Tatsamenie Lake Sockeye Fry Rearing - 2010

Prepared for:
Transboundary Panel
Pacific Salmon Commission

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February 2010

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Abstract

A sockeye enhancement program has been ongoing at Tatsamenie Lake over the period 1990 through 2010. As part of ongoing attempts to increase fry to smolt survivals of enhanced Tatsamenie sockeye, fry rearing experiments were conducted at Tatsamenie Lake in 2008, 2009, and 2010. The 2008 project which involved in-lake pen rearing resulted in the loss of all the fish to IHNV (Infectious Hematopoietic Necrosis Virus). The 2009 project involved onshore fry rearing using an IHNV free water source and 'Capilano' rearing troughs. The 2009 project was a qualified success with the release of 115,000 sockeye pre-smolts into Tatsamenie Lake. Rearing mortalities in 2009 were negligible and it was estimated that approximately 106,000 age 0+ and age 1+ smolts were produced. The operational plan of the 2010 project was to increase the number of fry reared and build on the experience and expertise developed during the sockeye fry rearing projects conducted at Tatsamenie Lake in previous years. Approximately 250,000 eggs of the 1.3 million eggs that were obtained from the BY 2009 Tatsamenie Lake egg take were allocated to the 2010 rearing project. All fry from Snettisham hatchery possessed a separate unique thermal mark for the reared group and the directly planted group. The 2010 operational plan was to use a total of four Capilano troughs to rear the 210,000 fry. In mid-May 2010 two additional Capilano troughs were purchased in Whitehorse YT, transported by truck to a site near Telegraph Creek B.C. and then moved to Tatsamenie Lake via helicopter. Due to a combination of environmental factors encountered at Tatsamenie Lake in spring 2010 it was determined the virus free water source used in the 2009 project would not supply enough water to rear 210,000 fry to 3.0 gm. A larger alternate stream and rearing site situated 1 km south of the 2009 project on the east side of the lake was identified and subsequently used. In early June all the fry rearing apparatus was re-located by boat to the new site. Emergent fry were reared at Snettisham for approximately 30 days to a mean weight of 0.6 gm before delivery to Tatsamenie Lake. The fry were delivered to Tatsamenie Lake via floatplane and equally distributed into the four troughs on June 9. The fry were fed EWOS brand fish food in sizes applicable to the fry size. Feed rates were set at 2% body weight/day. The fry were released into two net pens measuring 5m x 5m x 5m with ½ inch mesh for the final week of in-lake rearing. The first group of 105,000 was released into net pens on July 22. After a week of in-lake rearing these fry were released into the lake on July 29 at a mean weight of 2.4 gm. The second group of fry was placed into the net pens July 31 and released into the lake on August 12 at a mean weight of 3.2 gm. A total of 210,000 pre-smolts were released into the lake. Total rearing mortalities were approximately 500 fish. Results from the out-migrating smolt sampling and population estimates indicate that unlike in 2009 when 95% of the reared fish out migrated soon after release, in 2010 only 5% of the released pre-smolts out-migrated as age 0+ smolts. It is assumed the remaining released fish stayed in the lake and will out-migrate as age 1+ and age 2+ smolts. Experiments conducted in August 2010 indicated the age 0+ smolts from the 2010 rearing project had osmo-regulatory competence equal to the wild age1+ smolts.

1. Introduction

Tatsamenie Lake is located in the upper watershed of the Taku River in northwestern British Columbia. It is a narrow glacial fed lake 14 km long with an average width of approximately 1.5 km. The lake surface area is approximately 22 km^2. Maximum depth is 120 m. In some years it is a significant producer of Sockeye salmon (*Oncorhynchus nerka*) in the Taku River watershed with production contributing to the Canadian and U.S. commercial fisheries in southeast Alaska and on the lower Taku River in British Columbia (TTC 2008). Tatsamenie Lake, along with other Transboundary lakes, has been the object of a Transboundary River (TBR) sockeye enhancement program whose primary aim has been to increase overall sockeye production from lakes considered to have under utilized sockeye fry rearing habitat. The TBR enhancement program is a joint Canada-U.S. program created and managed under the aegis of the Transboundary chapter of the Pacific Salmon Treaty.

Sockeye enhancement efforts at Tatsamenie Lake, ongoing from 1990 through to 2008, have focused on unfed fry releases into the lake. These fry originate from eggs collected in the fall from adults returning to Tatsamenie Lake, and incubated at Snettisham Hatchery in southeast Alaska. The increased egg to fry survival as a result of hatchery incubation has been found to significantly increase sockeye smolt production in some Transboundary lakes (TTC 2008). However, at Tatsamenie Lake as a result of the relatively low wild sockeye egg to smolt survival (Riffe and Mercer 2006), the enhanced sockeye egg to smolt survival is also concordantly lower than that obtained at other Transboundary sockeye enhancement projects.

In 2006, the Enhancement Sub-committee of the TTC developed a proposal to rear Tatsamenie Lake sockeye fry to a “pre-smolt” stage of approximately four grams in net pens in the lake. This proposal was submitted to the Pacific Salmon Commission Northern Fund and accepted. Brian Mercer, a contract biologist with sockeye enhancement experience in the area, submitted the proposal and was the project facilitator. The fry were to be released around August 1, prior to the commencement of adult returns to the lake. This type of pen rearing was utilized with considerable success at Hugh Smith Lake in southeast Alaska (Piston et al. 2006). Increased enhanced egg to smolt production through the release of pre-smolts could potentially achieve the sockeye enhancement goals of the system while reducing present egg collection targets and the corresponding reduction of the natural spawning population.

The project in 2008 involved rearing 400,000 fry in Tatsamenie Lake in four net pens (Mercer and Gransden 2008). After 21 days of in-lake rearing, higher than expected mortalities were observed in one pen and samples were sent to the ADF&G pathology lab in Juneau for analysis. It was determined that IHNV was present in the samples. Over the following week an exponential increase in mortalities was observed in all 4 rearing pens and as per prescribed TTC protocol all the fish were eventually destroyed and none released.

While it is known that IHNV is endemic to the Tatsamenie sockeye stock (PSC 1999) the contraction and rapid spread of the pathogen in the pen held fish was unforeseen. It is

known that juvenile sockeye in high density rearing environments are more susceptible to the rapid horizontal transmission of IHNV. As all four pens eventually became infected, it is assumed the infection source was the lake water. In the free swimming lake environment with much lower fry densities the risk of horizontal transmission is significantly reduced (Plumb 1999).

In order to avoid exposure of the fish to the endemic IHN virus in Tatsamenie Lake during the early stages of the rearing process a project was conducted in 2009 that involved rearing the fish in on-shore tanks using piped IHNV free stream water. The fry were reared in "Capilano" type troughs situated on the lake shore using a virus free water source piped into the troughs (Mercer 2010). The 2009 project was a qualified [1] success with the release of 115,000 sockeye pre-smolts into Tatsamenie Lake. Rearing mortalities in 2009 were negligible and it was estimated that approximately 106,000 0+ and 1+ smolts were produced. Concerns with the 2009 project centered on the high number of 0+ smolts (96 % of out planted fry) produced from the out plants. Despite 18 years of smolt sampling at Tatsamenie Lake age 0+ smolts had not previously been observed. There was concern regarding the near term viability of these fish and smolt to adult survivorship of this age class. In addition there were concerns that the presence of a 0+ freshwater age class alters the present life history of the stock.

The operational plan in 2010 was to continue with an expanded on-shore fry rearing project and build on the experience and expertise gained during the sockeye fry rearing projects conducted at Tatsamenie Lake in 2008 and 2009.

Site Location

Tatsamenie Lake is located at the headwaters of the Taku River system within the upper Tatsatua Creek drainage in northwestern British Columbia (Figure 1). The lake lies on the eastern side of the coastal cordillera at 800 meters elevation within a transitional area between coastal and interior bio-geoclimatic zones. Tatsamenie Lake is within a remote area of British Columbia and is accessible only by air. It is approximately 160 km and 120 km respectively from Atlin, B.C. and Juneau, Alaska.

2. Methods

The 2010 target date determined by the TTC for delivery of designated rearing fry to Tatsamenie Lake was the first week of June. [2] This out plant timing was determined by the constraints of rearing the fry at Snettisham Hatchery to 0.4 gm before transport, the set up of the additional rearing troughs, and when the ice was off Tatsamenie Lake. Typically, Tatsamenie Lake does not become ice-free until the third or fourth week of May.

[1] Adult production from the fry plants will not be known until age 4 and age 5 adults return in 2011 and 2012.

[2] An additional 506,000 unfed hatchery incubated fry were out-planted directly into Tatsamenie Lake on May 22, 2010.

The original 2010 operational plan was to use the same site and water source used during the 2009 project. Due to a combination of a low snowfall in winter 2009/2010 and an warm early spring, conditions encountered at Tatsamenie Lake in late May 2010 indicated that the virus free water source used during the 2009 project would not supply enough water for the rearing of 210,000 fry to 3.0 gm. This was only determined in early June after the original site had been prepared for the incoming fry. In response a larger alternate stream and rearing site situated 1 km south of the 2009 project on the east side of the lake was investigated. It was determined this site was suitable for positioning of the troughs and the stream flows were more than adequate.

Re-locating to this new site and obtaining adequate head pressure to the trough necessitated additional pipe and couplers as the stream gradient was less than the original site. These were obtained from Snettisham Hatchery and Juneau Alaska and flown into Tatsamenie Lake in early June. During the first week of June all the fry rearing apparatus including piping, troughs, and disinfection equipment was re-located by boat to the new site (Figure 2).

Capilano Troughs

The operational plan was to use a total of four Capilano troughs to rear approximately 210,000 fry to 3 gm. In mid-May 2010 an additional two Capilano troughs were purchased in Whitehorse YT and transported to a site near Telegraph Creek B.C. These were then moved to Tatsamenie Lake via helicopter. The four cap troughs were set up at the new rearing site, which was located 8 m from the lake shore near the outlet of the virus free water source.

Preparation began for preparing the new rearing site by burning and clearing away brush and other debris. Six trees (30cm in diameter and 6m long) were procured for supports. These were laid perpendicular to shore, cross supports for the trough legs were notched into the logs and the structure made level using materials at hand. The 6m long Capilano troughs were then placed on top of the logs and final leveling accomplished with wood shims (Figure 3).

Hinged lids were then built out of 2x4 lumber and ¼" perforated plastic. The 2x4s were laid flat and screwed into the edges of the troughs with the lids hinged to the inside. A sheet of perforated plastic was cut to size and attached to each lid frame with several one-inch screws. Each trough had three lids: one 4' and two 8' sections enclosed an entire trough. Sticks were cut to hold the lids partially open throughout the day to allow both feeding and monitoring of the fry. The lids were shut between feeding sessions and for the night at the end of each feed day. An electric fence was installed around the rearing site to deter bears that may be attracted to the site.

Impoundment Dam and Piping

A small dam and water impoundment structure was constructed 50m upstream of the mouth of the small creek. The dam was made from two logs (each one meter long and 25cm in diameter) stacked one on top of the other. Two openings were cut into the dam

logs to allow insertion of two intake pipes (Figure 4). The top log was notched to allow for overflow to ensure a constant water level and flow rate into the intake.

The piping materials consisted of 150m of 4" PVC pipe, two 4" ball valves, two 4" flanges, eight 4" 45° PVC elbows and four 4" 90° PVC fittings. The pipe was shipped in 4.5m lengths and "welded" together using a thermal welding machine. The length of each pipe from the intake at the dam to the trough was approximately 50m. At the dam the intake pipe was sandwiched between the two logs and fitted with wire 1 cm mesh screens to prevent debris from entering the inlet. At the inlet to each pair of troughs a 4" ball valve fed into a Tee which directed water up to the troughs via a 70cm segment of 4" PVC pipe where it joined to another 45° PVC elbow itself attached to a 4" flange at the trough. A 4" 90° PVC fitting, attached to the flange on the inside of the trough, directed flow down into the trough. At the outlet, a 45 cm standpipe of 4" ABS was fitted, but not fastened, into the drain hole. The drain was attached to a vertical 50cm segment of 4" pipe and joined below to a 90° PVC elbow, which joined to another 3m section of 4" pipe and ran horizontally until its termination in the lake.

The plumbing of the system was finished on the 8th of June and was capable of delivering approximately 500 litres per minute (L.P.M.) into each trough. Each trough was configured to hold 2.9 m^3 of useable water volume. Using the ball valves the flows were adjusted to 250 LPM into each trough. This flow rate was sufficient for the expected biomass of reared fish. The fry ready troughs are illustrated in figure 5.

As fish food is a powerful bear attractant a 12-volt electric fence, purchased for the 2010 project, and was positioned in a 5 m perimeter around the trough area. The fence stood 1.2 m tall and consisted of three wires evenly spaced 25cm vertically, a metal ground, a control box and a 12-volt deep cycle battery. The fence was electrified at all times, except when personnel were entering and exiting the perimeter.

Fry delivery

At 11:00 hrs on the 10th of June a single engine Otter aircraft arrived from Snettisham hatchery carrying a load of approximately 105,000 sockeye fry. A second load of 105,000 fry were delivered at 15:00. Fry were divided into four equal groups into the troughs using volumetric displacement methods and hand carried buckets (Figures 6 and 7). Attempts were made to distribute fry evenly resulting in approximately 52,500 fish in each tank. Thermal marking had been employed at the hatchery to provide the fry with a distinct otolith mark for later identification and determination of survival rates and eventual adult production.

Feed/rate/schedule

The fry in the Cap troughs were hand fed every day at intervals of every 2 hours over a 12 hour period, beginning at 07:00hrs. Quantities and size of feed were based on the standard Ewos™ feed chart, which factors in mean water temperature and fish size as its two primary determinants. However, unlike hatchery conditions where water

temperatures vary little, the creek fed troughs experienced wide daily fluctuations in water temperature. In order to standardize feed rates it was decided to feed at a rate of 2% body weight/day. Fry were fed a mixture of #0 and #1 crumble from their arrival on June 10th for the first 4 days. The fry were fed #1 for the period they remained in the troughs . After planting in pens in the lake the fry were fed a mixture of #1 and # 2 crumble.

Length and weight sampling

Sampling to determine feed rates, growth, biomass, densities and food conversion was conducted on a weekly basis commencing on June 18th.

Bulk samples were taken using a portable "Ohaus" electronic scale, accurate to 0.1 gram, set up on the work platform at the Cap trough site. A sample of the fry was removed to a bucket using a minimum of three separate scoops of a dip net. From this sample, a sub sample of 50 – 100 fry was netted, allowed to drip dry for 10 seconds and poured into a tared container of water to obtain a total weight. The fry were then counted back into the trough of origin. This procedure was repeated three times for each pen to obtain an average bulk weight. For length-weight samples, 20 fry were randomly selected from the initial sample and brought back to camp to be individually weighed on a Metzler electronic balance accurate to 0.01 grams. Individual fork length (tip of nose to fork in tail) was recorded to the nearest millimeter.

In order to prevent contamination and/or cross contamination of the troughs, separate sampling equipment was used for each trough and all implements (nets, containers) were disinfected with 100 ppm iodine solution between each round of sampling.

Temperature and Dissolved Oxygen readings

Temperature and dissolved oxygen readings were taken twice each day around 09:00 and again at 19:00. An Oxy-guard TM oxygen meter was used to obtain both readings, taken at a depth of 0.25M in the center of the trough. After the fish were transferred to in-lake holding pens the temperature and dissolved oxygen readings were obtained from the center of the pen at a 1 m depth. The oxygen meter malfunctioned approximately a week after the project started and was not replaced.

Trough cleaning

The cap troughs were cleaned by gently sweeping accumulated debris, uneaten food and feces to the downstream end of the trough using short handled plastic brooms. The stand pipe on the downstream side of the screened trough outlet was removed to create a siphoning action to flush out the accumulated detritus at the end of the trough. Care was taken to minimize disturbance of the fry. Separate cleaning apparatus was used for each pen and disinfected in 100 ppm iodine solution after every use.

Smolt Sampling and Population Estimates

From 1998 - 2010 and during the period May 20 through June 30 a sockeye smolt sampling and mark/recapture population estimate project has been conducted at Tatsamenie Lake under the aegis of a DFO contract. This is an ongoing annual project that is designed to provide data on the growth and survival of out-planted enhanced sockeye fry as well as stock assessment information on the total wild and enhanced smolt production in the system. The methodology and results of the project are detailed in annual reports (unpublished reports, DFO Whitehorse) and in the TTC annual reports (PSC TTC reports). It is possible to track the survivals and growth of the wild, reared, and directly out planted enhanced fish due to the presence of unique thermal marks (applied at the hatchery) on the otoliths of both enhanced groups of fry. The wild fish do not possess the otolith marks.

In 2010, because the extended rearing crew was on site, the smolt sampling and mark recapture project was extended through to July 31. After August 12 the smolt enumeration/sampling project was further extended to August 25 when the Tatsamenie adult weir and egg take crew took over operation of the project.

3. Results

Water temperatures and dissolved oxygen

Water temperatures ranged from 4.0 to 10.0 Cº over the course of the project (Figure 9). As expected, higher ambient air temperatures, as seen in early July, increased the daily maximum temperatures as well as the diurnal temperature spread.

Growth and Food Conversion

On the first day following delivery the fish demonstrated a vigorous feeding response when feed was offered. Growth and food conversion rates are presented in Figure 11 and Appendix 1. The growth and conversion rates observed were within the range predicted in published fish culture indices (Fisheries and Oceans Canada) and the Ewos™ food manufacture charts.

During the period from June 10 through August 1 the mean weight of the fry reared in troughs 3 and 4 increased from 0.61 gm to 2.32 gm, representing a mean increase of 1.72 gm over 51 days. The mean conversion rate was 0.77 over this period. The growth rates observed during the 2008 in-lake rearing project (Mercer and Gransden 2009) were considerably higher than the on-shore rearing in 2009 and 2010 due to the higher average water temperatures in the lake. The growth rate within the in-lake rearing pens was higher than the troughs likely due to the higher mean temperatures.

Smolt Sampling and Smolt Population Estimates

The 2010 smolt sampling results are presented in Appendix 3 and in Figures 11 and 12. There are 7 separate age classes and fry origin that were identified from the 2010 smolt sampling. The total smolt population estimate was 581,000[3] (S.E. 43,800). The calculated age structure of the population was 273,000 wild 1+ and 2+, 238,000 directly planted age 1+, 8,700 age 1+ reared fry, 23,000 wild age 0+, 23,000 directly planted age 0+ , and 14,000 age 0+ reared fry.

The reared age 0+ fish were observed in the outmigrating smolt population 3 days after the first group was released into the lake (Figure 12). Unlike that which occurred in 2009 when 90% of the released reared fry out-migrated as 0+ smolts within 3 weeks of their release (Mercer 2010), only 5% of the 2010 reared fish out-migrated as 0+ fish. It is assumed the remaining reared fry will out-migrate as age 1+ and 2+ smolts in the following 2 years.

Wild and directly planted age 0+ smolts were also observed in 2010. These 0+ fish were first detected in the samples in early July. The age 0+ fish continued to out-migrate along with the other smolts for the remaining seven weeks the smolt project was in operation. The peak of the 0+ out-migration appeared to occur approximately 2 weeks after fish were planted in the lake.

Smolt osmo-regulatory competence evaluation

The results of the smolt osmo-regulatory competence trials are presented in Table 1. Age 1+ wild and age 0+ reared smolts that were placed in water with salt solution of 30,000 ppm died within one hour. It was decided to treat these groups with a salt solution of 15,000 ppm. The 1+ wild and age 0+ reared smolts in this solution survived for a period of 6 hours after which they were released. Beach seine caught sockeye fry with an average weight of approximately 1 gm survived less than one hour in the 15,000 ppm solution. The results suggest that the age 0+ smolts possessed an osmo-regulatory capability that was similar to that of the age 1+ wild smolts.

4. Discussion

The rationale for the on-shore rearing projects in 2009 and 2010 was to attempt to increase survival of enhanced sockeye fry out-plants in Tatsamenie Lake by rearing the fry to a threshold size above which egg to smolt survival would be significantly increased; but without the risk of exposure to in-lake IHN virus as occurred in 2008. Based on smolt sampling and outmigrating smolt population estimates the egg to smolt survival of the age 0+ and age 1+ reared fish from the BY 2009 rearing project was 83% (Figure 13). This compares with 2% and 5% egg to smolt survivals for the wild and directly planted fish. The average egg to smolt survival of enhanced fish released directly into the lake from 1998-2008 was 4.8% (TTC 2008). Based on estimated smolt

[3] The smolt population estimates presented are rounded to the nearest 1000.

production from BY 2009 it appears the on-shore fry rearing strategy may confer a significant increase in the egg to smolt survival of the enhanced fish. However, it is not known if the smolt to adult survival of the reared fry will be comparable to that observed in the directly out-planted and wild fish. These smolt to adult survivals are variable but average approximately 7% (TTC 2008). As noted in other systems, Tatsamenie sockeye smolt to adult survivals increase with larger smolt size (unpublished DFO Whitehorse data). The first principal age class of returning adults from the shore reared fry (3 year ocean) will occur in 2012.

The fry reared in on-shore rearing tanks at Tatsamenie Lake in 2009 were released into the lake at approximately 2 gm in the latter part of July. It is apparent that most or all of these released fry out-migrated from the lake within 30 days of being released. The out-migration of these released fry was premature and unexpected. The in-lake rearing at Hugh Smith Lake (Piston et al., 2006)) and at other sockeye fry rearing projects in B.C. have never resulted in the early out-migration of the released fry (Doug Lofthouse SEP DFO Vancouver, per. comm.). Age 0+ sockeye smolts are not typically found in lake rearing environments in northern latitudes. Previous to 2009 an age 0+ freshwater age class had never been observed at Tatsamenie Lake in 18 years of smolt sampling. In addition, 0+ freshwater age classes had never been observed in sampled adults[4]. However re-examination of the 2009 smolt sampling data indicates that a small number of 0+ wild fry were also present in the outmigrating smolt population. As occurred in 2010 these fish out-migrated in late July and early August. Based on the past two years data it now appears that a relatively small 0+ component of wild and directly out planted fish out-migrate during this period. This age class was not detected in the previous 18 years of smolt sampling because the sampling program always ended by June 30 when it was thought at least 90% of the population had out-migrated. The absence of 0+ freshwater age classes in the adult samples may be due to misidentification of the age class resulting from the high growth rates of the 0+ wild fry

The mean weight of the 0+ wild smolts encountered is an inexplicable anomaly. The mean weight of 0+ wild smolt sampled in 2010 is 6.1 gm (n=59), a full 2 gm larger on average than the fed and unfed out planted 0+ smolt (Figure 14). Further monitoring and research on the sockeye smolt age class structure at Tatsamenie Lake may help explain this enigma.

It is not known why most of the fed fry out-migrated as 0+ smolts in 2009 and only 5% out-migrated as 0+ in 2010. However, the 2010 fry were released into the lake as two groups on July 29 and August 12. This is 12 days later than the groups released in 2009. The 2009 and 2010 sampling data suggest there may be a short out-migration window in late July and early that occurs for the 0+ smolts. The 2010 releases were in the latter period of that window which may be the reason 95% of the released fry stayed in the lake. It is preferable that most of reared fry out-migrate as 1+ smolts because:

1. A predominant age 1+ age structure is concordant with the wild smolt age structure.

[4] 750 adult sockeye are sampled annually as part of an adult weir project at Tatsamenie Lake that has been ongoing since 1984.

2. Although egg to smolt survival decreases the longer the fish stay in the lake, the higher smolt to adult survivals resulting from the larger average size could offset this effect.
3. Natural selection pressures will have a longer opportunity to operate on the reared fry and mitigate loss of fitness within the Tatsamenie Lake sockeye stock that may occur from long term artificial propagation.

The 2010 fry rearing project at Tatsamenie Lake was a qualified success. It was shown that fry can be successfully reared to approximately 3 gms using this strategy and that egg to smolt survivals can be significantly increased. Indications are that 0+ smolts may be a natural component of the sockeye stock and that these smolts are beginning the process of osmo-regulatory competency. The water source at new site would be able to support a rearing population of at least 500,000 fry with the addition of more troughs and additional piping. Operational expenses would only increase minimally if rearing targets increased. However, it is suggested the project continue in 2011 using the same number of fry and similar methodology used in 2010. Until the first adult returns from the BY2008 project are assessed and quantified in 2011 and 2012, the net benefits of the onshore fry rearing strategy will not be known.

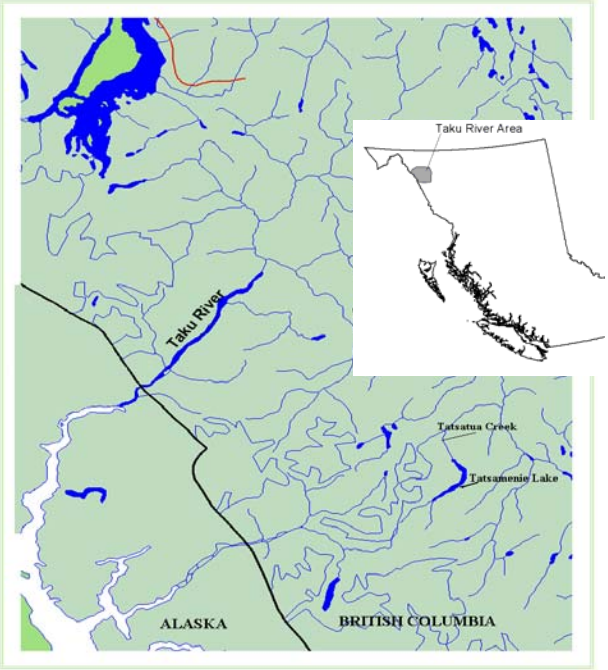

Figure 1. Location of Tatsamenie Lake within Taku River drainage.

Figure 2. Transfer of troughs and equipment to new location.

Figure 3. Preparation of site and bases for Capilano troughs.

Figure 4. Dam and water impoundment structure.

Figure 5. Troughs ready to receive fry.

Figure 6. Transferring fish from transport aircraft to rearing troughs.

Figure 7. Placing transported fry into rearing troughs.

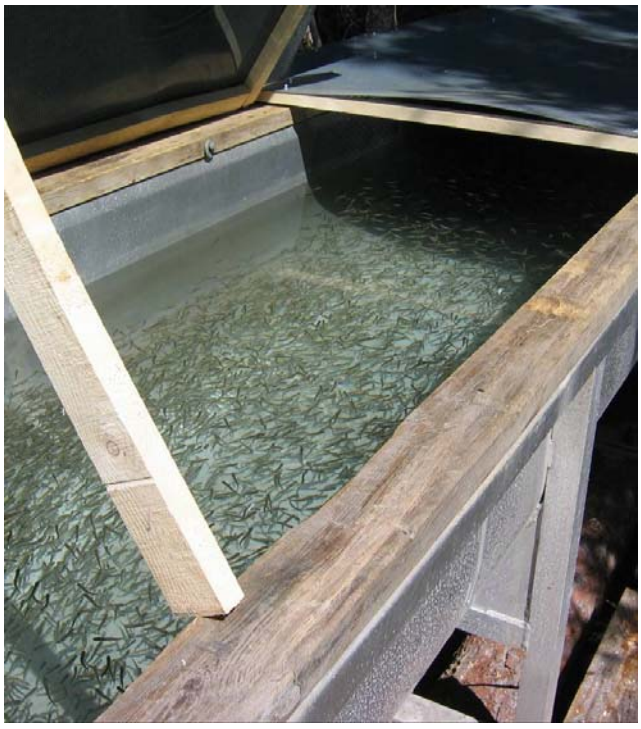

Figure 8. Fry in rearing trough.

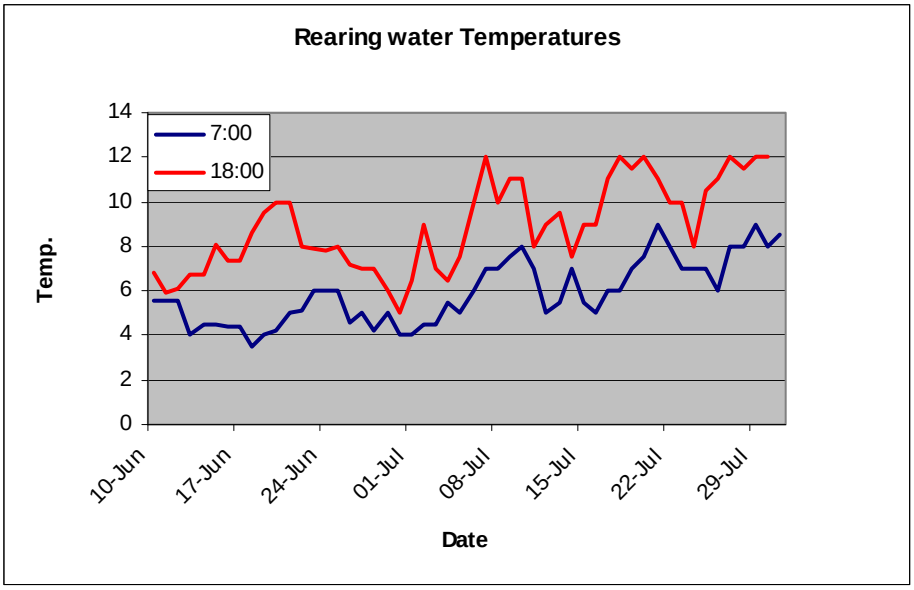

Figure 9. Diurnal temperatures (07:00 and 18:00) in trough #1 during fry rearing at Tatsamenie Lake 2010.

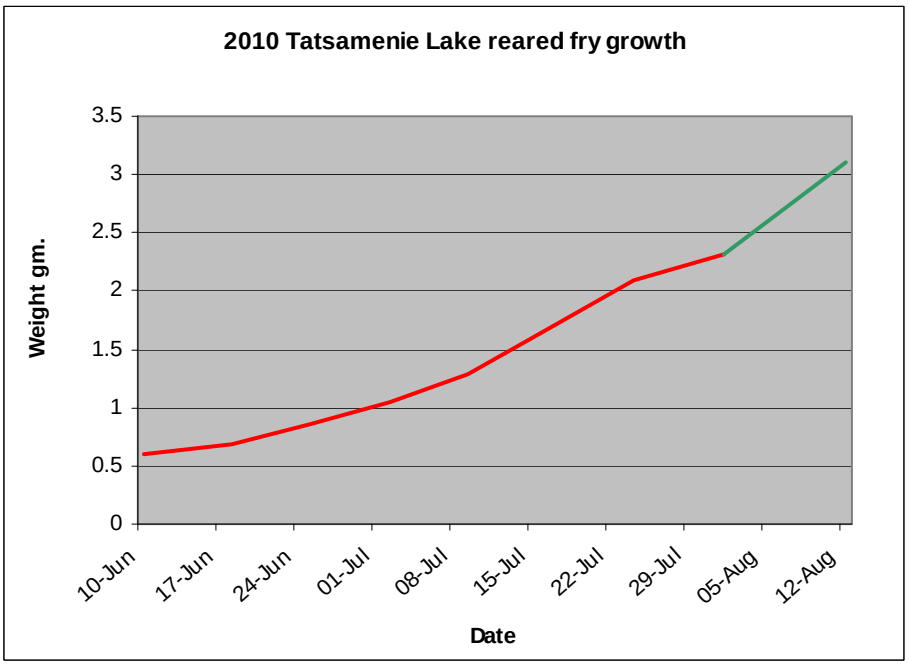

Figure 10. Growth of fry in troughs #3 and #4, Tatsamenie Lake 2010.
Note: Green line denotes growth in lake net pen.

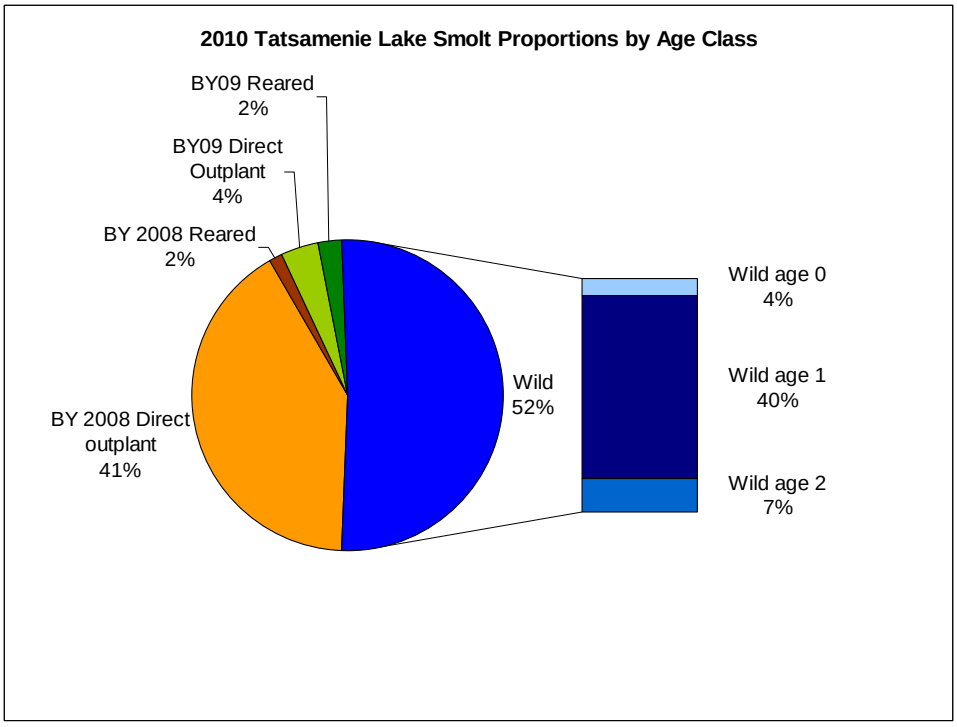

Figure 11. Population and age structure of sockeye smolts out-migrating from Tatsamenie Lake 2010.

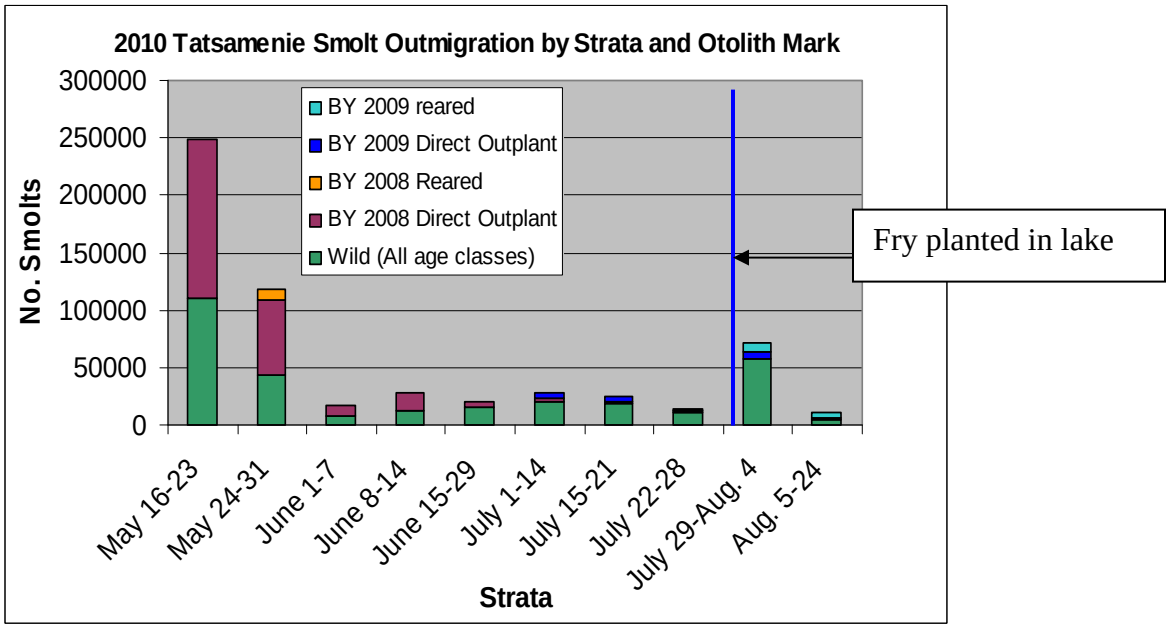

Figure 12. Population and age structure of sockeye smolts out-migrating from Tatsamenie Lake by week in 2010.

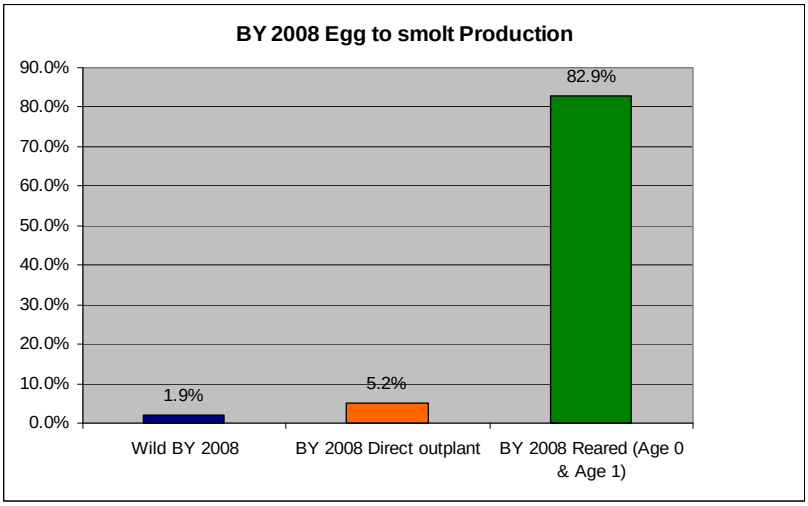

Figure 13. Tatsamenie Lake BY 2008 egg to smolt survival for age 1+ wild, age 1+ directly planted fry, and age 0+ and age 1+ reared fry.

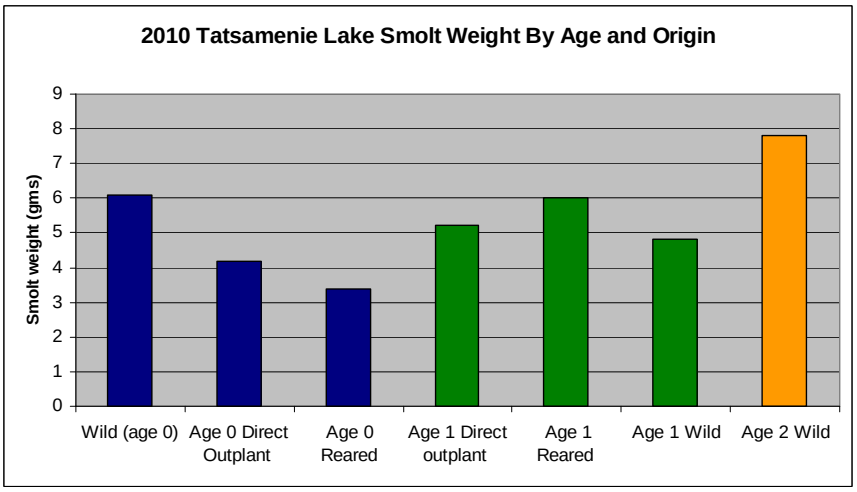

Figure 14. 2010 Tatsamenie Lake smolt weights by age class and origin.

Table 1. Results of Tatsamenie Lake 2010 smolt osmo-regulatory competence evaluation.

Treatment Group	n	Salt solution (PPM)	Soak time	Results
Age 1+Wild smolt	6	30,000	1 hour	Mortality in less than 60 minutes
Age 0+ reared	6	30,000	1 hour	Mortality in less than 60 minutes
Age 1+Wild smolt	6	15,000	6 hours	Alive after 6 hours
Age 0+ reared smolt	6	15,000	6 hours	Alive after 6 hours
Beach seine caught fry	6	15,000	6 hours	Mortality in 30 minutes

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Acknowledgements

Many people contributed to the development and execution of the 2010 Tatsamenie sockeye fry extended rearing project. Ron Josephson of ADF&G and Eric Prestegaard, and Kevin Steck from DIPAC/ Snettisham Hatchery donated valuable time, material, logistical support, and advice. Bob Gransden, Mike Phelps, Danielle Dessureault, Robert Basok, Jane Wilson, and Natasha Ayoub all capably performed fish culture, sampling, and smolt mark/recapture duties.

Appendix 1(a). Daily feeding rate, %BWD fed, and conversion for Troughs 1 and 2.

Date	# of Fish	Morts	Mean wt/fish (gm)	Biomass (kg)	Kg Fed	% BWD FED	Net Gain/fish (gm)	Conversion
10-Jun-09	105988	38	0.635	67.30	0.2	0.30		
11-Jun-09	105950	13	0.635	67.28	1	1.49		
12-Jun-09	105937	4	0.635	67.27	1.5	2.23		
13-Jun-09	105933	5	0.635	67.27	1.3	1.93		
14-Jun-09	105928	3	0.635	67.26	1.3	1.93		
15-Jun-09	105925	0	0.635	67.26	1.3	1.93		
16-Jun-09	105925	7	0.635	67.26	1.3	1.93		
17-Jun-09	105918	4	0.635	67.26	1.3	1.93		
18-Jun-09	105914	63	0.69	73.08	1.3	1.78	0.055	1.59
19-Jun-09	105851	1	0.69	73.04	1.6	2.19		
20-Jun-09	105850	1	0.69	73.04	1.8	2.46		
21-Jun-09	105849	1	0.69	73.04	1.8	2.46		
22-Jun-09	105848	4	0.69	73.04	1.8	2.46		
23-Jun-09	105844	2	0.69	73.03	1.8	2.46		
24-Jun-09	105842	0	0.69	73.03	1.8	2.46		
25-Jun-09	105842	24	0.97	102.67	1.8	1.75	0.28	0.4
26-Jun-09	105818	3	0.97	102.64	1.8	1.75		
27-Jun-09	105815	1	0.97	102.64	1.8	1.75		
28-Jun-09	105814	5	0.97	102.64	2	1.95		
29-Jun-09	105809	2	0.97	102.63	2	1.95		
30-Jun-09	105807	0	0.97	102.63	1.9	1.85		
01-Jul-09	105807	2	0.97	102.63	1.9	1.85		
02-Jul-09	105805	23	1.13	119.56	1.9	1.59	0.16	0.78
03-Jul-09	105782	0	1.13	119.53	2.2	1.84		
04-Jul-09	105782	2	1.13	119.53	2.2	1.84		
05-Jul-09	105780	1	1.13	119.53	2.2	1.84		
06-Jul-09	105779	3	1.13	119.53	2.2	1.84		
07-Jul-09	105776	7	1.13	119.53	2.5	2.09		
08-Jul-09	105769	6	1.13	119.52	3	2.51		
09-Jul-09	105763	25	1.54	162.88	3	1.84	0.41	0.37
10-Jul-09	105738	2	1.54	162.84	3.7	2.27		
11-Jul-09	105736	0	1.54	162.83	3.7	2.27		
12-Jul-09	105736	2	1.54	162.83	3.7	2.27		
13-Jul-09	105734	0	1.54	162.83	3.1	1.90		
14-Jul-09	105734	1	1.54	162.83	3.7	2.27		
15-Jul-09	105733	1	1.54	162.83	3.7	2.27		
16-Jul-09	105732	26	1.79	189.26	3.7	1.95	0.25	0.93
17-Jul-09	105706	0	1.79	189.21	4	2.11		
18-Jul-09	105706	3	1.79	189.21	4	2.11		
19-Jul-09	105703	0	1.79	189.21	4	2.11		
20-Jul-09	105703	6	1.79	189.21	4.3	2.27		
21-Jul-09	105697	1	1.79	189.20	0	0.00		
22-Jul-09	105696	4091	1.79	189.20	2.3	1.22		
23-Jul-09	101605	12	1.79	181.87	4.3	2.36		
24-Jul-09	101593	218	2.2	223.50	4.3	1.92	0.41	0.78
25-Jul-09	101375		2.2	223.03	5	2.24		
26-Jul-09	101375		2.2	223.03	5	2.24		
27-Jul-09	101375		2.2	223.03	5	2.24		
28-Jul-09	101375		2.2	223.03	5	2.24		
29-Jul-09	101375	15	2.47	250.40	1	0.40	0.27	0.89

Appendix 1(b). Daily feeding rate, %BWD fed, and conversion rate for Trough 3 and 4.

Date	# of Fish	Morts	Mean wt/fish (gm)	Biomass (kg)	Kg Fed	% BWD FED	Net Gain/fish (gm)	Conversion
10-Jun-09	105761	53	0.606	64.09	0.2	0.31		
11-Jun-09	105708	32	0.606	64.06	1	1.56		
12-Jun-09	105676	7	0.606	64.04	1.5	2.34		
13-Jun-09	105669	9	0.606	64.04	1.3	2.03		
14-Jun-09	105660	4	0.606	64.03	1.3	2.03		
15-Jun-09	105656	2	0.606	64.03	1.3	2.03		
16-Jun-09	105654	7	0.606	64.03	1.3	2.03		
17-Jun-09	105647	1	0.606	64.02	1.3	2.03		
18-Jun-09	105646	28	0.69	72.90	1.3	1.78	0.084	1.05
19-Jun-09	105618	1	0.69	72.88	1.6	2.20		
20-Jun-09	105617	5	0.69	72.88	1.8	2.47		
21-Jun-09	105612	6	0.69	72.87	1.8	2.47		
22-Jun-09	105606	5	0.69	72.87	1.8	2.47		
23-Jun-09	105601	8	0.69	72.86	1.8	2.47		
24-Jun-09	105593	1	0.69	72.86	1.8	2.47		
25-Jun-09	105592	28	0.86	90.81	1.8	1.98	0.17	0.66
26-Jun-09	105564	1	0.86	90.79	1.8	1.98		
27-Jun-09	105563	5	0.86	90.78	1.8	1.98		
28-Jun-09	105558	7	0.86	90.78	2	2.20		
29-Jun-09	105551	1	0.86	90.77	2	2.20		
30-Jun-09	105550	2	0.86	90.77	1.9	2.09		
01-Jul-09	105548	0	0.86	90.77	1.9	2.09		
02-Jul-09	105548	26	1.05	110.83	1.9	1.71	0.19	0.66
03-Jul-09	105522	2	1.05	110.80	2.1	1.90		
04-Jul-09	105520	2	1.05	110.80	2.1	1.90		
05-Jul-09	105518	0	1.05	110.79	2.1	1.90		
06-Jul-09	105518	1	1.05	110.79	2.1	1.90		
07-Jul-09	105517	0	1.05	110.79	2.4	2.17		
08-Jul-09	105517	6	1.05	110.79	2.8	2.53		
09-Jul-09	105511	32	1.28	135.05	2.8	2.07	0.23	0.64
10-Jul-09	105479	5	1.28	135.01	3.3	2.44		
11-Jul-09	105474	10	1.28	135.01	3.3	2.44		
12-Jul-09	105464	7	1.28	134.99	2.7	2.00		
13-Jul-09	105457	2	1.28	134.98	3.3	2.44		
14-Jul-09	105455	7	1.28	134.98	3.3	2.44		
15-Jul-09	105448	4	1.28	134.97	3.3	2.44		
16-Jul-09	105444	38	1.66	175.04	3.3	1.89	0.38	0.54
17-Jul-09	105406	6	1.66	174.97	3.7	2.11		
18-Jul-09	105400	8	1.66	174.96	3.7	2.11		
19-Jul-09	105392	10	1.66	174.95	3.7	2.11		
20-Jul-09	105382	9	1.66	174.93	4.1	2.34		
21-Jul-09	105373	15	1.66	174.92	4.1	2.34		
22-Jul-09	105358	8	1.66	174.89	4.1	2.34		
23-Jul-09	105350	10	1.66	174.88	4.1	2.34		
24-Jul-09	105340	35	2.09	220.16	4.1	1.86	0.43	0.68
25-Jul-09	105305	6	2.09	220.09	4.4	2.00		
26-Jul-09	105299	5	2.09	220.07	4.4	2.00		
27-Jul-09	105294	4	2.09	220.06	4.4	2.00		
28-Jul-09	105290	4	2.09	220.06	4.4	2.00		
29-Jul-09	105286	4	2.09	220.05	0	0.00		
30-Jul-09	105282	25	2.09	220.04	2.3	1.05		
31-Jul-09	105257	20	2.09	219.99	4.5	2.05		
01-Aug-09	105237	118	2.32	244.15	5	2.05	0.23	1.19
02-Aug-09	105119	2	2.32	243.88	5.5	2.26		
03-Aug-09	105117	0	2.32	243.87	5.5	2.26		
04-Aug-09	105117	0	2.32	243.87	5.5	2.26		
05-Aug-09	105117	1	2.32	243.87	5.5	2.26		
06-Aug-09	105116	5	2.32	243.87	5.5	2.26		
07-Aug-09	105111	3	2.32	243.86	5.5	2.26		
08-Aug-09	105108	0	2.32	243.85	6.4	2.62		
09-Aug-09	105108	1	2.32	243.85	6.4	2.62		
10-Aug-09	105107	0	2.32	243.85	6.4	2.62		
11-Aug-09	105107	0	2.32	243.85	6.4	2.62		
12-Aug-09	105107	5	3.11	326.88	4.5	1.38	0.79	0.77

Appendix 2. Weight and length sampling data of trough and pen reared fry at Tatsamenie Lake in 2010.

Tatsamenie Lake Extended Rearing Sockeye Fry Individual Length Weight Sampling 2010								
Date	Trough 1		Trough 2		Trough 3		Trough 4	
	weight gms	length mm	weight gms	length mm	weight gms	length mm	weight gms	length mm
Jun-18	0.72	42	0.48	38	0.87	45	0.77	45
Jun-18	0.84	47	0.66	40	0.34	35	0.63	42
Jun-18	0.71	44	0.67	41	0.59	40	0.56	40
Jun-18	0.83	45	0.75	43	0.73	43	0.9	49
Jun-18	0.49	38	0.64	41	0.75	44	0.73	44
Jun-18	0.59	40	0.78	44	0.8	46	0.63	44
Jun-18	0.98	48	0.73	40	0.68	47	0.85	46
Jun-18	0.5	39	0.84	46	0.71	45	0.64	42
Jun-18	0.95	46	0.81	44	0.6	41	0.74	45
Jun-18	0.73	44	0.63	42	0.76	44	0.63	42
Jun-18	0.8	43	0.42	38	0.56	42	0.78	45
Jun-18	0.53	40	0.78	45	0.52	40	0.69	42
Jun-18			0.7	44			0.71	44
Average	0.72	43	0.68	42	0.66	42.7	0.71	43.8
Jun-25	1.14	49	1.13	49	1.13	50	0.6	41
Jun-25	0.88	46	1.28	52	0.81	44	0.86	44
Jun-25	0.86	44	0.96	46	0.88	45	0.92	45
Jun-25	0.77	44	0.78	44	0.94	47	0.9	46
Jun-25	0.85	45	1.11	49	0.78	44	0.87	45
Jun-25	1.2	51	1.1	50	1.03	48	0.88	47
Jun-25	0.66	42	0.96	47	0.84	45	0.95	46
Jun-25	0.99	45	0.92	48	0.52	39	0.72	43
Jun-25	0.95	47	1.1	48	0.9	46	0.97	47
Jun-25	1.01	48	1.06	49	1	46	0.82	43
Jun-25	1.01	48	1.23	51	0.9	46	0.8	45
Jun-25	0.99	47			0.75	44	0.83	45
Jun-25					0.91	45		
Jun-25					1.06	48		
Average	0.94	46.3	1.06	48.5	0.89	45.5	0.84	44.8
Jul-02	1.27	50	0.82	44	1.04	48	1.1	49
Jul-02	0.98	47	1.33	52	1	47	0.8	42
Jul-02	0.77	45	1.18	50	1.03	49	0.48	39
Jul-02	0.93	45	1	47	1.25	50	1.06	48
Jul-02	0.97	46	1.32	52	1.48	53	1.15	50
Jul-02	1.6	55	1.2	51	0.94	47	1.1	49
Jul-02	1.11	48	0.85	44	1	47	0.91	47
Jul-02	1.19	50	1.1	50	0.9	46	1.01	49
Jul-02	1.2	50	0.94	47	0.73	44	0.82	44
Jul-02	0.8	45	1.02	48	1.09	48	1.12	50
Jul-02	0.78	44			0.92	48	1.1	48
Jul-02	1	48			1.03	48	0.94	48
Jul-02							0.81	45
Average	1.05	47.8	1.08	48.5	1.03	48	0.95	46.8
Jul-09	1.3	51	1.5	52	1.66	55	1.58	55
Jul-09	2.03	60	2.11	60	0.92	47	1.37	52
Jul-09	1.57	54	0.98	49	1.42	52	1.27	52
Jul-09	1.19	50	1.55	54	1.22	51	1.43	53
Jul-09	1.28	53	1.87	60	1.71	57	1.22	50
Jul-09	1.1	49	1.75	55	1.63	55	1.09	48
Jul-09	1.56	54	1.44	54	1.18	50	1.05	48
Jul-09	1.4	53	0.98	47	1.43	52	1.69	57
Jul-09	0.99	47	1.33	53	0.94	48	1.44	57

Tatsamenie Lake Extended Rearing Sockeye Fry Individual Length Weight Sampling 2010								
Date	Trough 1		Trough 2		Trough 3		Trough 4	
	weight gms	length mm	weight gms	length mm	weight gms	length mm	weight gms	length mm
Jul-09	1.18	50	1.88	58	1.14	51	1.46	52
Jul-09	1.53	54	1.52	53	1.23	51	1.21	51
Jul-09	1.4	54	1.82	57	1.58	55	1.19	50
Jul-09							0.74	44
Average	1.38	52.4	1.56	54.3	1.34	52	1.29	51.5
Jul-16	1.04	48	2.32	61	1.03	50	2.25	60
Jul-16	2.11	60	1.52	55	1.44	52	1.45	52
Jul-16	1.74	55	2.22	61	1.86	58	1.81	58
Jul-16	1.71	57	1.86	58	1.09	49	1.95	58
Jul-16	1.86	58	1.37	51	1.4	52	1.69	56
Jul-16	1.58	54	1.6	55	1.4	53	1.73	58
Jul-16	1.68	54	1.19	50	1.94	57	1.62	55
Jul-16	1.6	52	1.48	52	1.59	54	1.4	50
Jul-16	1.5	53	1.98	60	0.76	45	1.26	52
Jul-16	1.68	55	1.92	58	1.65	56	1.6	55
Jul-16	1.79	57	1.53	54	1.42	52	1.31	52
Jul-16	1.97	58	1.91	59	1.5	54	1.66	55
Jul-16							1.51	53
Jul-16							1.66	56
Jul-16							0.85	46
Jul-16								
Average	1.69	55.1	1.74	56.2	1.42	52.7	1.58	54.4
Jul-24	2.3	62	2.26	62	2.67	64	2.36	63
Jul-24	1.8	60	1.76	57	2.11	62	1.32	52
Jul-24	2.11	60	2.59	66	2.12	60	1.45	55
Jul-24	1.78	57	2.01	60	1.56	55	1.64	56
Jul-24	2.18	60	2.22	61	2.28	61	2.66	65
Jul-24	2.37	62	2.26	61	2.2	60	1.9	58
Jul-24	2.77	65	2.29	62	2.05	60	2.35	60
Jul-24	2.32	63	2.07	60	2.14	61	2.24	62
Jul-24	2.34	61	1.76	58	2.01	59	1.73	59
Jul-24	2.15	61	2.03	60	2.41	60	1.68	58
Jul-24	2.34	61	1.73	58	2.53	63	0.91	47
Jul-24	1.71	59	2.14	60	2.46	61	2.1	61
Jul-24	2.06	60	1.69	57	2.03	59	1.98	60
Jul-24			1.45	53			1.81	57
Jul-24								
Jul-24								
Average	2.17	60.8	2.02	59.6	2.2	60.4	1.87	58.1
Jul-29	2.62	64	2.91	66	n/a	n/a	n/a	n/a
Jul-29	2.28	63	3.04	68				
Jul-29	2.15	62	2.17	62				
Jul-29	1.81	58	2.74	65				
Jul-29	2.64	65	2.2	63				
Jul-29	2.1	60	2.96	68				
Jul-29	1.8	59	2.16	61				
Jul-29	2.1	61	2.86	66				
Jul-29	2.86	68	2.38	62				
Jul-29	2.93	68	3.36	71				
Jul-29	1.87	60	1.97	59				
Jul-29	2.55	64	2.21	62				
Jul-29	2.34	65	2.49	65				
Jul-29	2.59	65	2.08	60				
Jul-29	1.81	58	2.42	65				
Jul-29	2.16	63	2.85	66				
Jul-29			1.97	60				

Tatsamenie Lake Extended Rearing Sockeye Fry Individual Length Weight Sampling 2010								
Date	Trough 1		Trough 2		Trough 3		Trough 4	
	weight gms	length mm	weight gms	length mm	weight gms	length mm	weight gms	length mm
Jul-29								
Average	2.29	62.7	2.52	64.1				
Aug-01	n/a	n/a	n/a	n/a	2.32	64	2.15	61
Aug-01					2.76	71	2.21	62
Aug-01					2.21	62	2.87	67
Aug-01					1.92	59	2.35	63
Aug-01					2.08	62	1.93	60
Aug-01					2.12	61	2.47	62
Aug-01					2.44	63	2.54	64
Aug-01					2.01	59	2.31	62
Aug-01					2.61	65	2.6	65
Aug-01					2.19	63	2.7	67
Aug-01					2.9	69	3.06	68
Aug-01					2.07	63	2.3	62
Aug-01								
Aug-01								
Aug-01								
Aug-01								
Aug-01								
Aug-01								
Average					2.3	63.4	2.46	63.6
Aug-12	n/a	n/a	n/a	n/a	2.41	63	3.75	72
Aug-12					2.91	68	3.2	69
Aug-12					2.79	65	3.64	74
Aug-12					3.14	68	3.53	70
Aug-12					3.19	70	3.73	75
Aug-12					3.59	70	3.61	71
Aug-12					2.94	69	3.14	70
Aug-12					2.38	64	4.03	74
Aug-12					2.04	61	3.03	69
Aug-12					2.59	65	3.06	67
Aug-12					2.48	64	4.56	76
Aug-12					2.19	63	3.8	73
Aug-12					2.88	69	2.89	70
Aug-12					3.22	71	3.69	74
Aug-12					3.53	70	2.64	63
Aug-12					2.94	67	3.39	68
Aug-12					2.83	65	3.5	72
Aug-12								
Average					2.83	67	3.48	71

Tatsamenie Lake reared Sockeye Fry 2010 Bulk Sampling					
Date	TR 1	TR 2	TR 3	TR 4	Average
Jun-09	0.63	0.63	0.60	0.60	0.62
Jun-18	0.71	0.67	0.66	0.72	0.69
Jun-25	0.94	1.03	0.89	0.83	0.92
Jun-27	0.93	0.99	0.94	0.95	0.95
Jul-02	1.15	1.11	1.07	1.03	1.09
Jul-09	1.52	1.56	1.28	1.28	1.41
Jul-16	1.74	1.84	1.69	1.63	1.73
Jul-24	2.26	2.13	2.16	2.02	2.14
Jul-29	2.44	2.49	n/a	n/a	2.47
Aug-01	n/a	n/a	2.26	2.38	2.32
Aug-12	n/a	n/a	2.95	3.27	3.11

Appendix 3. Tatsamenie Lake 2010 smolt sampling results and population estimates.

Smolt mark-recapture results		
Total sampled	712	
Total captured	19950	
Total tagged	9975	
Total examined	19950	
No. Tags Recaptured	339	
Total Smolt Population Estmate 2010	**581000 (Std. Err. 43,800)**	

(Darroch Estimate)

Population estimate by thermal mark	Population	%
Wild (All age classes)	296421	0.52
BY 2008 Direct outplant	238116	0.41
BY 2008 Reared	8721	0.01
BY 2009 Direct Outplant	23119	0.03
BY 2009 Reared	13851	0.02
Total	580228	

Percent egg to smolt production	
Wild (All age classes)	2.3%
BY 2008 Direct outplant	5.2%
BY 2008 Reared (Age 0 & Age 1)	82.9%
BY 2009 Direct Outplant	n/a
BY 2009 Reared	n/a

Weights (gm)	
Wild (age 0)	6.1
Wild (age 1)	4.8
Wild (age 2)	7.8
BY 2008 Direct outplant (Age 1+)	5.2
BY 2008 Reared (Age 1+)	6.0
BY 2009 Direct Outplant (age 0)	4.2
BY 2009 Reared (Age 0)	3.4