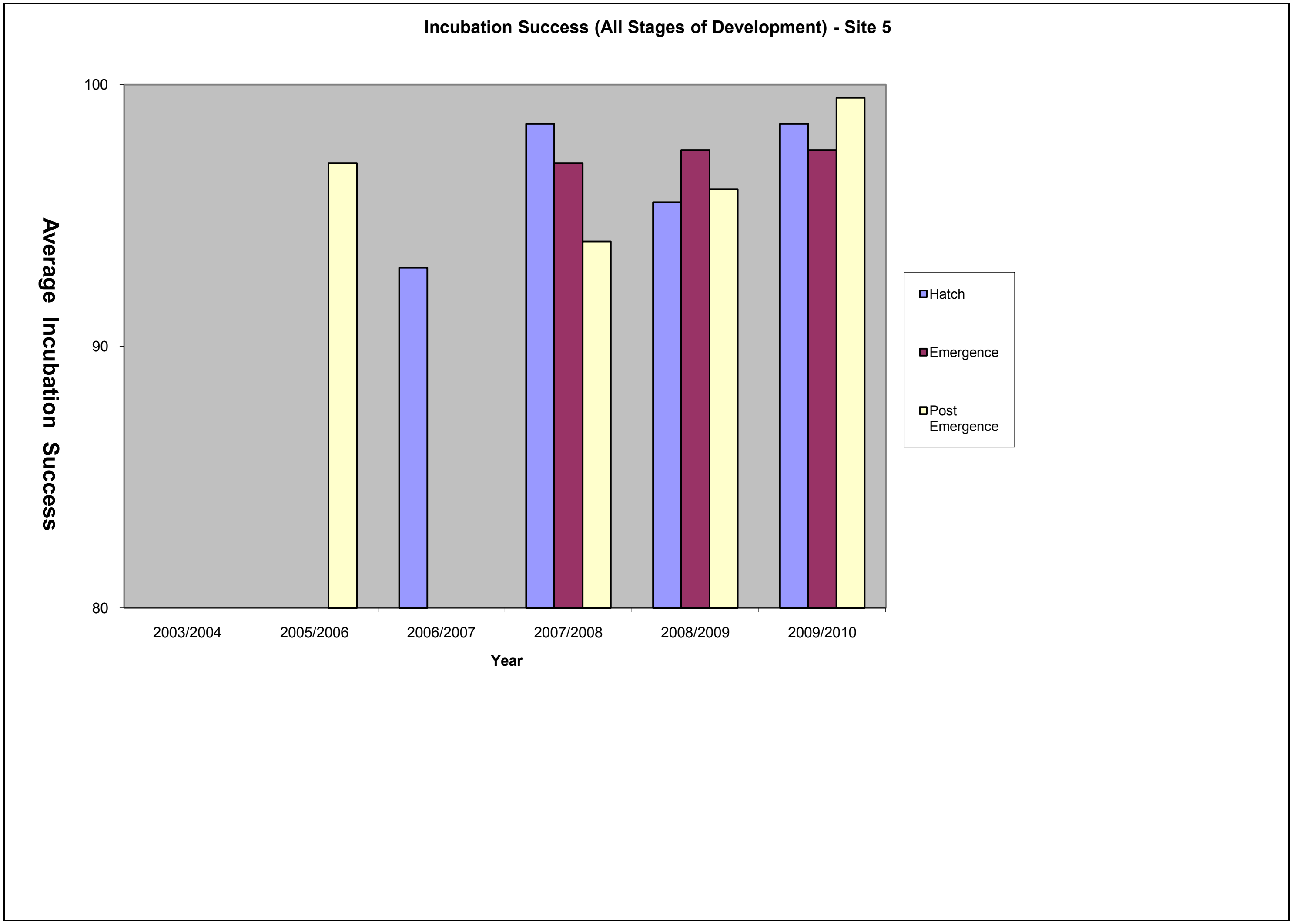


Figure 11 Incubation Success – Hatch, Emergence and Post Emergence Stages (Site 5)



4.0 Summary and Discussion

Overall, a total of 4 adults (4 coho salmon) were observed during both our fall and spring enumeration assessments. The individuals were observed swimming adjacent to the mine tailings on the left bank of the river. Upon comparison to results obtained during the 2005/2006, 2006/2007, 2007/2008, 2008/2009 and 2009/2010 seasons, overall numbers of adult fish have remained relatively consistent from Year 1, Year 2, Year 3, Year 4 which saw four, fourteen, three and one adult salmon(s) respectively. When considering individual species, returning coho remained close to previous years ranging from 4 individuals in Year 1, 1 individual in Year 2 to 0 individuals in both the 3rd and 4th years. Chum salmon decreased dramatically from 0 in Year 1 to 13 in Year 2 compared with 0 in years 3, 4 and 5. Steelhead remained close to previous years with 0 in Year 1 to 2 individuals both in Year 2 and 3, 0 in Year 4 to 0 in Year 5 of the study. Although the observed adult returns has decreased considerably from Year 2 of the study, the juvenile (0+) rainbow trout as well as the 1+ cohorts appear to have increased dramatically over the same study period. This is most evident when grouping all the cohorts together as Year 5 of the study shows 131 individuals compared to 131 individuals in Year 4, 53 individuals in Year 3 and 13 individuals in Year 2. Year 1 results were not included in the comparisons, as the study did not include rainbow trout observations. Overall, the observations (not including rainbow trout cohorts) remains extremely low when comparing results to neighboring rivers. It is speculated that low returns may be due to several limiting factors including an absence of adequate spawning habitat (flow, gravel quality and quantity) as well as potential water quality issues from historic mine abandonment discussed above. Other potentially limiting factors to spawning success include predation in the lower reaches by eagles and seals, a lack of freshwater attraction flows from the Lower Jordan River and confounding effects of generation which may attract fish to the tailrace rather than to the Lower Jordan River mainstem. Of the limiting factors, water quality concerns (high copper concentrations) appear to be limited to a small section of river, where an unnamed tributary comes in through mine tailings before being deposited into the left bank. Another potentially limiting factor is the mortalities associated with the upstream migration of salmon into the tailrace. This has been documented on several occasions by BC Hydro staff where individuals are often stranded in the tailrace pool when power generation is turned off. When stranded in the pool, salmon are easily predated by seals and eagles which often wait immediately downstream of the tailrace. Overall, spawning gravel area was limited to

144 square meters of which 118 square meters is accessible within low/moderate discharge levels. As a result of a potential spawning area of 144 m^2, the carrying capacity for coho redds is 51 based on an average redd area of 2.8 m2 (Reiser and Bjornn 1979), and *Habitat Suitability Index Models and Instream Flow Suitability Curves: Coho Salmon* (McMahon 1983). Alternatively, the carrying capacity for the number of adults this system would support is 12 pairs based on 1 spawning pair for every 12 m^2 (Groot and Margolis 1991). Overall, when comparing our enumeration program over the five years, the low tallies suggest that the spawning adults returning to the system are opportunist from neighboring watersheds and are not native to the river. This statement is correlated to the fact that no active redds have survived intact through all five years of the study. The poor survival is attributed to spill events, which scour out gravel deposits during the fall spawning period. This was especially evident in Year 2 of the program when several redds associated with spawning chum salmon were destroyed after three weeks of spill events. Although a natural occurrence in most coastal rivers, the high flow events last longer and are more severe when dams and the associated operational requirements sustain full pools through the winter to maximize energy output. Overall, incubation success in 2010 was high through all three stages of development: all five incubation sites averaged survival rates over 97.6%. Comparison of these results to Years 1, 2, 3 and 4 (data limited to hatch phases for Year 2) of the study suggest that overall; incubation success is very high across the board. The exception to this is Site 3, which consistently produces lower survival rates except for the last two years were survival rates have been more comparable to the other sites. Located next to a copper mine tailings slag pile, Year 1 results showed 0% survival through all three stages of development. Year 2 at this site was limited to only the first stage of development due to extreme weather (cassettes lost). Survival at this stage in the second year was 87.5%. This improvement was believed to be associated with a change in location of the cassettes as they were moved approximately 15m upstream of a small tributary entering the river through the tailings pile. Another possible reason for the increase in survival rates at this site was that approximately 40 cubic materials of potentially toxic material was removed in association with high flow events in the winter of 2006/2007. This is further correlated with the results in Year 3, which show high survival rates through all three stages of development (>84%). Year 4 of the study also shows high survival rates through all three stages of development with the hatch, emergence and post-emergence stages of development at 98%, 96.5% and 91.5% respectively. Year 5 of the study shows high survival rates through all three stages of development at 97.5%, 97% and 98%.

The data collected for this project represents Year 5 of a 6-year monitoring program, and is the third year analyzing incubation success for a 0.25cms release from Elliott Dam initiated in January 2008. After all six years (3 years monitoring pre-treatment) of data are collected, an in-depth analysis of factors limiting spawning/incubation success in the Lower Jordan River will be conducted. It is premature to define absolute factors that may or may not be limiting production at this stage in the monitoring program.

5.0 Recommendations

This study encountered several issues associated with the implementation of the study terms of reference that should be rectified in Year 6 to increase the effectiveness of the project. The following improvements to the study program are recommended:

- Egg incubation site selection: due to the removal of gravel from existing sites due to severe high water events, it is suggested that smaller cobble sized material again be used to cover the cassettes as opposed to importing gravel and/or a change in site location.

6.0 References

BC Hydro. 2001. JOR WUP data collection terms of reference.

BC Hydro. 2005. Jordan River Water Use Plan Monitoring Program Terms of Reference.

Griffith, R.P. 1996. Biophysical Assessment of fish production within the Jordan River drainage 1994. Final Report. R.P. Griffith and Associates, Sidney, BC for BC Hydro and Power Authority, Burnaby, BC.

D. Burt Ltd.. *in prep*. Lower Jordan River Inflow Monitoring Study. Prepared for BC Hydro, Burnaby, BC.

Reiser, D.W., and T.C. Bjornn. 1979. 1. Habitat Requirements of Anadromous Salmonids. W.R., Technical Editor. Influence of Forest and Rangeland Management on Anadromous Fish Habitat in the Western United States and Canada. USDA Forest Service GTR PNW-96. 54 pp.

Wright, M. C. and E. Guimond, 2003. Jordan River pink salmon incubation study. Prepared for the Bridge-Coastal Restoration Program, Burnaby, BC.

Pers comm. BC Hydro (Jordan River) – Operational staff comments 2007-2009

Attachment I – Incubation Summary Protocol (Transplant Procedures Jordan River Egg Incubation)

Each year of the Jordan River Spawning Study, BC Hydro needs to submit a Transplant Application to DFO and coordinate acquiring the coho eggs from a local hatchery.

August of each year

1. Prior to submitting the transplant application
    a. Consult with Tom Rutherford DFO Community advisor to determine where to obtain the eggs. Mr. Rutherford is very helpful and was able to coordinate obtaining the eggs from San Juan when it was determined that the Jack Brooks hatchery did not have enough available. Mr. Rutherford's email address is RutherfordT@pac.dfo-mpo.gc.ca.
    b. Contact Jack Brooks hatchery and San Juan hatchery to determine if they will be collecting coho eggs, and if available, will provide BC Hydro with 3000.
        i. Jack Brooks hatchery contact is Glenn Varney at
            1. Cell#250-213-1282 (best)
            2. Home#250-642-5490 (next best)
            3. Hatchery#250-642-0031 (nobody answers)
            4. Email Address benvar@shaw.ca (best also)
        ii. San Juan hatchery contact is Maurice Tremblay
            1. Home#250-647-5568
            2. Email Address lou&maurice@telus.net
    c. Once determined who is supplying eggs send an email to the following agency representative's with a short description of the request
        i. Leroy Hop Wo at HopWoL@pac.dfo-mpo.gc.ca
        ii. Bob Hooton at Bob.Hooton@gov.bc.ca
        iii. Bill Shaw at ShawB@pac.dfo-mpo.gc.ca
        iv. Mel Sheng at ShengM@pac.dfo-mpo.gc.ca
2. Complete the APPLICATION FOR INTRODUCTION OR TRANSPLANT OF FISH OR AQUATIC INTERBRATES (FORM B).
3. Send the email with the application and approval emails to Brian Anderson at AndersonBr@pac.dfo-mpo.gc.ca

October every year

Coordinate with Hatchery timing of pickup in line with appropriate ATU (eyed stage 225-350). Note: ATU's ranging from 245 – 275 ATU are preferred.

General Recommendations

1. Eyed coho salmon eggs (*Oncorhynchus kisutch*) will be obtained from either the San Juan Hatchery in Port Renfrew, BC, the Nitinat Hatchery in Nitinat Lake BC or the Jack Brooks Hatchery in Sooke BC depending on availability.
2. Eggs are to be picked up and transported to Jordan River when ATU's (accumulated thermal units) are at approximately 258 ATU (range acceptable 245 – 275 ATU).
3. Prior to transportation, all equipment including a 15-gallon tote (used for egg transport) will be sanitized with a diluted iodine solution (refer to sanitization procedures on following page).
4. Eggs will then be placed in the tote with water from the hatchery and covered with a sterilized cloth to reduce impacts associated with travel.
5. Prior to departure from hatchery, ensure current ATU's of eggs and current water temperature are noted. The total time elapsed between the hatchery and insertion into the cassettes should be less than 4 hours.
6. Once at the incubation site locations (5 sites in total – refer to following Table for GPS locations and other relevant characteristics of incubation sites), eggs will manually inserted into the cassettes (200/cassette - Jordan-Scotty incubation cassettes).

Incubation Site Characteristic Table

Site #	UTM	Approximate Water Levels Over Cassettes (+-10cm)
1	10.422241.5364675	0.31m
2	10.422215.53647174	0.38m
3	10.422210.5364746	0.46m
4	10.422180.5364921	0.22m
5	10.422187.5365001	0.35m

7. Once inserted, the cassettes will be planted in the gravel/cobble (holes are to be pre-dug within a week of cassette insertion as there is not enough time to insert eggs into cassettes, dig holes and plant rebar in one day).
8. In order to avoid complications, ensure the three cassettes once planted can be easily removed from one another during future assessment stages of development (do not use bolts and nuts supplied with cassettes – instead, use zip straps as they can easily be cut with pliers and removed one at a time from another). Cassettes can also be individually tied into a piece of embedded rebar in as close proximity as is possible to one another given incubation site characteristics.
9. Once planted, the cassettes will be covered with gravel/cobble (10-20cm where possible) and sites flagged for easy recognition.
10. Flow velocities at each of the five sites will be measured at time of implant as well as at each stage sampled. Note: It is important to assess the incubation cassettes at the lowest flows possible during the sampling period to ensure cassettes remain covered with water even at low flow conditions. This can be achieved by visiting the site during extending cold dry periods and taking note of the staff gauge height as well as verifying water height above cassettes.

Stage Sampling Parameters

Egg survival at each site will be assessed at hatch (approximately 450 ATU – range acceptable 425-475 ATU), emergence (750 ATU – range acceptable 725 – 775 ATU) as well as at post emergence (>900 ATU). This process will be completed by removing one of the three cassettes at each stage of development and recording the number of mortalities, individuals hatched, as well as individuals emerged. The ATU's are calculated from either visiting the site (neighboring watershed can also be used) once a week and extrapolating the data from that days temperature and/or retrieving temperature data online from various sources when and if this data is made available. After each assessment and where possible, eggs/alevins will be buried in the gravel where the cassette was removed. Note: Typically, an earlier stage is assessed at approximately 220 ATU to determine % Survival to the eyed stage, however, it has been decided for this particular assessment that eggs would be put into the ground at the eyed stage therefore, eliminating the very first stage of assessment.

Water temperature will be monitored at each of to the incubation sites using a handheld mercury thermometer.

Stage will be monitored by BC Hydro's gauging station located approximately 125m upstream of the tailrace and correlated to flow using the stage-discharge relationship for the station generated by Burt & Associates

Egg Disinfection

Prior to egg transplant, the following disinfection procedures must be followed at the hatchery.

1. Dilute a stock iodine-based disinfectant to give a solution containing 100 parts per million (ppm) of active iodine. The stock solution can be prepared using 100mg/L (37.8ml of organic iodine to 3.78L of H_2O) of active iodine solution. If the pH of the water is below 6.5, add 0.01% $NaHCO_3$ (0.378 grams $NaHCO_3$ – baking soda to 3.78L of H_2O) to augment to pH to 7-7.5.

Disinfection Procedure1. Use a fresh solution of diluted disinfectant as described above.

2. To avoid temperature shock, adjust the disinfectant solution to the same temperature as the subsequent egg incubation temperature.

3. In the case of freshly fertilized eggs, allow eggs to water harden one hour before disinfection.

4. Immerse water hardened green eggs or early-eyed eggs in the disinfectant for ten min.

5. Treat approximately 2000 eggs per litre before discarding the disinfectant.

6. Rinse eggs thoroughly in uncontaminated water after disinfection.

7. Arrange the egg handling program to ensure that disinfected eggs do not have subsequent contact with contaminated equipment, water or personnel. Diluted iodophors can also be used to disinfect work surfaces, utensils, nets and other equipment used during the egg taking process, but rinse thoroughly in clean, uncontaminated water following the disinfection