Bridge River Water Use Plan

Lower Bridge River Adult Salmon and Steelhead Enumeration 2012

Implementation Year 1

Reference: BRGMON-3

Study Period: August to December 2012

Don McCubbing[1] R.P.Bio., Caroline Melville[1], Stephen Hall[2], and Josh Korman[3]

[1]InStream Fisheries Research Inc.
1698 Platt Crescent,
North Vancouver, BC.
V6J 1Y1

[2]Crane Creek Enterprises
8808 Texas Creek Road
Lillooet, BC
V0K 1V0

[3]Ecometric Research Inc.
3560 W 22nd Ave.
Vancouver, B.C.
V6S 1J3

July 12, 2013

Lower Bridge River Adult Salmon and Steelhead Enumeration 2012

Executive Summary

The primary focus of the Water Use Plan monitoring program in the lower Bridge River is an evaluation of the effects of different flow releases on juvenile and adult salmon productivity. This monitor is developing new and refining old approaches for adult estimation to provide adult escapement data and thus egg deposition estimates. The data combined with juvenile data collected in Monitor 1, will allow over time the development of river specific stock recruitment models which should allow evaluation of the effects of flow separately from other factors such as marine survival and adult exploitation.

In 2012, data from visual stream walk spawner surveys were utilized to provide area under the curve (AUC) type escapement estimates of salmon to the lower Bridge River. These estimates were generated utilizing radio telemetry mark/recapture techniques to provide residence period and observer efficiency data. Twenty Chinook salmon adults and 30 coho salmon adults were tagged with radio tags, providing estimates of residence time of 10 and 16 days on the spawning grounds and observer efficiencies of 0.54 and 0.16 respectively. A total spawner estimate of 436 chinook adults and 3,161 coho adults were thus derived for the area upstream of the confluence with the Yalakom river using a maximum likelihood model. Using the residence and observer efficiency from 2012 to generate estimates with 2011 data, comparable escapements were 81 fish for chinook in 2011 and 5,142 for coho. The application of data from 2012 across years is likely applicable for residence time based on out of watershed data on file with DFO, but may be sensitive to observer efficiency variance as the individual technicians undertaking streamwalks have varied through time. .

Examination of the sensitivity of AUC estimates indicates that small variations or error in calculating observer efficiency or residence data can affect estimates greatly. The installation of a full river fish counter in 2013 will allow for improved spawner estimates and for improved validation of AUC estimates that may be generated on historically archived data.

Acknowledgments

St'át'imc Eco Resources staff provided administrative support for this project. Ron and Brandon James and Alyson McHugh provided essential field services. Dave Levy, provided review comments on reporting of 2011 data collected for BC Hydro thus improving this project report.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

1.1 Background

The Bridge River is an important salmon, steelhead and hydroelectric power producing tributary of the middle Fraser River and has current and historic significance for the St'at'imc Nation. River discharge is affected by BC Hydro through the operation of Carpenter Reservoir (CR) and Bridge River Generating Stations #1 and #2 (BRGS). The river was initially impounded in 1948 by the construction of the Mission Dam approximately 40km upstream of the confluence with the Fraser River. The dam was subsequently raised to its present configuration (~60m high, ~366m long earth fill structure) in 1960 and renamed Terzaghi Dam in 1965. From 1960 to 2000 with the exception of periodic spill releases during high inflow years, all flows were diverted through the BRGS to the adjacent Seton catchment for further power production at the Seton Generating Station (Figure 1). As a result, a four-kilometer section of Bridge River channel immediately downstream of Terzaghi Dam remained dewatered. Downstream of this dewatered reach, the influence of groundwater and small tributaries resulted in river discharge that was 1% of the mean annual discharge before regulation (Longe and Higgins 2002), approximately 1 cms averaged across the year.

The lack of a continuous flow release from Terzaghi Dam was an issue of long-standing concern for the St'at'imc Nation, federal and provincial regulatory agencies, and the public. During the late 1980s, BC Hydro, the Department of Fisheries and Oceans, and the Provincial Ministry of Environment engaged in discussions over appropriate flow releases from the dam. In 1998, an agreement was reached for a continuous water release from Carpenter Reservoir, via a low-level flow control structure, to provide fish habitat downstream from the base of the dam. The agreement included the provision of a 3.0 m^3s^{-1} interim water budget for instream flow releases, which was based on a hydrograph that ranged from a minimum of 2 m^3s^{-1} to a maximum5 m^3s^{-1}. The Deputy Comptroller of Water Rights for British Columbia issued an Order under Section 39 of the Water Act to allow initiation of the interim flow releases from Carpenter Reservoir into the Lower Bridge River (LBR). The continual release of water from Terzaghi Dam to the Lower Bridge River began August 1st, 2000.

In response to concerns raised by the St'at'imc Nation and the regulatory agencies regarding environmental impacts of the introduction of water from Carpenter Reservoir, and the need to develop a better understanding of the influences of reservoir releases on the aquatic ecosystem of the Lower Bridge River, a condition of the Interim Flow Order (IFO) was the continuation of environmental monitoring studies. The Aquatic Ecosystem Monitoring Program was implemented (continuing as BRGMON-1, Bridge-Seton WUP Monitoring Terms of Reference 2012), which was designed to collect data on baseline conditions before the continuous release began, and to measure ecosystem response to the flow trials. Data on baseline conditions (no release flow) was collected from May 1996 to August 2000. The aquatic monitoring program for the 3 m^3s^{-1} hydrograph (Trial 1) was conducted from August 2000 until December 2010 (Sneep and Hall 2011).

The IFO continued until the Water Use Plan (WUP) for the Bridge-Seton system had been approved by the St'at'imc and regulatory agencies, and authorized by the Comptroller of Water Rights for the Province of British Columbia. The Bridge-Seton Water Use Plan consultative process was initiated in September 1999 and completed in December 2001. The Bridge-Seton Consultative Committee (BRS CC) participated in the draft Water Use Plan submitted to the Comptroller in September 2003. Subsequent recommendations by the St'at'imc in 2009 and 2010 were included, and a final WUP was submitted to the Comptroller of Water Rights on March 17th, 2011.

A 12 year test flow release program was proposed under the draft WUP to test three alternative flow release regimes (referred to as: 1 cms/y, 3 cms/y, 6 cms/y treatments) that do not differ in the relative shape of the delivered hydrograph but rather the total magnitude of the flow regime in terms of annual water budget. The flow treatment was subsequently revised, and was 3 cms/y from Aug 2000 to Apr 2011, and will be 6 cms/y from May 1, 2011 to Apr 15, 2015. Detailed monitoring of physical habitat, aquatic productivity, and fish population response was recommended by the BRS CC and developed by the BRS Fisheries Technical Committee (BRS FTC) to obtain the required information to evaluate the physical and biological responses to instream flow.

The BRS FTC expressed uncertainty about the availability and relative importance of spawning habitat for anadromous species, and how this may affect interpretation of the juvenile salmonid response being monitored in BRGMON-1. Coincident time series data of salmon escapement and juvenile standing crop estimates during the flow trials are required so that any differences can be interpreted as the effects of flow rather than the influence of a spawner density effect associated with low or high numbers of spawners. Accordingly, the BRS CC recommended a monitoring program to evaluate effects of the flow regime on spawning habitat and distribution and to enumerate spawning escapements under the alternative test flow regimes (Adult Salmon and Steelhead Enumeration Program BRGMON-3, Bridge-Seton WUP Monitoring Terms of Reference 2012).
Escapement and distribution of spawning salmonids has been assessed previously on the Lower Bridge River and at various levels of intensity. Previous salmon and steelhead escapement and distribution in the lower Bridge River have been derived from:

1. historic stream walks (DFO data on file),
2. more recent stream walks (BC Hydro, data on file),
3. a counting fence in Reach 3 (Figure 1) just upstream of the Yalakom confluence (Diversified Ova Tech Ltd. 1994),
4. steelhead investigations using stream walks, aerial surveys, snorkel surveys and telemetry (Hebden 1981, Hebden and Baxter 1999, Baxter and Roome 1997, Webb et al. 2000, Hagen 2001), and
5. spawning evaluations (Nishimura et al. 1995a, 1995b).

A secondary objective of the present monitoring program is to build on the previous studies by developing survey methods and analytical techniques that will produce rigorous, quantitative estimates of Bridge River salmon and steelhead abundance and distribution to assist in evaluating the usefulness of historical archived data.

1.2 Management Questions

This monitoring program addresses two management questions:

> **H_1:** Adult spawner escapement is not the limiting factor in the production of juvenile salmonids in the lower Bridge River.

and

> **H_2:** The quantity and quality of spawning habitat in the lower Bridge River is sufficient to provide adequate area for the current escapement of salmonids.

The first is associated with the interpretation of the results of the Aquatic Ecosystem Monitoring Program (BRGMON-1). The fundamental management question is related to how informative is the use of juvenile salmonid standing crop biomass as the primary indicator of flow impact . The adult enumeration monitoring program will collect the data needed to support evaluations of whether sufficient numbers of adults of each species are present in the system to produce progeny that would fully seed the available rearing habitat. For chinook salmon, this will include obtaining an improved understanding of juvenile life history and movements, which is currently being assessed under BRGMON-1 (Sneep and Hall, 2012, Coldstream Ecology, 2013).

The second management question is associated with filling data gaps identified during the development of the WUP. In addition to the value of this program to support interpretation of the findings of the aquatic monitoring program, the BRS WUP process identified that there is significant uncertainty about the quality and quantity of spawning habitat in the Lower Bridge River. The implementation of this monitoring program will improve the utility of the primary aquatic benefit response measure (juvenile standing crop) by relating it to egg deposition and the amount of spawning habitat available compared to adult escapement.

1.3 Key Water Use Decision Affected

The key water use plan decision influenced by the results of this monitoring program is the development of the long term flow regime for the Lower Bridge River. The Adult Salmon and Steelhead Enumeration Program (BRGMON-3) will provide the data needed to support Monitor 1 in the interpretation of the response of the aquatic ecosystem to the varied flow treatments (0 m^3s^{-1} vs. 3 m^3s^{-1} vs. 6 m^3s^{-1}) and thus a better understanding of how instream flow influences salmon spawning and rearing habitat quantity and quality in the Lower Bridge River.

2. METHODS

2.1 Objectives and Scope

The objective of the test flow program is to determine the relationship between the magnitude of flow release from the dam and the relative productivity of the Lower Bridge River aquatic and riparian ecosystem by observing fish responses to test flows. The objectives of BRGMON-3 include documenting the escapement of salmonids to:

1) Ensure changes in standing crop are associated with flow changes and not confounded by variations in spawner escapements due to factors external to the watershed, i.e. marine survival or harvest.

2) Fill data gaps associated with the effects of flow releases on salmon and steelhead spawning habitat.

The scope of this program is limited to monitoring the changes in abundance and distribution of spawning salmon and steelhead with particular focus on key stream rearing species in the Bridge River between its confluence with the Fraser River and Terzaghi Dam. Adult salmon and steelhead escapement on its own is not considered a direct indicator of habitat condition because adult returns are affected by downstream conditions (ocean survival and fishing mortality) and there is a 2-4 year lag in the response of adults to changes in freshwater conditions experienced as juveniles (Korman and Higgins 1997). Rather, responses in juvenile production while accounting for adult spawner abundance variance will be the key metric of the impact of changes to discharge. This may be evaluated as egg to fry survival, smolts produced per spawner and/or fry/parr standing crop as a function of spawner abundance.

2.2 Monitoring Approach

The approach to this project is to develop and refine the stock assessment methodology, followed by annual implementation of detailed systematic assessment of the escapement of chinook (*Onchorhynchus tshawytscha*), coho (*O. kisutch*), and steelhead (*O. mykiss*). Supplemental surveys will be conducted to estimate spawning population abundance of sockeye (*O. nerka*) and odd year pink salmon (*O.gorbushca*).

Two levels of survey intensity are utilized for developing spawning population abundance estimates. As chinook, coho and steelhead are the only species of anadromous salmonid where juveniles are rearing for an extended period in the Lower Bridge River; most effort is directed at those species to achieve accurate and precise estimates. Rigorous estimates of chinook salmon escapement are particularly important, since the time series of juvenile stock assessment may be confounded by hypothesized temperature-mediated changes in juvenile life history (BRGMON-1, Bridge-Seton WUP Monitoring Terms of Reference 2012). Chinook salmon escapement may therefore become an important indicator of the effects on the ecosystem of variances in discharge, over and above just water quantity.

A fish enumeration facility (resistivity counter) will be constructed in 2013, to evaluate the escapement of salmon and steelhead trout into the lower Bridge River through 2021. This facility will allow for high precision estimates of salmonid escapement above the selected location near the downstream end of Reach 3 (Figure 2 and 3) with acceptable confidence limits +/- 10% of estimate. Combined with the methods described below (radio telemetry and visual counts) this facility should also allow for back calculated estimates of historic spawning trends. The enumeration site will be capable of fish capture to allow biological sampling, tagging, and species identification.

Stream walk surveys of the Lower Bridge River are being continued annually for a minimum of five years following methodologies developed and implemented during BRGMON-1 to estimate the abundance, distribution and biological characteristics of the populations of salmon and steelhead and to provide the data for back-calculating historical escapement estimates from archived data. The visual survey area extends from the Terzaghi Dam to the confluence with Yalakom River (Figure 3 and Table 1).

Radio telemetry offers a means to address spawner distribution as highlighted above. Radio tags will be applied to chinook, coho and steelhead adults for the first five years of the monitor. Radio tracking relies on a sub-sample of a spawner population to identify key spawning areas and evaluate residence time, migration flow and timing (Brown and Mackay 1995, Bison 2006, McCubbing and Melville 2000). The approach provides representative data on localized habitat use. In conjunction with the fish enumeration facility and/or visual assessment methods (Korman et al. 2002) the results can be expanded to provide full river estimates of escapement by back calculation (Troffe et al. 2008) or by determining observer efficiency in Area-Under-the-Curve (AUC) estimates (English et al. 1992, Hilborn et al 1999).

Standardized data management and base mapping is being developed to determine the linkage between spawner survey program observations, habitat inventory and aquatic ecosystem productivity monitoring. This will include but may not be limited to: attempts to access historical raw streamwalk data from DFO archives with translation to standard excel spreadsheets, evaluation of habitat and GIS mapping data collected in BRGMON-1 with an assessment of its applicability to spawner densities by reach, and spawning location/GIS mapping of all verified tagged spawners during all years of radio telemetry.

2.3 Radio Telemetry

2.3.1 Tag Application and Bio-sampling

Attempts to capture fish were conducted by skilled anglers fishing throughout the lower Bridge River (Figure 2). No steelhead trout were sampled or tagged in 2012. Chinook and coho were radio tagged using different methodologies:

- Chinook: an external Pisces 5 tag (Sigma Eight Inc.) was attached through the dorsal muscle mass behind the dorsal fin using stainless steel pins and a plastic backing.
- Coho: an MCF2-3A radio tag (Lotek Engineering Inc.) was gastrically implanted in the stomach of each fish (Appendix 3).

For both species a 5/8” Petersen disc tag was attached through the dorsal muscle mass so that technicians could visually identify fish during stream walks that were radio tagged to determine detection probability.

Fork length and gender were recorded during tagging and scale samples were taken from coho adults for ageing. No scale samples were taken from chinook adults in 2012 as these fish were in advanced spawning condition when capture making scale recovery difficult and potentially a source of infection prior to spawning. Coho and chinook were held in a submersible holding tube for a minimum of one-half hour prior to release to ensure that the radio tag was properly placed and that tag regurgitation had not occurred.

Tag application was distributed throughout the migration period of chinook and coho. Efforts to ensure even distribution of tags between sexes was made, as migration behaviour and run timing of males and females differs(Korman et al. 2010; Troffe et al. 2010). The tagging schedule was adaptive in nature as fish access (suitable capture locations) is limited on the Lower Bridge River, thus application timing depended on capture success, angler conditions, and fish behaviour.

2.3.2 Mobile Tracking

Mobile tracking with a hand held Lotek W31 radio receiver was conducted in reaches 3 and 4 (Figure 2) of the Lower Bridge River at a minimum of once weekly. Weekly tracking was co-incident with stream walks during the period tags were present in the area based on fixed station analysis. Manual tracking was completed by vehicle or foot and in isolation of the technicians conducting the visual count to avoid observer bias, i.e. searching for known tags in the area. Fish location and tag code were recorded as well as visual sighting of tagged and untagged individuals by species. Dates for tracking included the periods August 20th to September 28thth for chinook salmon, and October 5th to December 13th for coho salmon.

2.3.3 Fixed Station Telemetry Receivers

Fixed station logging was conducted at four sites (Figure 2 & Table 1) with Lotek W31 receivers linked to two Yagi 6-prong directional aerials oriented upstream and downstream powered by 12v deep cycle (110amp hour) lead acid batteries. The fixed stations were operated from August 15th prior to tagging operations commencing through to December 13th when fish movement for tagged chinook and coho salmon had ceased and stream walks were completed.

Locations included:

Site 1: 500 m upstream of Fraser River and Bridge Confluence (River Kilomter - RK 0.5)
Site 2: Camoo Creek (RK 17)
Site 3: 500m upstream of Yalakom and Bridge River Confluence at DFO spawning bed (RK 24.5)
Site 4: 500m upstream of Reach 3 and 4 boundary (RK 37)

Fixed station data was used to corroborate fish location (during mobile tracking), identify entry and exit timing of each fish into each reach , and collect basic data on chinook, and coho adult migration and spawning behaviour in the lower Bridge River.

2.3.4 Visual Counts

Visual stream bank counts were undertaken for spawning chinook, sockeye, and coho salmon weekly in Reaches 3 and 4 which are historically known to hold fish during peak migration and spawning periods (BC Hydro, data on file). Methods replicated those utilized in previous surveys and data are relative abundance rather than total counts. Briefly, two observers walked in a downstream direction on the riverbank looking for visible signs of fish. Fish were classified by species and location and recorded in field notebooks. Viewing conditions, cloud cover and lateral water visibility were also recorded. Surveys commenced August 27th for the enumeration of chinook and sockeye salmon and were completed for coho salmon December 13th when no further active spawners were observed.

2.3.5 Model Used to Estimate Escapement from Count and Telemetry Data

An Area-Under-the-Curve (AUC) methods were utilized to estimate escapement for coho and chinook salmon based on repeat visual counts from stream walks, combined with estimates of observer efficiency (o.e) and survey life from radio telemetry. Estimates were created by maximum likelihood using Hilborn et al.'s (1999) approach where spawn timing is modelled using a beta distribution,

1) $$S_t = E\frac{t}{T}^{(\alpha-1)}\left(1-\frac{t}{T}\right)^{(\beta-1)}$$

where S_t is the number of spawners in week t in the survey area (with a maximum week T), E is the total number of spawners over the spawning season (i.e., escapement), and α and β are parameters of the beta distribution that determine the proportion of the total spawners present on each week. We use a convenient re-parameterization of the beta distribution where the week of peak spawning (γ, the mode of the beta distribution) and the relative precision in spawn timing (α) are estimated, and β is computed from $\beta = \frac{\alpha - 1}{\gamma} + 2 - \alpha$.

The predicted number of spawners present on each model week (s_t) is calculated as the difference between the cumulative number of spawners that have entered through week t (Eqn. 1) and the cumulative number that have died or left from,

2) $$s_t = (\sum_t S_t - \sum_t D_t)$$

where, D_t is number that died or left the survey area on week t, and is computed from D_t=S_t-*surv*, where surv is the survey life in weeks. Thus, we assume that survey life is constant over the spawning season.

The number of spawners that are observed on any survey date ($\hat{c}_t$) is computed from

3) $$\hat{c}_t = s_t * o.e$$

where, o.e is the observer efficiency. The model is then fitted to the data by minimizing the negative log likelihood (NLL) of a Poisson probability distribution whose kernel is,

(4) $$NLL = \sum_t \hat{c}_t - c_t \log(\hat{c}_t)$$

where, c_t is the observed count of spawners on a survey in week t.

Observer efficiency was calculated as the number of externally tagged fish observed in each visual enumeration stream walk divided by the total number of fish calculated as being present in each through manual and fixed station telemetry records. Each externally tagged fish was fitted with a radio tag so that the number of externally tagged fish in the count area was known on each survey date, through a combination of mobile tracking, generally on the day of visual count and through evaluation of fixed station downloads. Fish which were evaluated as deceased were not used in observer efficiency calculations as only live counts were used in AUC estimates. The date of each tagged fishes death was evaluated as the time of first day of which a significant (>1km) downstream movement was recorded either by fixed station records or mobile tracking.

Residence was estimated as the time period in which a live spawning fish was located within the visual counting zone (Reach 3 & 4). Residence time data were calculated as an average by species and survey year of all tagged fish which were marked either outside of the visual count zone or at the lower portion of the count zone, (within 50m of the lower boundary). Briefly residence time was calculated as the number of days post tagging that a fish was observed moving in an upstream direction followed by a large (>1km) directional downstream movement. Fish which exhibited little or no upstream movement post tagging or during periods of extended residency in one location without directional movement (post spawning) were not used for calculations unless visually verified as live at the time of the survey. Fish tagged at the lower boundary but within the count zone had their period of residence time increased by 2 days to accommodate time that the fish may have spent in the count area prior to tagging. This period of two days was based on observations by field staff of the arrival of fish into the count zone, but between weekly enumeration surveys. While attempts were made to tag fish outside or at the lower boundary of the visual count area, some fish were tagged within the counting zone to increase the number of fish available for calculating observer efficiency. These fish were excluded from our residence time estimates as the period of residency prior to capture cannot be determined.

The first day of survey life was evaluated as the week that historically fish have been observed as being present in the survey count zone, while the total survey days was calculated as the difference in days between the first zero count following peak spawning and the initial survey day as described.

3. RESULTS

3.1 Radio Telemetry

3.1.1 Chinook Salmon

Tag Application and Bio-sampling

Anglers in teams of 2 attempted to capture 30 chinook adults and apply external radio tags and Petersen discs. Fish capture attempts were conducted commencing the week of August 20th 300-1500m upstream of the confluence of the Bridge and the Fraser River. This strategy was employed in an attempt to better assess the distribution of chinook throughout the Lower Bridge River. On August 26th chinook were observed holding in the pool just upstream of the Yalakom confluence and in order to get fish tagged to assess the visual counts effort was re-directed to this location (Figure 2). Twenty (10 male and 10 female) external radio tags were applied over a two day period; August 27th and 28th (Table 2).

Mean length for male and female chinook captured on the Lower Bridge River in 2012 was 718 (range 420-865) and 780mm (range 740-855) respectively (Table 2).

Fixed and Mobile Tracking

Tags were detected by the series of fixed telemetry stations and by mobile tracking by vehicle and on foot. Fifteen of the twenty fish tagged were detected in locations upstream of the tagging location at the Yalakom confluence. Of the remaining five fish tagged; four were not located after tagging and one made no movement from its tagging location; this fish possibly lost its tag or expired at the tagging location (Figure 3 & Table 3).

The distribution of the 15 fish that made an upstream migration movement is as follows:

- Ten (67%) were assessed as most likely spawning in stream walk sections 3 to 5; RK 30.7-38.2, Reach 4 and upper section of Reach 3.
- Five of the ten were assessed as spawning in stream walk section 3; RK 30.7-33.2, upper Reach 3.
- Five (33%) attained Station 3 and were assessed as spawning in stream walk section 2, lower Reach 3.

An assessment of distribution (between Reach 1-2 & Reach 3- 4) and average migration time (days) from the confluence with the Fraser River (300-1500m upstream) to spawning location was not possible as no fish were tagged in Reach 1.

3.1.2 Coho Salmon

Tag Application and Bio-sampling

Efforts to capture 30 coho salmon adults commenced the week of October 9th, 2012 and continued through mid-November. A total of 31 fish were tagged in the Lower Bridge River in 2012. Coho were tagged in three distinct areas Reach 1 (300 m to 1500 m above the Fraser confluence), Reach 3-downstream of fixed station 3 and Reach 3-upstream of fixed station 3 (Figure 2).

Angling in Reach 1 resulted in 10 fish (4 males and 6 females) being tagged between October 12th and October 31st, 2012. As capture of fish in Reach 1 of the Lower Bridge requires a much higher catch per unit effort (CPUE), angling effort was also applied to Reach 3 to ensure tags were available in the stream walk section (Reach 3 & 4) during visual counts. A total of 12 fish (5 males and 7 females) were tagged between October 18th and November 2nd in Reach 3 at the Yalakom confluence and 9 fish (5 males and 4 females) tagged at RK 31 & 36 on October 17th.

Mean length for male and female coho on the Lower Bridge River was 635 mm (range 505-740) and 594 mm (range 470-640) respectively (Table 4). Scale samples were taken from all fish and archived for ageing.

Fixed and Mobile Tracking

Nine of the ten fish tagged in the lower river (Reach 1) were detected on the lower fixed station (station 1) post tagging. One fish tagged in this area had no fixed or mobile tracking records thus it likely dropped out into the Fraser River immediately after tagging. Three of the ten fish tagged remained in the vicinity of Station #1-RK 0.7 throughout the assessment period. Six of the ten fish made migrations upstream with one achieving Station # 2-RK 18.3, three achieving Station #3-RK 25.9 and two achieving Station #4-RK 37.3 (Figure 2 & Table 5).

Nine fish were tagged in Reach 1 and remained in the Lower Bridge River. Of these four did not achieve detection at station #3 spawned and were assessed as spawning downstream of the Yalakom confluence. Thus spawning distribution of coho adults in the Lower Bridge River is estimated in 2012 as 44 % spawning in Reach 1-2 and 66% spawning in Reach 3-4.

Mean migration time (number of days to achieve assessed spawning location) of the five lower river fish that made migrations upstream past Station #3 was 17 days with an SD of 7 days (Table 5).

3.2 Visual Counts

3.2.1 Chinook Salmon

Visual counts of chinook salmon were conducted weekly from August 20th through to October 12th, 2012 at which time spawning was assessed to be complete and no further chinook adults were observed. The first holding fish were observed on the 27th of August at the Yalakom confluence, with peak live fish count (116 fish) observed 10 days later on September 7th (Table 6 &7). The majority of these spawners were observed in stream walk section 1 (Figure 3 & Table 1) between the Yalakom confluence and Hell Creek (73 fish). In the following week (September 14th) 61 fish were visually counted these fish were more evenly distributed through the stream walk area. Relative abundance in each stream walk section ranged from 21-31% of fish counted, for sections 1 through 4 (Yalakom Confluence to RK 34.4).

A total of 7 tags were observed visually; all on the September 7th stream walk. These were distributed throughout the stream walk section with tags being observed in section 1 (3), section 2 (1), section 4 (2) and section 7 (1). Tags were not observed on any of the other stream walk dates for chinook (Table 6 &7).

3.2.2 Coho Salmon

Visual counts of coho salmon were conducted weekly from October 5th through to December 13th, 2012 at which time spawning was complete and no further coho adults were observed. The first holding fish were observed on the 12th of October, with peak live fish count (268 fish) observed on November 8th. The majority of active spawners were observed above river kilometer 36.8 in the week starting 16th November (Table 6 &7).

Tags were observed visually on the four stream walks between November 2nd and November 23rd. This also coincided with the range of peak counts. Nine of the total eleven tags (82%) visually observed were seen in stream walk sections 6-8 (Figure 3 & Table 6 &7).

3.2.3 Sockeye Salmon

Sockeye salmon were visually counted in moderate abundance specifically spawning in the area immediately downstream of the dam. The peak count was 27 fish on September 14th. All sockeye observed on stream walks with the exception of 16 were located in stream walk section 8. Thirteen of these were observed in Section 4 on August 27th and were likely in the process of migrating to section 8 (Figure 3 & Table 8). No observation of actively spawning sockeye were made in any reach other than section 8.

3.3 Escapement Estimates

For the purposes of calculating 2011 provisional spawner estimates from visual count data, the observer efficiency and residence data collected in 2012 were applied for chinook and coho spawner calculations. No calculation of sockeye escapement was determined in 2011 or 2012 via AUC estimates.

3.3.1 Chinook Salmon

2012

Data on observer efficiency (o.e) for chinook salmon visual counts for AUC calculations were only available for a limited number of fish in the 2012 survey year. Of the 20 fish which were radio tagged, thirteen were assessed by fixed and mobile tracking as having moved upstream into the visual count zone. The remaining tagged fish likely either dropped back out of the counting zone, moved into the Yalakom River to spawn or lost tags soon after application. Tagged fish were only observed during one of six subsequent visual stream walk counts. On September 7th, 6 of twelve tagged fish were observed, giving an o.e. of 0.50 at peak count. During the following survey only one tag remained active based on fish behavior, as all other tags stayed in the same location to the end of the survey but this tag was not observed. Thus when accounting for residence time (i.e. live tags in count area), 6 of 13 available tags were on average observed giving an average o.e. value in 2012 of 0.46 (Table 7).

Residence time in the visual count zone was calculated based on fish movements as described in the methods section of this report. Of the eight tagged chinook which remained in the visual count zone post tagging, five provided reliable data on residence time. On average these fish spent 10 days alive in the counting area (SD = 3).

Using an o.e. value of 0.50, a residence time of 10 days, a survey start date of August 25th and a survey life of 50 days, we calculate the maximum likelihood estimate of chinook spawners in 2012 in the area of the Lower Bridge River between the Yalakom Confluence to Terzaghi Dam at 471 fish (Figure 3 &4). Assuming a 3 day variance in residence time around the mean data (calculated value of SD), this value varies from 339 to 697 fish. Examining the effect of variation in o.e. we calculated spawner estimates of 389-457 fish with one additional or one less live tag observation, while utilizing the mean residence time of 10 days.

2011

Applying the limited o.e. and residence time data derived from 2012 tagged fish to 2011 visual stream walk counts, with a survey start date of 25 August, but a reduced survey life of 41 days, results in a provisional estimate of 81 chinook spawners in 2011, in the area of the Lower Bridge River between the Yalakom Confluence to Terzaghi Dam (Figure 3 & 4). Utilizing the same variance in residence time as examined in 2012 provides a range of estimates between 64 to 116 spawners. Examining the effect of variations in o.e. we calculated spawner estimates of 72-96 fish using the methods discussed for 2012, and utilizing the mean residence time of 10 days from 2012 data.

3.3.2 Coho Salmon

2012

Data on observer efficiency of coho salmon, visual counts for AUC calculations are only available for fish in the 2012 survey year, although tag observation data from 2011 indicated likely low o.e. values (zero of 11 tags observed at peak count in 2011). Of the 31 fish which were radio tagged in 2012 a maximum of sixteen fish were recorded by fixed and mobile tracking as being available in the visual count zone for sighting. Tagged fish were only observed in four of seven days when live tags were evaluated as being available for enumeration in the visual count zone. O.e. data were highly varied across surveys from 0 in early surveys (19th and 26th October) when fish were generally holding in deeper pools to 31% of tags available on 8th November during or close to peak spawning activity. Overall 11 of 70 potential tag observations were enumerated giving an average o.e. value of 0.16 (Table 7).

Residence time of live fish in the visual count zone was calculated based on fish movements as described in the methods section of this report. Of the 26 tagged coho salmon which entered or remained in the visual count zone post tagging, 13 were utilized to provide data on residence time. On average these fish spent 16 days alive in the counting area (SD = 5).

Using an o.e. value of 0.16, a residence time of 16 days, a survey start date of October 5th and a survey life of 75 days, we calculated the maximum likelihood estimate of coho spawners in the area of the Yalakom Confluence to Terzaghi Dam in 2012 at 3,161 fish (Figure 3 & 5). Assuming a 5 day variance in residence time around the mean data (value of SD) this value varies from 2,404 to 4,598 fish, due in part to the low value of o.e.

To evaluate full river spawner abundance we extrapolated the Yalakom to Terzaghi Dam population estimate based on the spawning distribution of coho pre-spawners tagged in the lower river in 2012. Of the nine Bridge River spawners tagged in this area, 44% were assessed to have spawned between the Bridge/Fraser confluence and the Yalakom. This indicates that full river escapement may have been as high as 5,268 coho in 2012.

<u>2011</u>

Applying the limited o.e. and residence time data derived from 2012 tagged fish to 2011 visual stream walk counts, with a survey start date of October 5th, and a survey life of 75 days, results in an estimate of 5,142 coho spawners in the area of the Yalakom to Terzaghi Dam in 2011 (Figure 3 & 5). To evaluate full river spawner abundance we extrapolated the Yalakom to Terzaghi Dam population estimate based on the spawning distribution of coho pre-spawners tagged in the lower river in 2011. Of the ten Bridge River spawners tagged, 40% were assessed to have spawned between the Bridge/Fraser Confluence and the Yalakom. This indicates that full river escapement may have been as high as 8,569 coho in 2011.

Note: in 2011 we estimated that o.e. was likely less than 20% based on a lack of observation of any of the live tags during stream walks. Residence data in 2011 were limited due to tag detection problems at fixed stations.

4. DISCUSSION

The primary goal of this study is to provide reliable, unbiased and precise estimates of adult salmon and trout spawner abundance along with behavioral data on spawning locations and timing. This data will be utilized in BRGMON 1 to evaluate the egg and juvenile seeding levels of the area of the Lower Bridge River specifically between the Yalakom River Confluence and Terzaghi Dam (Reach 3 & 4), the upper limit of anadromous fish spawning. This reach of the river is predominantly regulated by discharges through Terzaghi dam with very minor tributary influences. Additional data will be collected when possible (i.e. depending on reach 1 and 2 angling success) to evaluate complete watershed spawning abundance through marking of fish in Reach 1 of the Bridge River close to the confluence with the Fraser River. The proportion of these tagged fish which remain in the Bridge River (i.e. not fish that strayed in to the river then leave and spawn elsewhere) but do not spawn above the Yalakom can be used to evaluate a total river spawner escapement using back calculation methods (McCubbing 2012).

In 2012, data were collected for chinook, coho and sockeye salmon. No pink salmon were observed as it was an “off” year for pink salmon in the Fraser River Watershed. No steelhead were tagged or enumerated in 2012 as migration into the river typically occurs in the spring period and spawning under elevated river discharges in the month of May when visual counts would be unlikely to be productive in data acquisition. The timing of contract set up (September, 2012) and complications in the Provincial application process for fish counter installation delayed the start date of the preferred method of adult salmon escapement enumeration until October 2014 and thus excluded steelhead enumeration by this method. In the absence of resistivity fish counter information, data were collected using historical stream walk methodologies only. These data were collected in the same manner as previous years (pre WUP monitoring, DFO data on file), and for the first time were validated by marking fish with external visual tags and radio tags. The data provided from these tagged fish which include observer efficiency and residence time in the counting zone, and for coho salmon full river spawner distribution were combined with AUC calculations allowing for the calculation of provisional estimates of salmon spawner escapements in 2012. Through transference of observer efficiency and residence data across years where we have access to daily count data, an estimate was also calculated for the 2011 spawner year class.

Ideally in AUC studies of this type, marking of individuals is undertaken remotely from the area of visual count. This is undertaken to provide data on full river escapement and residence time on the spawning grounds. Data which are derived from fish captured within the spawning area are not useful for residence time evaluations as they may have spent an unknown period of time within the area and could have been enumerated by visual counts prior to tagging.

Efforts to tag chinook salmon in Reach 1 of the Lower Bridge River, to provide a full river estimate have been unsuccessful despite almost daily visual checks for migrant fish. The reasons for this lack of success in 2012 and 2011 are likely related to low population abundance and a short duration of residence in the lower section of the river. Fish which are captured during aboriginal fisheries in the Fraser River at the mouth of the Bridge River are poor candidates for tagging as the majority are likely not destined to spawn in the Bridge River, instead migrating to tributaries higher in the Fraser Watershed. Based on observations of fish arrival in reach 3, target dates for lower river (reach 1) fish capture by angling will be scheduled in future during the second and third week of August, although evaluation of full river spawner estimates may remain a challenging endeavor for chinook at current escapement numbers.

Using maximum likelihood methods, Reach 3 and 4 chinook spawner escapements were estimated at 436 fish in 2012 and 81 fish in 2011, five-fold variation between years. These data are expected to be reasonably precise due to a high observer efficiency resulting from fish behavior during spawning as chinook tend to hold in open water and are relatively undisturbed by bank side activity. However the population estimates are affected (biased high or low) by small changes in the value of estimated residence time utilized in calculations so additional years of local data collection are warranted. A large variance in this metric is unlikely as chinook from this watershed are most likely of the Beringia glacial refuge "genetic" lineage which in interior Fraser River fish occur almost exclusively above the Thompson River/Fraser confluence. Chinook of this origin are typically observed in the absence of competition for spawning habitat or predation to exhibit spawning residence periods of 10-12 days (R.Bailey, DFO data on file). Our calculated value of 10 days in 2012 indicates typical residence behavior and that is most likely stable across sample years (see NFCP Technical Data Review 2005 which provides documentation).

Efforts to tag coho salmon in the Lower Bridge River (reach 1), to provide a full river estimate were only moderately successful with 10 fish tagged in 2012 (compared to 11 in 2011). The earliest fish captured in the lower river was tagged on October 12th compared with October 19th in 2011. In both years fish were tagged over a period of approximately 2 weeks at this location. Daily angling effort is proposed for Reach 1 in 2013 to provide data for a full watershed population estimate.

Using maximum likelihood methods, Reach 3 and 4 coho spawner escapements were estimated at 3,161 fish in 2012 and 5,142 fish in 2011. The precision of these data is unclear as observer efficiency resulting from fish behavior prior to and perhaps during spawning is low, associated with the fish being cryptic and avoiding detection. Our calculated residence time of 16 days is slightly higher than typically seen in coastal BC, 13 days (REF), in Thompson River studies, 10 days, south Thompson, and 12 days North Thompson (DFO data on file). Using the proportion of fish which utilized reach 1 and 2 for spawning based on lower river tagged fish our full watershed estimates of spawners is 5,268 fish in 2012, and 8,570 fish in 2011. These estimated spawner escapements result in a spawner per kilometer abundance of between 131 to 214 fish per km for the full river and 203 to 313 fish in reach 3 and 4. These data indicate that seeding may be at the higher end of published data (Korman & Tompkins, 2008), and sufficient to utilize the available habitat to capacity. Efforts to increase confidence in o.e. data and residence data will be undertaken by marking fish at the new trap/resistivity counter facility due for installation in 2013. Additional effort to refine full river estimates will require many more fish (>30 chinook and steelhead and >100 coho, see as example McCubbing et al 2012) to be tagged in the lower river (Reach 1). While attempts to achieve this goal with PIT tags will be undertaken in 2013 and beyond, the full river estimate may always be of much lower confidence due to access issues created by the canyon nature of this area and lack of safe access roads or trails.

No steelhead trout spawner data are yet available for Bridge River at the current discharge regime as flows during the spring migration and spawning period are elevated (6-9 m^3s^{-1}) and visual observation limited. The fish counter will accurately assess escapement to reach 3 and 4, from the spring of 2014 using the methods described in McCubbing and Bison (2009). Full river estimates will be calculated using radio tagged fish captured in reach 1 or in the Fraser River, in a mark recapture study similar to the methods used on the Thomspon River (Renn et al 2001). As the fish counter will not be operating until the fall of 2013, no fish will be handled and no data will be collected prior to the 2013 spawning period. Evidence of relatively large numbers of resident trout (5 to 10 individuals captured in each days effort) were made during angling efforts for salmon tagging in the summer and fall of 2012. While, these fish may be predominantly male an unknown portion will be females and will thus be contributing to egg deposition and trout production in the watershed (Hagen et al 2012). To evaluate their abundance relative to migratory steelhead trout, all rainbow trout handled will be tagged with a PIT tag to evaluate movements during the spawning period and to potentially provide a basic population estimate through a mark recapture estimate at the trap/resistivity counter and/or by angling.

On completion of the fish counter installation enumeration of chinook, coho, sockeye and pink salmon as well as steelhead trout will be conducted at this site, (400m above the Yalakom confluence). Counts will be validated and are expected to be within 5% of total escapement (McCubbing and Ignace 2000, McCubbing and Gillespie 2008). A portion of salmon adults will be marked at a trap within the counter structure to allow for verification of future AUC visual escapement estimates thus allowing the annual variance in observer efficiency and residence time to be calculated. Once these data are sufficiently described, visual counts will cease as the counter will provide improved escapement accuracy over traditional methods (McCubbing and Espinoza 2012). The data collected during the period when both methods are being utilized will allow for back-calculations of historical escapements based on archived visual count data, 5 years of which was collected during the previous WUP discharge regime which was a water budget of 3 m^3s^{-1}.

5. SUMMARY and RECOMMENDATIONS

In summary the work undertaken in 2013 to generate adult spawner escapements on the Lower Bridge River below Terzaghi dam was successful in generating AUC estimates of total spawners for coho and chinook salmon. Confidence in these estimates is as yet low as they rely on limited radio tag derived data for evaluating observer efficiency and residence time in the visual count zone, although o.e. and residence data are within the expected range as observed in similar studies.

A number of recommendations are provided that are critical to improving estimates of adult spawner escapement and seeding levels on the Lower Bridge River, particularly in the area between the Yalakom confluence and Terzaghi Dam. These include:

1) Installation of a full span resistivity fish counter and fish trap in the fall of 2013 (as planned in 2012) to provide high confidence escapement estimates of all species above the chosen site which encompasses the majority of the Yalakom to Terzaghi dam area.

2) Relocation of fixed telemetry station from Camoo Creek (Reach 1-2 boundary) to the confluence of the Yalakom river to provide data on post tagging but pre spawning fish “drop back” to spawn in Reach 2 and to assess use of Yalakom river by spawners.

3) Increased frequency of mobile tracking and visual stream walks around peak spawner abundance to improve o.e. estimates over the next four years. This will provide context on historical visual count numbers and potential escapement estimate derivation from archived data.

4) Increased angling/netting effort on the lower river (reach 1) to obtain improved full river estimates of spawner abundance.

5) Opportunistic PIT tagging of all rainbow trout encountered during salmon tagging to evaluate the potential, resident trout contribution to O.Mykiss juvenile production as monitored in BRGMon 1.

6) Installation of PIT tag arrays to delineate spawner distribution in the Yalakom to Terzaghi reach for coho, pink, chinook and sockeye salmon and steelhead trout through tagging during angling and at the fish counter trap site.

7) Marking of steelhead trout with radio tags in the fall and spring of 2013 to establish spawning distribution data and verify fish counter estimates.

6.0 TABLES

Table 1. Stream walk Section Designations and Fixed Station Telemetry Receiver Locations for the Lower Bridge River, 2012.

River Km	Location Description
0.0	Confluence of Bridge & Fraser Rivers
0.7	Fixed Station Telemetry Receiver Site 1
18.3	Fixed Station Telemetry Receiver Site 2
25.5	Downstream Boundary of Stream walk Section 1 & Confluence of Yalakom & Bridge Rivers
25.9	Fixed Station Telemetry Receiver Site 3
28.8	Downstream Boundary of Stream walk Section 2
30.7	Downstream Boundary of Stream walk Section 3
33.2	Downstream Boundary of Stream walk Section 4
34.4	Downstream Boundary of Stream walk Section 5
37.3	Fixed Station Telemetry Receiver Site 4
38.2	Downstream Boundary of Stream walk Section 6
38.8	Downstream Boundary of Stream walk Section 7
39.6	Downstream Boundary of Stream walk Section 8
40.0	Upstream Boundary of Section 8 & Terzaghi Dam

Table 2. Biological and tagging data of adult chinook salmon migrants in the Lower Bridge River, 2012.

FISH #	CAPTURE DATE	CAPTURE LOCATION	RK CAPTURE	Reach	CAPTURE METHOD	FREQUENCY	Ch.Code	FORK (mm)	SEX	Comments
1	28-Aug-12	Yalakom Confluence	25.5	3	Angle	150.600	136	740	F	
2	28-Aug-12	Yalakom Confluence	25.5	3	Angle	150.600	13	755	F	
3	28-Aug-12	Yalakom Confluence	25.5	3	Angle	150.600	81	750	M	
4	28-Aug-12	Yalakom Confluence	25.5	3	Angle	150.600	205	855	M	
5	28-Aug-12	Yalakom Confluence	25.5	3	Angle	150.600	156	810	F	
6	28-Aug-12	100m u/s of Station 3	26.0	3	Angle	150.800	149	770	F	
7	28-Aug-12	Yalakom Confluence	25.5	3	Angle	150.800	121	420	M	Jack
8	29-Aug-12	Yalakom Confluence	25.5	3	Angle	150.800	184	785	F	
9	29-Aug-12	Yalakom Confluence	25.5	3	Angle	150.600	28	755	F	
10	29-Aug-12	Yalakom Confluence	25.5	3	Angle	150.600	175	745	M	
11	29-Aug-12	Yalakom Confluence	25.5	3	Angle	150.800	189	855	F	
12	29-Aug-12	Yalakom Confluence	25.5	3	Angle	150.800	190	755	F	
13	29-Aug-12	Yalakom Confluence	25.5	3	Angle	150.800	193	770	F	
14	29-Aug-12	Yalakom Confluence	25.5	3	Angle	150.800	192	865	M	
15	29-Aug-12	Yalakom Confluence	25.5	3	Angle	150.600	196	450	M	
16	29-Aug-12	Yalakom Confluence	25.5	3	Angle	150.600	201	765	F	
17	29-Aug-12	Yalakom Confluence	25.5	3	Angle	150.600	197	710	M	
18	29-Aug-12	Yalakom Confluence	25.5	3	Angle	150.600	127	810	M	
19	29-Aug-12	Yalakom Confluence	25.5	3	Angle	150.600	194	760	M	
20	29-Aug-12	Yalakom Confluence	25.5	3	Angle	150.600	199	810	M	
Mean Length (mm)										
Male	Female									
718	780									

Table 3. Assessed spawning distribution of radio tagged chinook salmon on the Lower Bridge River, 2012.

Tag #	Tagging Location	Tagging Rkm	Assumed RKm spawning location
13	Yalakom Confluence	25.5	unknown
28	Yalakom Confluence	25.5	31.5
81	Yalakom Confluence	25.5	31.5
121	Yalakom Confluence	25.5	29.3
127	Yalakom Confluence	25.5	unknown
136	Yalakom Confluence	25.5	30.5
149	500m u/s of Hippy Pool	26.3	28
156	Yalakom Confluence	25.5	lower river
175	Yalakom Confluence	25.5	26.9
184	Yalakom Confluence	25.5	31.5
189	Yalakom Confluence	25.5	36.4
190	Yalakom Confluence	25.5	33.5
192	Yalakom Confluence	25.5	33.7
193	Yalakom Confluence	25.5	32.2
194	Yalakom Confluence	25.5	31.5
196	Yalakom Confluence	25.5	unknown
197	Yalakom Confluence	25.5	36.4
199	Yalakom Confluence	25.5	34.2
201	Yalakom Confluence	25.5	28
205	Yalakom Confluence	25.5	unknown

Table 4. Biological and tagging data of adult coho salmon migrants in the Lower Bridge River, 2012.

FISH #	CAPTURE DATE	CAPTURE LOCATION	RK CAPTURE	Reach	CAPTURE METHOD	FREQUENCY	Ch.Code	FORK (mm)	SEX	Comments
1	12-Oct-12	500m u/s Hwy Br	1.0	1	Angle	149.260	014	595	F	
2	11-Oct-12	850m u/s Hwy Br	1.3	1	Angle	149.500	033	640	F	
3	12-Oct-12	750m u/s Hwy Br	1.2	1	Angle	149.260	013	645	M	
4	12-Oct-12	850m u/s Hwy Br	1.3	1	Angle	149.500	028	505	M	
5	15-Oct-12	850m u/s Hwy Br	1.3	1	Angle	149.260	025	605	F	
6	17-Oct-12		36	3	Angle	149.500	029	610	F	
7	17-Oct-12		36	3	Angle	149.600	017	675	M	
8	17-Oct-12	fraser lake	31	3	Angle	149.500	035	590	M	
9	17-Oct-12	fraser lake	31	3	Angle	149.260	019	745	M	
10	17-Oct-12	fraser lake	31	3	Angle	149.500	027	570	F	
11	17-Oct-12	fraser lake	31	3	Angle	149.260	015	680	M	
12	17-Oct-12	fraser lake	31	3	Angle	149.260	020	655	M	
13	17-Oct-12	fraser lake	31	3	Angle	149.500	030	615	F	
14	17-Oct-12	fraser lake	31	3	Angle	149.500	034	560	F	
15	18-Oct-12	Yalakom Confl.	25.5	3	Angle	149.260	016	590	M	
16	18-Oct-12	850m u/s Hwy Br	1.3	1	Angle	149.500	032	470	F	
17	26-Oct-12	Yalakom Confl.	25.5	3	Angle	149.260	021	640	F	
18	26-Oct-12	Yalakom Confl.	25.5	3	Angle	149.260	018	610	F	
19	26-Oct-12	Yalakom Confl.	25.5	3	Angle	149.260	024	560	F	
20	26-Oct-12	Yalakom Confl.	25.5	3	Angle	149.500	026	640	M	
21	26-Oct-12	Yalakom Confl.	25.5	3	Angle	149.500	039	545	M	
22	26-Oct-12	Yalakom Confl.	25.5	3	Angle	149.260	023	605	M	
23	26-Oct-12	850m u/s Hwy Br	1.3	1	Angle	149.260	011	685	M	
24	29-Oct-12	850m u/s Hwy Br	1.3	1	Angle	149.500	038	570	F	
25	29-Oct-12	850m u/s Hwy Br	1.3	1	Angle	149.500	040	570	F	
26	31-Oct-12	850m u/s Hwy Br	1.3	1	Angle	149.500	037	590	M	
27	01-Nov-12	Yalakom Confl.	25.5	3	Angle	149.500	031	630	F	
28	02-Nov-12	Yalakom Confl.	25.5	3	Angle	149.500	028	595	F	
29	02-Nov-12	Yalakom Confl.	25.5	3	Angle	149.260	022	610	F	
30	02-Nov-12	Yalakom Confl.	25.5	3	Angle	149.500	036	600	F	
31	02-Nov-12	Yalakom Confl.	25.5	3	Angle	149.260	012	740	M	
Mean Length (mm)										
Male	Female									
635	594									

Table 5. Assessed spawning distribution of radio tagged coho salmon on the Lower Bridge River, 2012.

Tag #	Tagging Location	Tagging Rkm	Assumed RKm spawning location	Days to Migrate to Spawning Location from tagging site
011	850m u/s Hwy Br	1.4	31.2	21
012	Yalakom Confluence	25.5	26	
013	750m u/s Hwy Br	1.3	lower river	unknown
014	500m u/s Hwy Br	1.1	39.9	21
015	fraser lake	33.8	37.7	
016	Yalakom Confluence	25.5	26.3	
017	35.9 km	35.9	38.9	
018	Yalakom Confluence	25.5	36.3	
019	fraser lake	33.8	33.8	
020	fraser lake	33.8	37	
021	Yalakom Confluence	25.5	31.2	
022	Yalakom Confluence	25.5	32.6	
023	Yalakom Confluence	25.5	34.1	
024	Yalakom Confluence	25.5	37.7	
025	850m u/s Hwy Br	1.4	lower river	unknown
026	Yalakom Confluence	25.5	37.3	
027	fraser lake	33.8	34	
028a	850m u/s Hwy Br	1.4	lower river	unknown
028b	Yalakom Confluence	25.5	31.4	
029	35.9 km	35.9	40	
030	fraser lake	33.8	39	
031	Yalakom Confluence	25.5	38.1	
032	850m u/s Hwy Br	1.4	lower river	unknown
033	850m u/s Hwy Br	1.4	29.6	22
034	fraser lake	33.8	30	
035	fraser lake	33.8	35.1	
036	Yalakom Confluence	25.5	37.7	
037	850m u/s Hwy Br	1.4	37.9	5
038	850m u/s Hwy Br	1.4	40	17
039	Yalakom Confluence	25.5	25.5	
040	850m u/s Hwy Br	1.4	lower river	unknown

Table 6. Visual stream walk and telemetry observations for chinook and coho salmon from the Lower Bridge River, 2012

			Section 1: Yalokom to Hell RK 25.5-28.8				Section 2: Hell to Russel RK 28.8-30.7				Section 3: Russel to Fishfence RK 30.7-33.2				Section 4: Fishfence to Cobra RK 33.2-34.4			
			Observed		Present in Section		Observed		Present in Section		Observed		Present in Section		Observed		Present in Section	
Species	Date	Water Visibility (m)	Untagged	Tagged	Tracked # of tags	# of tags adjusted for survey life	Untagged	Tagged	Tracked # of tags	# of tags adjusted for survey life	Untagged	Tagged	Tracked # of tags	# of tags adjusted for survey life	Untagged	Tagged	Tracked # of tags	# of tags adjusted for survey life
CHA	20-Aug-12	1.0 - 3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHA	27-Aug-12	1.0 - 3.0	21	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
CHA	07-Sep-12	1.0 - 3.0	73	3	6	6	0	1	3	2	11	0	2	2	18	2	2	2
CHA	14-Sep-12	1.0 - 3.0	13	0	5	1	19	0	2	0	15	0	2	0	14	0	1	0
CHA	21-Sep-12	0.0 - 0.5	3	0	3	0	4	0	0	0	5	0	0	0	8	0	0	0
CHA	28-Sep-12	0.0 - 0.5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHA	05-Oct-12	0.0 - 0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHA	12-Oct-12	n/a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COA	05-Oct-12	0.0 - 0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COA	12-Oct-12	n/a	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0
COA	19-Oct-12	n/a	0	0	1	1	11	0	1	1	0	0	0	0	126	0	4	4
COA	26-Oct-12	0.0 - 0.5	0	0	9	9	2	0	1	1	0	0	1	1	0	0	1	1
COA	02-Nov-12	0.25 - 0.50	6	0	8	7	0	0	2	1	7	0	1	1	0	0	0	0
COA	08-Nov-12	1.0 - 1.5	0	0	6	5	7	0	3	2	11	0	3	2	13	0	0	0
COA	15-Nov-12	1.0 - 1.5	0	0	4	1	3	0	1	0	6	2	6	4	0	0	2	1
COA	23-Nov-12	1.0 - 1.5	12	0	5	0	0	0	4	0	0	0	4	0	0	0	0	0
COA	3-Dec-12	1.0-1.5	1	0	5	0	0	0	4	0	0	0	4	0	0	0	0	0
COA	13-Dec-12	1.0-1.5	0	0	4	0	0	0	4	0	0	0	4	0	0	0	1	1

Table 6. cont.

			Section 5: Cobra to Bluenose RK 34.4-38.2				Section 6: Bluenose to Eagle RK 38.2-38.8				Section 7: Eagle to Longskinny RK 38.8-39.6				Section 8: Longskinny to Plungepool River km 39.6-40.0			
			Observed		Present in Section		Observed		Present in Section		Observed		Present in Section		Observed		Present in Section	
Species	Date	Water Visibility (m)	Untagged	Tagged	Tracked # of tags	# of tags adjusted for survey life	Untagged	Tagged	Tracked # of tags	# of tags adjusted for survey life	Untagged	Tagged	Tracked # of tags	# of tags adjusted for survey life	Untagged	Tagged	Tracked # of tags	# of tags adjusted for survey life
CHA	20-Aug-12	1.0 - 3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHA	27-Aug-12	1.0 - 3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHA	07-Sep-12	1.0 - 3.0	0	0	0	0	0	0	0	0	14	1	0	0	0	0	0	0
CHA	14-Sep-12	1.0 - 3.0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
CHA	21-Sep-12	0.0 - 0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHA	28-Sep-12	0.0 - 0.5	0	0	0	0	0	0	0	0	2	0	0	0	17	0	0	0
CHA	05-Oct-12	0.0 - 0.5	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
CHA	12-Oct-12	n/a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COA	05-Oct-12	0.0 - 0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COA	12-Oct-12	n/a	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
COA	19-Oct-12	n/a	0	0	3	3	1	0	1	1	0	0	0	0	0	0	0	0
COA	26-Oct-12	0.0 - 0.5	0	0	2	2	13	0	1	1	0	0	1	1	0	0	0	0
COA	02-Nov-12	0.25 - 0.50	20	0	8	4	52	0	0	0	54	0	1	0	0	1	1	1
COA	08-Nov-12	1.0 - 1.5	20	0	11	6	99	2	0	0	17	1	1	0	101	2	1	1
COA	15-Nov-12	1.0 - 1.5	0	0	9	4	1	0	0	0	0	0	1	0	168	1	2	2
COA	23-Nov-12	1.0 - 1.5	17	0	9	1	43	1	1	1	20	0	1	0	42	1	1	0
COA	3-Dec-12	1.0-1.5	1	0	9	0	11	0	1	0	0	0	2	0	8	0	0	0
COA	13-Dec-12	1.0-1.5	0	0	8	0	0	0	1	0	0	0	2	0	0	0	0	0

Table 7. Summary of visual stream walk and telemetry observations for chinook and coho salmon from the Lower Bridge River, 2012.

			All Reaches			
			Total			
			Observed		Present in Section	
Species	Date	Water Visibility (m)	Untagged	Tagged	Tracked # of tags	# of tags adjusted for survey life
CHA	20-Aug-12	1.0 - 3.0	0	0	0	0
CHA	27-Aug-12	1.0 - 3.0	23	0	0	0
CHA	7-Sep-12	1.0 - 3.0	116	7	13	12
CHA	14-Sep-12	1.0 - 3.0	61	0	11	1
CHA	21-Sep-12	0.0 - 0.5	20	0	3	0
CHA	28-Sep-12	0.0 - 0.5	20	0	0	0
CHA	5-Oct-12	0.0 - 0.5	2	0	0	0
CHA	12-Oct-12	n/a	0	0	0	0
			242	7	27	13
					O.E	O.E
					0.26	0.54
COA	5-Oct-12	0.0 - 0.5	0	0	0	0
COA	12-Oct-12	n/a	18	0	0	0
COA	19-Oct-12	n/a	138	0	9	10
COA	26-Oct-12	0.0 - 0.5	15	0	14	16
COA	2-Nov-12	0.25 - 0.50	139	1	20	14
COA	8-Nov-12	1.0 - 1.5	268	5	24	16
COA	15-Nov-12	1.0 - 1.5	178	3	24	12
COA	23-Nov-12	1.0 - 1.5	134	2	23	2
COA	3-Dec-12	1.0-1.5	21	0	22	0
COA	13-Dec-12	1.0-1.5	0	0	21	1
			911	11	157	71
					O.E	O.E
					0.07	0.16

Table 8. Visual stream walk observations for sockeye salmon from the Lower Bridge River, 2012.

			Section 1: Yalokom to Hell RK 25.5-28.8	Section 2: Hell to Russel RK 28.8-30.7	Section 3: Russel to Fishfence RK 30.7-33.2	Section 4: Fishfence to Cobra RK 33.2-34.4	Section 5: Cobra to Bluenose RK 34.4-38.2	Section 6: Bluenose to Eagle RK 38.2-38.8	Section 7: Eagle to Longskinny RK 38.8-39.6	Section 8: Longskinny to Plungepool River km 39.6-40.0	All Reaches Total
Species	Date	Water Visibility (m)	Observed	Observed	Observed	Observed	Observed	Observed	Observed	Observed	Observed
SKA	20-Aug-12	1.0 - 3.0	0	0	0	0	0	0	0	0	0
SKA	27-Aug-12	1.0 - 3.0	0	0	0	13	0	0	0	0	13
SKA	7-Sep-12	1.0 - 3.0	0	0	0	1	0	0	0	22	23
SKA	14-Sep-12	1.0 - 3.0	0	0	0	0	0	0	0	27	27
SKA	21-Sep-12	0.0 - 0.5	0	0	0	2	0	0	0	18	20
SKA	28-Sep-12	0.0 - 0.5	0	0	0	0	0	0	0	0	0
SKA	5-Oct-12	0.0 - 0.5	0	0	0	0	0	0	0	3	3
SKA	12-Oct-12	n/a	0	0	0	0	0	0	0	0	0
											86

7.0 FIGURES

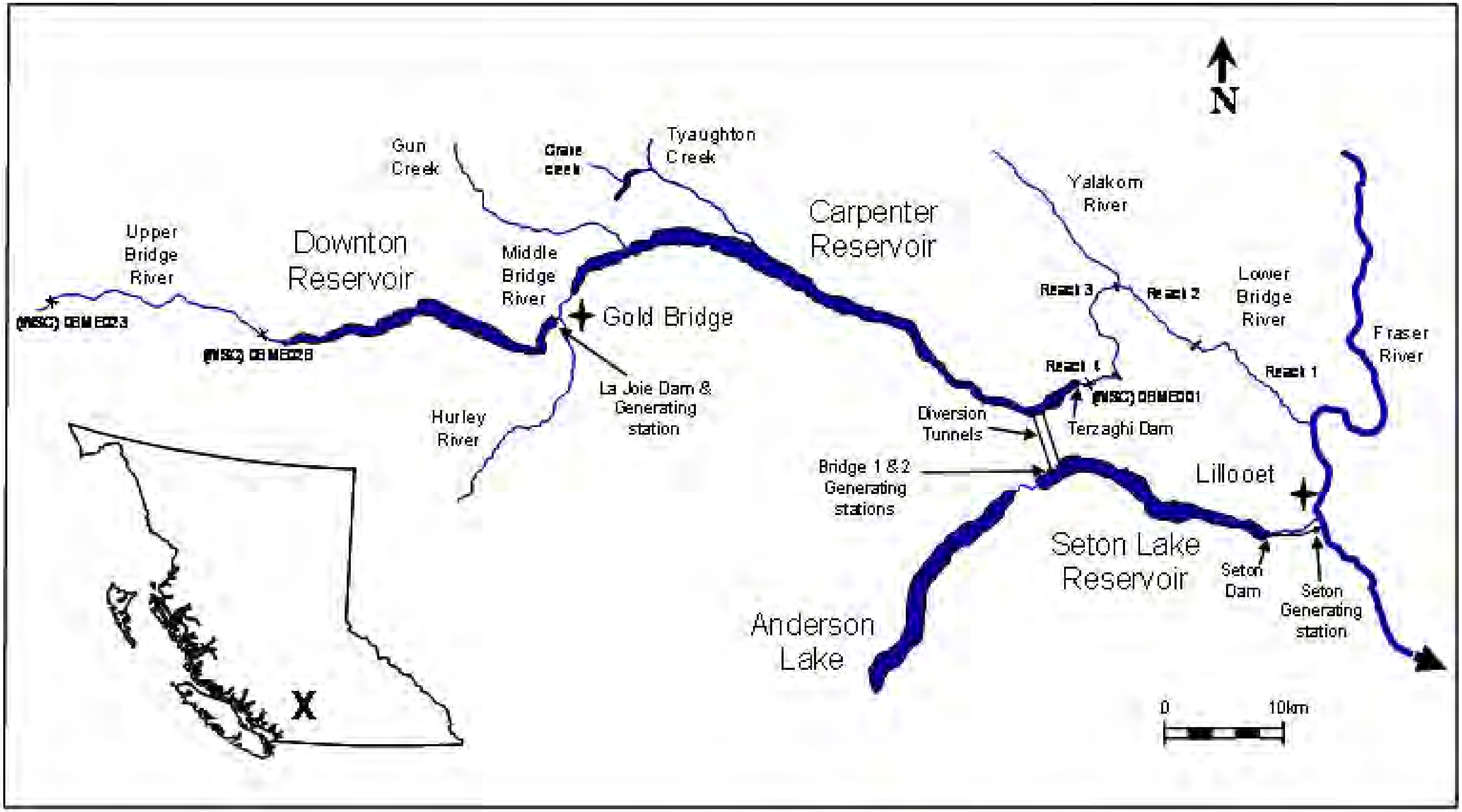


Figure 1. Bridge & Seton Watersheds showing Terzaghi Dam and diversion.

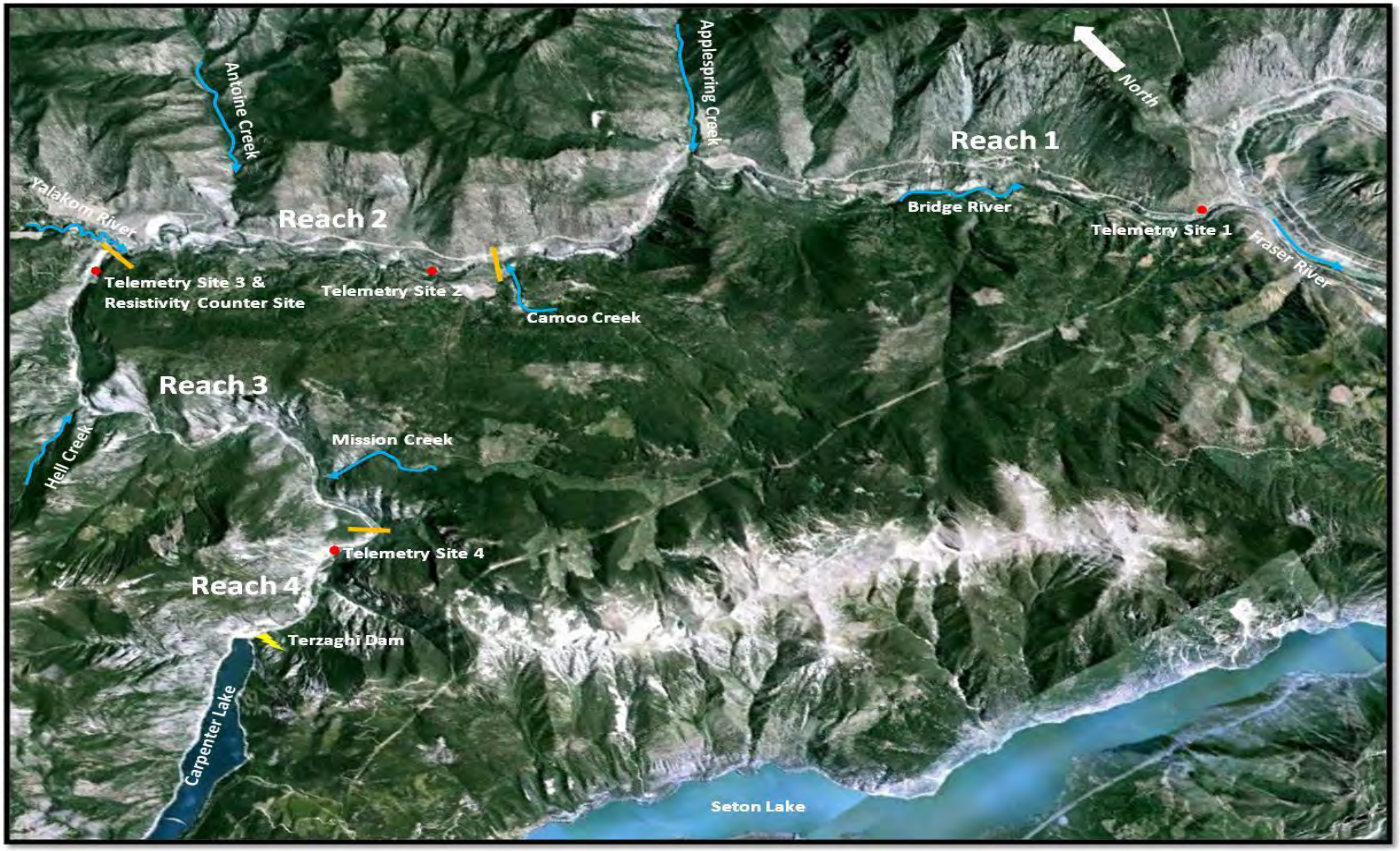


Figure 2. Bridge River Study Area showing Reach Breaks (indicated by orange lines) and Fixed Station Telemetry Receiver Sites (indicated by red dots).

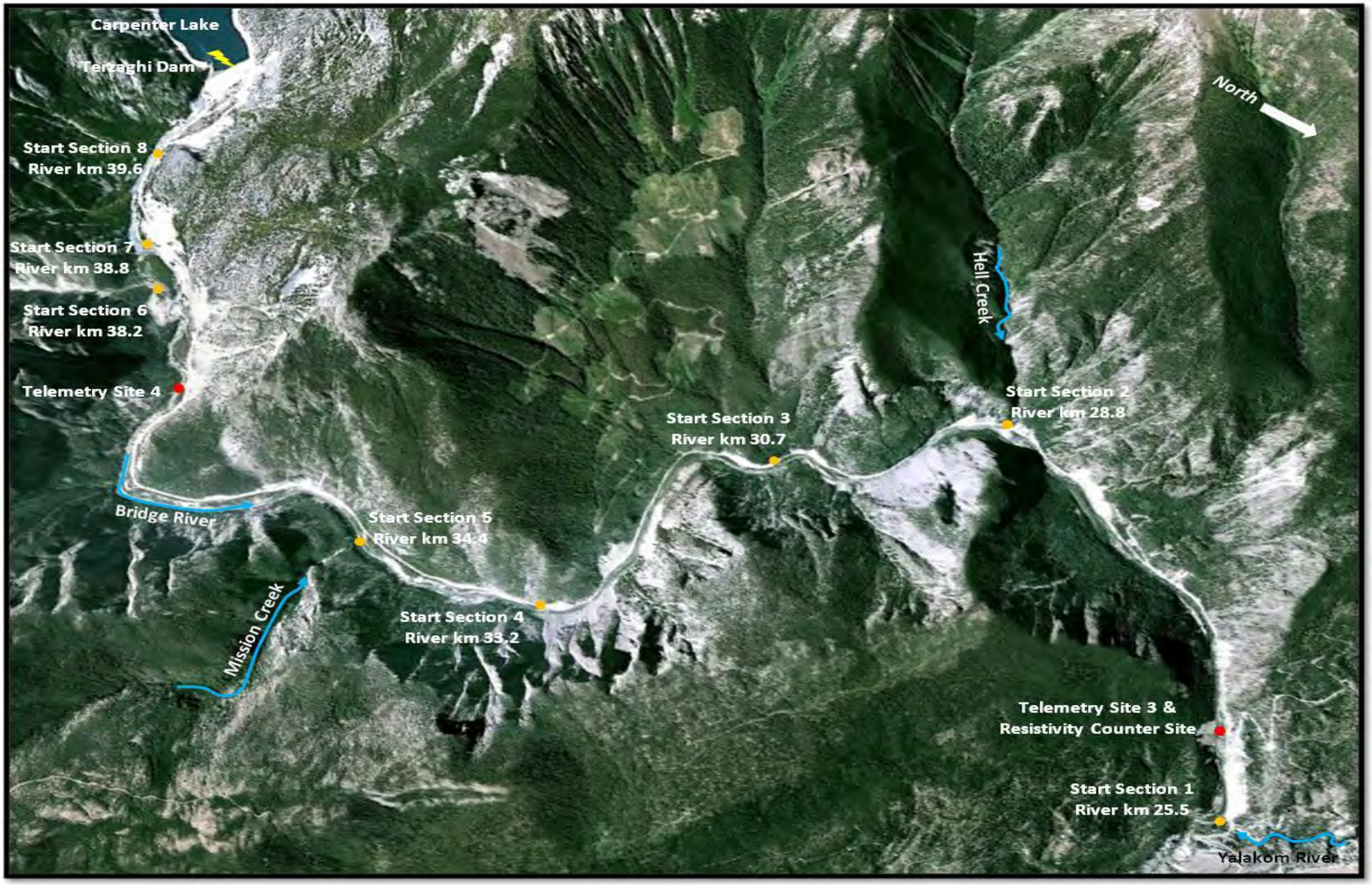


Figure 3. Lower Bridge River Streamwalk Section Boundaries (indicated by orange dots) & Fixed Station Telemetry Receiver Sites (indicated by red dots)

Figure 4. AUC estimate curves for chinook adult spawners at the Bridge River in 2011 (dashed line) and 2012 (solid line).

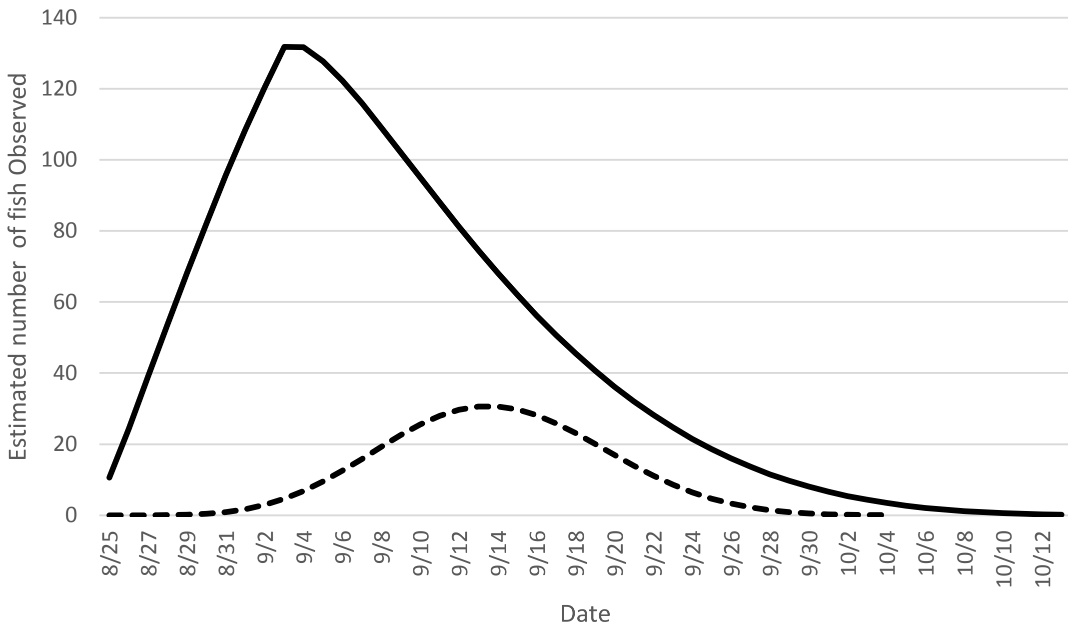
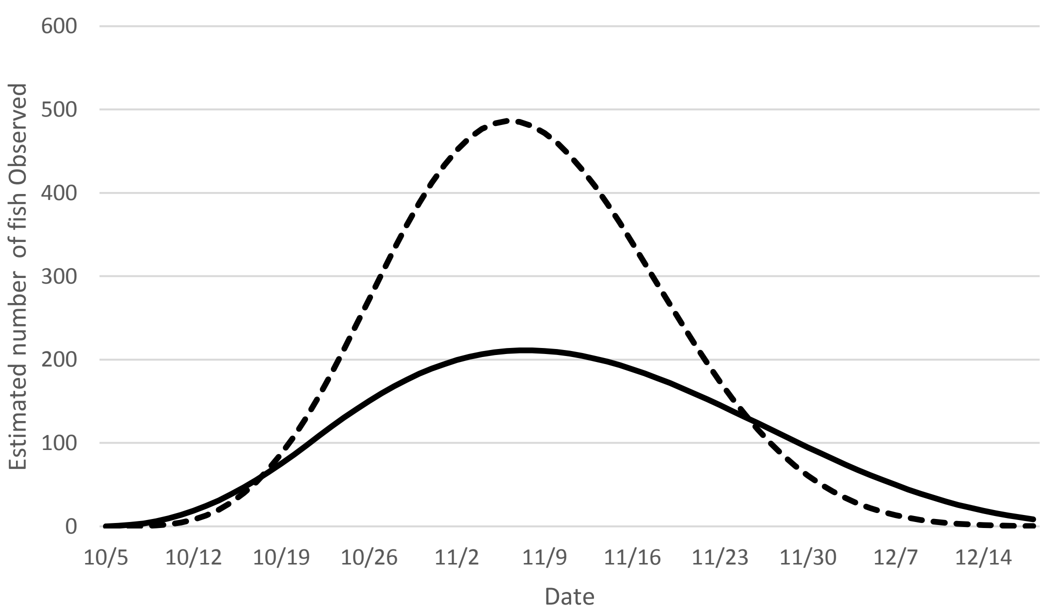


Figure 5. **AUC estimate curves for coho adult spawners at the Bridge River in 2011 (dashed line) and 2012 (solid line).**



8.0 REFERENCES

Baxter, J. and R. Roome. 1997. Reproductive biology of steelhead (*Oncorhynchus mykiss*) in the Bridge and Seton Rivers, 1997. Unpubl. report prepared for BC Hydro, Kamloops, BC. 40 p.

Bison. R. 2006. Estimation of Steelhead Escapement to the Nicola River Watershed Ministry of Environment, Fish & Wildlife Branch Report to Habitat Conservation Trust Fund. 34p

Bridge-Seton Water Use Plan: Monitoring Program Terms of Reference, Water Use Planning, BC Hydro. January, 2012

Brown, S.R., Mackay, W.C. 1995. Fall and winter movement of and habitat use by cutthroat trout in the Ram River, Alberta. Trans. Am. Fish. Soc. 124, 873-885

Coldstream Ecology, Ltd. 2013. Lower Bridge River Aquatic Monitoring. Year 2012 Data Report. Bridge Seton Water Use Plan. Prepared for St'at'imc Eco Resources, Ltd. and BC Hydro for submission to the Deputy Comptroller of Water Rights, August 2013.

Diversified Ova Tech Ltd. 1994. Summary Report on the Bridge River Fence Operation, August 1993 – January 1994. Report to B.C. Hydro, Environmental Affairs Division.

English, K.K, R.C. Bocking and J.R. Irvine. 1992. A Robust Procedure for Estimating Salmon Escapement based on the Area-Under-the-Curve Method. Canadian Journal of Fisheries and Aquatic Sciences, 1992, 49(10): 1982-1989, 10.1139/f92-220

Hagen, J. 2001. Adult steelhead (*Oncorhynchus mykiss*) habitat use and population size in the Bridge River, springtime 2000. Prepared for BC Ministry of Environment, Lands and Parks, Fisheries Branch, Southern Interior Region. http://a100.gov.bc.ca/appsdata/acat/documents/r7/Bridge2000SteelheadTelemetry_1055785446479_7d9a69fb290b4d7b924bbd4547c2e1d2.pdf

Hagen,J., R. Bison, and S. Decker 2012. Steelhead and Resident Rainbow Trout Maternal Origin among Juvenile and Adult Rainbow Trout (Oncorhynchus mykiss) in Steelhead Streams of the lower Thompson River Basin, 2006-2010. British Columbia Ministry of Natural Resource Operations Report 27p.

Hebden, B.W. and J. Baxter. 1999. Reproductive biology of steelhead trout (*Oncorhyncus mykiss*) in the Bridge and Seton rivers, 1996. In progress. B.C. Hydro - Power Facilities. 45 p.

Hebden, B.W. 1981. Summary Report West Fraser Steelhead Program S.E.P. 1980/81 http://a100.gov.bc.ca/appsdata/acat/documents/r346/Hebden1981_1064872960859_4703063e22c455980efa72e1b43dcb5.pdf

Hilborn, R., Bue, B.G., and S. Sharr. 1999. Estimating spawning escapements from periodic counts: a comparison of methods. Can J. Fish. Aquat. Sci. **56:** 888-896.

Korman, J. and P.S. Higgins. 1997. Utility of escapement time series data for monitoring the response of salmon populations to habitat alteration. Can. J. Fish. Aquat. Sci. 54:2058-2097.

Korman, J., R.N.H. Ahrens, P.S.Higgins and C.J. Walters. 2002. Effects of observer efficiency, arrival timing, and survey life on estimates of escapement for steelhead trout (*Oncorhynchus mykiss*) derived from repeat mark–recapture experiments. Canadian Journal of Fisheries and Aquatic Sciences. Volume 59. Number 7. 1116-1131.

Korman, J. and A. Tompkins, 2008. Estimating Regional Distributions of Freshwater Stock Productivity, Carrying Capacity, and Sustainable Harvest Rates for Coho Salmon Using a Hierarchical Bayesian Modelling Approach. Pacific Scientific Advice Review Committee Report. 60pp.

Korman, J, J. Schick and A.Clarke, 2010. Cheakamus River Steelhead Juvenile and Adult Abundance Monitoring 2008-2009. BC Hydro WUP Report. http://www.bchydro.com/etc/medialib/internet/documents/planning_regulatory/wup/lowermainland/2010q4/cmsmon-3_yr2_2010-02-09.Par.0001.File.CMSMON-3-Yr2-2010-02-09.pdf

Longe, R., and P.S. Higgins. 2002. Lower Bridge River Aquatic Monitoring: Year 2001 Data Report. Unpublished report prepared for the Deputy Comptroller of Water Rights, April 2002.

Nishimura, D.J.H., D.R.P. Swanston and N. Todd. 1995a. Draft report on 1994-1995 Bridge River chinook, sockeye and coho salmon life history and enumeration; a description of stream habitat is also included. Prepared for B.C. Hydro, Kamloops, BC. 43 p.

Nishimura, D.J.H., N.L. Todd and D.R.P. Swanston. 1995b. Run strength, timing and reproductive characteristics of chinook, coho and sockeye in the Bridge River 1994-1995. Report of Seacology, Diversified Ova Tech Ltd. to B.C. Hydro, Kamloops, B.C. 77 p.

McCubbing, D.J.F, 2012, BRGMON-3. Lower Bridge River Adaptive Management Program: Adult Salmon and Steelhead Enumeration 2011, BC Hydro WUP Report.

McCubbing, D.J.F. and Bison, R. 2009. Steelhead and Rainbow Trout Escapement Estimates for the Deadman River based on resistivity counts, 2003 through 2006. B.C. Ministry of Environment, Kamloops, B.C. 30p.

McCubbing, D.J.F and M.Clark, 2012. Coho Salmon Adult Spawner Escapement Estimates for the Lemieux River based on resistivity counts 2011. DFO contract report, 11p

McCubbing, D.J.F and A. Gillespie. Deadman River Coho Escapement Enumeration 2007 - fish weir and fish counter comparative data analysis 2007. Report produced for Department of Fisheries and Oceans Kamloops BC. 11pp.

McCubbing,D.J.F and Ignace D. 2000. Salmonid Escapement Estimates on the Deadman River, resistivity counter video validation and escapement estimates. MEOLP Project Report

McCubbing D.J.F and Melville C.M. 2000. Chinook Spawning Migration in the Cheakamus River from

Radio Tracking Observations in the Summer of 1999. Instream Fisheries Consultants report to BC Hydro Cheakamus WUP 34pp.

Renn, J.R, R.G. Bison, J. Hagen and T.C. Nelson. Migration characteristics and stock composition of interior Fraser steelhead as determined by radio telemetry, 1996-1999

Sneep, J. and S. Hall. 2011. Lower Bridge River Aquatic Monitoring: Year 2010 Data Report. Unpublished report prepared for the Deputy Comptroller of Water Rights, August 2011.

Sneep, J. and S. Hall. 2012. Lower Bridge River Aquatic Monitoring: Year 2011 Data Report. Unpublished report prepared for the Deputy Comptroller of Water Rights, August 2012.

Troffe, P.M., D. McCubbing and C.Melville. 2010. *Cheakamus River Water Use Plan Monitoring Program:* 2009Cheakamus River Chum Salmon Escapement Monitoring and Mainstem Spawning Groundwater Survey. Report to BC Hydro. 58p

Webb, S, R. Bison, A. Caverly and J. Renn. 2000. The reproductive biology of steelhead (*Onchorhynchus mykiss*) in the Bridge and Seton Rivers, as determined by radio telemetry 1996/97 and 1998/99. Technical report of the BC Ministry of Environment, Lands, and Parks, Kamloops 42 pp. http://a100.gov.bc.ca/pub/acat/public/viewReport.do?reportId=11

9.0 APPENDIX

Appendix 1. Visual stream walk observations for chinook and coho salmon from the Lower Bridge River, 2011.

			Section 1 &2: Yalakom to Russel RK 25.5-30.7	Section 3-5: Russel to Bluenose RK 30.7-36.8	Section 6-8: Bluenose to Terzaghi RK 36.8-40.0	
Species	Date	Water Visibility	Observed	Observed	Observed	Total Observed
CHA	15-Aug-11	<0.5	0	0	0	0
CHA	30-Aug-11	<0.5	0	0	2	2
CHA	9-Sep-11	<0.5	2	2	4	8
CHA	13-Sep-11	<0.5	30	9	9	48
CHA	19-Sep-11	<0.5	8	3	5	16
CHA	27-Sep-11	<0.5	0	0	2	2
CHA	3-Oct-11	<0.5	0	0	0	0
						76

			Section 1 &2: Yalakom to Russel RK 25.5-30.7	Section 3-5: Russel to Bluenose RK 30.7-36.8	Section 6-8: Bluenose to Terzaghi RK 36.8-40.0	
Species	Date	Water Visibility	Observed	Observed	Observed	Total Observed
COA	3-Oct-11	<0.5	0	0	0	0
COA	17-Oct-11	<0.5	0	0	0	0
COA	24-Oct-11	<0.5	14	240	2	256
COA	1-Nov-11	<0.5	1	370	148	519
COA	7-Nov-11	<0.5	0	5	236	241
COA	16-Nov-11	<0.5	0	52	412	464
COA	21-Nov-11	<0.5	0	16	412	428
COA	28-Nov-11	<0.5	14	20	171	205
COA	6-Dec-11	<0.5	3	18	44	65
COA	12-Dec-11	<0.5	0	1	17	18
COA	19-Dec-11	<0.5	0	0	0	0
						2196

Appendix 2. Visual stream walk observations for sockeye and pink salmon from the Lower Bridge River, 2011.

			Section 1 &2: Yalakom to Russel RK 25.5-30.7	Section 3-5: Russel to Bluenose RK 30.7-36.8	Section 6-8: Bluenose to Terzaghi RK 36.8-40.0	
Species	Date	Water Visibility	Observed	Observed	Observed	Total Observed
SKA	15-Aug-11	<0.5	0	0	0	0
SKA	30-Aug-11	<0.5	4	0	79	83
SKA	9-Sep-11	<0.5	6	6	88	100
SKA	13-Sep-11	<0.5	0	24	254	278
SKA	19-Sep-11	<0.5	7	6	340	353
SKA	27-Sep-11	<0.5	2	6	128	136
SKA	3-Oct-11	<0.5	0	0	78	78
SKA	17-Oct-11	<0.5	0	0	10	10
SKA	24-Oct-11	<0.5	0	0	0	0
						1038

			Section 1 &2: Yalakom to Russel RK 25.5-30.7	Section 3-5: Russel to Bluenose RK 30.7-36.8	Section 6-8: Bluenose to Terzaghi RK 36.8-40.0	
Species	Date	Water Visibility	Observed	Observed	Observed	Total Observed
PKA	15-Aug-11	<0.5	0	0	0	0
PKA	30-Aug-11	<0.5	1	0	3	4
PKA	9-Sep-11	<0.5	256	51	5	312
PKA	13-Sep-11	<0.5	1100+	400+	368	1800+
PKA	19-Sep-11	<0.5	1000+	800+	1400+	3200+
PKA	27-Sep-11	<0.5	2000+	1400+	2000+	5400+
PKA	3-Oct-11	<0.5	0	0	2000+	2000+
						12,500+

Appendix 3 Fish tag placements