Bridge River Water Use Plan

Lower Bridge River Adult Salmon and Steelhead Enumeration

Implementation Year 3

Reference: BRGMON-3

Study Period: April 1, 2014 to March 31, 2015

Caroline Melville, Daniel Ramos-Espinoza, Douglas Braun, and D. McCubbing

InStream Fisheries Research Inc.
215 – 2323 Boundary Road
Vancouver, BC
V5M 4V8

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Bridge-Seton Water Use Plan

Implementation Year 3 (2014):

Lower Bridge River Adult Salmon and Steelhead Escapement

Reference: BRGMON-03

Caroline Melville, Daniel Ramos-Espinoza, Douglas Braun, and D. McCubbing

Prepared for:

St'át'imc Eco-Resources

10 Scotchman Road

PO Box 2218

Lillooet, BC V0K 1V0

Prepared by:

InStream Fisheries Research Inc.

215 – 2323 Boundary Road

Vancouver, BC V5M 4V8

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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 estimates of egg deposition. In combination with juvenile data collected in BRGMON-1, these data will allow the development of river specific stock recruitment models to evaluate the effects of flow independently of other factors such as marine survival and adult exploitation.

In 2014, data from visual streamwalk spawner surveys were used to provide area under the curve (AUC) type escapement estimates of adult Chinook and Coho Salmon and Anadromous Rainbow Trout (Steelhead) to the lower Bridge River. Residence time and observer efficiency data were generated using radio and PT telemetry mark-recapture. Twenty-two Chinook Salmon, and 20 Steelhead Trout adults were tagged with radio tags and external spaghetti tags, providing residence time estimates of 12 and 17 days on the spawning grounds and observer efficiencies of 0 and 0.27, respectively. Thirty-three Coho Salmon were PIT tagged in 2014, generating residence time and observer efficiency estimates of 17.5 days and 0.26 (average of 2012 and 2013 radio telemetry data), respectively. Using AUC methods, a total spawner estimate of 591 Chinook and 394 Coho Salmon, and 51 Steelhead Trout were derived for the area upstream of the confluence with the Yalakom River.

Historic visual count data were compiled and preliminary AUC estimates were calculated for Chinook and Coho Salmon in the area upstream of the Yalakom confluence. Chinook Salmon estimates from 1993 to 2013 ranged from 151 to 3,479 fish, and from 76-3,422 fish for Coho Salmon from 1997 to 2013. Examination of the sensitivity of AUC estimates indicates that small variations or error in calculating observer efficiency or residence data can greatly affect estimates. No historical visual count data are available for Steelhead Trout prior to 2014.

Estimates from the counter installed in October 2013 were calculated for Chinook, Coho and Steelhead. A total estimate of 947 Chinook, 1,543 Coho and 238 Steelhead was calculated using counter data in 2014. Confidence limits within 10% accuracy will be generated with more video and graphics validation in the next few years. An AUC data comparison will be completed once counter data is fully tested. Visual counts may cease as the counter is expected to provide improved escapement accuracy for Reaches 3 and 4.

A detailed examination of Chinook spawner habitat was undertaken in 2014 to better assess the effects of different flow regimes on habitat selection. Physical habitat characteristics were measured including water depth, velocity, substrate composition, and water temperature at 62 Chinook redds in Reach 3. Redd location was then cross referenced with GIS habitat data collected at 1.5 $m^3 s^{-1}$ to identify hydrological units where Chinook were spawning. In general, Chinook spawning occurred in run and riffle habitat under this flow regime. Further assessment in 2015 will be undertaken to assess 3 $m^3 s^{-1}$ discharge and the effect(s) of pink spawning on Chinook redd selection.

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Acknowledgements

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1.0 Introduction

1.1 Background

The Bridge River is a hydroelectric power producing tributary of the middle Fraser River and serves as important habitat for Salmon and Steelhead. The Bridge River has historic and current significance for the St’át’imc Nation. River discharge is affected by BC Hydro through the operation of Carpenter Reservoir and Bridge River Generating Stations #1 and #2 (BRGS). The Bridge River was originally impounded in 1948 through the construction of the Mission Dam approximately 40 km upstream of the confluence with the Fraser River. In 1960, Mission Dam was raised to its present configuration (~ 60 m high, ~ 366 m long earth fill structure) and renamed to 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 River catchment for power production at the Seton Generating Station (Figure 1). A four kilometer section of the Bridge River channel immediately downstream of Terzaghi Dam remained continuously dewatered; groundwater and small tributaries accounted for the total in-river discharge below the dewatered reach (~ 1 $m^3 s^{-1}$ averaged across the year; Longe and Higgins 2002).

The lack of a continuous flow release from Terzaghi Dam was an issue of long-standing concern for the St’át’imc Nation, federal and provincial regulatory agencies, and the public. During the late 1980s, BC Hydro, Fisheries and Oceans Canada, and the BC 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 of the base of the dam. The agreement included the provision of a 3.0 $m^3 s^{-1}$ interim water budget for instream flow releases based on a hydrograph ranging from 2 $m^3 s^{-1}$ to 5 $m^3 s^{-1}$. 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 and the continual release of water from Terzaghi Dam to the lower Bridge River (LBR) began on August 1, 2000.

A condition of the Interim Flow Order (IFO) was the continuation of environmental monitoring studies in response to concerns raised regarding environmental impacts of the introduction of water from Carpenter Reservoir and the need to develop a better understanding of the influence of reservoir releases on the aquatic ecosystem of the LBR. The Aquatic Ecosystem Monitoring Program was implemented (continuing as BRGMON-1, Bridge-Seton WUP Monitoring Terms of Reference 2012), which collected data on baseline conditions before the continuous release began and measured ecosystem responses to the flow trials (Sneep and Hall 2011).

The IFO continued until the Water Use Plan (WUP) for the Bridge-Seton system was approved by the St'át'imc First Nation and regulatory agencies, and authorized by the Comptroller of Water Rights for the Province of British Columbia. The Bridge-Seton Consultative Committee (BRS CC) submitted a draft Water Use Plan to the Comptroller in September 2003. Subsequent recommendations by the St'át'imc First Nation 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 in 1998 that tested three alternative flow release regimes (referred to as: 1 $m^3 s^{-1}$/y, 3 $m^3 s^{-1}$/y, 6 $m^3 s^{-1}$/y treatments) that differed in the total magnitude of the annual water budgets, but not the shape of the hydrograph. The flow treatment was subsequently revised, and was set to 3 $m^3 s^{-1}$/y from August 2000 to April 2011, and to 6 $m^3 s^{-1}$/y from May 1, 2011 to April 15, 2015. The BRS CC recommended detailed monitoring of ecosystem responses to instream flow. In response, the BRS Fisheries Technical Committee (BRS FTC) developed a monitoring program aimed at evaluating the physical habitat, aquatic productivity, and fish responses to instream flow.

The BRS FTC expressed uncertainty about the availability and importance of spawning habitat for anadromous species, and how this may affect interpretation of the juvenile salmonid response monitored under 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 spawner density on juvenile recruitment. 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 by DFO in the LBR. A secondary objective of BRGMON-3 is to build on previous studies by developing survey methods and analytical techniques that 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

The fundamental management question of BRGMON-3 relates to how informative is the use of juvenile salmonid standing crop biomass as an indicator of flow impact. This monitoring program addresses this management question via two hypotheses:

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

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 hypothesis relates to the interpretation of the results from BRGMON-1. BRGMON-3 aims to collect the data needed to support evaluations of whether there are sufficient numbers of adults to produce progeny that would fully seed available rearing habitat.

The second hypothesis attempts to fill data gaps identified during WUP development. The BRS WUP process identified significant uncertainty regarding the quality and quantity of spawning habitat in the LBR. The implementation of this monitoring program is intended to improve the utility of the juvenile standing crop data by relating it to egg deposition and the amount of spawning habitat available for adult escapement.

1.3 Key Water Use Decisions Affected

The key WUP decision influenced by the results of BRGMON-3 is the development of the long term flow regime for the LBR. This monitor will provide the data needed to support BRGMON-1 in the interpretation of the response of the aquatic ecosystem to the varied flow treatments (0 $m^3 s^{-1}$, 3 $m^3 s^{-1}$, and 6 $m^3 s^{-1}$). Ultimately, this will improve understanding of the influence of instream flow on salmon spawning and rearing habitat quantity and quality in the LBR.

2.0 Methods

2.1 Objectives and Scope

The objective of the test flow program is to determine the relationship between the magnitude of flow releases from Terzaghi Dam and the relative productivity of the LBR aquatic and riparian ecosystem by observing fish responses to test flows. BRGMON-3 objectives include documenting the escapement of salmonids to:

1. Ensure changes in standing crop are associated with flow changes and not confounded by variation in spawner escapements.
2. Understand the effects of flow releases on Salmon and Steelhead spawning habitat.

The scope of this program involves monitoring changes in abundance and distribution of spawning Salmon and Steelhead, with particular focus on streamirearing species (Chinook and Coho Salmon, and Steelhead Trout) in the Bridge River between its confluence with the Fraser River and Terzaghi Dam. The key metric of the impact of changes in discharge is the responses in juvenile productivity, as measured by BRGMON-1. Responses in juvenile productivity include egg to fry survival, smolts produced per spawner, and fry/parr standing crop as a function of spawner abundance. Since Salmon and Steelhead escapement are not direct indicators of habitat condition, changes in adult abundance alone will not be used as a metric of response to impact. Escapement is affected by downstream conditions (i.e., ocean survival and fishing mortality), and there is a 2 to 4 year lag before a response to changes in freshwater conditions experienced as juveniles can be measured (Korman and Higgins 1997).

2.2 Monitoring Approach

This monitoring project focuses on the stock assessment of adult Chinook Salmon (*Onchorhynchus tshawytscha*), Coho Salmon (*O. kisutch*), and Steelhead Trout (*O. mykiss*) in the LBR. Supplemental surveys are conducted to estimate spawning population abundance of Sockeye Salmon (*O. nerka*) and odd-year Pink Salmon (*O.gorbushca*). This monitor focuses primarily on Chinook, Coho, and Steelhead, as these are the only anadromous salmonids that rear for an extended period in the LBR. Rigorous estimates of Chinook escapement are particularly important because the time series of juvenile stock assessment data may be confounded by hypothesized temperature-mediated changes in juvenile life history due to elevated winter temperatures induced by dam releases (BRGMON-1, Bridge-Seton WUP Monitoring Terms of Reference 2012).

Construction of a fish enumeration facility was completed in October 2013, where a five-channel (Channel 1 on river left and Channel 5 on river right) electronic resistivity counter will enumerate Chinook, Coho, and Steelhead escapement in the LBR through 2021. The counter is being used to estimate salmonid escapement above the counter site (i.e., near the downstream end of Reach 3; Figure 2

& 3). Resistivity counters provide accurate estimates (with confidence limits of +/- 10% of true abundance) in other systems (McCubbing and Bison 2009). Further, the accuracy of a resistivity counter estimate can be determined using video validation. Aquantic's (Scotland, UK) proprietary graphics software provides a graphical trace of each counter record to ensure that the counter algorithm has correctly identified a fish. Each individual trace can be viewed, and thus serves as a form of pseudo-validation.

Visual counts of Salmon and Steelhead in the LBR have occurred annually since 2011 using methods developed and implemented in BRGMON-3 and prior to 2000 using several methods. The survey area extends from the Terzaghi Dam to the confluence with the Yalakom River (Figure 3 and Table 1), and is used in the present monitoring program as the location for estimating abundance, distribution, and biological characteristics of spawning Salmon and Steelhead.

Historic fish counts are available for the LBR from Fisheries and Oceans Canada visual surveys, helicopter surveys, and fence counts. Escapement estimates for these historic counts are calculated through area-under-the-curve (AUC) estimation (English et al. 1992, Hilborn et al. 1999) using observer efficiencies and residence times determined by radio telemetry and visual surveys conducted since 2011. Counter estimates will be compared in the future to aid in back-calculating historic escapement from AUC alone (Troffe et al. 2008). Generating accurate and precise historic AUC estimates is challenging due to inconsistencies in historic methods, a lack of historic observer efficiency data, and at present a short time series of AUC estimates for resistivity counter comparisons.

In 2014, InStream Fisheries Research Ltd. (IFR) conducted an assessment of Chinook spawner habitat quantity and quality. Two years of Chinook redd habitat surveys will be completed in the LBR at minimum, and will be combined with habitat mapping and GIS data from BRGMON-1 and related to spawner densities and the locations of tagged spawners as determined in BRGMON-3. Field data collection is important in this instance, as spawning Chinook are experiencing discharges different from an unregulated system which may affect local spawning habitat selection.

2.2.1 Tag Application and Bio-sampling

Fish capture was completed by skilled SER fisheries technicians. Steelhead were tagged at the Seton-Fraser and Bridge-Fraser confluences. Chinook were tagged immediately downstream of the counter site at the Bridge-Yalakom confluence. Coho were primarily tagged in Reach 1 (Bridge-Fraser confluence to Camoo Creek). Tag application was distributed throughout each species migration periods: March to May for Steelhead, August to September for Chinook and October to November for Coho. Efforts were made to evenly distribute tags between males and females as migration behaviour and run timing can differ by sex (Korman et al. 2010, Troffe et al. 2010).

Steelhead and Chinook received a gastrically implanted MCF2-3A radio tag (Lotek Engineering Inc., Ontario, Canada). A brightly coloured spaghetti tag was also placed through the dorsal muscle for visual identification of radio-tagged fish during visual surveys. The proportion of spaghetti tags visually identified was then compared to radio telemetry results to estimate observer efficiency (*o.e*.). Fork length and sex were recorded during tagging, and scale samples were obtained from study subjects for ageing purposes. Scale samples collected in 2014 had not been read prior to the submission of this report, and will be reported in future years. We will collect otoliths from carcasses if we are unable to collect scales from future study subjects. Fish were held in a submersible holding tube for a minimum of 30 minutes prior to release to ensure survival and tag retention.

In 2014, IFR suspended radio tagging of Coho and only applied Passive Integrated Transponders (PIT). Radio tags are a much more invasive tagging method compared to PIT tags, and based on the three previous years of BRGMON-3, it was determined that additional data on *o.e*. and residence time data would provide little improvement to the accuracy of AUC estimates. PIT antennas at the counter provided data on the proportion of Coho captured in Reach 1 that moved past the counter into Reach 3. Such data allowed for an estimate of the population of Coho in the entire LBR. Coho were also sampled for fork length, sex, and scales.

2.2.2 Radio Tracking

Fixed radio telemetry stations were installed at four locations along the LBR (Figures 2 & 3, and Table 1). Stations consisted of Lotek SRX_400 receivers linked to two Yagi 6-prong directional antennas oriented upstream and downstream. Fixed stations were installed prior to tagging and operated during the Chinook Salmon (August to October) and Steelhead (March to June) migratiosn. Fixed station data was used to corroborate fish location identified during mobile tracking, identify entry and exit timing of fish into each reach, and collect basic information on Chinook and Steelhead migration and spawning behaviour in the LBR.

Mobile radio tracking with a hand-held Lotek SRX_400 receiver was conducted twice a week for Steelhead and weekly for Chinook in Reaches 3 and 4 (Figure 3). Tracking was carried out from April 23, 2014 to June 23, 2014 for Steelhead and September 2, 2014 to October 9, 2014 for Chinook. Radio tracking quantified the number of tags available to be seen during each visual survey in the two reaches. Radio tracking was conducted by vehicle or on foot independently of the technicians conducting the visual count to avoid observer bias (i.e., searching for tags known to be in the area).

2.2.3 Visual Counts

Visual counts occurred twice weekly for Steelhead Trout and weekly for Chinook, Sockeye, and Coho Salmon in Reaches 3 and 4. Surveys started on April 22, 2014 and ended on June 23, 2014 for Steelhead Trout. Surveys started again on August 13, 2014 for the salmon species, and continued until December 3, 2014 when fish activity ceased based on streamwalk, telemetry and counter observations.

Visual surveys followed methods used in previous assessments, where two observers walked in a downstream direction on the riverbank and recorded the species, location, and presence of spaghetti-tagged fish. Viewing conditions, cloud cover, and lateral water visibility were also recorded (Sneep and Hall 2011).

2.2.4 Spawner Habitat Evaluation

In 2014, a detailed evaluation of Chinook spawning habitat was undertaken in the LBR. Physical habitat characteristics including water depth, velocity, substrate composition, and water temperature are primary factors influencing where and when Chinook spawn (Groves 2011). Water depth, velocity, and substrate characteristics were measured at each redd. Depth was measured at three locations around the redd (depression or leading edge, tail spill and adjacent), and velocities were measured adjacent to the redd and at the tail spill (Figures 4 & 5). Measurements adjacent to the redd were assumed to be representative of stream conditions prior to the digging of the redds, and thus can be interpreted as the preferable spawning habitat for Chinook. Substrate composition was estimated to the nearest 5% for eight size categories (fines, sand, small gravel, large gravel, small cobble, large cobble, boulder and bedrock) in and around the redd (Wentworth 1922). Data were used to identify the dominant substrate size category at each redd. Velocities were taken at 60% of the total depth (mean column velocity-V60), where depths were less than one meter. A Swoffer (Model 2100) current velocity meter was used to measure velocities and the top set wading rod of the Swoffer was used to measure depth to the nearest centimeter.

Sections of the LBR where high numbers of Chinook spawners were observed were sampled and assumed to represent typical spawning habitat (i.e., not marginal habitats). All survey sites were geo-referenced using a hand-held GPS receiver accurate to within 10 m. The GPS coordinates of each site were recorded in UTM format and the sites were clearly labeled. Redd locations were then cross referenced with GIS habitat data collected by Coldstream Ecology (McHugh and Soverel, 2015) to identify hydrological units where Chinook were spawning. Frequency histograms were used to describe the distribution of depth, mean water column velocity, and dominant substrate associated with Chinook redds.

Steelhead and Coho redds were not sampled in 2014 due to high water levels and turbidity, which prohibited locating redds to measure physical habitat characteristics.

2.3 Analysis Methods

2.3.1 Area Under the Curve Estimates of Spawner Abundance

In 2014, as in previous years, an AUC analysis (Hilborn et al. 1999) was used to estimate escapement for Coho and Chinook Salmon using visual count data combined with *o.e.* and residence time estimates obtained from radio telemetry. An estimate for steelhead adults was also calculated using this method, although observer efficiency and residence time data were limited. In this method, escapement is modelled as a quasi-Poisson distribution with arrival timing characterized by a beta distribution. We found a normal distribution adequately described arrival timing of Salmon in the LBR and resulted in a simpler AUC model compared to the beta distribution version of the model. Consequently, Coho and Chinook abundance in 2014 were modelled using a quasi-Poisson distribution with normally distributed arrival timing (described in Millar et al. 2012). Both methods were evaluated using maximum likelihood (ML), and differ only in the distribution of arrival timing. Abundance estimates were thus insensitive to this change in analysis, and thus, we used the methods described below from Millar et al. (2012).

With escapement modelled as a quasi-Poisson distribution with normally distributed arrival timing (Millar et al. 2012), the number of observed spawners at time t (C_t) is

(1) $$C_t = a\, exp\left[-\frac{(t-m_s)^2}{2\tau_s^2}\right]$$

where a is the maximum height of the spawner curve, m_s is the time of peak spawners, and τ_s^2 is the standard deviation of the arrival timing curve.

Because the normal density function integrates to unity, the exponent term in Equation 1 becomes $\sqrt{2\pi\tau_s}$ and Equation 1 can be simplified to

(2) $$C_t = a\sqrt{2\pi\tau_s}$$

A final estimate of escapement ($\hat{E}$) is obtained by applying observer efficiency (v) and survey life (l) to the estimated number of observed spawners

(3) $$\hat{E} = \frac{\hat{C}_t}{l * v}$$

$\hat{E}$ in Equation 3 is estimated using ML, where $\hat{a}$ and $\hat{\tau}$ are the ML estimates of a and τ_s in Equation 2 ($\hat{C}_t = \hat{a}\sqrt{2\pi\hat{\tau}_s}$).

The AUC estimation in Equation 1 can be re-expressed as a linear model, allowing the estimation to be performed as a simple log-linear equation with an over-dispersion correction factor. The over-dispersion correction accounts for instances where the variance of the observations exceeds the expected value. The log-linear model is computationally simple and can be completed using standard generalized linear modelling software.

Chinook Salmon

In 2012 and 2013, *o.e*. for Chinook Salmon was calculated as the number of externally-tagged fish observed in each visual survey divided by the total number of tagged fish present as indicated by radio telemetry. Deceased fish were not included in calculations of *o.e*., as only live counts are used in AUC estimates. We determined the date of death of tagged fish to be the first day of significant downstream movement (> 1 km), or the day that the fish ceased movement completely according to fixed and mobile telemetry data. No tagged Chinook were observed in 2014 due to turbidity issues, and thus *o.e*. could not be estimated. For 2014, the *o.e*. from 2013 (0.28) was used with a standard error of 0.075. We assumed the *o.e*. to be similar between 2013 and 2014 because water clarity was poor in both years, but the application of this *o.e.* may bias the estimate low given the lack of any observed tagged fish.

Residence time was estimated as the number of days post tagging that a fish was observed moving in an upstream direction followed by either a large (> 1 km) directional movement downstream or remaining in place for several weeks after completing the upstream movement. Residence times were averaged by species and survey year and calculations consisted only of fish that were tagged outside of the visual survey area or inside the survey area but within 50 m of the downstream boundary. In 2014, the average residence time for Chinook Salmon from the three years of study (2012-2014) was used in AUC estimation.

To build on our currently developing database, historical Chinook count data for the length of river between the confluence of the Yalakom River and the Terzaghi Dam (Reaches 3 and 4) were obtained from DFO. From 1993-1996, a counting fence was used to determine the number of fish from the Yalakom confluence to Terzaghi Dam. Visual data from 1997 to 2010 were used to reconstruct AUC estimates of spawner abundance following the methods outlined above. For more recent years (post-2000), visual count data were retrieved from the DFO stock assessment database, whereas for earlier years (prior to 2000), data were recorded from paper copies of spawner survey datasheets by IFR staff. Prior to 1993, the data did not have sufficient detail to calculate estimates, and three years (2000, 2002-2003) were missing from the dataset; therefore, no estimate is available for these years. Historical count data were often missing zero counts at the beginning and end of surveys, which can result in inaccurate estimates or no estimate. Zeroes were added to the count dataset to improve the accuracy and temporal coverage of estimates. A zero count was added on August 8 for all years that did not start with a zero count. A zero count was added on October 2 for all years that did not end with a zero count. We chose these dates based on other years of count data that had zero count surveys at the beginning and end of the survey.

No historical data exist for *o.e.* or survey life. Mean and standard error of *o.e.* and survey life from the three years of this study were used in the historical AUC modelling of both helicopter and streamwalk counts (Tables 2 & 3).

Coho

In 2012 and 2013, *o.e.* and residence time for Coho Salmon were calculated using the same methods outlined above for Chinook Salmon. In 2014, no Coho were radio tagged, as high turbidity indicated that *o.e.* would be close to zero. Therefore, the mean *o.e.* and residence time from the previous two years were used in AUC modeling (Tables 2 & 3).

Historical AUC estimates of Coho spawner abundance from 1997 to 2010 were calculated using the methods described for Chinook. Data prior to 1997 was of insufficient detail to produce estimates and the years 2000, 2002 and 2007 were missing from DFO's historical records.

Mean and standard error of *o.e.* and residence time from 2012 and 2013 radio tagging were used in the historical AUC modelling of Coho spawner abundance (Tables 2 & 3).

Steelhead

In 2014, *o.e.* and residence time for Steelhead were calculated using the same methods outlined above. No historical count data are available for Steelhead.

2.3.2 Salmon Resistivity Counter Enumeration

Steelhead, Chinook and Coho escapement was estimated using data from the resistivity counter following similar methods to those of McCubbing and Bison (2009) on the Deadman River (1999-2008). Briefly, spurious debris or wave action data (i.e., a large number of events over a short period of time on a single channel) were removed from the raw dataset. Next, target species were identified using size cut-offs (see details below) and counter accuracy was estimated through video validation when data were available. Video data were collected throughout the migration period for Coho and Chinook on Channels 1 and 2 using an infrared camera (Lorax 700TVL) connected to a batter- powered eight channel DVR (DVR90004N, Supercircuits). Video validation provided estimates of upstream and downstream counter accuracy, which were used to expand the number of up and down counts detected by the counter in to escapement estimates. Finally, the total estimated escapement above the counter was calculated as:

(4) $$E = \sum_{t=1}^{k}\left(\frac{U_t}{q_{up}} - \frac{D_t}{q_{down}}\right) + \sum_{t=k}^{\infty}\left(\frac{U_t}{q_{up}}\right)$$

where E is the estimated escapement, U_t is the daily number of upstream fish detections for day t, D_t is the daily number of downstream detections for day t, q_{up} is the counter accuracy for detecting upstream migrating fish, and q_{down} is the counter accuracy for detecting downstream migrating fish. The k parameter is defined as the day Steelhead kelts begin moving in a downstream direction, and is estimated using movement data obtained through radio telemetry and PIT tag recovery. We do not estimate k for Chinook and Coho Salmon as these species die after spawning and thus the relative proportion of spawned fish that are detected passing over the counter is low (< 1%). Therefore, we use Equation 5 to estimate escapement of Chinook and Coho above the counter:

(5) $$E = \sum_{t=1}^{n}\left(\frac{U_t}{q_{up}} - \frac{D_t}{q_{down}}\right)$$

where n is the end date of the species' upstream migration. We estimate n using video validation and known species run timing. Overlaps in species migration timing make it difficult to determine the start and end date for each species. Species-specific migration start and end dates were determined by collating information from other data sources, which included radio telemetry, streamwalks, video observations and a historical telemetry study (Webb et al. 2002).

Steelhead Trout

Video data were not collected during the Steelhead migration because of low water visibility caused by high water and turbidity. Counts were therefore not adjusted for counter accuracy or the presence of migrating resident Rainbow Trout. The 2014 Steelhead escapement estimate was calculated using the raw counter data and subtracting the number of down counts from the total number of up counts over the Steelhead migration period.

Chinook Salmon

Examination of peak signal size data for Chinook and Sockeye did not indicate any relationship between large bodied upstream migrating Chinook and Sockeye and peak signal size (PSS) (Figures 5 & 6). Fish length was measured on the screen from video recording. This was done by placing a ruler to the screen and measuring screen shots of individual fish. This length was then scaled using a known length on the screen (length between the first and last electrodes = 700 mm) to convert to a standard length. Standard length was then converted to fork length using a conversion equation identified in Pahlke (1989). A size cut-off was determined by comparing the size distributions of Chinook and Sockeye measured during other studies in the Bridge-Seton system (BRGMON-3 – 2013, Casselman et al. 2013). We selected a cut-off of 680 mm because it minimized the overlap between the two species (Figure 6). This size cut-off was used to determine the percentage of Chinook and Sockeye observed on the video and was applied to the counter data.

A total of 55 hours of video data was used to verify resistivity counter efficiency for Chinook and Sockeye. An hour of video was examined every two hours from September 4 to 15. To estimate Chinook and Sockeye escapements, we multiplied the escapement from Equation 4 by the ratio of the two species.

Coho Salmon

Coho lengths were measured from video recordings using the same methods described above for Chinook Salmon. Measured lengths were positively correlated with counter peak signal size (Figure 7); therefore, a peak signal size cut-off was used to differentiate between sub-adult Bull Trout and Coho Salmon. Examination of measured lengths from video indicated the majority of larger bodied upstream Coho Salmon produced signal sizes in excess of 40, while smaller sub-adult Bull Trout and resident Rainbow Trout generated signal sizes below 40 (mean = 39, SD =1). Two Coho would have been misclassified using this rule, but there are far more smaller resident fish (n = 9) that would be included. Misclassified Coho were accounted for during the calculation of counter efficiency during the validation exercise. The peak signal size cut-off of < 40 was used to exclude resident fish from the counter data.

A total of 9 hours of video data was used to verify resistivity counter accuracy for Coho. As the majority of Coho Salmon migrate at night, one hour of randomly-selected night-time video was examined from October 20 to 29 to verify counter efficiency and species classification. Coho escapement was estimated using Equation 4.

3.0 Results

3.1 Radio Telemetry

3.1.1 Steelhead Trout

Tag Application and Bio-sampling

Steelhead Trout were angled by teams of two SER technicians at the confluences of the Seton and Fraser and Bridge and Fraser Rivers, and were implanted with gastric radio tags and spaghetti tags (Floy Tag

Ltd.). Angling commenced the week of March 9 and continued through to May 13, 2014. A total of 20 Steelhead (5 males and 15 females) were implanted with radio tags over the 65 day study period. Mean fork lengths of radio-tagged male and female Steelhead were 875 mm (range: 820 to 910 mm) and 739 mm (range: 620 to 870 mm), respectively. Of the 20 radio tags, 14 were applied at the confluence of the Seton and Fraser River, and 6 were applied at the confluence of the Bridge and Fraser River (Appendix 1).

Fixed and Mobile Tracking

Radio tags were detected via fixed telemetry stations and mobile tracking by vehicle and on foot (Figures 2 & 3). No fish tagged at the confluence of the Bridge and Fraser River were detected post-tagging by fixed telemetry stations or mobile tracking. Eleven of the 14 radio tags applied at the confluence of the Seton and Fraser River were detected upstream of the original tagging location in both the Seton and Bridge Rivers. Three Steelhead (27% of the 11 detected fish) were detected in the Seton River as far upstream as Seton Dam. Of the eight Steelhead detected in the Bridge River, one (12.5%) spawned in Reach 4, six (75%) likely spawned in the upper section of Reach 3 (visual survey sections 3 to 5; river km 30.7 to 38.0), and one (12.5%) was detected as far upstream as station 3 but spawned in the lower section of Reach 3 (Figure 3 & Table 4).

3.1.2 Chinook Salmon

Tag Application and Bio-sampling

Chinook Salmon were angled by teams of two SER technicians. Thirty individuals were captured, and received a gastrically implanted radio tag and external spaghetti tag below the dorsal fin in the LBR in 2014. Fish capture started on August 20, 2014 and continued until September 1, 2014. All Chinook were captured at the Yalakom confluence (Figure 3). Twenty-two (8 males, 10 females and 4 unknown sex) Chinook were captured and tags applied from August 20 to September 1. Mean fork lengths of radio-tagged male and female Chinook were 797mm (range: 700 to 1015 mm) and 803 mm (range: 720 to 975 mm), respectively (Appendix 1).

Fixed and Mobile Tracking

Tags were detected by the series of fixed telemetry stations and mobile tracking by vehicle and on foot. Eight (36%) of the 22 fish tagged were assessed as spawning in the middle to upper end of Reach 3 between river km 28.8 and 34.4. Eleven fish (50%) were assessed as spawning between the Yalakom confluence and just upstream of the counter (river km 25.5 to 28.8). No fish were assessed as migrating to

Reach 4. Three Chinook (14%) moved downstream towards the Fraser River and a determination of spawning location was not possible (Figure 3 & Table 5).

An assessment of distribution (between Reaches 1-2 and Reaches 3-4) and average migration time (days) from the confluence with the Fraser River (300 to 1500 m upstream) to spawning location was not possible as no fish were tagged in Reach 1. This was similar to 2011 to 2013, where efforts to capture fish in Reach 1 failed to produce fish for tagging.

3.1.3 Coho Salmon PIT Tagging

A total of 32 Coho Salmon (12 males and 20 females) were angled, sampled and PIT tagged in the LBR between October 9 and November 5, 2014. Mean fork lengths for male and female Coho were 636 mm (range: 530 to 720 mm) and 613 mm (range: 490 to 750 mm), respectively (Appendix 1).

Twenty-six tags were applied in Reach 1, one tag was applied in Reach 2, and 5 tags were applied in Reach 3. A PIT antenna located at the resistivity counter site detected 15 (47%) of the total Coho Salmon tags (first detection: October 18, 2014; last detection: November 8, 2014). The remaining 17 (53%) individuals could have either moved back into the Fraser River to tributaries elsewhere or spawned in Reaches 1 and 2. Ten (38%) of the tags applied in Reach 1 were detected at the counter site, 5 (83%) tags applied in Reach 3 were detected, and no fish tagged in Reach 2 were detected. The average length of time for a tagged fish to reach the counter site was 9.7 days (n = 10, SD = 4.6 days) for a fish tagged in Reach 1 and 1.6 days (n = 5, SD = 1.5 days) for a fish tagged in Reach 3. The average period of residence time above the fish counter was 8.7 days (n = 6, SD = 1.9 days).

3.2 Visual Surveys

3.2.1 Steelhead Trout

Visual counts of Steelhead were conducted from April 22 to June 23, 2014, at which time spawning was assessed to be complete and no further Steelhead were observed. The first group of holding fish was observed on May 13 between the Yalakom confluence and Hell Creek, with peak live fish count (15 fish) observed 13 days later on May 26. Steelhead spawners were observed primarily in two sections; streamwalk sections 7 and 8 (Terzaghi Dam to Eagle, river km 40.0-38.8) between May 26 and June 13. During this time, 23 of the 34 fish observed (68%) were seen in this area. After June 13, no Steelhead spawners were observed (Figure 3 & Appendix 2).

Two tags were observed on consecutive streamwalks (May 13 and May 19): the first one was observed in section 1 and the second in section 2. No tags were observed during the peak count. Water visibility was poor to fair but variable, and was assessed to be between 0.25 and 1 m during the survey time (Appendix 2).

3.2.2 Chinook Salmon

Visual counts of Chinook Salmon were conducted from August 13 to October 9, 2014, at which time spawning was assessed to be complete and no Chinook were observed. The first group of holding fish was observed on August 20 at the Yalakom confluence, with peak live fish count (93 fish) observed 19 days later on September 8. The majority of these spawners were observed in streamwalk section 1 (Figure 3 & Table 1) between the Yalakom and Hell Creek (67 fish). No fish were visually counted by the September 24 survey. Relative abundance of spawners was highest in sections 1 (Yalakom confluence to river km 28.8), with peak counts on average of 66% of total fish counted, and low for sections 6 through 8 where counts represented 3% of total counts (Figure 3 & Appendix 2).

No tags were observed during the 2014 streamwalks. Water visibility was poor (0.25 to 0.5 m) from September 8 through to the end of the survey on September 29 (Appendix 2).

3.2.3 Coho Salmon

Visual counts of Coho Salmon were conducted weekly from October 9 to December 3, 2014 at which time spawning was complete and few Coho (four individuals) were observed. The first holding fish were observed on the October 22 in sections 1 and 2, with peak live fish count (79 fish) observed on November 5. The majority of active spawners (75%) were observed above river km 38.3 in sections 7 and 8 between November 5 and 27 (Figure 3 & Appendix 2).

Coho were not radio tagged in 2014. Water visibility was poor (< 0.25 m) throughout the survey (Appendix 2).

3.2.4 Sockeye Salmon

Sockeye Salmon were visually counted in low abundance, with some evidence of active spawning immediately downstream of Terzaghi Dam. Peak count was 268 fish on September 15, 2014, and decreased to 8 fish on November 5. Most (77%) of the spawning sockeye observed on streamwalks were located in streamwalk sections 7 and 8 below Terzaghi Dam (Figure 3 & Appendix 2).

3.3 Spawner Habitat Evaluation

Chinook redd surveys were completed on September 18, 22, 25 and 26. Discharge from Terzaghi Dam during the surveys was 3 $m^3 s^{-1}$. In total, 15 different sections of the river were surveyed (Figure 9). Sixtytwo redds were surveyed in total: 61 in Reach 3, and one in Reach 2 just downstream of the Yalakom confluence (Figures 10-13). No redds were surveyed in Reach 4. Redd locations were overlaid onto the habitat data provided by Coldstream Ecology (BRGMON 1, McHugh and Soverel 2014) and occurred within 15 habitat units (9 runs and 6 riffles) in Reach 3 (Figures 10-13). Only 1.5 $m^3 s^{-1}$ habitat GIS data was available for comparative purposes at the time of writing this report. Therefore, a detailed comparison to available habitat at 3.0 $m^3 s^{-1}$ was not possible but will be completed in the future.

Water depths of the 62 redds ranged from 0.23 to 0.80 m, and averaged 0.43 m (Figure 14). Mean water-column velocity over redds ranged from 0.25 m s^{-1} to 1.0 m s^{-1}, with a mean of 0.67 m s^{-1} (Figure 15). Fifty-two percent of the redds surveyed occurred in small cobble substrate (Figure 16). Large cobble and large gravel made up the dominant substrate at 22% and 15% of redds surveyed, respectively. Small gravel and boulder made up the dominant substrate at 9% and 2 % of redds surveyed, respectively.

3.4 *Escapement Estimated using AUC*

3.4.1 Steelhead Trout

Limited data on *o.e.* for Steelhead Trout for AUC calculations were available on two of the early streamwalks (May 13 and 19) in 2014. One tagged fish out of potentially 3 and 5 tagged fish available were observed on each survey, respectively, generating an average estimate of *o.e.* of 27% for these two surveys (Appendix 2).

Residence time in the visual count zone was calculated based on fish movements as described in the Methods (Section 2.0) of this report. Of the 20 Steelhead tagged in 2014, eight were available for assessment of residence time. On average, these fish spent 17 days alive in the counting area (SD = 11 days) (Tables 2 & 3).

Using an *o.e.* of 0.27, a residence time of 17 days, a survey start date of April 22 and a survey life of 62 days, we calculate the maximum likelihood estimate of 51 Steelhead (95% confidence limits: 35-66) in 2014 between the Yalakom confluence and Terzaghi Dam (Figure 17).

3.4.1 Chinook Salmon

2014

Data on *o.e.* for Chinook Salmon visual counts for AUC calculations was not available in 2014. Of the 21 tags available in the count zone at peak, zero were seen (Appendix 2).

Residence time in the visual count zone was calculated based on fish movements as described in the Methods (Section 2.0) of this report. Of the 21 tagged Chinook which remained in the visual count zone post tagging, eight provided reliable data on residence time. On average, these fish spent 12 days alive in the counting area (SD = 4 days) (Tables 2 & 3).

Using an *o.e.* value of 0.28, a residence time of 12 days, a survey start date of August 13 and a survey life of 47 days, we calculate the maximum likelihood estimate of 591 Chinook (95% confidence limits: 386-796) in 2014 between the Yalakom confluence to Terzaghi Dam (Table 6 & Figure 18).

Historic

Count data obtained from DFO was used to reconstruct AUC estimates for Chinook adults from the Yalakom confluence to Terzaghi Dam (Reaches 3 and 4) since 1993. Chinook were counted at a fish fence from 1993 to 1996, so AUC methodology was not applied, and these counts were considered a total population assessment. Population abundance during this time period varied from a minimum estimate of 23 fish in 2009 to a maximum of 3,479 in 2004 (Table 6 and Figure 19).

3.4.1 Coho Salmon

2014

Observer efficiency and residence time data from 2012 and 2013 radio tagging were used for the AUC estimate of Coho Salmon in 2014 as no fish were radio tagged.

Using an *o.e.* value of 0.26, a residence time of 17.5 days, a survey start date of October 9 and a survey life of 55 days, we calculated the maximum likelihood estimate of 397 Coho (95% confidence limits: 288-506) in 2014 between the Yalakom confluence to Terzaghi Dam (Table 7 & Figure 20).

To evaluate full river spawner abundance, we extrapolated the Yalakom to Terzaghi Dam population estimate based on the spawning distribution of Coho pre-spawners PIT tagged in the lower river in 2014. Of the 26 Bridge River spawners tagged in this area, 38% were assessed to have spawned upstream of the Yalakom confluence. Based on average *o.e.*, residence time and spawner distribution, this indicates that full river escapement may have been as high as 1,037 Coho in 2014.

Historic

Count data obtained from DFO was used to reconstruct AUC estimates for Coho from the Yalakom confluence to Terzaghi Dam (Reaches 3 and 4) since 1997. Population abundance during this time period varied from a minimum estimate of 76 fish in 1999 to a maximum of 3,422 in 2011 (Table 7 and Figure 21).

3.5 Escapement Estimated using Resistivity Counter Detections

3.5.1 Steelhead Trout

Video Validation

No video validation was undertaken in 2014 due to poor water clarity.

Counter Estimate

Two distinct migration peaks were observed between April 1 and June 15, 2014: the first peak occurred between April 13 and 21, and the second peak occurred between May 27 and June 4. Both peaks included relatively large numbers of up and down counts (Figure 21). During times of peak upstream movement, there is often a corresponding peak in downstream movement that is created by individuals moving up and down over the counter. In 2014, we observed this phenomenon during the migration periods of all study species (Figures 21, 23 & 24).

In the absence of video validation data in 2014 (see Section 2.3.2), radio telemetry, and historic and regional migration timing data were used to make assumptions about the counter data. We assumed that the first peak was caused by upstream migrating Steelhead Trout based on radio telemetry data collected in 2014, when 63% (5/8) of tagged fish migrated upstream between April 15 and May 7. Based on the migration timing of these radio-tagged individuals, it is unlikely that the second peak was caused by upstream migrants and may have been caused by resident Bull Trout or Rainbow Trout. Down counts during the second peak were likely to have been caused by Steelhead Trout kelting, as 100% (8/8) of the radio-tagged Steelhead kelted between May 19 and June 5. Therefore, these down counts were not used in the estimation of Steelhead Trout escapement in spring 2014.

Upstream and downstream migration data from the resistivity counter between April 1 and May 1 was used to derive a counter estimate of the population. During this time, 238 Steelhead migrated upstream over the counter, and 112 migrated downstream. Spawner escapement above the counter was estimated to be 126 Steelhead for 2014, and is likely a minimum estimate.

3.5.2 Chinook Salmon

Video Validation

We estimated the up count accuracy to be 88% on Channel 2 for Chinook and Sockeye in 2014. This was based on 115 up counts recorded on the counter during the validation period, during which 131 Chinook were observed on video records. One Bull Trout or Rainbow Trout was misclassified but was accounted for during the validation procedure. Down count accuracy on Channel 2 was estimated to be 41%, which was derived from 7 counter records compared to 17 down-migrant Chinook on the corresponding video records. Channel 3 has the same exact design as Channel 2, and thus it was assumed that data are comparable across both channels. We used the same up and down accuracies for Channel 3.

We estimated up-count accuracy to be 36% on Channel 1 for Chinook and Sockeye migrants. This was based on 32 up-counts recorded on the counter during the validation period, during which 89 Chinook and Sockeye were observed on video records. Two Bull Trout or Rainbow Trout were misclassified using the above methods, and they were accounted for during the validation procedure. Down count accuracy on Channel 1 was estimated to be 15%, which was derived from 3 counter records compared to 20 down-migrant Chinook on the corresponding video records.

Validation analysis identified 74% of the upstream migrating fish as Chinook and 26% as Sockeye.

Counter Estimate

Estimates of Chinook and Sockeye escapement were calculated using the ratio of visually observed migrant Chinook to Sockeye and the accuracy of the counter channels as described above. These calculations resulted in a total upstream migration estimate for Chinook Salmon of 1,245 fish passing over the counter, with a downstream migration (down counts) of 298 fish. As downstream migrants were not observed to have spawned, a total spawner abundance above the counter of 947 Chinook Salmon was estimated in 2014 by subtracting down-counts from up-counts. For Sockeye, a total upstream migration of 438 fish over the counter was observed with 105 downstream migrants. In 2014, total estimated spawner abundance above the counter for Sockeye was 332 individuals. Migration timing indicated that a peak of movement, possibly related to stream temperature, occurred in early September (Figure 23).

3.5.3 Coho Salmon

Video Validation Results

We estimated up count accuracy to be 93% on Channel 2 for Coho with a peak signal size (PSS) cut-off of > 40. This was based on 38 up counts recorded on the counter with a PSS > 40 during the validation period, during which time 41 Coho were observed on video records along with two Coho that were misclassified due to the PSS cut off. Down count accuracy on Channel 2 was estimated to be 100%, which was derived from 7 counter records with a PSS > 40 compared to 7 down migrant Coho on the corresponding video records. Channel 3 has the same exact design as Channel 2, and thus it was assumed that these data are comparable across both channels. The same up and down accuracies were used for Channel 3.

We estimated up count accuracy to be 71% on Channel 1 for Coho with a PSS cut-off of > 40. This was based on 10 up counts recorded on the counter with a PSS > 40 during the validation period, during which time 10 Coho were observed on video records. Examination of PSS for downstream migrating fish on Channel 1 showed that having a PSS cut-off of 40 would exclude four Coho and only include two resident fish (Figure 3); thus, no PSS cut off was used for downstream migrating Coho on Channel 1. Down count accuracy on Channel 1 was estimated to be 37%, which was derived from 10 down counter records compared to 27 down migrant Coho on the corresponding video records.

Counter Estimate

Estimates of Coho escapement were calculated using a PSS cut-off in excess of 40, and the accuracy of the counter channels as described above. Based on these calculations, 1,543 fish migrated upstream over the counter, 273 fish migrated downstream over the counter, yielding a total spawner abundance of 1,270 Coho Salmon above the counter in 2014. Migration timing indicated that a peak of movement, possibly related to stream temperature, occurred in late October (Figure 24).

4.0 Discussion

In 2014, the primary goal of the study was to provide reliable, unbiased and precise estimates of Salmon and Steelhead Trout spawner abundance along with behavioral data on spawning distrubtion and timing. In this report, we build on the data already collected and create historical estimates of escapement so that time series data on river discharge and juvenile production can be compared without the confounding effects of adult seeding levels. We explain the shortcomings in this evaluation at present, and the need for ongoing data collection to refine these new estimates. Data herein will be used, in combination with data collected from BRGMON-1, to evaluate the egg and juvenile seeding levels of the area of the LBR between the Yalakom River confluence and Terzaghi Dam (Reaches 3 and 4), the upper limit of anadromous fish spawning. This reach of the river is predominantly regulated by discharges through Terzaghi Dam and minor tributary influences.

The second goal of the project was to evaluate the quantity and quality of spawning habitat as it relates to spawner abundance. We collected information on habitat criteria – water depth, velocity, and dominant substrate – in which Chinook Salmon spawn in the LBR. We await habitat data from BRGMON-1 to assess capacity issues, and co-incident Chinook and Pink spawning years to evaluate redd superimposition effects. Habitat data collected during Chinook spawning will be used to evaluate the total area of spawning available based on the habitat type, water depth, depth and substrate used by Chinook spawners in 2014. Examination of redd superimposition will be undertaken by marking a representative number of completed Chinook redds with rebar markers and then re-examining redd structure and completeness after Pink Salmon spawning is completed.

Additional spawner data will be collected when possible (i.e., depending on tagging success in Reaches 1 and 2) to evaluate complete watershed spawning abundance through marking of fish in Reach 1 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 into 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). However, this area of evaluation is not deemed a priority by BC Hydro, as the area of spawning and rearing is only partially regulated and under the influence of natural flows from the Yalakom River. With limited annual funds, methods developed to derive full river estimates must be cost-effective for the quality of data derived and may fall outside of the scope of this project.

In 2014, abundance and behavioural data were collected for Chinook, Coho, and Sockeye Salmon and Steelhead Trout. Chinook Salmon (for the third study year) and Steelhead Trout (for the first year) were radio-tagged and externally-tagged for continued data collection on spawning distribution, residence time and observer efficiencies during visual streamwalks. Coho Salmon were PIT-tagged to evaluate full river spawner distribution and to assist in residence time evaluations. Radio tags and external tags were not applied to Coho due to high river turbidity resulting in an inability to collect meaningful observer efficiency data. A new electronic resistivity counter installed in October 2013 approximately 200 m above the Yalakom – Bridge River confluence was used to enumerate all target species. Streamwalk data were collected in the same manner as previous years (pre-WUP monitoring, DFO data on file, McCubbing et al 2013).

Ideally in AUC studies of this type, marking of individuals is undertaken remotely from the area of visual count 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. As in 2013, this was successfully achieved in 2014 for all Chinook and Coho Salmon tagged below the counter site.

Efforts to tag Chinook Salmon in Reach 1 of the LBR that would allow for the production of a full river estimate continued to be unsuccessful despite almost daily visual checks for migrant fish. Unsuccessful fishing for Chinook from 2011 to 2014 is likely related to low population abundance and a short duration of residence in the lower reaches of the LBR. Fish that are captured during aboriginal fisheries in the Fraser River at the mouth of the Bridge River are poor candidates for tagging, as the majority of individuals are not likely destined to spawn in the Bridge River, instead migrating to upstream tributaries of the Fraser River. Based on these observations, evaluation of full river spawner estimates may remain a challenging endeavor for Chinook at current escapement numbers without the use of alternate methods outside of the scope of this project.

Reach 3 and 4 Chinook AUC spawner escapements were estimated at 591 fish in 2014, 168 in 2013, 364 fish in 2012 and 92 fish in 2011, representing a five-fold variation in estimates among years (Table 6). Of course these data are expected to be reasonably precise in 2012 and 2013 due to a high observer efficiency (0.54 and 0.28, respectively) but less so in 2014 when no tagged fish were observed. In 2014, the fish counter estimate was 947 Chinook, indicating that the AUC population estimate was biased low. This data will be further evaluated as we derive confidence limits on counter estimates and daily above counter escapement estimates.

Efforts to tag Coho Salmon in Reaches 1 and 2 of the LBR to provide a full river estimate were successful in 2014, with 33 fish PIT-tagged (compared to 70 in 2013, 32 in 2012 and 18 in 2011). We link the increase in fish capture since 2011 to angler experience and increased effort. Lower capture in 2014 was likely due to a lower estimated return than in 2013 (394 vs. 2974). The earliest fish captured in Reaches 1 and 2 was tagged on October 9 compared with October 8 in 2013, October 12 in 2013 and October 19 in 2011. In all years, fish were tagged over a period of approximately 4 weeks.

Reach 3 and 4 Coho AUC spawner escapements were estimated to range from 394 in 2014 to 3,422 in 2011 (Table 7). Precision of these data is unclear, as observer efficiency is low due to cryptic behaviours prior to and perhaps during spawning. Our calculated residence time of 19 days in 2013 and 16 days in 2012 is slightly higher than typically seen in other interior BC watersheds (10 days in South Thompson, and 12 days in North Thompson; R. Bailey, personal communication). Residence time data collected in the future from PIT-tagged fish will increase confidence when calculating estimates. Using the proportion of fish which used Reaches 1 and 2 for spawning, our full river estimate of spawners is 1,037 fish in 2014, 4,634 fish in 2013, 5 268 fish in 2012, and 8 570 fish in 2011. Estimated spawner escapements in a spawner per kilometer abundance (between 16 to 214 fish per km for the full river, and 24 to 313 fish in Reaches 3 and 4) indicate that seeding may be at the higher end of published data (Korman & Tompkins, 2008), and sufficient to use the available habitat to capacity except in 2014 when abundance was much lower. Efforts to increase confidence in *o.e.* and residence time data will in part be undertaken by PIT-tagging fish and using daily derived fish counter estimates from the resistivity counter facility.

Additional effort to refine full river estimates will require many more fish (i.e., > 30 Chinook and Steelhead, and > 100 Coho [see McCubbing et al. 2013]) to be tagged in the lower river (Reach 1). While attempts to achieve this goal with PIT tags will be undertaken in 2015 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, the lack of safe access roads or trails, and the migration behaviour of the fish making it difficult to capture in this area (particularly for Chinook).

Steelhead migration over the counter was evaluated for the first time in 2014. Little was known about the migration timing and distribution of Steelhead in the LBR. In 2001, a study by Webb et al. (2002) indicated that 10 of the 13 fish radio-tagged migrated above the Yalakom and into the Bridge River prior to May 5. We confirmed this in 2014, when a similar migration pattern was observed in radio-tagged individuals. Due to higher discharges throughout the migration period (5 to 15 $m^3 s^{-1}$; Figure 4) and expected turbid waters, video validation was not attempted in 2014. Due to the lack of video validation, up and down count accuracies for the counter during Steelhead migration could not be determined. Thus, correction factors for up and down counts could not be calculated. Steelhead Trout spawner data from the resistivity counter in 2014 are therefore provisional, as validation of species type passing over the counter is not yet available for the LBR at the current discharge regime. Flows during the spring migration and spawning period are high (6-9 $m^3 s^{-1}$). Visual observation techniques were better than expected despite elevated water levels, however only limited numbers of tagged fish were available for re-sighting and creation of AUC observer efficiency and residence time data. Nevertheless, a counter derived estimate without validation of species or counter accuracies indicated a potential total spawner escapement of 126 fish, while the AUC estimate was 51 fish. Of course these estimates will likely change as our knowledge of fish behavior, counter accuracy and species composition develops.

With the fish counter installation now complete, enumeration of Chinook, Coho, Sockeye and Pink Salmon, and Steelhead Trout will be conducted annually at this site. Counts are being validated and are expected to be within 10% of true escapement (McCubbing and Ignace 2000, McCubbing and Gillespie 2008). Confidence limits will be generated as soon as the counter is fully tested and calibrated for maximum performance. Once these data are sufficiently described, comparison between counter- and AUC-derived estimates of abundance will be completed and visual counts may cease as the counter will provide improved escapement accuracy at reduced cost compared to traditional methods (McCubbing and Espinoza 2012). Data collected during the period when both methods are being used will allow for improved back-calculations of historical escapements based on archived visual count data, five years of which was collected during the previous WUP discharge regime (annual water budget of 3 $m^3 s^{-1}$). Back calculating will require multiple years (5 to 10 years) of observer efficiency data, which may be difficult to obtain based on turbidity conditions experienced during Coho Salmon and Steelhead Trout migration in the LBR. Residence time data will provide an accurate evaluation of population trends based on current observed annual changes in these parameters and their relationship to fish density and water turbidity. We do, however, provide these historic data, which show:

1) Historic estimates of Chinook escapement ranged from 23 (2009) to 3,479 (2004).Helicopter-based visual counts by DFO from 1997 to 2004 were more uncertain than streamwalk-based visual counts from 2005 to present (Table 6).
2) No trend in long term Coho escapement, with estimates varying annually from 76 to 3,422. Recent estimates (2011-2013) were among the highest spawner years.

Data were collected on redd location, macro habitat type, micro habitat selection and spawner density of Chinook Salmon within the confines of highly turbid water. Data were analyzed to evaluate preferred habitat utilization. It is the intention to combine these data with literature data and local macro-habitat records to evaluate the current availability of spawning habitat area and its historic utilization. Data from previous habitat surveys (BRGMON-1) have been reviewed and planning is underway to collect further data in 2015, as analysis of Chinook redd habitat selection indicates a potential overlap with Pink Salmon spawning habitat selection and the potential for redd superimposition when large abundances of Pink Salmon spawn after Chinook spawning is complete. This risk requires evaluation to establish how it may affect Chinook egg survivorship and methods to undertake this are proposed.

5.0 Summary and Recommendations

In summary, progress has been made to document a time series of adult spawner escapement values for Chinook and Coho Salmon, and Steelhead Trout in the LBR in the area directly affected by BC Hydro's operations. These time series data are our best estimates of adult spawner abundance based on data collected in the current Monitor, specifically using mark recapture techniques through the application of radio and PIT tags. Future estimates will rely more heavily on validated fish counter escapement estimates which will, if combined with ongoing visual counts, further strengthen context for historical estimate refinement. For these reasons, we promote the ongoing collection of data through:

1) Annual streamwalks for Coho and Chinook Salmon
2) Continued PIT tagging of target species
3) Validation of fish counter data, particularly at higher flows
4) Modification of Channel 1 and 4 sensor units to improve count efficiency of Chinook Salmon
5) Collection of graphics data for all species
6) Use of two electronic counters for data collection and possible splitting of the wide, high flow channel into two sensor units under elevated flows if they are to be incurred
7) Inaugural collection of Pink Salmon escapement data by fish counters in late summer/fall 2015
8) Continued re-evaluation of Chinook and Coho Salmon AUC data as additional years of counter data provide more detailed modelling of turbidity and observer efficiency relationships

Data on habitat utilization for spawning by Chinook Salmon has indicated a set of suitable habitat requirements within which the majority of fish spawn. Data will be combined with habitat data being collected within BRGMON-1 to evaluate the total area available to spawners and thus the potential saturation density of Chinook Salmon that the system can accommodate. Further studies are required to evaluate the effects that Pink Salmon spawners may have on Chinook redds. Pink Salmon can be very abundant in the LBR, and have the potential to excise existing Chinook redds as they tend to spawn after Chinook Salmon. This potential conflict will be evaluated by the following methods:

1) Marking Chinook redds
2) Evaluating bed material used in each redd
3) Re-evaluating redd integrity post Pink Salmon spawning activity
4) Extrapolation of Pink Salmon impacts to stratified spawner habitat data

Data from this report will be made available to the BRGMON-1 to evaluate the relationship between juvenile salmon production in the LBR and river discharges such that variance in juvenile fish abundance due to varying adult spawner abundance is not a conflicting variable.

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7.0 Tables

Table 1. Streamwalk section designations and fixed station telemetry receiver locations for the lower Bridge River, 2014.

River km	Location description
0.0	Confluence of Bridge and Fraser Rivers
0.7	Fixed Station Telemetry Receiver Site 1
25.5	Downstream Boundary of Streamwalk Section 1
	Fixed Station Telemetry Receiver Site 2
	Confluence of Yalakom and Bridge Rivers
25.9	Fixed Station Telemetry Receiver Site 3
	Counter
28.8	Downstream Boundary of Streamwalk Section 2
30.7	Downstream Boundary of Streamwalk Section 3
33.2	Downstream Boundary of Streamwalk Section 4
34.4	Downstream Boundary of Streamwalk Section 5
37.3	Fixed Station Telemetry Receiver Site 4
38.2	Downstream Boundary of Streamwalk Section 6
38.8	Downstream Boundary of Streamwalk Section 7
39.6	Downstream Boundary of Streamwalk Section 8
40.0	Upstream Boundary of Section 8
	Terzaghi Dam

Table 2. Visual fish count observer efficiency data derived from radio telemetry data on the lower Bridge River.

Year	Species	Average observer efficiency
2011	Coho	NA
2012	Coho	25%
2013	Coho	27%
2012	Chinook	58%
2013	Chinook	28%
2014	Chinook	0%
2014	Steelhead	27%

Table 3. Fish spawner residence times derived from radio telemetry data on the lower Bridge River.

Year	Species	N	Average residence time (days)	Survey life (days)
2011	Coho	NA	NA	NA
2012	Coho	13	16	75
2013	Coho	18	19	63
2012	Chinook	5	10	50
2013	Chinook	22	11	32
2014	Chinook	8	12	47
2014	Steelhead	8	17	62

Table 4. Assessed spawning distribution of radio tagged steelhead trout on the lower Bridge River, 2014.

Tag No.	Tagging location	Tagging rkm	Assumed river km of spawning location	Days to migrate to spawning location
33	Seton Confluence	NA	Unknown	NA
35	Bridge Confluence	0	Unknown	NA
36	Seton Confluence	NA	36	37
37	Seton Confluence	NA	38	35
43	Seton Confluence	NA	28.2	66
48	Seton Confluence	NA	Unknown	NA
49	Seton Confluence	NA	31.1	32
51	Seton Confluence	NA	36.1	42
53	Seton Confluence	NA	Unknown	NA
54	Bridge Confluence	0	Unknown	NA
56	Seton Confluence	NA	39.8	22
57	Bridge Confluence	0	Unknown	NA
59	Seton Confluence	NA	36.3	24
61	Seton Confluence	NA	Unknown	NA
62	Bridge Confluence	0	Unknown	NA
63	Bridge Confluence	0	Unknown	NA
64	Seton Confluence	NA	Unknown	NA
68	Seton Confluence	NA	Unknown	NA
69	Bridge Confluence	0	Unknown	NA
72	Seton Confluence	NA	37.4	31

Table 5. Assessed spawning distribution of radio tagged Chinook Salmon on the lower Bridge River, 2014.

Tag no.	Tagging location	Tagging river km	Assumed river km of spawning location	Days to migrate to spawning location
11	Yalakom Confluence	25.5	28.7	11
12	Yalakom Confluence	25.5	27.3	5
13	Yalakom Confluence	25.5	28.3	17
14	Yalakom Confluence	25.5	35.9	19
16	Yalakom Confluence	25.5	28.3	15
17	Yalakom Confluence	25.5	37.3	11
18	Yalakom Confluence	25.5	Unknown	NA
19	Yalakom Confluence	25.5	26.0	NA
22	Yalakom Confluence	25.5	26.0	NA
23	Yalakom Confluence	25.5	34.1	13
24	Yalakom Confluence	25.5	26.0	NA
25	Yalakom Confluence	25.5	26.0	NA
27	Yalakom Confluence	25.5	34.3	9
28	Yalakom Confluence	25.5	33.0	10
29	Yalakom Confluence	25.5	Unknown	NA
30	Yalakom Confluence	25.5	26.0	NA
31	Yalakom Confluence	25.5	Unknown	NA
34	Yalakom Confluence	25.5	35.3	7
35	Yalakom Confluence	25.5	26.0	NA
36	Yalakom Confluence	25.5	25.5	NA
39	Yalakom Confluence	25.5	26.0	NA
40	Yalakom Confluence	25.5	25.5	NA

Table 6. Chinook AUC estimates for the lower Bridge River from 1993-2014.

Year	o.e.	o.e. SE	Survey life	Survey life SE	Escapement	Escapement SE	Method of estimation	Lower 95 CI	Upper 95 CI
1993	NA	NA	NA	NA	151	NA	fence count	NA	NA
1994	NA	NA	NA	NA	550	NA	fence count	NA	NA
1995	NA	NA	NA	NA	851	NA	fence count	NA	NA
1996	NA	NA	NA	NA	1100	NA	fence count	NA	NA
1997	0.38	0.1	12.3	1.86	2246	1651	visual helicopter	-991	5482
1998	0.38	0.1	12.3	1.86	978	53	visual helicopter	873	1083
1999	0.38	0.1	12.3	1.86	2885	471	visual helicopter	1961	3809
2001	0.38	0.1	12.3	1.86	1999	940	visual helicopter	157	3841
2004	0.38	0.1	12.3	1.86	3479	802	visual helicopter	1907	5052
2005	0.38	0.1	12.3	1.86	662	178	visual streamwalk	313	1010
2006	0.38	0.1	12.3	1.86	447	54	visual streamwalk	341	553
2007	0.38	0.1	12.3	1.86	346	70	visual streamwalk	209	483
2008	0.38	0.1	12.3	1.86	184	92	visual streamwalk	4	364
2009	0.38	0.1	12.3	1.86	23	5	visual streamwalk	14	32
2010	0.38	0.1	12.3	1.86	233	35	visual streamwalk	163	302
2011	0.38	0.1	12.3	1.86	92	25	visual streamwalk	42	142
2012	0.58	0.1	10	1.86	364	70	visual streamwalk	227	501
2013	0.28	0.1	11	1.86	168	32	visual streamwalk	105	230
2014	0.28	0.1	12	1.86	591	105	visual streamwalk	386	796

O.E. = observer efficiency, SE = standard error, CI = confidence interval.

Table 7. Coho AUC estimates for the lower Bridge River from 2011-2014.

Year	o.e.	o.e. SE	Survey life	Survey life SE	Escapement	Escapement SE	Method of estimation	Lower 95 CI	Upper 95 CI
1997	0.26	0.01	17.5	1.5	576	1319	visual helicopter	-2008	3161
1998	0.26	0.01	17.5	1.5	1004	356	visual helicopter	307	1701
1999	0.26	0.01	17.5	1.5	76	NA	visual helicopter	NA	NA
2001	0.26	0.01	17.5	1.5	961	67	visual helicopter	830	1092
2003	0.26	0.01	17.5	1.5	1132	15	visual helicopter	1102	1162
2004	0.26	0.01	17.5	1.5	217	40	visual helicopter	138	296
2005	0.26	0.01	17.5	1.5	688	87	visual streamwalk	518	858
2006	0.26	0.01	17.5	1.5	627	76	visual streamwalk	478	777
2008	0.26	0.01	17.5	1.5	95	11	visual streamwalk	74	116
2009	0.26	0.01	17.5	1.5	1490	155	visual streamwalk	1186	1793
2010	0.26	0.01	17.5	1.5	431	59	visual streamwalk	316	547
2011	0.26	0.01	17.5	1.5	3422	458	visual streamwalk	2524	4320
2012	0.25	0.01	16	1.5	1662	339	visual streamwalk	997	2327
2013	0.27	0.01	19	1.5	2974	206	visual streamwalk	2570	3378
2014	0.26	0.01	17.5	1.5	394	53	visual streamwalk	290	499

O.E. = observer efficiency, SE = standard error, CI = confidence interval.

8.0 Figures

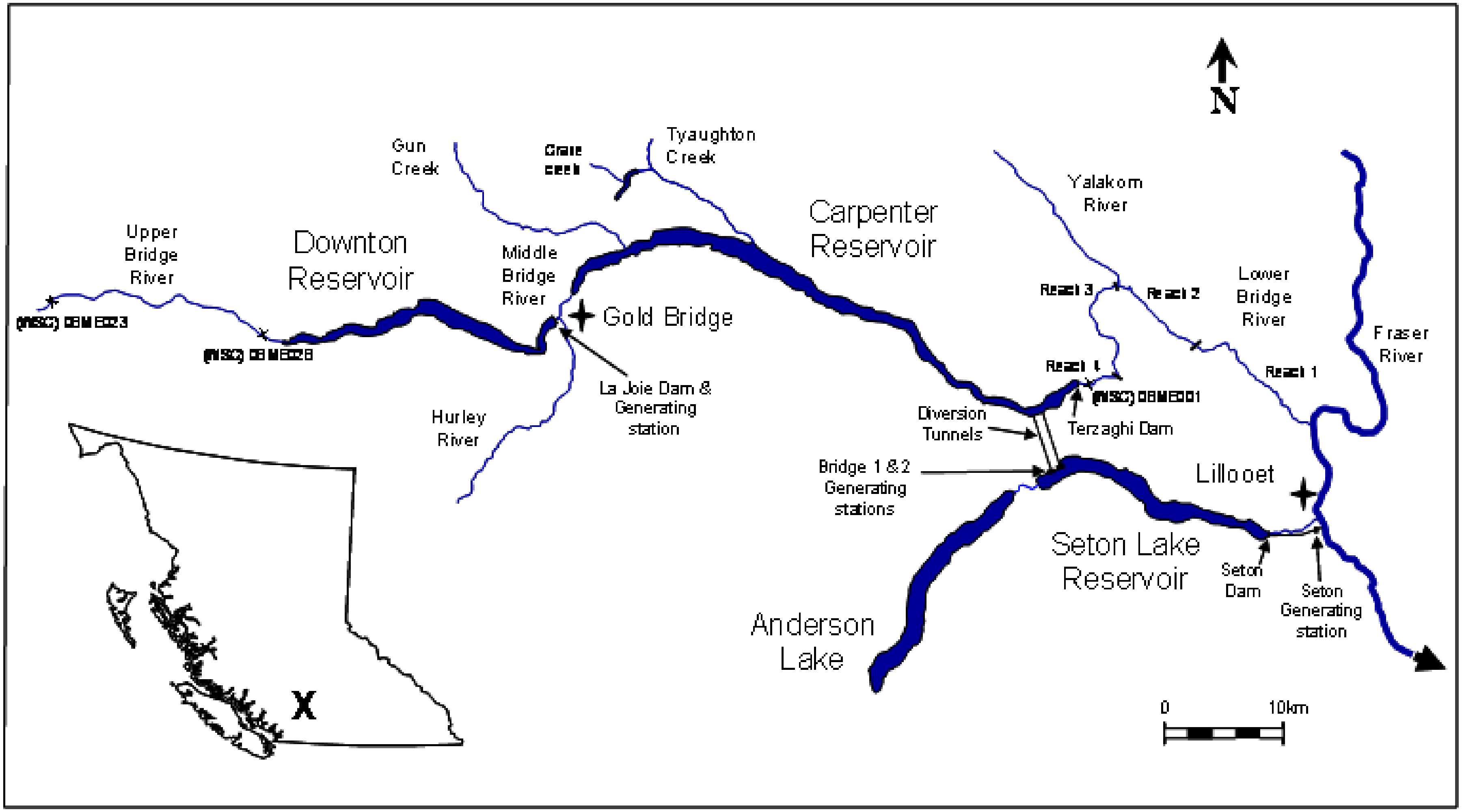

Figure 1. Bridge and Seton watersheds showing Terzaghi Dam and diversion.

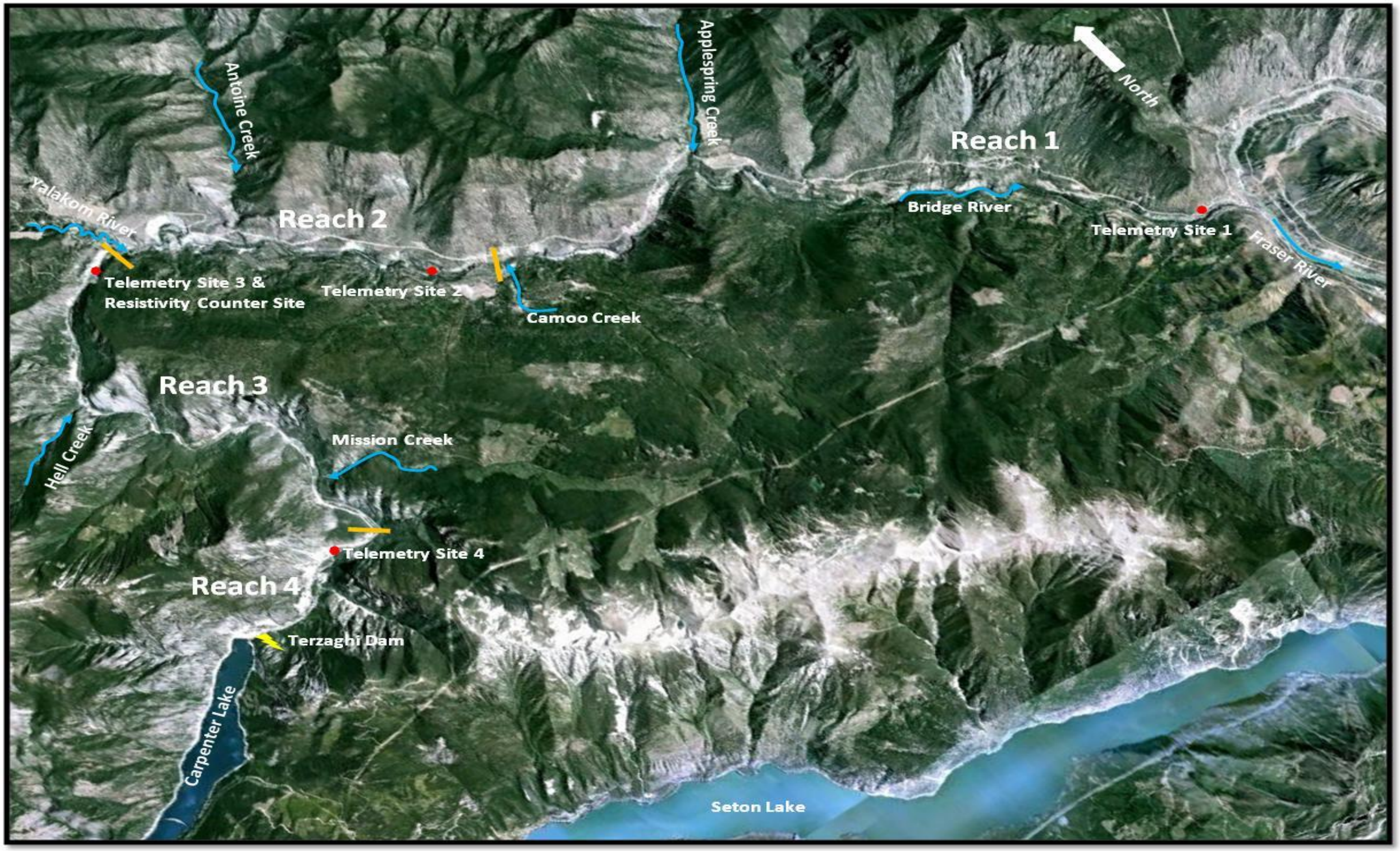

Figure 1. Bridge River study area showing reach breaks (orange lines) and fixed radio telemetry stations (red dots).

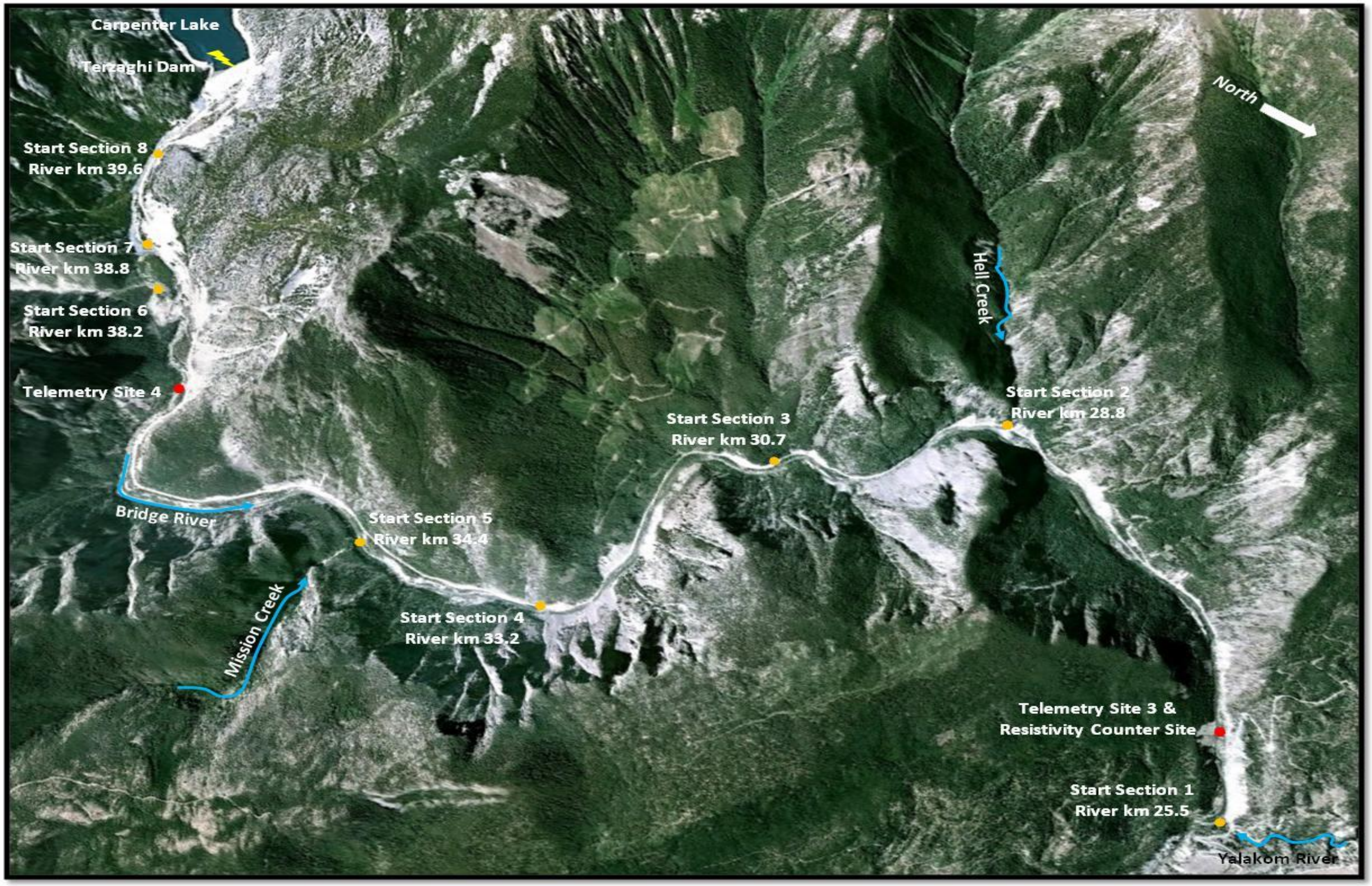

Figure 2. Bridge River streamwalk section boundaries (orange dots) and fixed radio telemetry stations (red dots).

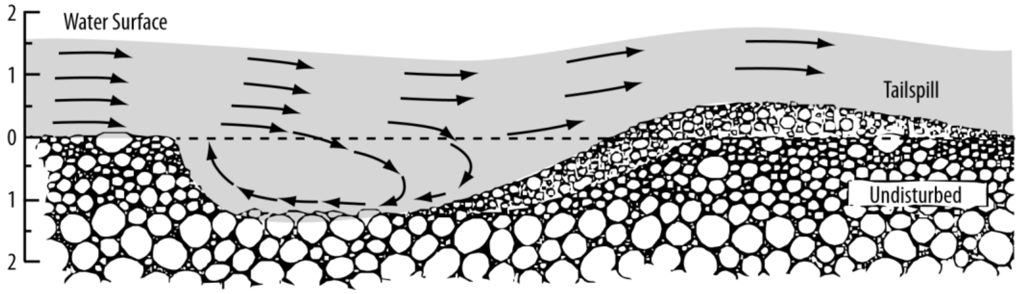

Figure 3. Typical currents in a salmonid redd (illustration: Andrew Fuller; Burner 1951, 98).

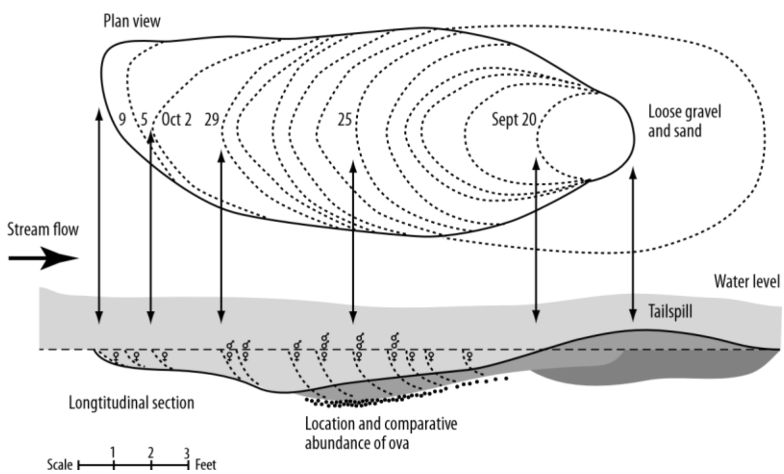

Figure 4. Diagrammatic views of a fall chinook salmon redd measured daily (illustration: Andrew Fuller; Burner 1951, 101)

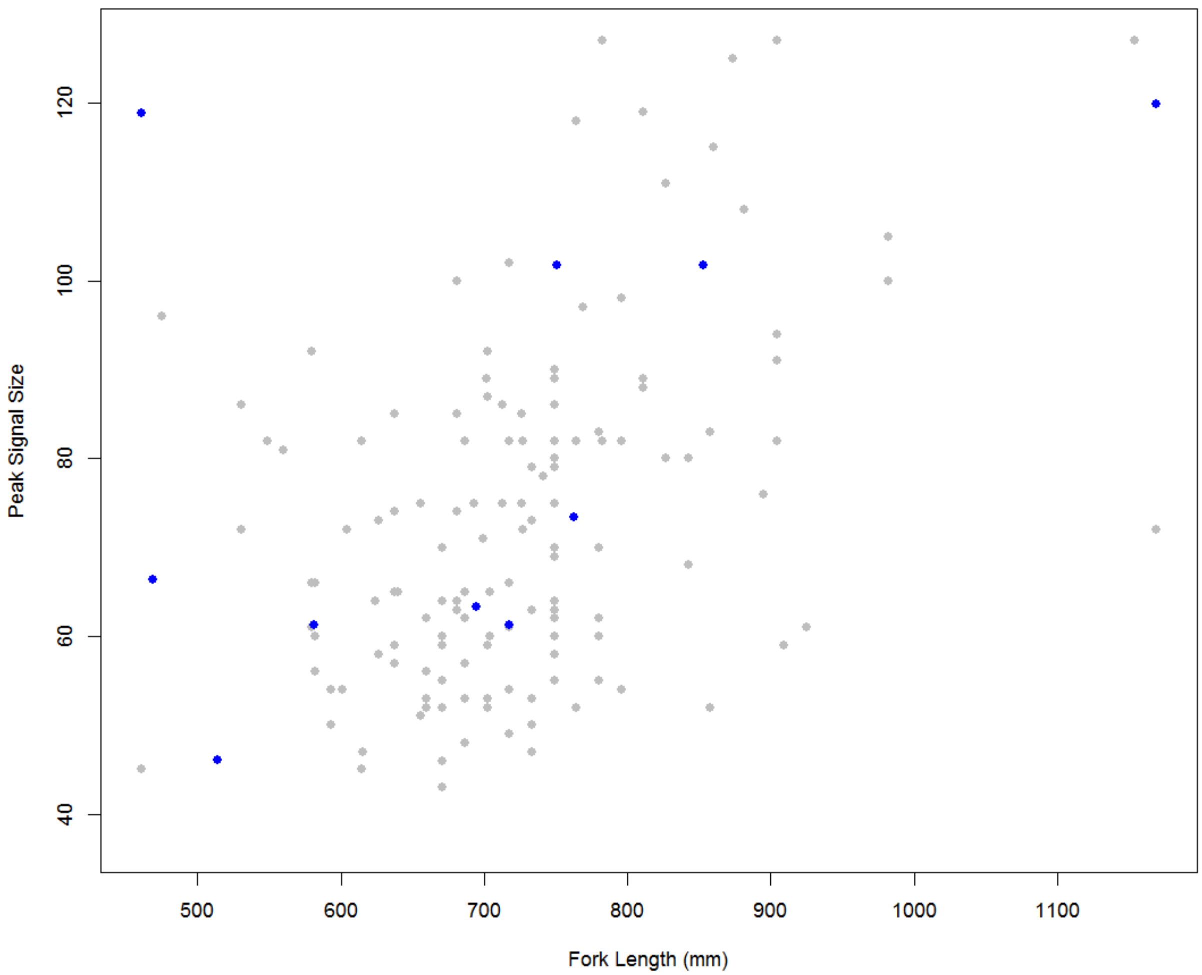

Figure 5. Chinook fork length and peak signal size relationship, lower Bridge River 2014. Grey circles = up fish, blue circles = down fish.

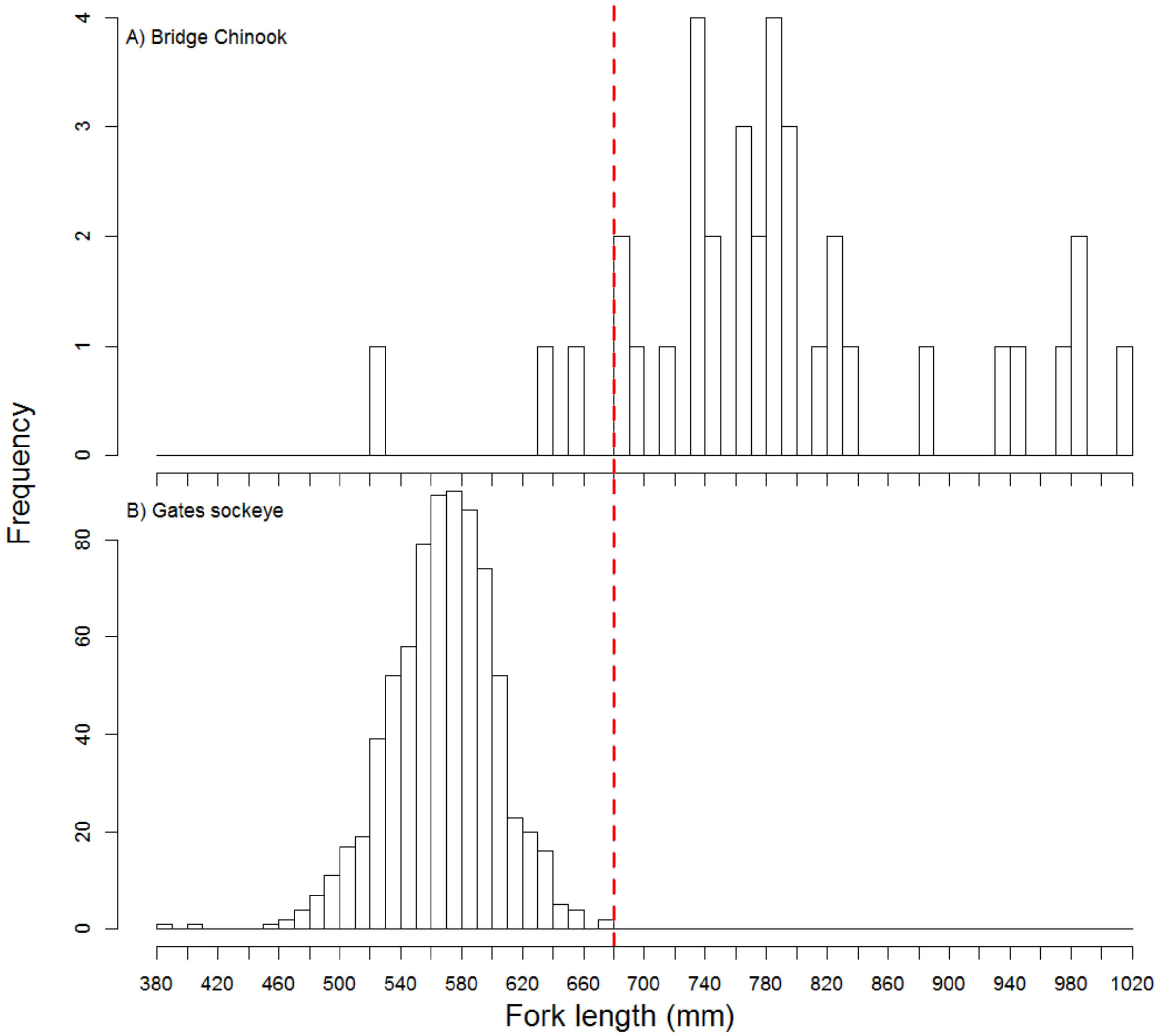

Figure 6. Bridge River Chinook and Gates Creek Sockeye fork length (mm) frequency distributions and size cut-off (red line) 2014.

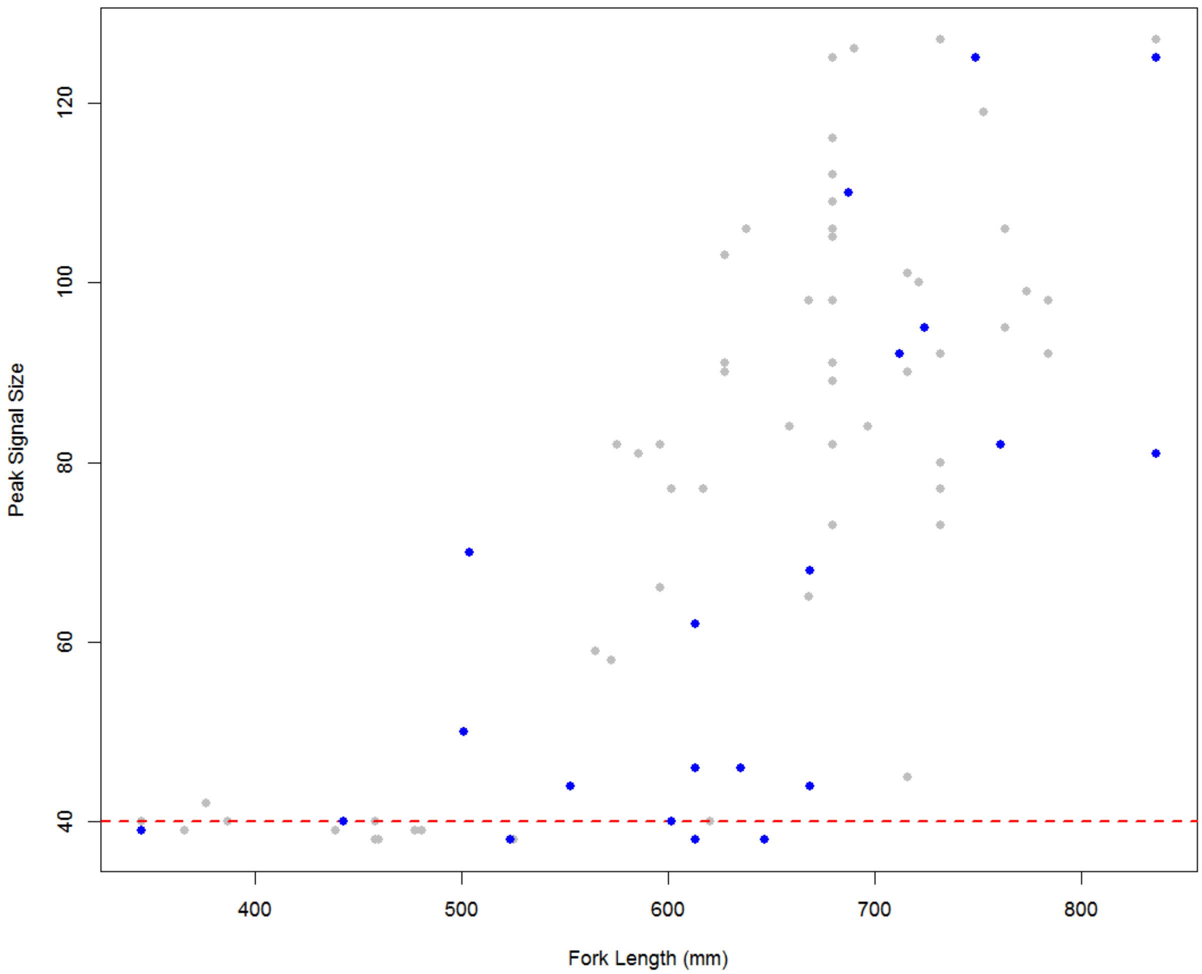

Figure 7. Coho fork length and Peak Signal Size relationship, lower Bridge River 2014. Grey closed circles = up fish, blue circles = down fish. Red dash line represents cut – off point.

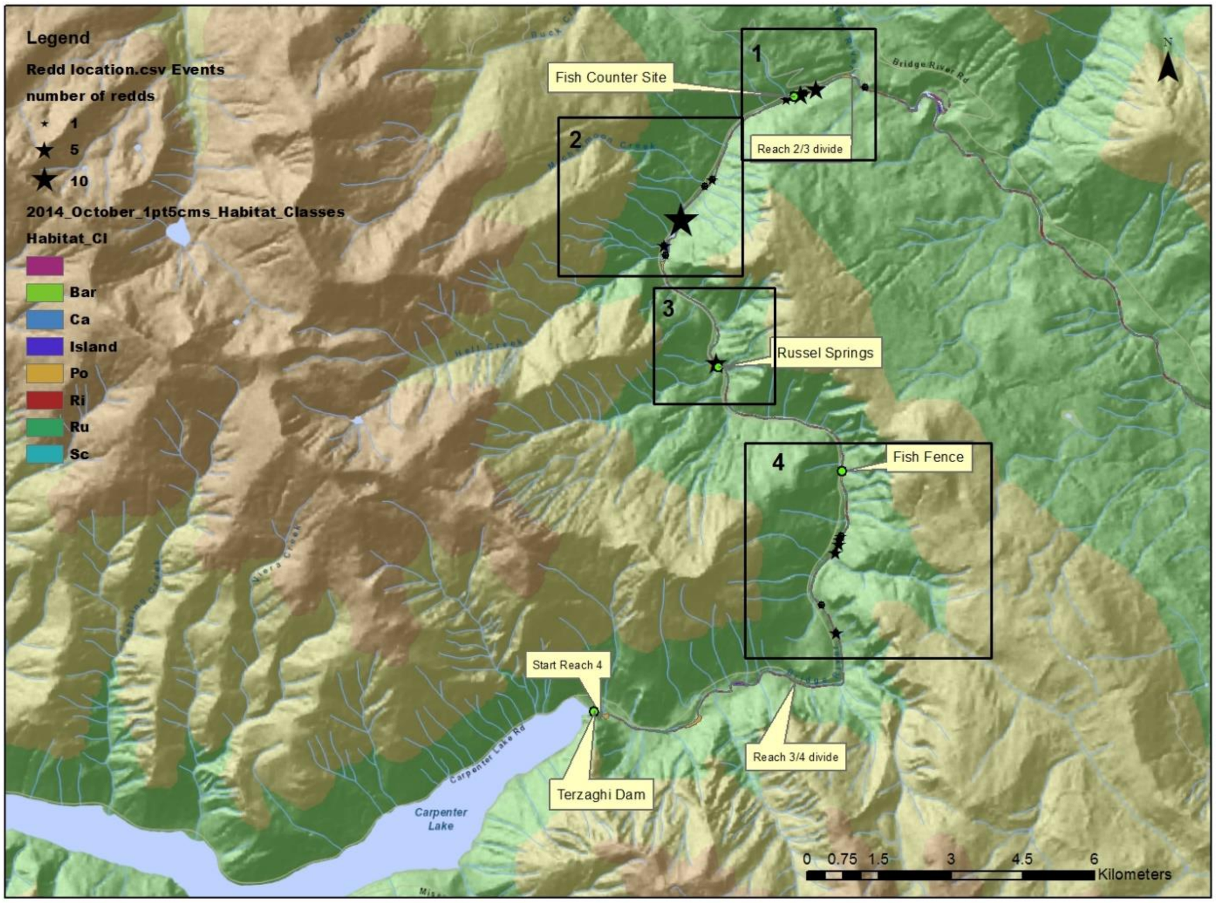

Figure 8. Map of lower Bridge River with location of Chinook redds measured in fall, 2014.

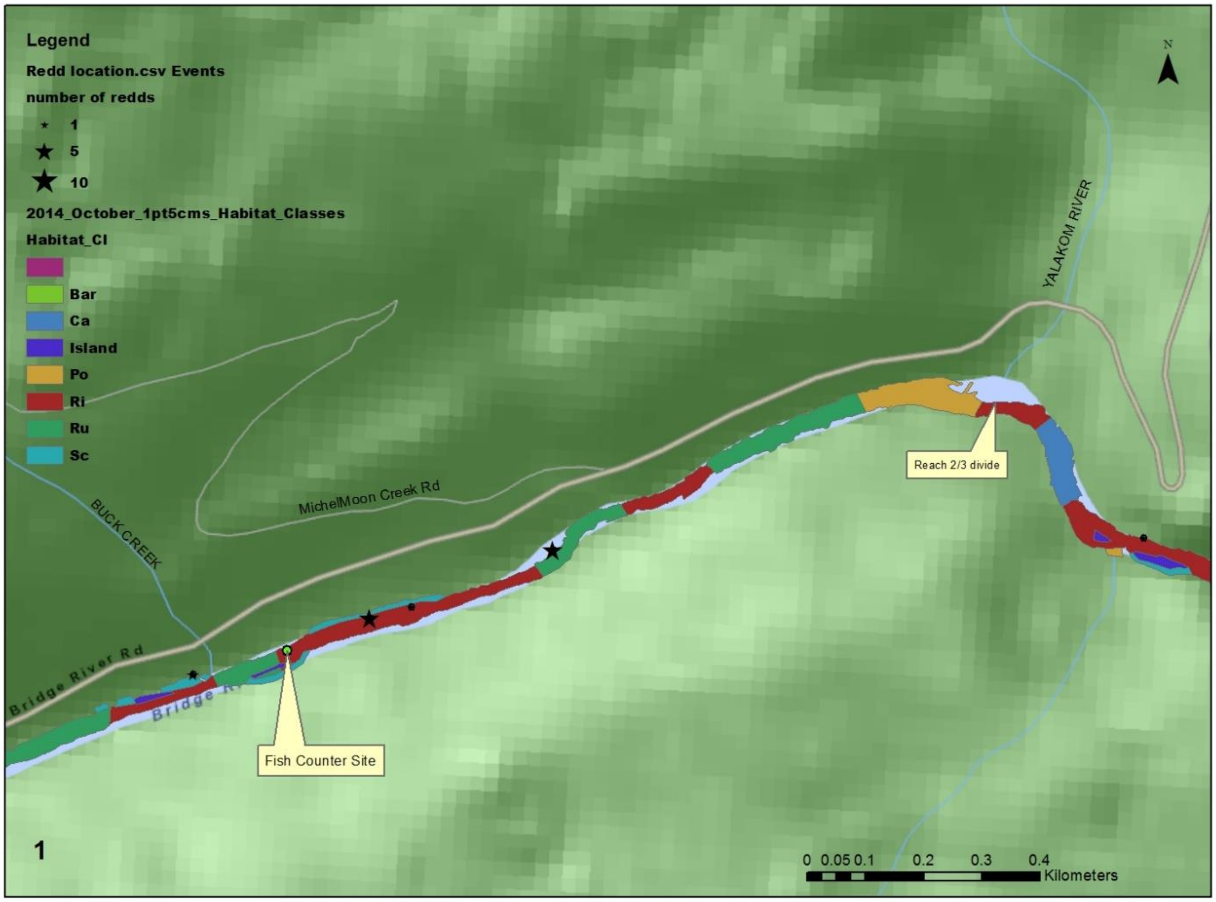

Figure 9. Map of lower section of Reach 3, showing distribution of habitat classes (Po = pool, Ri = riffle, Ru = run, Sc = side channel, and Ca = cascade) and location of redds surveyed. Size of stars represents the number of redds observed.

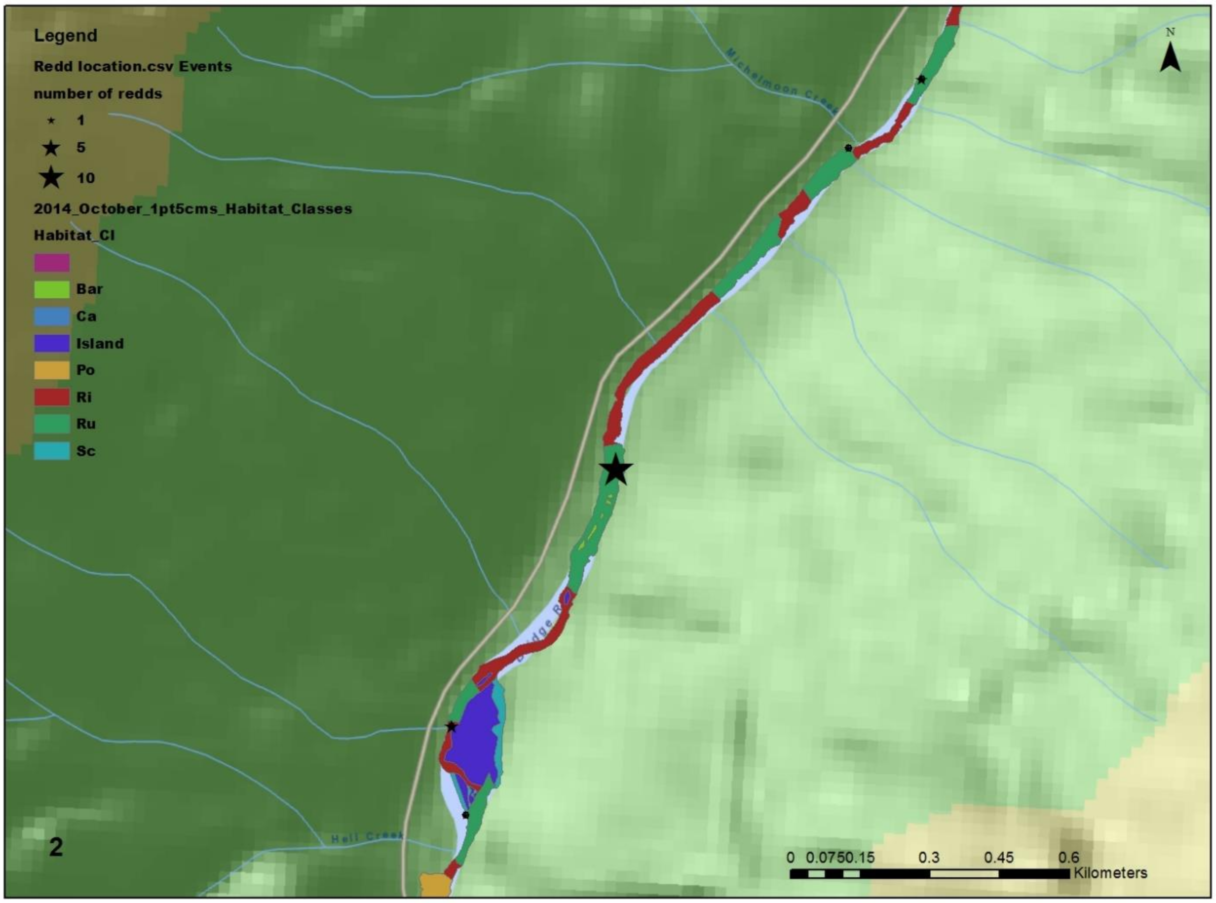

Figure 10. Map showing distribution of habitat classes (Po = pool, Ri = riffle, Ru = run, Sc = side channel, and Ca = cascade) and location of redds surveyed. Size of stars represents the number of redds observed.

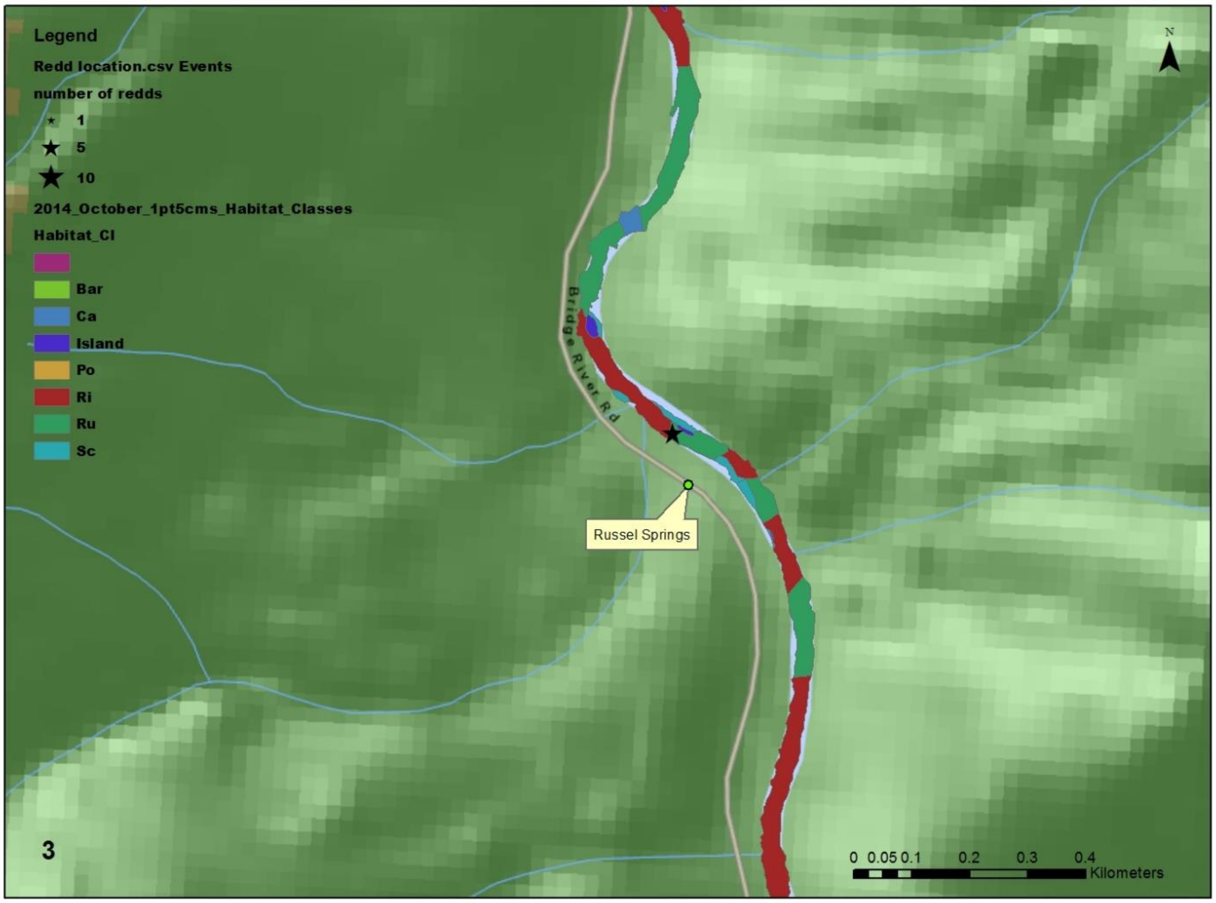

Figure 11. Map of mid section of Reach 3, showing distribution of habitat classes (Po = pool, Ri = riffle, Ru = run, Sc = side channel, and Ca = cascade) and location of redds surveyed. Size of stars represents the number of redds observed.

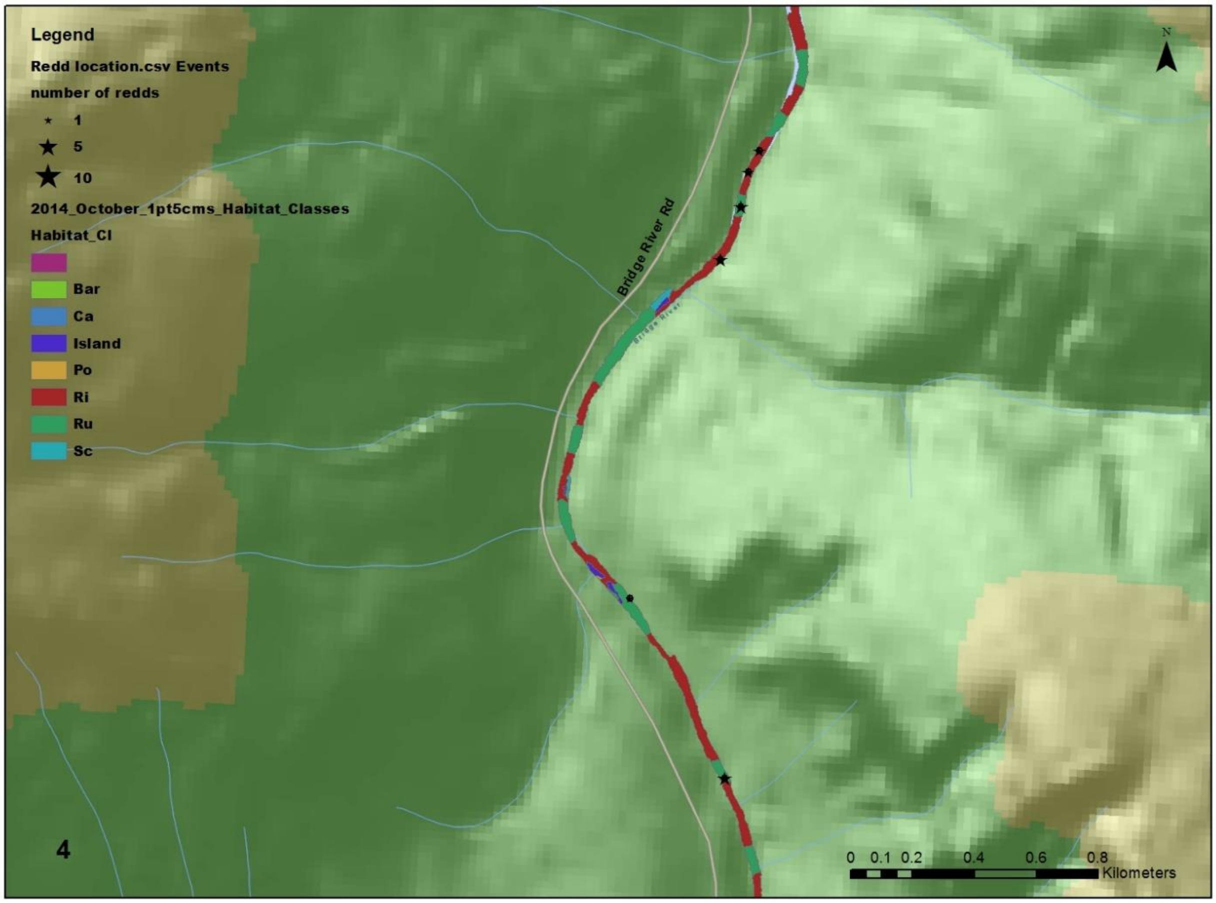

Figure 12. Map of upper section of Reach 3, showing distribution of habitat classes (Po = pool, Ri = riffle, Ru = run, Sc = side channel, and Ca = cascade) and location of redds surveyed. Size of stars represents the number of redds observed.

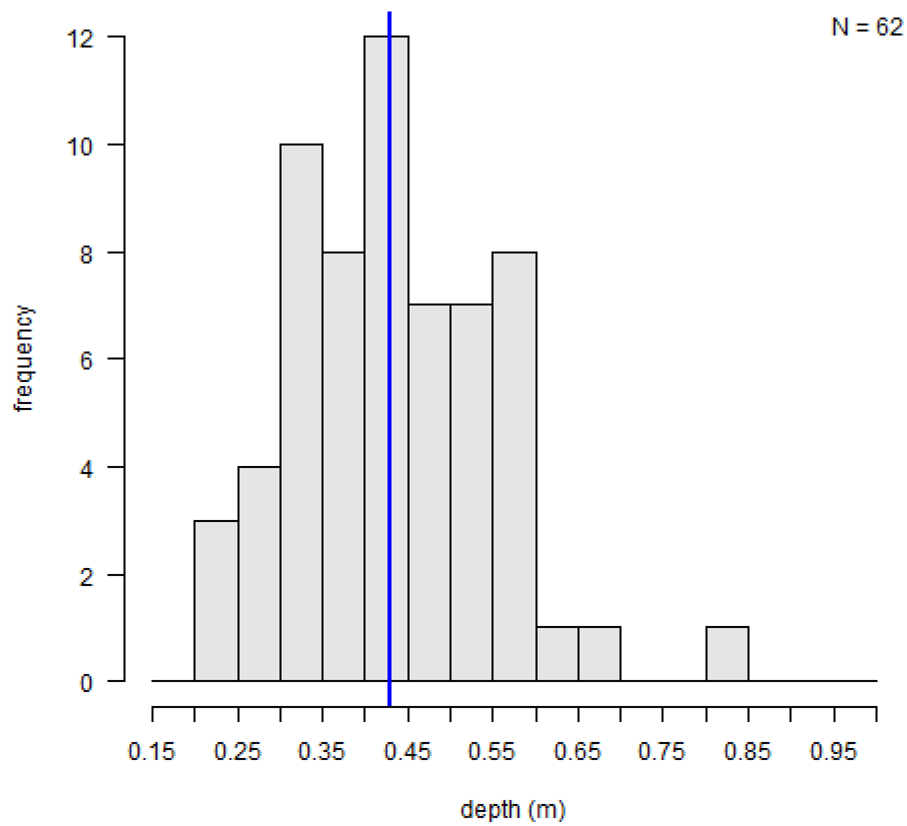

Figure 13. Frequency distribution of water depths measured at fall Chinook Salmon redds in the lower Bridge River during the 2014 spawning period. N is the total number of redds where water depth was measured.

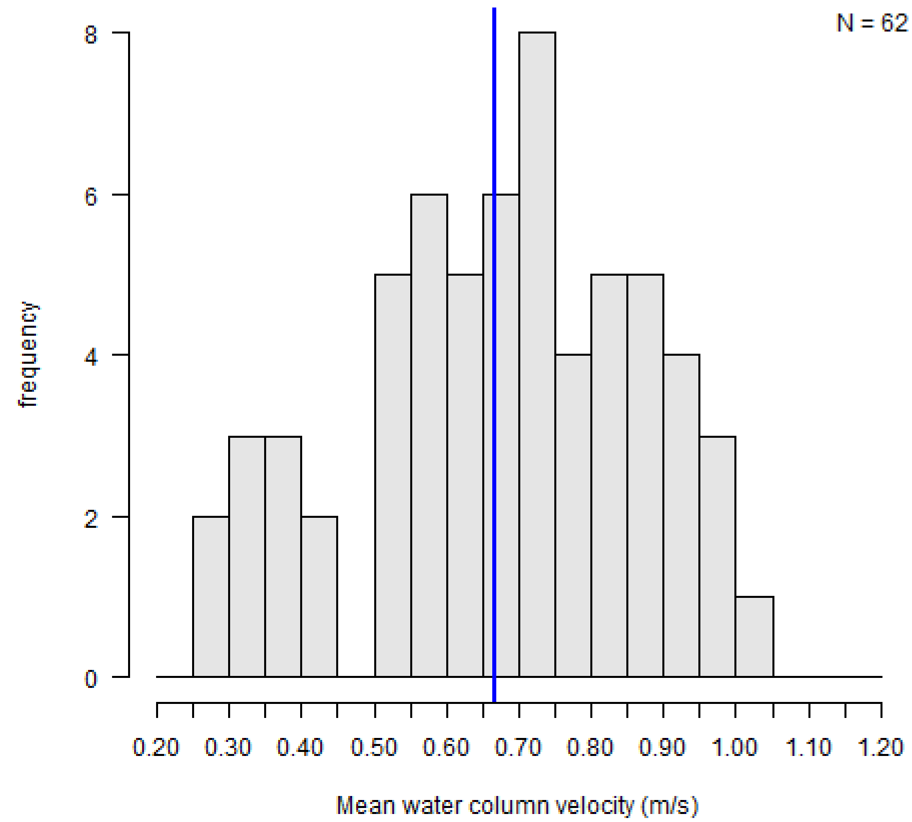

Figure 14. Frequency distribution of mean water column velocity measured over fall Chinook Salmon redds in the lower Bridge River during the 2014 spawning period. N is the total number of redds where water-column velocity was measured.

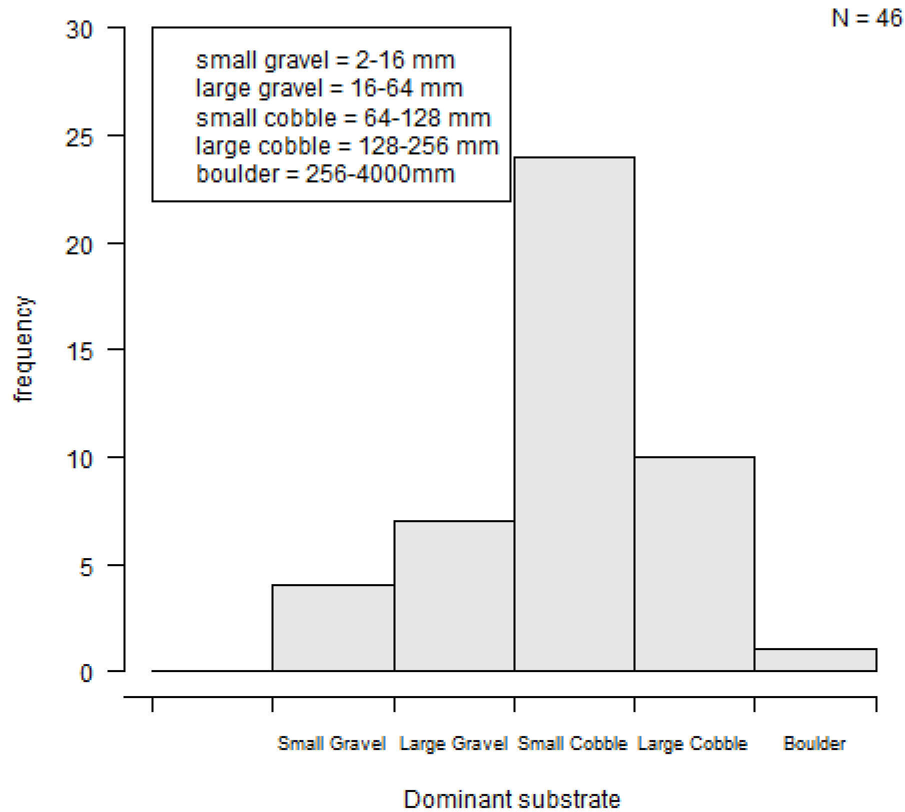

Figure 15. Frequency of dominant substrate types observed at fall Chinook Salmon redds in the lower Bridge River 2014. N is the total number of redds for which substrate composition was determined.

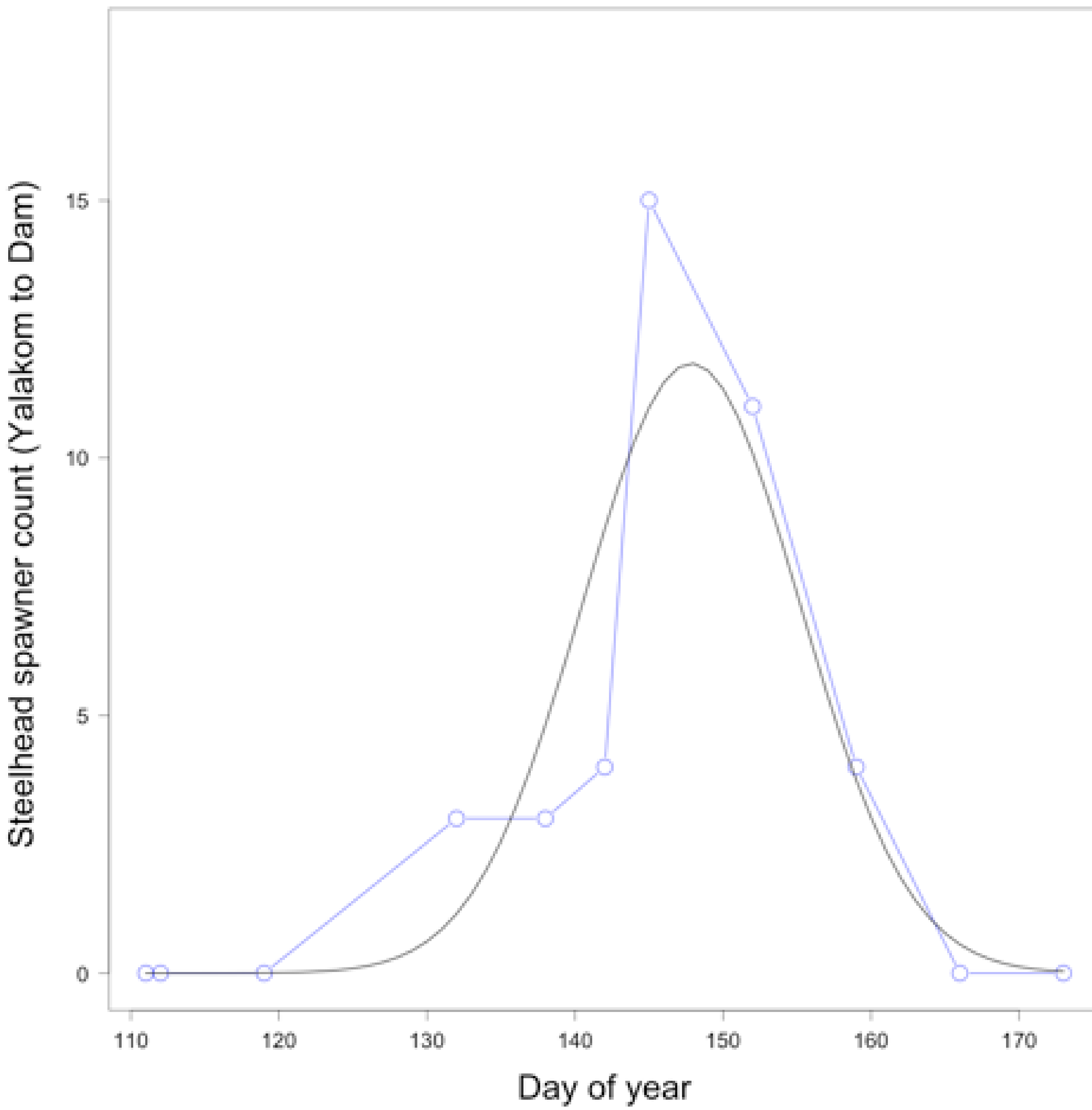

Figure 16. AUC estimate curve for steelhead adult spawners at the lower Bridge River in 2014 (solid line) and observed visual counts (blue circles).

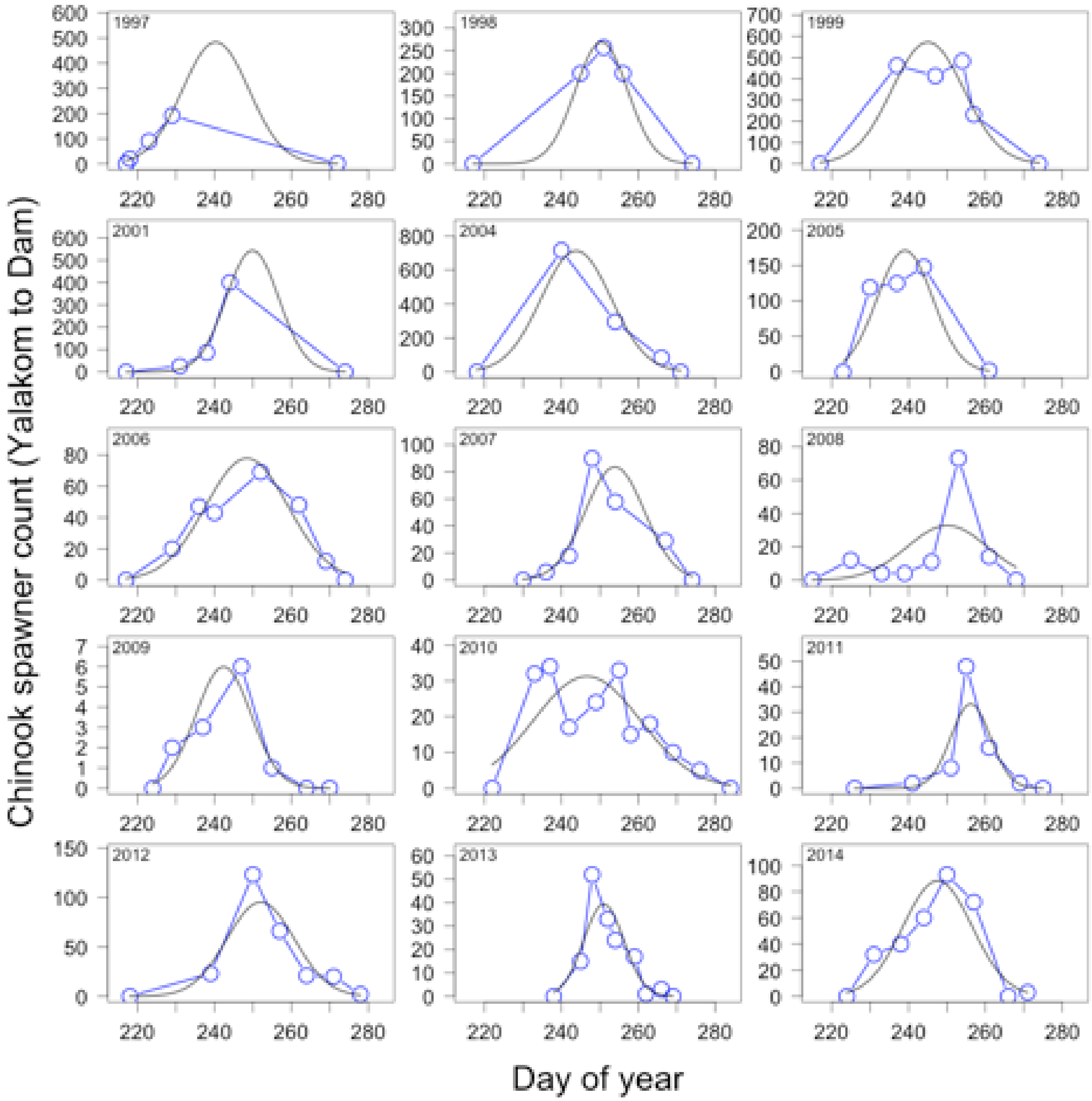

Figure 17. AUC estimate curve for Chinook adult spawners in the lower Bridge River 1997-2014 (solid line) and observed visual counts (blue circles).

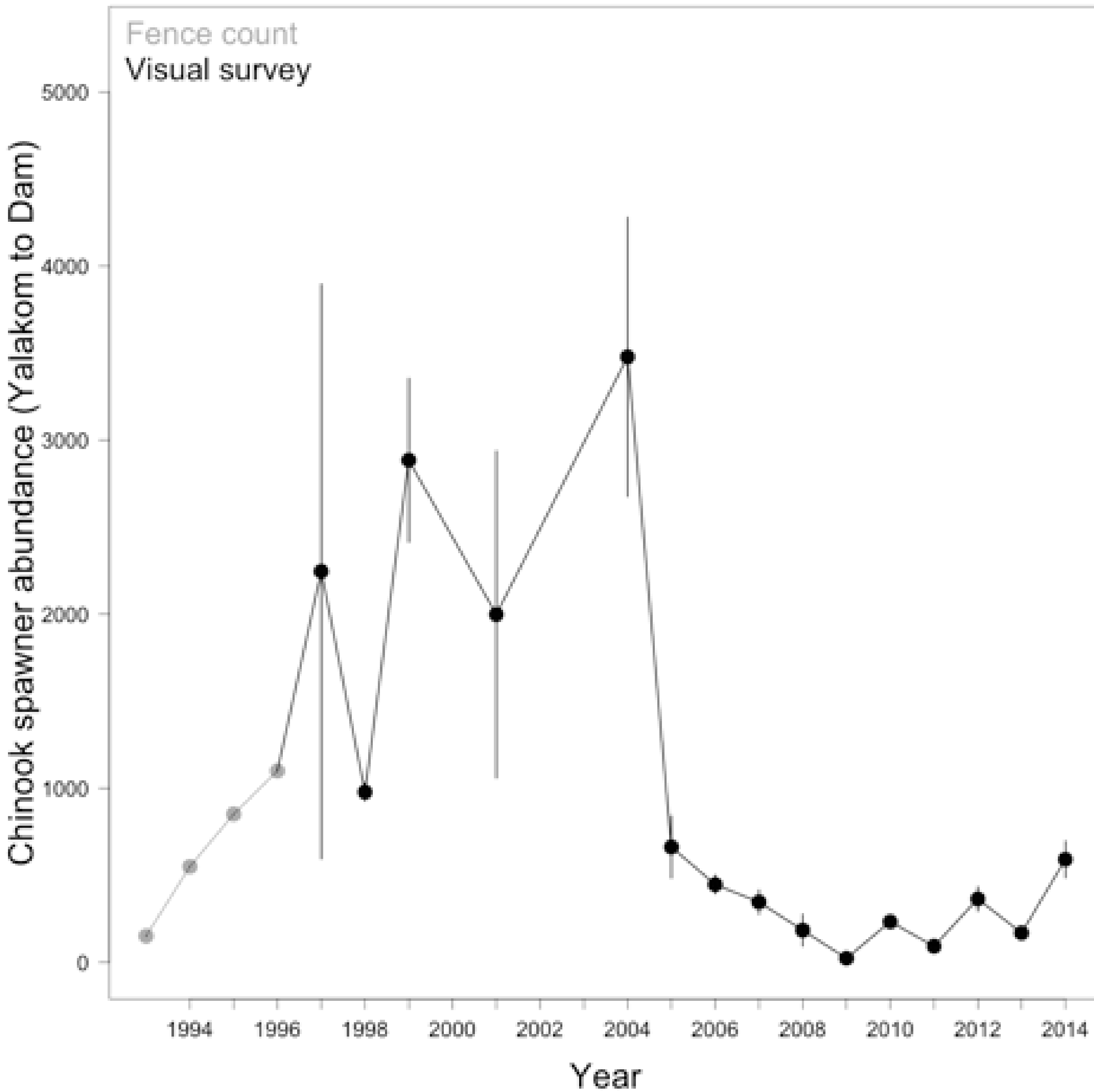

Figure 18. AUC and fence estimates for Chinook adults 1993-2014 in the lower Bridge River. Vertical lines represent 95% confidence intervals.

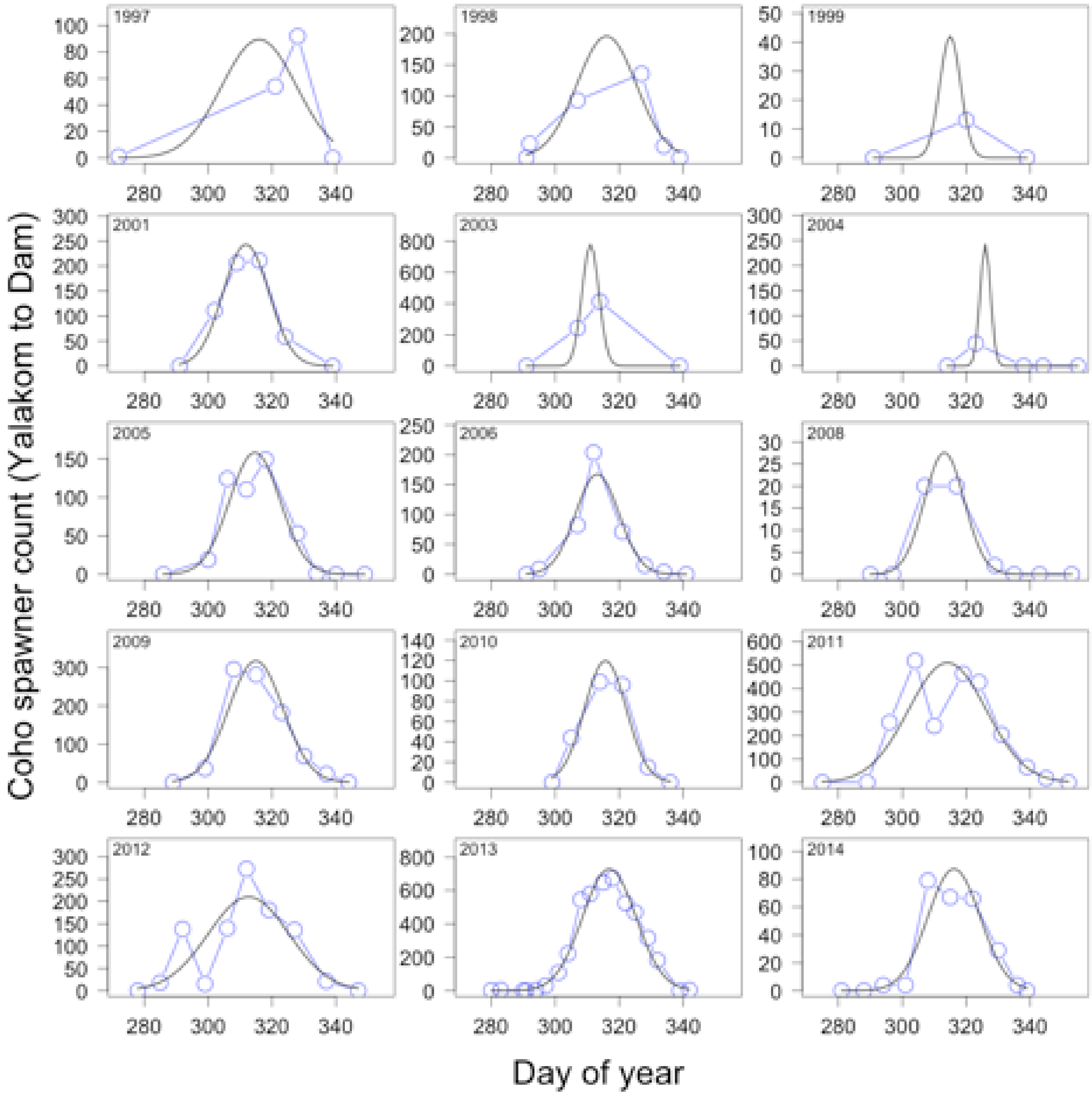

Figure 19. AUC estimate curve for Coho adult spawners in the lower Bridge River 1997-2014 (solid line) and observed visual counts (blue circles).

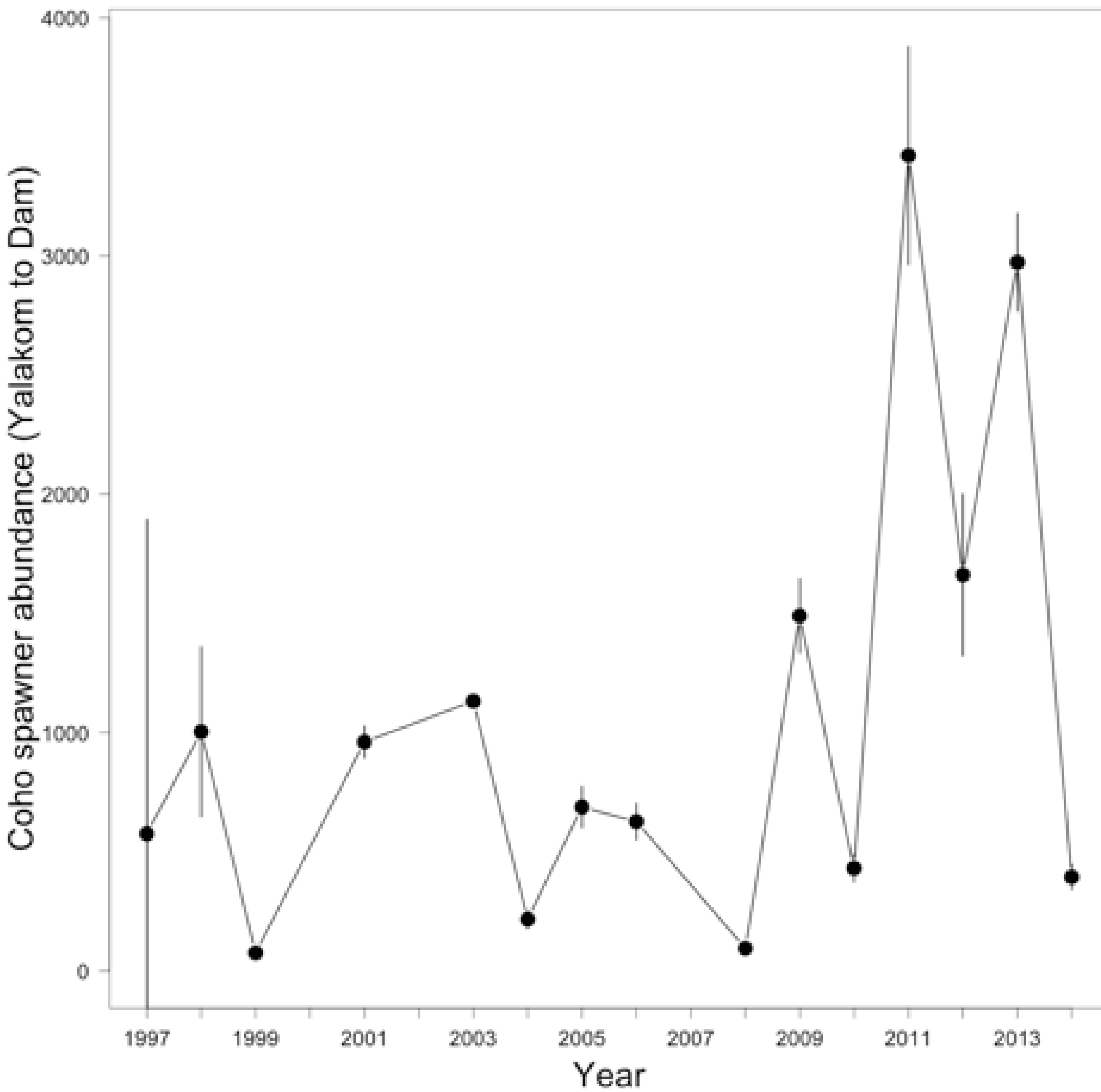

Figure 20. AUC estimates for Coho adults 1997-2014 in the lower Bridge River. Vertical lines represent 95% confidence intervals.

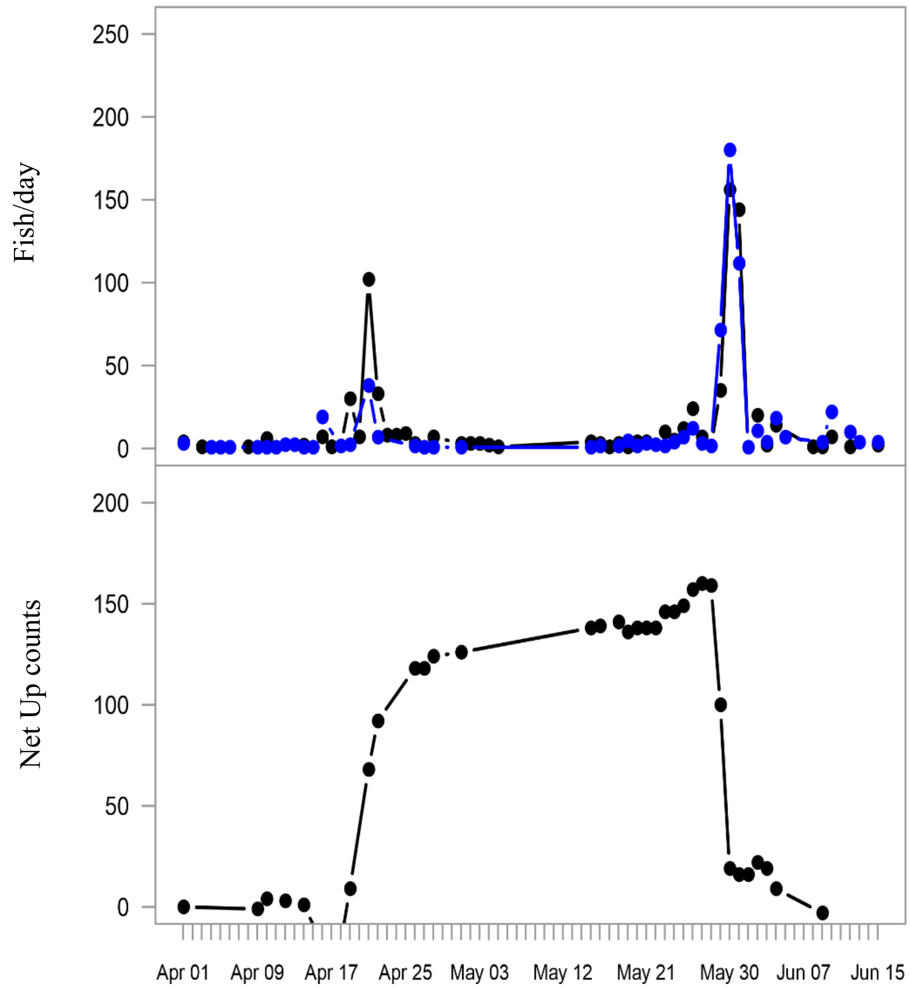

Figure 21. Top panel indicates total daily up (black filled circles) and down (blue filled circles) migration for estimated Steelhead Trout movement in the lower Bridge River in 2014 (late April/early May) and movement of other large bodied fish in late May. Bottom panel shows net daily up counts uncorrected for uncertain counter efficiency.

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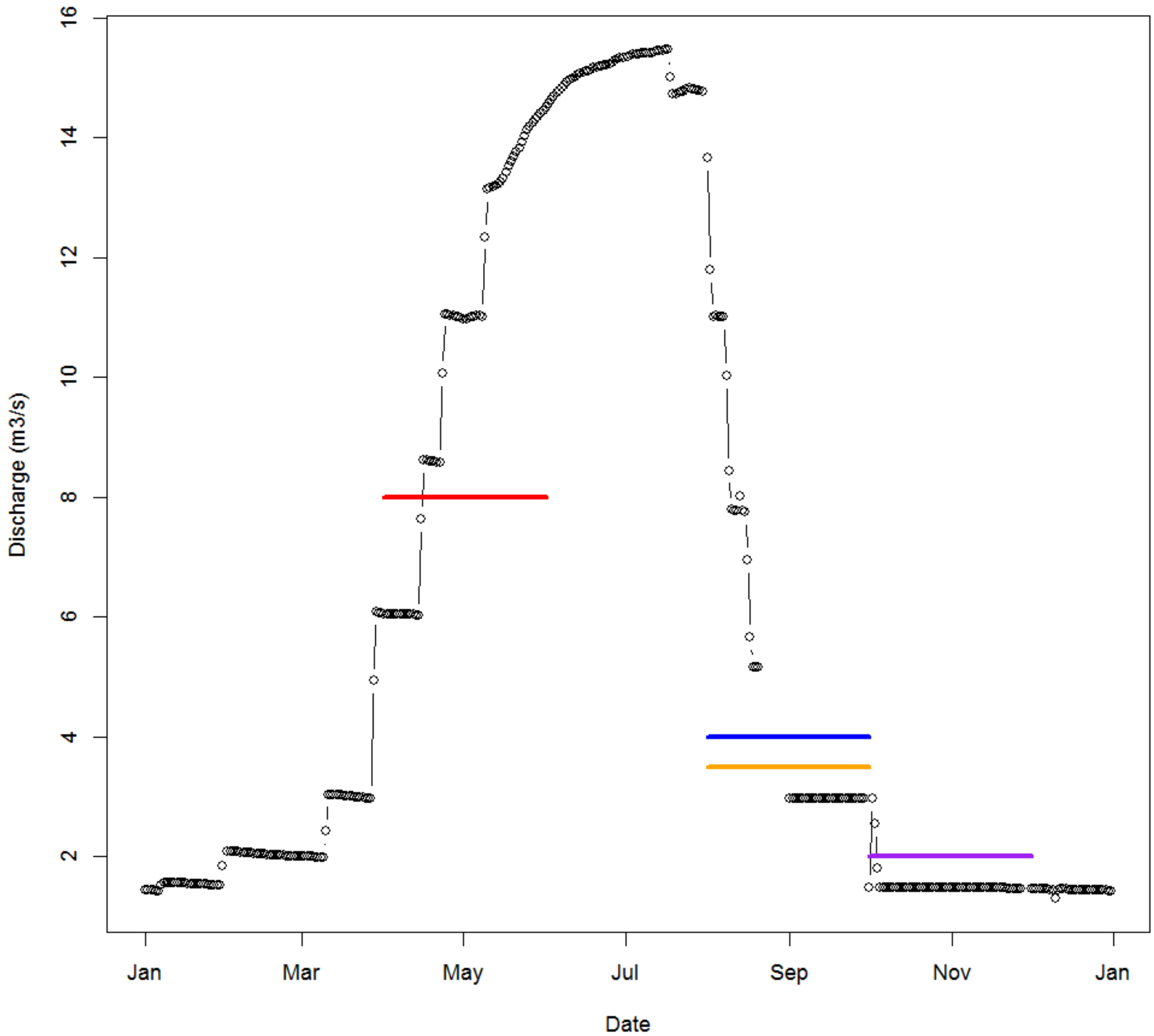

Figure 22. Discharge from Terzaghi Dam into the lower Bridge River in 2014. Spawning migration timing of anadromous salmonids are represented by different colours. Red line = steelhead, Blue line = Chinook, Orange line = Sockeye and Purple line = Coho.

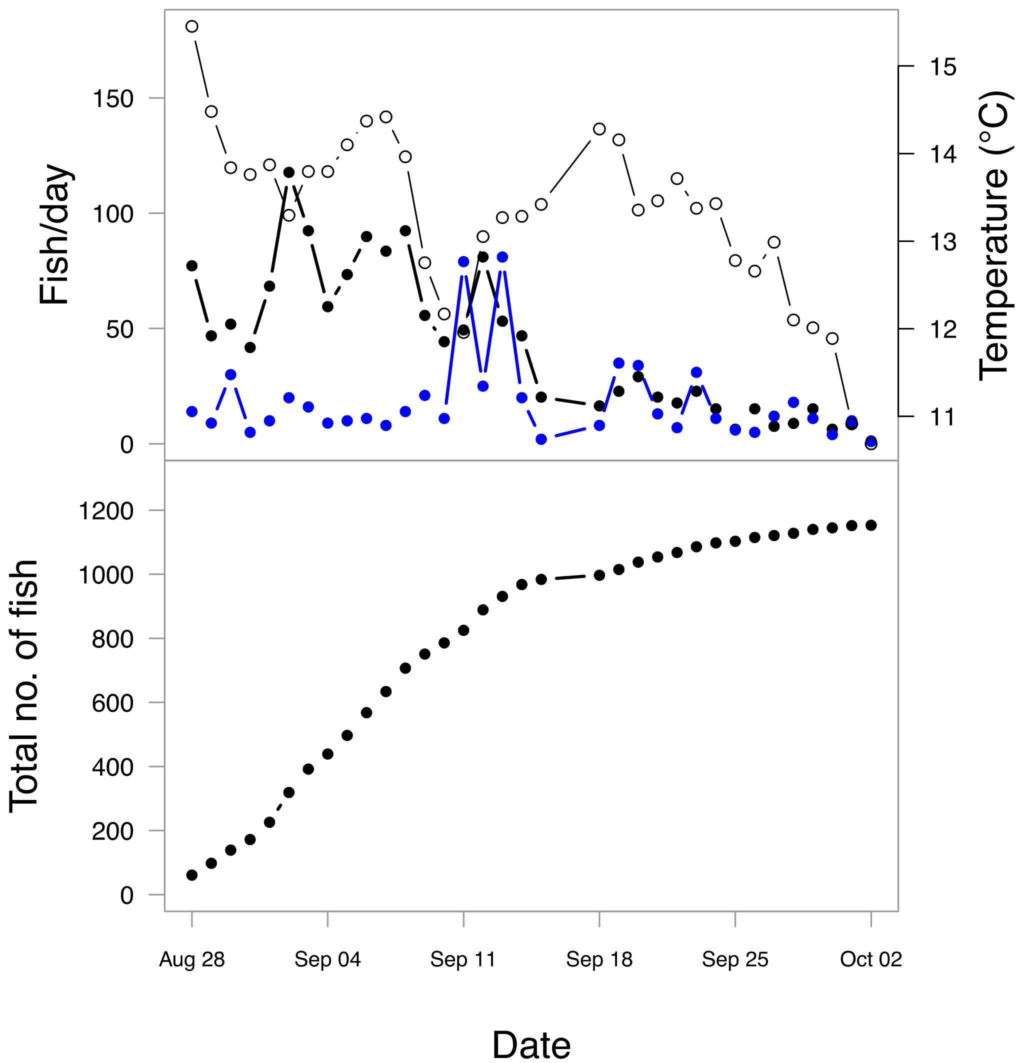

Figure 23. Top panel shows the total daily up (black filled circles) and down (blue filled circles) migration for lower Bridge River Chinook Salmon in 2014 on Channels 1-3. White filled circles show the daily mean temperature (°C) from Coldstream Ecology's temperature logger at 26.3 km. Bottom panel shows the cumulative daily upstream migration totals uncorrected for counter efficiency (Channels 1-3).

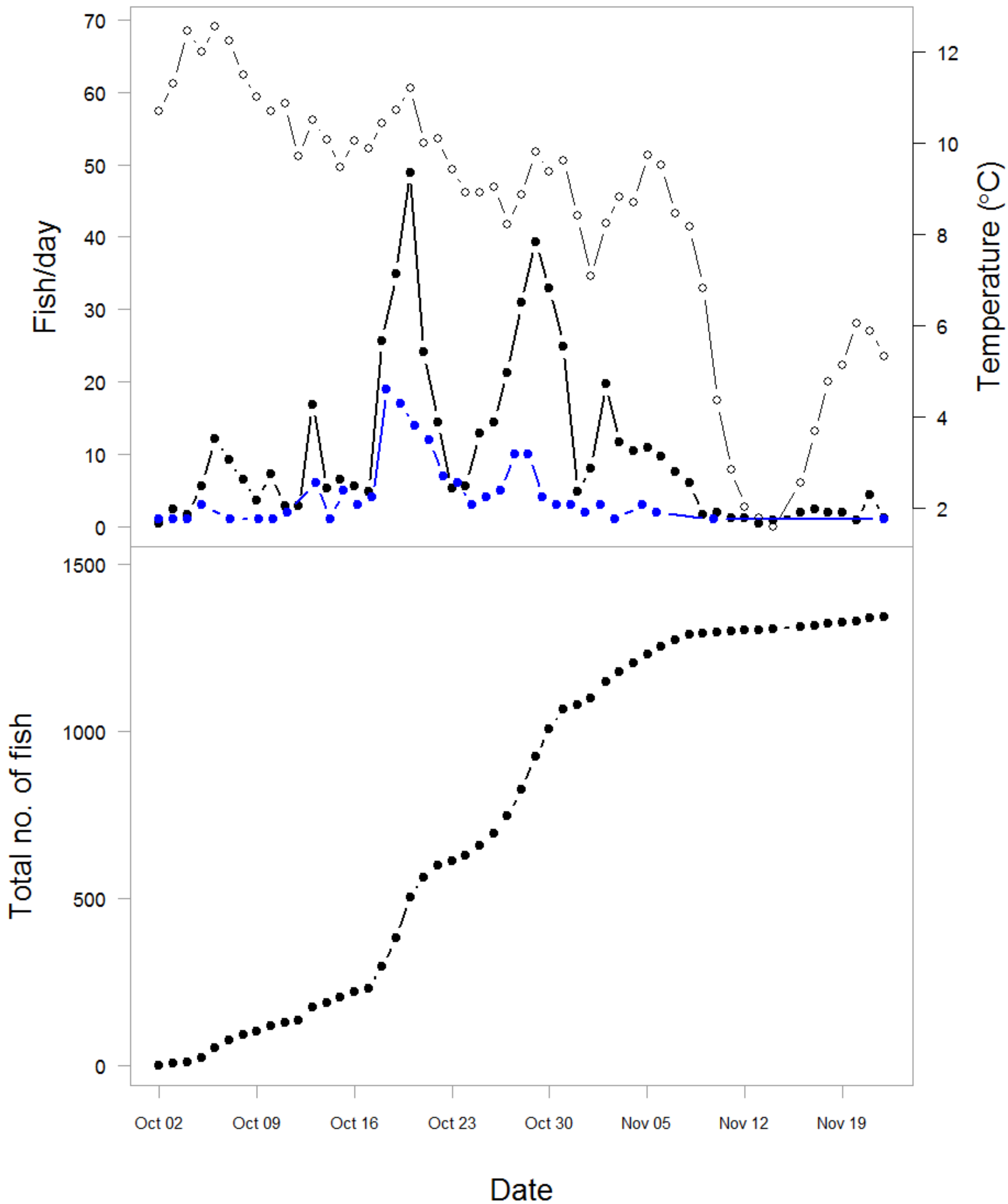

Figure 24. Total daily up (top panel, black filled circles) and down (top panel, blue filled circles) migration for lower Bridge River Coho Salmon in 2014 exhibiting PSS >40 on Channels 1-3. White filled circles show the daily mean temperature (°C) from Coldstream Ecology's temperature logger at 26.3 km. Bottom panel shows the cumulative daily upstream migration totals uncorrected for counter efficiency (Channels 1-3).

9.0 Appendix

Appendix 1. Tagging and sampling data of adult salmon migrants in the lower Bridge River 2014.

Steelhead Trout

Fish no.	Capture date	Species	Capture location	Capture method	Frequency	Code	Fork (mm)	Sex
1	14-Mar-14	SHA	Seton Confluence	angle	150.500	43	760	F
2	17-Mar-14	SHA	Seton Confluence	angle	150.500	36	870	M
3	20-Mar-14	SHA	Seton Confluence	angle	150.500	33	770	F
4	26-Mar-14	SHA	Seton Confluence	angle	150.500	37	670	F
5	26-Mar-14	SHA	Seton Confluence	angle	150.500	51	910	M
6	3-Apr-14	SHA	Seton Confluence	angle	150.680	61	825	F
7	3-Apr-14	SHA	Seton Confluence	angle	150.680	64	870	M
8	5-Apr-14	SHA	Seton Confluence	angle	150.680	68	830	F
9	9-Apr-14	SHA	Seton Confluence	angle	150.680	56	820	M
10	21-Apr-14	SHA	Seton Confluence	angle	150.500	49	870	F
11	25-Apr-14	SHA	Seton Confluence	angle	150.680	72	780	F
12	30-Apr-14	SHA	Bridge Confluence	angle	150.680	57	855	F
13	1-May-14	SHA	Bridge Confluence	angle	150.500	35	905	M
14	1-May-14	SHA	Bridge Confluence	angle	150.680	63	815	F
15	2-May-14	SHA	Seton Confluence	angle	150.500	48	620	F
16	2-May-14	SHA	Seton Confluence	angle	150.680	59	680	F
17	3-May-14	SHA	Seton Confluence	angle	150.680	53	800	F
18	5-May-14	SHA	Bridge Confluence	angle	150.680	62	815	F
19	9-May-14	SHA	Bridge Confluence	angle	150.680	54	790	F
20	13-May-14	SHA	Bridge Confluence	angle	150.680	69	815	F
Mean fork (mm)					**Fish tagged**			
Male	Female				Male	Female		
875	739				5	15		

Chinook Salmon

Fish no.	Capture date	Species	Capture location	Capture location (rkm)	Reach	Capture method	Frequency	Code	Fork (mm)	Sex
1	20-Aug-14	CHA	Yalakom Confluence	25.5	3	angle	149.260	23	935	M
2	20-Aug-14	CHA	Yalakom Confluence	25.5	3	angle	149.500	29	840	F
3	23-Aug-14	CHA	Yalakom Confluence	25.5	3	angle	149.260	22	745	M
4	27-Aug-14	CHA	Yalakom Confluence	25.5	3	angle	N/A	14	790	F
5	28-Aug-14	CHA	Yalakom Confluence	25.5	3	angle	N/A	12	785	F
6	28-Aug-14	CHA	Yalakom Confluence	25.5	3	angle	149.260	11	740	M
7	28-Aug-14	CHA	Yalakom Confluence	25.5	3	angle	149.260	18	790	M
8	28-Aug-14	CHA	Yalakom Confluence	25.5	3	angle	149.500	30	700	M
9	29-Aug-14	CHA	Yalakom Confluence	25.5	3	angle	149.500	28	800	F
10	29-Aug-14	CHA	Yalakom Confluence	25.5	3	angle	149.260	13	1015	M
11	30-Aug-14	CHA	Yalakom Confluence	25.5	3	angle	149.260	19	800	F
12	30-Aug-14	CHA	Yalakom Confluence	25.5	3	angle	149.500	40	975	F
13	30-Aug-14	CHA	Yalakom Confluence	25.5	3	angle	149.260	25	830	F
14	30-Aug-14	CHA	Yalakom Confluence	25.5	3	angle	149.500	27	720	F
15	31-Aug-14	CHA	Yalakom Confluence	25.5	3	angle	149.260	16	830	M
16	1-Sep-14	CHA	Yalakom Confluence	25.5	3	angle	149.260	17	765	F
17	1-Sep-14	CHA	Yalakom Confluence	25.5	3	angle	149.500	36	685	M
18	1-Sep-14	CHA	Yalakom Confluence	25.5	3	angle	149.500	31	815	M
19	1-Sep-14	CHA	Yalakom Confluence	25.5	3	angle	149.500	34	745	F
20	1-Sep-14	CHA	Yalakom Confluence	25.5	3	angle	149.500	35	785	F
21	1-Sep-14	CHA	Yalakom Confluence	25.5	3	angle	149.260	24	740	M
22	1-Sep-14	CHA	Yalakom Confluence	25.5	3	angle	149.500	39	775	M
Mean fork (mm)				**Fish tagged**						
Male	Female			Male	Female					
797	803			11	11					

Coho Salmon

Fish no.	Capture date	Species	Capture location	Capture method	Capture location (rkm)	Reach	PIT tag	Fork (mm)	Sex
1	09-Oct-14	COA	Below BR Bridge	angle	1	1	1.83E+08	720	M
2	10-Oct-14	COA	Below BR Bridge	angle	1	1	1.83E+08	695	M
3	10-Oct-14	COA	Below BR Bridge	angle	1	1	1.83E+08	635	M
4	12-Oct-14	COA	Below BR Bridge	angle	1	1	1.83E+08	580	F
5	12-Oct-14	COA	Corner Above BRB	angle	2	1	1.83E+08	555	F
6	12-Oct-14	COA	Corner Above BRB	angle	2	1	1.83E+08	575	F
7	12-Oct-14	COA	Lower Bridge	angle	1	1	1.83E+08	490	F
8	13-Oct-14	COA	Corner Above BRB	angle	2	1	1.83E+08	655	F
9	14-Oct-14	COA	Corner Above BRB	angle	2	1	1.83E+08	600	F
10	14-Oct-14	COA	Yalakom Confluence	angle	25.5	3	1.83E+08	595	M
11	15-Oct-14	COA	Corner Above BRB	angle	2	1	1.83E+08	605	M
12	17-Oct-14	COA	Bridge Mouth	angle	1	1	1.83E+08	570	F
13	17-Oct-14	COA	Bridge Mouth	angle	1	1	1.83E+08	610	F
14	17-Oct-14	COA	Bridge Mouth	angle	1	1	1.83E+08	660	M
15	17-Oct-14	COA	Bridge Mouth	angle	1	1	1.83E+08	690	F
16	17-Oct-14	COA	Bridge Mouth	angle	1	1	1.83E+08	690	M
17	17-Oct-14	COA	Bridge Mouth	angle	1	1	1.83E+08	520	F
18	17-Oct-14	COA	Bridge Mouth	angle	1	1	1.83E+08	565	F
19	18-Oct-14	COA	Bridge Mouth	angle	1	1	1.83E+08	660	F
20	18-Oct-14	COA	Bridge Mouth	angle	1	1	1.83E+08	595	F
21	18-Oct-14	COA	Bridge Mouth	angle	1	1	1.83E+08	625	M
22	21-Oct-14	COA	Above Camoo Bridge	angle	10	2	1.83E+08	530	M
23	22-Oct-14	COA	Bridge Mouth	angle	1	1	1.83E+08	660	F
24	22-Oct-14	COA	Bridge Mouth	angle	1	1	1.83E+08	750	F
25	27-Oct-14	COA	Bridge Mouth	angle	1	1	1.83E+08	600	F
26	29-Oct-14	COA	Corner Above BRB	angle	2	1	1.83E+08	585	F
27	29-Oct-14	COA	Below BR Bridge	angle	1	1	1.83E+08	585	M
28	29-Oct-14	COA	Below BR Bridge	angle	1	1	1.83E+08	710	F
29	03-Nov-14	COA	Yalakom Confluence	angle	25.5	3	1.83E+08	675	F
30	03-Nov-14	COA	Yalakom Confluence	angle	25.5	3	1.83E+08	640	M
31	04-Nov-14	COA	Hippie Pool	angle	26.5	3	1.83E+08	655	M
32	05-Nov-14	COA	Yalakom Confluence	angle	25.5	3	1.83E+08	600	F
Mean fork (mm)				**Fish Tagged**					
Male	Female			Male	Female				
636	613			12	20				

Appendix 2. Streamwalk data of adult salmon migrants in the lower Bridge River 2014.

Steelhead

			Yalokom to Hell River km 25.5-28.8				Hell to Russel River km 28.8-30.7				Russel to Fishfence (excluding Fishfence) River km 30.7-33.2				Fishfence to Cobra River km 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
SHA	22-Apr-14	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHA	23-Apr-14	0.25	0	0	0	0	0	0	0	0	0	0	2	2	0	0	1	1
SHA	30-Apr-14	0.0 - 0.5	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
SHA	13-May-14	1.0 - 1.5	2	1	1	1	0	0	0	0	0	0	0	0	0	0	2	1
SHA	19-May-14	0.25	0	0	2	2	2	1	1	1	0	0	1	1	0	0	0	0
SHA	23-May-14	0.25	4	0	1	1	0	0	1	0	0	0	1	1	0	0	0	0
SHA	26-May-14	0.25	6	0	2	0	0	0	1	0	0	0	0	0	3	0	0	0
SHA	02-Jun-14	0.25	2	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
SHA	09-Jun-14	0.25	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
SHA	16-Jun-14	0.25	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
SHA	23-Jun-14	0.0 - 0.5	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0

SHA	23-Jun-14	0.0 - 0.5	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0

			Cobra to Bluenose River km 34.4-38.2				Bluenose to Eagle River km 38.2-38.8				Eagle to Longskinny River km 38.8-39.3				Longskinny to Plungepool River km 39.3-40.0			
			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
SHA	22-Apr-14	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHA	23-Apr-14	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SHA	30-Apr-14	0.0 - 0.5	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0
SHA	13-May-14	1.0 - 1.5	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
SHA	19-May-14	0.25	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0
SHA	23-May-14	0.25	0	0	3	2	0	0	0	0	0	0	0	0	0	0	0	0
SHA	26-May-14	0.25	0	0	4	2	0	0	0	0	6	0	0	0	0	0	0	0
SHA	02-Jun-14	0.25	0	0	3	1	0	0	0	0	1	0	0	0	8	0	0	0
SHA	09-Jun-14	0.25	0	0	2	0	0	0	0	0	0	0	0	0	4	0	0	0

			All Reaches			
			Total			
			Observed		Present in Section	
Species	Date	Water Visibility (m)	Untagged	Tagged	Tracked # of tags	# of tags adjusted for survey life
SHA	22-Apr-14	0.25	0	0	0	0
SHA	23-Apr-14	0.25	0	0	3	3
SHA	30-Apr-14	0.0 - 0.5	0	0	3	3
SHA	13-May-14	1.0 - 1.5	2	1	4	3
SHA	19-May-14	0.25	2	1	7	5
SHA	23-May-14	0.25	4	0	6	4
SHA	26-May-14	0.25	15	0	7	2
SHA	02-Jun-14	0.25	11	0	5	1
SHA	09-Jun-14	0.25	4	0	4	0
SHA	16-Jun-14	0.25	0	0	4	0
SHA	23-Jun-14	0.0 - 0.5	0	0	4	0
			38	**2**	**47**	**21**

Chinook Salmon

			Yalakom to Hell River km 25.5-28.8				Hell to Russel River km 28.8-30.7				Russel to Fish Fence (Excluding Fish Fence) River km 30.7-33.2				Fish Fence to Cobra River km 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	13-Aug-14	1.8 CLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHA	20-Aug-14	3m / 100%	20	0	2	2	0	0	0	0	0	0	0	0	12	0	0	0
CHA	27-Aug-14	>1.5m	28	0	3	3	0	0	0	0	0	0	0	0	10	0	1	1
CHA	02-Sep-14	3m CLEAR	37	0	18	18	1	0	1	1	0	0	0	0	14	0	2	2
CHA	08-Sep-14	1.2	67	0	12	11	0	0	2	2	9	0	2	2	8	0	1	1
CHA	15-Sep-14	<1m	45	0	11	7	4	0	1	1	5	0	1	0	12	0	1	1
CHA	24-Sep-14	<0.25m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHA	29-Sep-14	<0.25 m	0	0	8	5	0	0	2	2	0	0	0	0	0	0	1	0
CHA	09-Oct-14	<0.25m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

			Cobra to Bluenose River km 34.4-38.2				Bluenose to Eagle River km 38.2-38.8				Eagle to Longskinny River km 38.8-39.3				Longskinny to Plunge Pool River km 39.3-40.0			
			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	13-Aug-14	1.8 CLEAR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHA	20-Aug-14	3m / 100%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHA	27-Aug-14	>1.5m	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHA	02-Sep-14	3m CLEAR	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHA	08-Sep-14	1.2	6	0	2	2	0	0	0	0	0	0	0	0	3	0	0	0
CHA	15-Sep-14	<1m	0	0	3	3	0	0	0	0	2	0	0	0	3	0	0	0
CHA	24-Sep-14	<0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CHA	29-Sep-14	<.25 m	0	0	1	0	0	0	0	0	3	0	0	0	3	0	0	0
CHA	09-Oct-14	<.25 m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

			All Reaches			
			Total			
			Observed		**Present in Section**	
Species	**Date**	**Water Visibility (m)**	**Untagged**	**Tagged**	**Tracked # of tags**	**# of tags adjusted for survey life**
CHA	13-Aug-14	1.8 CLEAR	0	0	0	0
CHA	20-Aug-14	3m / 100%	32	0	2	2
CHA	27-Aug-14	>1.5m	40	0	4	4
CHA	02-Sep-14	3m CLEAR	60	0	21	21
CHA	08-Sep-14	1.2	93	0	19	18
CHA	15-Sep-14	<1m	71	0	17	12
CHA	24-Sep-14	<0.25m	0	0	0	0
CHA	29-Sep-14	<0.25 m	0	0	11	7
CHA	09-Oct-14	<0.25 m	0	0	0	0
			296	**0**	**74**	**64**

Coho Salmon

			Section 1: Yalokom to Hell	Section 2: Hell to Russel	Section 3: Russel to Fishfence	Section 4: Fishfence to Cobra	Section 5: Cobra to Bluenose	Section 6: Bluenose to Eagle	Section 7: Eagle to Longskinny	Section 8: Longskinny to Plungepool		All Reaches
			RK 25.5-28.8	RK 28.8-30.7	RK 30.7-33.2	RK 33.2-34.4	RK 34.4-38.2	RK 38.2-38.8	RK 38.8-39.6	River km 39.6-40.0		Total
Species	**Date**	**Water Visibility (m)**	**Observed**	**Observed**	**Observed**	**Observed**	**Observed**	**Observed**	**Observed**	**Observed**	**Mortalities**	**Observed**
COA	09-Oct-14	.3 m	0	0	0	0	0	0	0	0	0	0
COA	16-Oct-14	<.25 m	0	0	0	0	0	0	0	0	0	0
COA	22-Oct-14	.3 m	4	0	0	0	0	0	0	0	0	4
COA	29-Oct-14	.3 m	2	0	0	0	0	0	1	1	0	4
COA	05-Nov-14	<.5 m	3	0	0	14	2	6	17	37	0	79
COA	12-Nov-14	.3 m	12	0	0	2	2	0	28	23	0	67
COA	19-Nov-14	<.25 m	0	0	2	2	14	0	20	29	2	69
COA	27-Nov-14	<.25 m	0	0	0	6	5	0	4	13	1	29
COA	03-Dec-14	.3 m	0	0	0	0	0	0	3	1	0	4
												256

Sockeye Salmon

			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 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	Mortalities	Observed
SKA	13-Aug-14	>1.5	0	0	0	0	0	0	0	0	0	0
SKA	20-Aug-14	3m CLEAR	0	0	0	0	0	0	0	0	0	0
SKA	27-Aug-14	>1.5m	9	0	0	1	3	0	0	18	4	35
SKA	02-Sep-14	3m CLEAR	0	3	5	9	7	0	35	63	7	129
SKA	08-Sep-14	1.2	8	0	0	0	20	0	68	87	23	206
SKA	15-Sep-14	<1m	4	0	0	61	0	0	108	94	1	268
SKA	24-Sep-14	<.25 m	0	0	0	4	9	0	0	95	0	108
SKA	29-Sep-14	<.25m	0	0	0	2	10	0	20	35	0	67
SKA	09-Oct-14	.3 m	0	0	0	0	0	0	10	28	0	38
SKA	16-Oct-14	<.25 m	0	0	0	0	0	0	0	9	0	9
SKA	22-Oct-14	<.25 m	0	0	0	0	0	0	0	0	0	0
SKA	29-Oct-14	<.25 m	0	0	0	0	0	0	0	0	0	0
SKA	05-Nov-14	<.25 m	0	0	0	0	0	2	6	0	0	8
SKA	12-Nov-14	<.25 m	0	0	0	0	0	0	0	0	0	0
SKA	19-Nov-14	<.25 m	0	0	0	0	0	0	0	0	0	0
SKA	27-Nov-14	<.25 m	0	0	0	0	0	0	0	0	0	0
SKA	03-Dec-14	<.25 m	0	0	0	0	0	0	0	0	0	0
												868