Gingit Creek and Lower Nass River Sea-Type Sockeye Salmon (*Oncorhynchus nerka*) Escapement and Stock Characteristics: 1994 to 2015

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GINGIT CREEK AND LOWER NASS RIVER SEA-TYPE SOCKEYE SALMON (*Oncorhynchus nerka*) ESCAPEMENT AND STOCK CHARACTERISTICS: 1994 TO 2015

by

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ABSTRACT

Beveridge, I.A., Duguid, W.D., Alexander, R.F., Bocking, R.C., Bussanich, R.J., and Cox-Rogers, S. 2017. Gingit Creek and Lower Nass River sea-type Sockeye Salmon (*Oncorhynchus nerka*) escapement and stock characteristics: 1994 to 2015. Can. Manuscr. Rep. Fish. Aquat. Sci. 3121: ix + 61 p.

The Nisg̱a’a Lisims Government Fisheries and Wildlife Department has conducted Sockeye Salmon (*Oncorhynchus nerka*) escapement surveys at Gingit Creek since 2000. Here we present revised escapement estimates based on a robust and standardized area under the curve (AUC) methodology and review abundance and biological data in the context of historical records of Sockeye Salmon populations in Lower Nass River tributaries. More than 90% of Gingit Creek Sockeye Salmon go to sea in their first summer after emergence and most returning adults are age 3_1 and 4_1. Relative to other Nass River Sockeye Salmon stocks, Gingit Creek fish exhibit consistently early and compressed run timing. Mean escapement to Gingit Creek has increased from 1,388 (2000–2005) to 10,069 adults (2010–2015). Escapement to Gingit Creek has been supported through improved access to spawning sites by consistent removal of beaver dams since 2000. Revised genetic distance data suggest that Gingit Creek is the primary spawning site for a genetically distinct sea-type Sockeye Salmon population that also spawns in other Lower Nass River tributaries. This Lower Nass sea-type population represents an important contribution to Canadian, Nisg̱a’a, and US fisheries, contributing on average 9% (range: 6% to 12%) of the total aggregate return of Sockeye Salmon to the Nass River from genetic analyses conducted from 2009 to 2015.

RÉSUMÉ

Beveridge, I.A., Duguid, W.D., Alexander, R.F., Bocking, R.C., Bussanich, R.J., and Cox-Rogers, S. 2017. Gingit Creek and Lower Nass River sea-type Sockeye Salmon (*Oncorhynchus nerka*) escapement and stock characteristics: 1994 to 2015. Rapp. manus. can. sci. halieut. aquat. 3121: ix + 61 p.

Le Département de Pêcheries, de la Faune et de la Flore du Gouvernement Nisga'a Lisims fait une enquête sur l'échappement de saumons Sockeye (*Oncorhynchus nerka*) du ruisseau Gingit depuis les années 2000. Ici, nous présentions une révision des échappements basée sur une méthodologie robuste et standardisée de l'aire sous la courbe et révisons l'abondance et les données biologiques dans le contexte des enregistrements historiques de la population de saumons Sockeye dans les affluents de la rivière Nass. Plus de 90% des saumons Sockeye du ruisseau Gingit vont à la mer à leur premier été après l'apparition et les adultes qui retournent sont principalement âgés de 3_1 à 4_1 ans. Par rapport aux autres stocks de saumons de la rivière Nass, les poissons de la rivière Gingit Creek présentent systématiquement des périodes précoces de moment de remontées. L'échappement moyen à la rivière Gingit a augmenté de 1,388 (2000-2005) à 10,069 adultes (2010-2015). L'échappement au ruisseau Gingit a été réalisée par des accès améliorés vers les frayères par la suppression des digues de castors depuis 2000. Les données révisées sur la distance génétique suggèrent que la rivière Gingit Creek est le principal site de ponte pour une population de saumons rouges de type maritime génétiquement distincte qui fraient également dans d'autres affluents inférieurs de la rivière Nass. Cette population de type maritime de la rivière Lower Nass constitue une contribution importante à la pêche du Canada, du Nisga'a et des États-Unis, une contribution moyenne de 9% (ordre de 6 à 12%) du total de retour d'agrégats de saumon à la rivière Nass à partir des analyses génétiques menées de 2009 à 2015.

PREFACE

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1.0 INTRODUCTION

Nass River Sockeye Salmon (*Oncorhynchus nerka*) are harvested in both Canadian and Alaskan commercial fisheries and are critically important to the economic and cultural life of the Nisg̲a'a Nation. Since 1992, stock assessment efforts for Nass River Sockeye Salmon have been based on tagging adult fish (≥45 cm nose-fork length [NFL]) with spaghetti tags at two fishwheels operated by the Nisg̲a'a Fisheries and Wildlife Department (NFWD) near the community of Gitwinksihlkw (Figure 1) and recovering these tags upstream (NFWD 2016). Robust post-season escapement estimates are generated using Chapman's modified Petersen population estimator based on spaghetti tag recoveries at the Meziadin River Fishway, approximately 150 km upstream of Gitwinksihlkw (Alexander and Bocking 2004). Escapements of smaller non-Meziadin stocks of Nass River Sockeye Salmon are not individually assessed as part of the fishwheel mark-recapture estimate. However, spawning escapements of a number of non-Meziadin Sockeye Salmon populations have been regularly assessed using visual survey methods. Gingit Creek Sockeye Salmon have been the most regularly and comprehensively assessed of all non-Meziadin Nass River Sockeye Salmon populations.

Gingit Creek is a small groundwater fed system which drains a watershed area of 38 km^2 to the north of the Nisg̲a'a community of Gitlax̲t'aamiks (New Aiyansh; Figure 1). The origin of Gingit Creek is a groundwater spring that feeds a spawning pond approximately 50 m in diameter with a large centre island (referred to hereafter as the "head pond"; located at 55°13.236′N, 129°03.516′W). The head pond was constructed by the Fisheries and Oceans Canada's (DFO) Salmon Enhancement Program in 1986. Approximately 4,500 m of Sockeye Salmon spawning habitat is available downstream of the head pond. Gingit Creek flows into the lower Ksi Sii Aks (Tseax River) immediately upstream of its confluence with Tseax Slough, about 8 km upriver of the Gitwinksihlkw fishwheels (Figure 1).

Gingit Creek is the primary spawning site for sea-type Sockeye Salmon in the Nass River watershed. Sea-type Sockeye Salmon, a subtype of river-type Sockeye Salmon, do not require lake habitat for rearing and can therefore spawn in systems that are not proximate to large lakes (Wood et al. 2008). Sea-type Sockeye Salmon go to sea in their first year of life and return as 0-check adults (i.e., Gilbert-Rich ages with the subscript 1; e.g., 3_1, 4_1, 5_1) whereas river-type Sockeye Salmon rear for one or two years in side channel habitat. Gingit Creek is grouped with a number of Lower Nass River stocks and the Khutzeymateen River (a coastal stock) to form the Lower Nass–Portland river-type Sockeye Salmon Conservation Unit (CU) as defined by Canada's Wild Salmon Policy (Holtby and Ciruna 2007; Figure 2).

Gingit Creek was sporadically surveyed for spawning Sockeye Salmon prior to the implementation of the Nisg̲a'a Treaty in 2000. Since 2000, NFWD crews have annually inspected the system for beaver dams and counted spawning Sockeye Salmon. From 2003 on, systematic surveys of eight defined reaches have been carried out, with the total number of surveys ranging from three to nine. Beginning in 2011, NFWD implemented a standardized area under the curve (AUC) methodology which uses

Monte Carlo simulation to model variation in survey life and observer efficiency to generate confidence bounded escapement estimates. This methodology is now used to generate escapement estimates for multiple species and systems and has been applied retrospectively to revise Gingit Creek Sockeye Salmon estimates from years prior to 2011. The extensive surveys of Gingit Creek, combined with biological (size, age, and genetic) sampling and tagging at the Gitwinksihlkw fishwheels, has generated a large body of data that characterize the abundance, timing, and size and age distribution of Gingit Creek Sockeye Salmon. To date, these detailed data have not been collated and reported.

In addition to Gingit Creek surveys, Sockeye Salmon have also been observed and counted in other Lower Nass tributaries in the course of NFWD stock assessment activities directed at other species. Specifically, Sockeye Salmon have been routinely observed during Pink (*O. gorbuscha*) and Chum (*O. keta*) salmon surveys of Gitzyon Creek and a groundwater fed channel which flows into Tseax Slough downstream of the mouth of Ksi Sii Aks (commonly referred to as the Tseax Side Channel; Figure 1). Juvenile and adult Sockeye Salmon have also been counted and sampled at the Zolzap Creek juvenile and adult Coho Salmon (*O. kisutch*) fences which were operated by NFWD from 1992 to 2004 and again from 2010 to the present (NFWD 2011–2016).

This report collates abundance, timing, and biological data for Sockeye Salmon in Gingit Creek and other Lower Nass systems to improve understanding of the Lower Nass–Portland river-type Sockeye Salmon CU and to assess whether this CU currently includes one or more distinct populations of Sockeye Salmon. Specific objectives of this data review were to:

1. Document methods currently used to calculate confidence bounded escapement estimates for Gingit Creek Sockeye Salmon;
2. Revise Gingit Creek escapement estimates prior to 2011 using standardized AUC methodology, and compile all Gingit Creek escapement data into one document;
3. Compile and report all biological data from recent and historical Gingit Creek spawning ground surveys and all age and genetic data from the Gitwinksihlkw fishwheel test fishery that pertain to Gingit Creek (sea-type) Sockeye Salmon;
4. Report escapement and biological data for Sockeye Salmon surveys by NFWD in other Lower Nass tributaries; and
5. Review whether biological and abundance data support the inclusion of all Lower Nass Sockeye Salmon in a single conservation unit (Lower Nass–Portland river-type).

2.0 METHODS

2.1 GINGIT CREEK

2.1.1 Beaver Dam Management

A large impassable beaver dam is established annually on Gingit Creek near its confluence with Ksi Sii Aks (Figure 1; Figure 3A). The dam prevents Gingit Creek Sockeye Salmon from migrating upstream and in mid-July NFWD crews open the dam prior to the first stream survey (Figure 3B; Table C - 1). The date the dam is opened provides a known zero-count date for the AUC calculation (see AUC Escapement Estimates section below). Following each dam break, Sockeye Salmon immediately pass through the dam (Figure 3C). Subsequent visits to the dam by NFWD crews ensure that fish passage is maintained throughout the spawning migration.

2.1.2 Survey Methodology

Gingit Creek surveys are conducted between mid-July and early September (Table C - 1), with the first survey occurring within 2–3 days of the beaver dam being opened. Currently, Gingit Creek surveys are conducted on foot by a 2–4 member crew consisting of a lead-counter, a data recorder, and one or two carcass counters; prior to 2012, survey methodology was more variable. The crew walk upstream for 3,550 m from an old road crossing at 55°13.979′N, 129°05.300′W to the head pond. The lead counter, an experienced NFWD technician, counts live adult (≥45 cm) and jack (<45 cm) Sockeye Salmon in each of seven approximately 500 m reaches and the 50 m diameter head pond (Figure 1). For each reach, the lead-counter estimates their observer efficiency (OE; %; proportion of live adult Sockeye Salmon present that were thought to be successfully counted). While making live counts, the lead-counter calls out the number and colour of fishwheel test fishery applied spaghetti tags observed on live fish (Figure 3D). The data recorder keeps a tally of all live tags observed, organized by tag colour (Table A - 1; Table A - 2). Crew counting carcasses follow behind the lead-counter to avoid spooking fish and affecting live counts. All carcasses within and immediately adjacent to the stream are counted and pitched well beyond the stream bank to prevent recounting on subsequent surveys (Figure 3E). Prior to pitching, carcasses are checked for tags; all tags are retained and their colour and tag numbers recorded (Figure 3F; Table A - 3). Further, any tags found alone in the stream or on stream banks are also collected and documented.

2.1.3 AUC Escapement Estimates

Confidence bounded escapement estimates for Gingit Creek adult and jack Sockeye Salmon are currently (since 2011) calculated using the Microsoft Excel program AUCmonteMASTER 2.04. This program uses Monte Carlo simulation of variation in OE and survey life (SL) to develop a frequency distribution of escapement values. Algorithms were developed by DFO (Prince Rupert, BC) from past studies on the Skeena River and elsewhere. The program requires a number of inputs, including:

1. estimated OE on either an overall or survey specific basis;
2. magnitude and nature of variation in OE for Monte Carlo modeling purposes
    a. OE can be either normally (magnitude of variation in form of standard deviation) or uniformly (magnitude of variation in form of minimum and maximum values) distributed;
3. raw live counts by survey date;
4. stream length surveyed and total length of spawning habitat;
5. estimated SL;
6. magnitude and nature of variation in SL for Monte Carlo modeling purposes
    a. SL can be either normally (magnitude of variation in form of standard deviation) or uniformly (magnitude of variation in form of minimum and maximum values) distributed; and
7. number of iterations for Monte Carlo simulation.

For Gingit Creek, OE is modeled on a per-survey basis. Crew estimates of reach-specific OE are first filtered to remove very low values. This is based on the assumption that if viewing conditions were so poor that the crew estimated that they could only see a small proportion of the fish, then conditions were also too poor to accurately estimate that proportion. Accuracy of OE estimates is also more critical for lower values than for higher values (e.g., a 10% underestimation of OE when the actual value is 80% will overestimate the number of fish present by 14%; the same 10% underestimation when the actual value is 20% will overestimate the number of fish present by 100%).

The following rules are applied to filter OE estimates:

1. for an estimated reach specific OE of <25%, count data are discarded and the number of fish in that reach was estimated as described below (or data from that survey day are not used for escapement estimation);
2. for observer efficiencies between 25% and 50%, a value of 50% is used; and
3. for OE >50%, the estimated value is used.

The estimated survey-specific value of OE is calculated as the average of the reach specific estimates, weighted by the estimated total number of live salmon in each reach. This in turn is calculated by dividing the raw live count for each reach by the estimated OE for that reach. Therefore, if *r* = reach specific raw count, *o* = estimated reach specific OE, and n = the number of reaches, estimated survey-specific OE is:

$$\sum_{i=1}^{n} r_i \;/\; \sum_{i=1}^{n} (r_i \,/ o_i).$$

As OE is derived from crew estimates rather than measured values, variation in OE is modelled as uniform. For estimated observer efficiencies between 75% and 100%, the maximum value is set as 100% and the minimum value is the estimated OE minus the difference between 100% and the estimated OE. For estimated observer efficiencies between 50% and 75%, the maximum and minimum values of OE are set as the estimated OE ± 25%.

Raw count values for each survey are simply the sum of the raw live counts in the eight surveyed reaches. Where not all reaches were surveyed or count data from some reaches were discarded due to observer efficiencies below 25%, the count value for the entire survey area is expanded from the count in the reaches successfully surveyed. Expansion factors are drawn from a series of linear regressions through the origin of the observer efficiency expanded count for a subset of reaches against the observer efficiency expanded count for the entire survey area developed using data from successful surveys of all reaches between 2004 and 2015 (Table B - 1).

One AUC modelling issue should be noted for years where counts in the upstream reaches were expanded to the whole survey area using the regressions in Table B - 1. As OE was typically very high in the head pond and other upstream reaches, very little uncertainty was assigned to the weighted observer efficiency used to model escapement. The uncertainty in OE would have been higher if all reaches had been surveyed. For this reason the confidence bounds for escapement estimates generated from partial surveys at Gingit Creek may be too narrow.

Area under the curve escapement estimates for Gingit Creek Sockeye Salmon by NFWD assume that spawning occurs in an additional 1,000 m of habitat downstream of the 3,550 m survey area at a density 1/3 of that in the survey area. This is reflected in the estimate produced using AUCmonteMASTER 2.04 by entering the survey area as 3,550 m and the total stream length as 3,883 m, where the additional 333 m is 1/3 of the estimated 1,000 m of additional spawning habitat. The AUC algorithm then in-fills this additional un-surveyed 333 m using the average spawner density.

Survey life (days) is estimated using a tag-life curve for spaghetti tags applied at the Gitwinksihlkw fishwheels and observed during visual surveys. Spaghetti tags are applied at the Gitwinksihlkw fishwheels in colour batches, with different colours being applied for one to two week periods throughout the run. The estimated minimum total number of tags of each colour batch entering the Gingit Creek survey area is calculated as either (1) the sum of highest combined count (tags on live fish, carcasses, and found on the bank or stream bed) for any one survey date and all tags physically recovered from the stream on surveys prior to that date; or (2) the sum of all tags physically recovered on all surveys, whichever is larger. When tags are found in the stream or on the bank and are not attached to a fish, care is taken to ensure that they are only included in the analysis if they had been applied in the current year (tags from previous years are frequently encountered in Gingit Creek). The minimum total number of tags in the system is estimated by adding the estimated totals for each tag colour observed during surveys. A tag-life curve is generated using the total number of live tags observed on each survey. As the estimated minimum total number of tags in the survey area is not expanded to account for observer efficiency, the live tag curve is also not expanded. However, for surveys where not all reaches are counted, the number of live tags observed is expanded for unsurveyed reaches using the same expansion factors as used for total adult counts (see above; Table B - 1). The total number of tag-days is calculated as the area under the tag-life curve, and the survey life is calculated as tag-days divided by the estimated minimum number of total tags in the survey area.

Variation in survey life is modelled as normal. The standard deviation is estimated as the inter-annual standard deviation in the estimates of survey life calculated using tag-life curves. For 2011 to 2015 AUC estimates, we used the standard deviation of survey life for 2004 and 2007 to the estimate year. For retrospective AUC estimates (pre-2011; see below), we used the standard deviation of survey life estimates for 2004 and 2007 to 2015. Survey life was not calculated in 2005 nor 2006.

Frequency distributions of Gingit Creek adult Sockeye Salmon escapement are generated in AUCmonteMASTER 2.04 using the parameters described above and running the model for 10,000 iterations. The midpoint of the frequency distribution is selected as the escapement point estimate (Figure C - 1; Figure C - 2). An estimate of jack Sockeye Salmon escapement is also generated assuming the same observer efficiency and survey life parameters as used for adult Sockeye Salmon.

2.1.4 Retrospective Escapement Estimates

To ensure consistency and facilitate comparison among years, adult Sockeye Salmon escapement estimates for Gingit Creek for post-treaty implementation years prior to 2011 were recalculated where possible using AUCmonteMASTER 2.04. Where sufficiently detailed data were available, annual survey life estimates were calculated from tag-life curves. For other years, the average value of survey life (14.7 days) from years with tag-life curve based estimates (2004 and 2007 to 2015) was used for analysis. Detailed survey data used to calculate escapement estimates from 2000 to 2015 are reported in Table C - 1.

The ratio between peak live plus dead counts and the best AUC escapement estimates for years with robust estimates (see Results and Discussion section below) was also calculated. This ratio was then used to generate alternate escapement estimates from the peak counts observed in all survey years. In addition, an annual fishwheel based index of the escapement of Nass River sea-type Sockeye Salmon was calculated by multiplying the sea-type proportion of fish biosampled at the fishwheels (= corrected adult sea-type Sockeye Salmon aged divided by total adult Sockeye Salmon aged) by the aggregate escapement estimate for Nass Sockeye Salmon (see Appendix F for an explanation of how values for corrected adult sea-type Sockeye Salmon aged were obtained). The ratio between this fishwheel based sea-type Sockeye Salmon escapement index and the best Gingit Creek AUC escapement estimates for years with robust estimates was calculated (excluding 2007; see Alternative (non-AUC) Escapement Estimates section below). This ratio was then used to generate a time series of alternative Gingit Creek escapement estimates for all years since the beginning of the fishwheel program (henceforth referred to as the “fishwheel based Gingit Creek Sockeye Salmon escapement estimates”). Justification for this methodology is provided in the Results and Discussion.

Alternative escapement estimates were compared and the best escapement estimate for each year since 1994 was selected and classified according to the DFO escapement estimate classification system (Table G - 1).

2.1.5 Fishwheel Test Fishery, Tag, Age, and Genetic Data Review

To assess run timing of Gingit Creek Sockeye Salmon and Nass sea-type Sockeye Salmon as a whole, and to assess differences between estimates of sea-type Sockeye Salmon abundance in the aggregate run and escapement estimates at Gingit Creek, age, genetic stock ID and tag recovery data collected since 1994 were collated and analysed. For all tags recovered in Gingit Creek since 2001, the date of tag application at the Gitwinksihlkw fishwheels was used to generate a cumulative Gingit Creek run timing curve at the fishwheels. Tag-based run timing data were compared to a cumulative run timing curve for Sockeye Salmon biosampled at the fishwheels and identified as sea-type adult Sockeye Salmon (Gilbert-Rich ages 3_1 and 4_1) by scale analysis. Life history type of Gingit Creek Sockeye Salmon was assessed by collating all available age data for Sockeye Salmon biosampled on the spawning grounds or identified as Gingit stock at the Gitwinksihlkw fishwheels using genetic analysis. Size distribution of sea-type Sockeye Salmon sampled on the spawning grounds and at the fishwheels was also summarized to confirm that 3- and 4-year-old sea-type Sockeye Salmon are being classified as adults at the fishwheels and during visual surveys. The relative frequency of 3-year-old (i.e., 3_1) to 4-year-old (i.e., 4_1) sea-type Sockeye Salmon sampled at the fishwheels was also compared across years and related to annual estimates of net aggregate escapement above Gitwinksihlkw.

2.1.6 Gingit Creek Biological Sampling

Prior to the present study, age data had not been collected on the spawning grounds for Gingit Creek Sockeye since the late 1980s (Rutherford et al. 1994). To confirm that Gingit Creek spawners were dominated by the sea-type life history, Sockeye Salmon were biosampled on the spawning grounds at Gingit Creek in 2011 to collect size and age (scales) data. This also provided the opportunity to collect DNA samples to bolster the genetic stock ID baseline for Gingit Creek Sockeye Salmon.

A single biosampling session was conducted on 2 August 2011 at the Gingit Creek head pond. Sockeye Salmon were captured using a dip-net and nose-fork length, mid-eye fork length, and sex were recorded. Five scales were taken from the preferred area for aging and a tissue punch was taken from the caudal fin to be contributed to the Gingit Creek genetic stock ID baseline sample. An attempt was made to target jacks to determine their age class but few jacks were present.

2.2 OTHER LOWER NASS SYSTEMS

2.2.1 Gitzyon Creek

Beginning in 2012, the NFWD began conducting summer surveys of Gitzyon Creek from where it flows into Spencer Lake (part of the Ksi Sii Aks) to a point approximately one kilometre upstream of the Skateen Avenue culvert (total survey length approximately 2.0 km; Figure 1) to calculate escapement estimates for Pink and Chum salmon (NFWD 2013–2016). Sockeye Salmon were counted during these surveys, and from 2013 to 2015, Sockeye Salmon escapement estimates were calculated using a peak count methodology based on that used for Gingit Creek (see Retrospective Escapement Estimates in Gingit Creek section above). The sum of the OE expanded peak live count and the unexpanded carcass count for the same day (peak count) was divided by the ratio of high quality Gingit Creek AUC escapement estimates to peak counts for years prior to the estimate year (Table D - 1).

During surveys conducted in 2013 and 2014, NFWD crews also dip-netted Sockeye Salmon on the spawning grounds at Gitzyon Creek for biological sampling. Fish were measured for nose-fork length and scales were collected for aging, genetic distance analysis, and contribution to the Nass Sockeye Salmon genetic baseline.

2.2.2 Tseax Side (Groundwater) Channel

Beginning in 2005, and resuming from 2009 to the present, the NFWD has conducted summer surveys of a groundwater fed channel which emerges from the lava beds at 55°13.084′N, 129°6.332′W, and flows into Tseax Slough downstream of the mouth of Ksi Sii Aks (total survey length approximately 0.38 km; Figure 1) to calculate escapement estimates for Pink and Chum salmon. This channel is commonly referred to as the Tseax Side Channel. Sockeye Salmon were also counted during these surveys, and from 2012 to 2015 Sockeye Salmon escapement estimates were calculated using AUC methodology (see AUC Escapement Estimates in Gingit Creek section above). Survey life estimates for these AUC calculations were based on those used for Gingit Creek and are provided in Table D - 1.

2.2.3 Zolzap Creek

Zolzap Creek, which flows into the Nass River downstream of the Nisga’a community of Gitwinksihlkw, is a wild Coho Salmon indicator stream, and has been identified as a river-type Sockeye Salmon stream (Holtby and Ciruna 2007; Figure 2). Coded wire tags are applied to Coho Salmon smolts at a juvenile fence which is installed in the spring. Adult Coho Salmon are then captured, sampled and marked at an adult fence which is operated in the fall. Operation of these fences has provided the opportunity to capture and sample adult and juvenile Sockeye Salmon. Operations of the Zolzap Creek adult and juvenile Coho Salmon fences from 1992 to 2004 are detailed in Baxter and Stephens (2005) and references cited therein. The Zolzap Creek program was suspended from 2005 to 2009 and resumed in 2010. Operations from 2010 to the present are documented in NFWD annual program summary reports (NFWD 2011–2016). In most years, the Zolzap juvenile fence operated from April to June and the adult fence operated from August or September to November or December. While Coho Salmon were the focus of the Zolzap Creek project, all salmon (and other species) captured at the fences were enumerated and released. In some years, some or all of the Sockeye Salmon catch was sampled for length, weight (juveniles only), scales for aging, and scales or fin clips for contribution to the Nass Sockeye Salmon genetic baseline.

2.3 GENETIC DISTANCE ANALYSES

Genetic distances between all Lower Nass River Sockeye Salmon genetic baseline samples, Upper Nass River Sockeye Salmon baseline samples, and representative neighbouring river-type stocks (Stikine River) were determined by the Molecular Genetics Laboratory at the Pacific Biological Station. Estimates of between-stock genetic distance (F_{ST}; Weir and Cockerham 1984) were derived by averaging across 14 highly variable microsatellite loci, as described in Beacham et al. (2005). Juvenile Sockeye Salmon samples collected at Zolzap Creek in 1996 (n = 36), and adult samples collected in 1997 (n = 24), were treated as separate populations in this analysis. The samples collected at Gitzyon Creek in 2013 and 2014 (n = 31) were also included as a separate population.

3.0 RESULTS AND DISCUSSION

3.1 GINGIT CREEK ESCAPEMENT ESTIMATES

A detailed summary of escapement estimates for Gingit Creek for 1994 to 2015 is presented in Table 1. Each escapement estimate was classified with a quality value ranging from 1 (high) to 5 (low) based on DFO criteria (Table G - 1).

We recommend that the DFO escapement database (New Salmon Escapement Database [NuSEDS]) be updated to include these revised escapement estimates and classifications.

3.1.1 1994–2001 Escapement Estimates

No spawning ground surveys were conducted at Gingit Creek in 1994 or 1996–1999, and escapement estimates for these years are not currently included in the NuSEDS database. We recommend that escapement estimates for these years be based on the proportion of sea-type catch at the Gitwinksihlkw fishwheels (Table 1; see Fishwheel Based Sea-type Sockeye Salmon Escapement Index section below). These estimates are classified as having low quality (class 5).

According to BC16 records, an escapement estimate of 1,800 was calculated for Gingit Creek in 1995 on the basis of four stream inspections. The methods used to generate this estimate were not documented, so it is uncertain if this was a peak count or AUC estimate. However, given the absence of any better escapement data, this estimate was selected as the final escapement estimate for Gingit Creek in 1995 (Table 1; Figure 4) and classified as 4 (medium) on the DFO estimate quality scale.

In 2000 and 2001, insufficient surveys were conducted to generate AUC escapement estimates (Table C - 1). In 2000, two surveys were conducted, and an adult Sockeye Salmon escapement estimate of 930 was calculated for Gingit Creek using an expanded peak count method (see Alternative (non-AUC) Escapement Estimates section below). In 2001, 1,500 Sockeye Salmon were counted passing through the beaver dam at the time it was broken, but no spawning ground surveys were conducted. An estimate of 1,500 spawners is currently recorded for 2001 in the DFO NuSEDS database; however, given the extreme uncertainty of this estimate, we recommend that the fishwheel based Gingit Creek Sockeye Salmon escapement estimate of 2,053 be used instead (as described above for 1994 and 1996–1999).

3.1.2 2002–2010 Retrospective AUC Escapement Estimates

Retrospective AUC escapement estimates were calculated for 2002 to 2010 and the results are presented in Table 1. These AUC escapement estimates were selected as the best available estimates of escapement for Gingit Creek sea-type Sockeye Salmon in these years (Table 1; Figure 4).

For 44% of these estimates, quality was considered medium (class 4) due to limited survey coverage or uncertainty regarding data quality (2002, 2003, 2006, and 2008). The remaining estimates were high quality (class 3).

In 2002 and 2003, three surveys were conducted, with the final surveys occurring on 14 August and 7 August, respectively. To generate AUC estimates for these years, assumed counts were included for 20 August. For both years, these counts were assumed to be half of the count on the last survey date. A survey life of 14.7 ± 2.3 days (mean ± SD of the tag-life based estimates in 2004 and 2007 to 2015) was used for the AUC calculation. The AUC escapement estimate for 2002 (333; Table 1) was the lowest escapement for years covered by this report, and the escapement estimate for 2003 (2,172; Table 1) was the lowest odd year escapement. Due to the low overall number of surveys, the 2002 and 2003 escapement estimates were classified as 4 (medium quality) on the DFO estimate quality scale.

The level of detail of survey data collected in 2006 was lower than in other years (Table C - 1). It is uncertain whether the counts included only live fish or both live fish and carcasses. Further, no tag count data were collected and a survey life of 14.7 ± 2.3 days (mean ± SD of the tag-life based estimates in 2004 and 2007 to 2015) was used for the AUC calculation. The AUC estimate calculated for 2006 (1,040; Table 1) assumed that counts represented live adult Sockeye Salmon. Due to this uncertainty, the 2006 escapement estimate was classified as a 4 on the DFO estimate quality scale.

Only three surveys were conducted at Gingit Creek in 2008 with the first occurring on 19 August (Table C - 1). A survey life of 14.0 days was calculated by dividing the area under the tag-life curve (896 tag days) by an estimated minimum total of 64 tags in the survey area. The AUC escapement estimate (4,516; Table 1) was possibly an underestimate of the overall escapement to Gingit Creek in 2008 given that in many years, the peak count occurs prior to 19 August (Table 1). Due to the low number of surveys and the possibility that the peak count was missed, the 2008 escapement estimate was classified as a 4 on the DFO estimate quality scale.

For years with high quality estimates (2004, 2005, 2007, 2009, 2010), five to six surveys spanning the peak count were conducted (Table C - 1). Sufficient tag count data were also collected, permitting the calculation of year-specific survey life estimates (Table C - 1). The exception to this was 2005, where a survey life of 14.7 ± 2.3 days (mean ± SD of the tag-life based estimates in 2004 and 2007 to 2015) was used for the AUC calculation due to uncertainty around the tag counts. AUC escapement estimates for these years ranged from 851 (2004) to 6,743 (2007).

3.1.3 2011–2015 AUC Escapement Estimates

Since 2011, AUC methodology has been used to generate high quality escapement estimates for Gingit Creek using year-specific estimates of survey life based on detailed tag counts (Table 1). Further, survey frequency has been increased to seven to nine surveys per year. Some surveys in 2011, 2013, and 2015 were incomplete due to high turbidity in some reaches or wildlife encounters. For these surveys, live counts were expanded to account for the unsurveyed reaches (Table C - 1).

The average escapement for 2011 to 2015 (11,581) was three times the 2004 to 2010 average high quality escapement (3,858). The 2015 escapement estimate (20,228) was the highest ever recorded for Gingit Creek (Table E - 1) and its brood year (2011) had the second highest escapement (12,941).

3.1.4 Alternative (non-AUC) Escapement Estimates

Alternative methods of estimating Gingit Creek sea-type Sockeye Salmon escapement include: (1) expansion of the peak count (live plus dead); and (2) calculation of a fishwheel based Gingit Creek Sockeye Salmon escapement estimate using a combination of the post-season Nass River aggregate Petersen mark-recapture escapement estimate, the proportion of sea-type fish in the fishwheel catch, and a correction for uneven sampling between fishwheels during peak Gingit Sockeye Salmon migration. Evaluation of these methods required a “gold standard” of escapement estimates for Gingit Creek. The AUC escapement estimates between 2002 and 2015 that were classified as having high quality (class 3) were selected for this purpose (ten years; Table 1). The years with high quality AUC estimates are hereafter referred to as the “AUC standard years” and were used to relate Gingit Creek AUC estimates to peak counts and the fishwheel based sea-type Sockeye Salmon escapement index (Figure 5). The only exception was 2007 which was excluded from the fishwheel based escapement index calculation due to exceptionally high water in the early summer that resulted in unusual fishing conditions for the fishwheels during peak Gingit Sockeye Salmon migration.

Peak Count: The peak live plus dead counts averaged 58% (SD = 10%) of AUC standard year estimates (n = 10; Table 1). When the peak live and dead counts for all years were divided by this factor, the resulting expanded peak count values were highly correlated with AUC estimates (R^2 = 0.88; n = 14, intercept = 0; Figure 5), and were within the 90% confidence limits of the AUC escapement estimates (Table 1, Figure 4) for all years except 2015. From 2004 to 2014, live counts generally exhibited a distinct peak (Figure 6). In 2015, a year which saw the highest recorded escapement to Gingit Creek (20,228), live counts remained high for three consecutive surveys spanning the peak count (11 August 2015; Figure 6). The peak count (6,195) was only 29 fish greater than the previous survey (3 August 2015; Table C - 1). This prolonged peak likely explains the poor relationship between the AUC and peak count escapement estimates in 2015.

The expansion of a peak live and dead count appears to be a reasonably accurate method to assess escapement of Gingit Creek Sockeye Salmon. If for any reason it is not possible to conduct a comprehensive survey program in the future, results of a single survey conducted in mid-August could be expanded to generate a relatively reliable escapement estimate. It should be noted that since the peak count expansion factor is based on AUC estimates which account for 1,000 m of unsurveyed habitat below the survey reaches, the expansion should be applied to the count for the survey reaches alone. Given the unique run timing and life history of Gingit Creek sea-type Sockeye Salmon relative to other Nass stocks, the use of the peak count expansion factor developed for Gingit Creek to derive escapement estimates from peak Sockeye Salmon counts conducted on other systems (e.g., Gitzyon Creek) should be considered only in the absence of any other estimation method.

Fishwheel Based Sea-type Sockeye Salmon Escapement Index: The use of the sea-type (Gilbert-Rich ages 3_1 and 4_1) adult Sockeye Salmon catch at the fishwheels to derive an escapement estimate for Gingit Creek Sockeye Salmon assumes that Gingit Creek escapement represents a component of a larger sea-type aggregate stock and fluctuates in abundance with that stock. Age, genetic, and tag recovery data from the Gitwinksihlkw fishwheels and Gingit Creek are consistent with this scenario (see Gingit Creek Age and Run Timing section below).

The fishwheel based sea-type Sockeye Salmon escapement index averaged 207% (SD = 68%) of the AUC standard year estimates (n = 9; excludes 2007). When the fishwheel sea-type escapement index was divided by this factor, the resulting fishwheel based Gingit Creek escapement estimates correlated well with AUC estimates (R^2 = 0.85; n = 14, intercept = 0; Figure 5).

It is interesting that the fishwheel based sea-type Sockeye Salmon escapement index was generally so much higher than AUC and peak count based escapement estimates for Gingit Creek (Table 1; Figure 4). One possible explanation for this would be if Gingit Creek Sockeye Salmon have significantly higher catchability at the fishwheels than co-migrating stocks. There is evidence that Gingit Creek Sockeye Salmon do have unusual catchability, as tag recovery data suggest that the vast majority are caught at fishwheel 2 (FW2; Table 2). This is likely due to either geographic or olfactory cues localizing Gingit Sockeye Salmon to the south side (FW2 side) of the river as they approach Gingit Creek. If migratory cues are concentrating Gingit Creek Sockeye Salmon along the south bank, they could be particularly vulnerable to capture at FW2. However, if Gingit Creek Sockeye Salmon were captured with very high efficiency at the Gitwinksihlkw fishwheels, their spaghetti tag mark rate should be consistently higher than the aggregate mark rate observed at the Meziadin fishway. In fact, for the 10 years of stream survey data with good live tag observations, the mark rate for Gingit Creek was lower than the aggregate mark rate in five years (Table 1). Another possible explanation for the discrepancy between the fishwheel based sea-type escapement index and Gingit Creek escapement estimates could be disproportionately intensive harvest of Gingit Creek Sockeye by Nisg̲a'a in-river fisheries. Intensive harvests of Sockeye Salmon from June to early July have occurred between Gitwinksihlkw and Grease Harbour in some years since 2000 (e.g., 2002 (38% of the total harvest) and 2012 (33% of the total harvest); Mathews et al. 2012; NFWD 2016). However, on average from 2000 to 2015, only 14% (7,500) of the total mean harvest (54,000) of

Sockeye Salmon has occurred during the peak migration period of Lower Nass sea-type Sockeye Salmon.

Another explanation for the discrepancy between the fishwheel based sea-type escapement index and Gingit Creek escapement estimates is that some Nass River sea-type Sockeye Salmon are spawning outside of Gingit Creek. Rutherford et al. (1994) stated that other sea-type Sockeye Salmon populations existed in the Lower Nass besides Gingit Creek and the present study suggests the presence of sea-type Sockeye Salmon populations in Gitzyon Creek and the Tseax Side (groundwater) Channel (Table 3; and see Gitzyon Creek and Tseax Side (Groundwater) Channel sections below). However, the escapements observed in these systems are not adequate to account for the discrepancy between the fishwheel index and Gingit Creek escapements. One possible site of significant additional sea-type Sockeye Salmon spawning outside of Gingit Creek is Tseax Slough. Large numbers of Sockeye Salmon are often observed in the slough downstream of the mouth of the Ksi Sii Aks, and while it has typically been assumed that these fish are staging to move into Gingit Creek, they could also be spawning in the slough itself (Leonard Squires, NFWD Technician, personal communication). Another possible site of significant sea-type Sockeye Salmon spawning is the Tseax mainstem. Historical records exist of Sockeye Salmon spawning in the Tseax River (Table E - 1), but it is not consistently clear whether these records refer to just the Tseax mainstem, include the Tseax Slough, or even include tributaries including Gingit Creek. If sea-type Sockeye Salmon are spawning in habitat within or adjacent to the Tseax system, this would be consistent with the elevated catch of sea-type Sockeye Salmon at FW2. Future research should focus on locating concentrations of spawning Sockeye Salmon in the Tseax system outside of Gingit Creek and obtaining scale samples for aging as well as contributing to genetic baselines and further stock composition analyses.

Regardless of whether a significant proportion of sea-type Sockeye Salmon spawn outside of Gingit Creek, fishwheel based Gingit Creek escapement estimates are a respectable match for Gingit Creek AUC escapement estimates in most years and fluctuate with the same high odd year, low even year pattern (Table 1; Figure 4). Two notable exceptions are 2007 and 2002. The failure of sea-type abundance at the fishwheels to correspond to Gingit Creek escapement in 2007 is not surprising given the exceptionally high water experienced at the fishwheels in early summer. The catch of sea-type Sockeye Salmon at the fishwheels in 2007 was not typical, with later than normal run timing and an extremely low mark rate observed during stream surveys (Table 1). The discrepancy between the fishwheel based Gingit Creek escapement estimate (1,493) in 2002 and the very low AUC estimate (333) is interesting. Review of BC16 escapement records maintained by DFO reveals no record of any inspection of Gingit Creek from 1996 to 1998. It is possible that the dam at the lower end of Gingit Creek was not broken in 1998 (and possibly in one or more preceding years). If this was the case, the 2002 return would be primarily the progeny of brood which were unable to spawn in Gingit Creek, and as a result may not have been imprinted to return to Gingit Creek to spawn. This possible scenario emphasizes the importance of ensuring that the Gingit Creek beaver dam is adequately managed.

Given the lack of reliable alternative escapement data, the corrected sea-type run size was selected as the best estimate of escapement in 1994, 1996 to 1999, and 2001 (Table 1; Figure 4). These estimates were classified as 5 (low) on the DFO estimate quality scale (Table G - 1). The relationship between sea-type Sockeye Salmon catch proportions at the fishwheels and Gingit Creek escapement should continue to be investigated and refined as more annual high quality escapement estimates are generated for Gingit Creek in future years.

3.2 GINGIT CREEK AGE AND RUN TIMING

Review of DNA, age, and tag recovery data from the Gitwinksihlkw fishwheels and Gingit Creek suggest that Gingit Creek is the primary spawning site for an almost entirely sea-type, 4-year-old dominated population of Sockeye Salmon with a distinct and compressed early run timing.

Matched age and genetic stock ID data from fish sampled at the Gitwinksihlkw fishwheels were obtained in 2005, 2009, 2010, 2011, and 2013–2015. When only fish that were assigned to a given stock with ≥90% probability were considered, the unique age structure of Gingit Creek became evident. Between 97% and 100% of sea-type Sockeye Salmon sampled at the fishwheels were identified as Gingit Creek by genetic stock ID; and 92% to 95% of Sockeye Salmon identified as Gingit Creek stock went to sea in their first year. A similar pattern emerged when age data for Sockeye Salmon tagged at the fishwheels (2003–2015) and recovered in Gingit Creek were analysed, with 89% of recoveries being sea-type fish (Table 3). Biosampling of Sockeye Salmon on the Gingit Creek spawning grounds in 1987–1988 also revealed the same pattern (97% to 100% sea-type fish; Table 3).

To confirm historical and fishwheel based age data, 100 Sockeye Salmon were captured by dip-netting at the Gingit Creek head pond on 2 August 2011; of these, 81 were successfully aged from scales. While an attempt was made to target jacks, very few were present and only five were captured. All fish successfully aged were sea-type Sockeye, with 85.2% 4_1, 7.4% 3_1, and 7.4% 2_1. The average NFL of 4_1, 3_1, and 2_1 Sockeye were 62.1 cm, 60.7 cm, and 36.2 cm, respectively. All age 4_1 and 3_1 fish were >45 cm and would have been classified as adults either during stream surveys or at the fishwheels. One age 2_1 Sockeye Salmon was 48 cm NFL and would also have been classified as an adult. It is possible that this fish was actually a 3_1 as the number of years of ocean rearing can be difficult to determine for scales collected during spawning ground surveys. Tissue samples from all fish sampled were shipped to the Molecular Genetics Laboratory at the Pacific Biological Station for inclusion in the Gingit Creek genetic stock ID baseline.

Historical review of the age distribution of sea-type Sockeye Salmon biosampled at the fishwheels reveals a slightly different size–age distribution than 2011 Gingit spawning ground surveys. While almost 100% of age 2_1 fish caught at the fishwheels were <45 cm, 24% of age 3_1 fish were also <45 cm (n = 211). Most of these fish are only slightly smaller than 45 cm (Figure 7), so it is difficult to say whether crews would classify them as jacks or adults during visual surveys. The vast majority of “true jacks” (age 2_1) are at least 10 cm smaller than the 45 cm cut off. Overall, given that more than half of Gingit Creek adult Sockeye Salmon are generally age 4_1, it is unlikely that the presence of age 3_1 fish smaller than 45 cm is leading to significant errors in escapement estimation.

The age distribution of sea-type Sockeye Salmon at the fishwheels exhibits an annual fluctuation with a higher proportion of 4-year-olds relative to 3-year-olds in odd years (Figure 8). Beamish et al. (2010a) attributed a similar (but opposite) pattern in Harrison River sea-type Sockeye Salmon to fluctuations in abundance of Pink Salmon, with even year Sockeye Salmon that migrate to sea with very abundant Pink Salmon more likely to return as 4-year-olds due to competition for resources. As Pink Salmon generally return to Northern British Columbia rivers in greater numbers in odd years, this explanation is consistent with the observed age ratio and abundance fluctuation for Nass River sea-type Sockeye Salmon. However, the higher proportion of 4-year-olds at the fishwheels also corresponds to larger escapements of Gingit Creek Sockeye Salmon in odd years relative to even years (Figure 8). Therefore, a simpler explanation for this pattern is that two more-abundant brood cycles return primarily as 4-year-olds in odd years. The even year returns are therefore a combination of two very weak brood cycles of 4-year-olds and 3-year-olds spilling over from the more abundant odd year cycles.

Another line of evidence that Gingit Creek is a component of a distinct sea-type stock is provided by run timing data derived by two independent methods. When the fishwheel tagging dates for tags recovered during Gingit Creek spawning ground surveys are compared to the timing of sea-type Sockeye Salmon biosampled at the fishwheels, the run timing is nearly identical (Figure 9). The vast majority of sea-type Gingit Creek Sockeye Salmon pass Gitwinksihlkw in the last two weeks of June and first week of July, with approximately 50% of the run passing within three days either side of 25 June.

3.3 OTHER LOWER NASS SYSTEMS

3.3.1 Gitzyon Creek

Nisga’a Fisheries and Wildlife Department crews have conducted reconnaissance surveys of salmon escapement to Gitzyon Creek since 2012. Surveys have been conducted mainly in August and adult Sockeye Salmon have been observed each year (Table D - 2). Escapement estimates have been derived since 2013 and range from 612 (2014) to 1,360 (2015; Table D - 2). The much higher escapement in 2015 was consistent with the high Gingit Creek escapement and fishwheel based sea-type escapement index. These escapement estimates are much higher than the sparse estimates in DFO BC16 records from the 1950s to 1980s (<100 adults; Table E - 1).

In 2013 and 2014, 23 spawners were successfully aged from scales collected from 30 individuals (Table 3). Of these, 20 (87%) were aged 3_1 or 4_1 indicating that Gitzyon Sockeye Salmon are primarily sea-type. The Gitzyon Creek Sockeye Salmon run also seems to have similar timing to Gingit Creek. In 2015, Sockeye Salmon were only observed on the first survey (7 August; Table D - 1), suggesting that this was the tail end of the run. In 2013 and 2014, early August counts were higher than mid-August counts. Age-structure and run timing similarities between Gitzyon and Gingit Creek Sockeye Salmon were confirmed by genetic distance analysis (see Lower Nass Sockeye Salmon Population Structure Summary section below). Gitzyon Creek Sockeye Salmon surveys should commence in early to mid-July to determine run timing and to collect scale samples for aging and addition to the Gitzyon Creek genetic baseline.

3.3.2 Tseax Side (Groundwater) Channel

Since 2012, AUC escapement estimates have been calculated for Sockeye Salmon counted during Tseax Side (groundwater) Channel Pink and Chum salmon surveys (Figure 1; Table D - 1). Escapement estimates have ranged from 78 to 289, with the highest escapement observed in 2015, consistent with the high Gingit Creek escapement and fishwheel based sea-type escapement index. It is currently unknown if these fish represent a sea-type stock. In future years, scales should be collected from any carcasses found in this channel to determine age structure and for genetic analysis.

3.3.3 Zolzap Creek

From 1959 to 1979, an early Sockeye Salmon run was documented in Zolzap Creek, with counts ranging from 20 to 900 (Table E - 1). Fish from this run arrived at Zolzap Creek in early to mid-July and spawning was complete by mid to late August. After 1980, survey effort was shifted to Coho Salmon surveys later in the season (late August onwards). This later timing is after the Sockeye Salmon spawning period and could explain the lack of Sockeye Salmon counts in BC16 records after 1980. The life history of these fish is not known, but the early run timing was consistent with that observed for sea-type populations (Gingit and Gitzyon creeks).

Since 1997, 211 juvenile Sockeye Salmon captured at the juvenile Coho Salmon fence on Zolzap Creek, apparently migrating downstream, have been successfully aged (Table 3). The majority of these fish (55%) were age 2_2 or 3_3, suggesting a river-type stock. However, the remaining 45% of aged juveniles were young of the year (age 1_1), which could indicate a sea-type stock. It is possible that the age 1_1 juveniles caught at the fence were not actually smolting and migrating to sea but were rearing in Zolzap Creek in the vicinity of the fence. Another possibility is that the age 1_1 juveniles caught at the fence were sea-type fish from Gingit Creek or another sea-type population that moved into the lower portion of Zolzap Creek to feed prior to installation of the fence and were now migrating downstream. The Zolzap Creek smolt and adult fence site is located in a very low gradient reach close to where Zolzap Creek flows into the Nass River; during high water events this entire reach is a deep slow moving slough in which juvenile Sockeye Salmon could easily move upstream. During extreme high water events, the Nass River may even spill over its banks and flow into Zolzap Creek upstream from the fence site. It seems reasonable that juvenile Sockeye Salmon from other systems may at times use lower Zolzap Creek as rearing habitat or become trapped there by chance. The mean number of Sockeye Salmon smolts captured annually at the Zolzap Creek fence is low (194; NFWD 2016).

Adult Sockeye Salmon have also been captured and sampled at the annual adult Coho Salmon tagging fence in Zolzap Creek. Since 1995, 40 adults captured at this fence have been aged (Table 3) and only two were sea-type; most (63%) were aged 4_2. These data were insufficient to determine life history type (i.e., lake-type or river-type) and it is possible that these fish were not actually Zolzap Creek fish, but were just nosing into the system. The mean number of adult Sockeye Salmon captured annually at the Zolzap Creek fence is low (10; NFWD 2016), suggesting the absence of a significant late season spawning population.

Genetic distance analyses for adult and juvenile Sockeye Salmon collected at the Zolzap Creek fences suggest that these collections may include individuals from separate sea-type and river-type populations (see Lower Nass Sockeye Salmon Population Structure Summary section below). More juvenile and adult Sockeye Salmon data (age, DNA) are needed for Zolzap Creek to determine the status of this stock. Adult spawner surveys should be conducted in July to determine if the early run is still utilizing Zolzap Creek, and if present, scale samples should be collected for age and genetic analysis.

3.3.4 Seaskinnish Creek, Ishkheenickh River, Cranberry River, Tchitin River, and Brown Bear Creek

Sporadic BC16 escapement records are available for Seaskinnish Creek and Ishkheenickh River in the Lower Nass–Portland river-type CU and for Cranberry River, Tchitin River, and Brown Bear Creek in the Upper Nass river-type CU (Table E - 1; Table E - 2). We are not aware of any age data for the Lower Nass systems (with the exception of a single age 4_2 carcass at Seaskinnish Creek in 2010 [Duguid et al. 2011]) or for Cranberry and Tchitin rivers. In 2015, the Gitanyow Fisheries Authority (GFA) collected scale samples from Sockeye Salmon in Brown Bear Creek, a river-type population. Thirty-eight fish were fully aged, none were sea-type, and the majority (89%) were aged 4_2 or 5_2. The remainder (4) were age 3_2, 5_3, and 6_3.

Recorded escapements to these systems have generally been small (≤500) and, with the exception of Brown Bear Creek, no surveys have occurred in recent years. The GFA conduct annual spawner counts in Brown Bear Creek. Where available, peak spawning data suggests that Ishkheenickh River (mid-July), Zolzap Creek (late July to early August), and Seaskinnish Creek (late July to early August) share similar spawn timing with sea-type stocks (Gingit and Gitzyon creeks; Table E - 1). Peak spawning at Brown Bear Creek occurs in mid-October (Table E - 2). No spawn timing data were available for Cranberry and Tchitin rivers.

3.4 LOWER NASS SOCKEYE SALMON POPULATION STRUCTURE SUMMARY

Previous population genetic analyses which have included Lower Nass Sockeye Salmon are somewhat contradictory. Gustafson and Winans (1999) suggested that lack of differentiation in allozyme loci between populations of river-type and sea-type Sockeye Salmon suggests significant straying and gene flow. However, in their analysis of 38 populations of lake and river-type Sockeye Salmon from throughout the Eastern Pacific, Gingit Creek was not included in the clade that contained 10 out of 11 other river/sea-type populations. More recent analysis of variation at polymorphic microsatellite loci has indicated that sea-type or river-type populations generally group with other populations within the same drainage (Beacham et al. 2006, Wood et al. 2008). However, Wood et al. (2008) found Gingit Creek to be an exception as it did not group with other Nass River populations.

Previous analyses of genetic differentiation within the Nass watershed suggested that Zolzap Creek, Gingit Creek, and Brown Bear Creek (an Upper Nass river-type stock; Figure 2) grouped together and separately from Nass lake-type stocks (Beacham and Wood 1999). These authors analyzed adult (1997) and juvenile (1996) collections from Zolzap Creek separately, and found that the former was closer genetically to Brown Bear Creek, while the latter was closer to Gingit Creek. Subsequent analyses have grouped these Zolzap Creek collections together into a single population, possibly due to the 1997 samples being erroneously labelled as juvenile samples in the genetics laboratory database (Andres Araujo, Pacific Biological Station, personal communication). Beacham et al. (2004) analysed Northeast Pacific river- and sea-type populations using variation at polymorphic microsatellite loci, and found that this combined Zolzap sample grouped with Gingit Creek and Harrison River (a Fraser River population with close to 100% sea-type life history [Schaefer 1951]). This result is interesting, as the Gingit Creek and Harrison River populations were two of only five sea/river-type populations with a sea-type component of greater than 90% out of 43 populations reviewed by Gustafson and Winans (1999).

The genetic distance analyses in the present study (Figure 10) are consistent with those of Beacham and Wood (1999) in suggesting that the 1996 Zolzap Creek juvenile samples are more similar to the Gingit Creek population and the 1997 adult samples are more similar to the Brown Bear Creek population (Table H - 1). Unfortunately, age data are not available for the 1996 Zolzap Creek juvenile samples; however, in some years, either a large proportion (e.g., 2011) or all (e.g., 1997) juvenile Sockeye Salmon sampled at Zolzap Creek have been age 0 and potentially sea-type, while only two (2015) adult samples have been sea-type (Table 3). It is possible that some or all of the adult and juvenile samples collected at the Zolzap Creek Coho Salmon juvenile and adult fences may not be from Zolzap Creek spawning populations. We also included Gitzyon Creek samples in a genetic distance analysis for the first time and these fish were nearly identical to the Gingit Creek population which was unsurprising given their close geographic proximity, similar age structure, and early spawn timing.

All non-lake rearing Sockeye Salmon in the Lower Nass River and adjacent coastal regions are grouped in a single Canadian Wild Salmon Policy Conservation Unit (Holtby and Ciruna 2007; Figure 2). However, age, run timing, and genetic data presented here suggest the existence of a distinct population with almost 100% sea-type life history that spawns primarily in Gingit Creek and adjacent systems. This population has early and compressed run timing through the Lower Nass (late June) and also spawns earlier than other Nass Sockeye Salmon populations (peak in mid-August). Historical escapement records (Table E - 1) suggest that this population, or a similar one, also used to spawn in Zolzap Creek, Seaskinnish Creek, and Ishkheenickh River. This early (sea-type) population appears to be distinct from the scattered records and observations of fall spawning Sockeye Salmon in other Nass tributaries, including the collections of exclusively river-type adult fish at the Zolzap Creek adult Coho Salmon fence. Given the current data, the status of fall spawning river-type Sockeye Salmon in the Lower Nass River is very uncertain. Future considerations of Sockeye Salmon conservation unit status in the Nass Area should take into account this distinction and associated data gaps.

The fishwheel based sea-type Sockeye Salmon index and visual escapement estimates for Gingit Creek both reveal a dramatic increase in sea-type Sockeye Salmon returns between 2002 and 2015 (Figure 11). A contributing factor to the increase could be more consistent removal of beaver dams since 2000 that has allowed access to the spawning areas. Lower Nass sea-type Sockeye Salmon contributions to the net aggregate return have been relatively consistent from 2009 to 2015 (average 9%; range: 6–12%) based on recent genetic results (Table 4). Gitzyon Creek and Tseax Side (groundwater) Channel escapement estimates were consistent with peak abundance occurring in 2015. This sea-type increase has not been matched by an overall increase in aggregate Sockeye Salmon run size or in the estimated non-Meziadin escapement (Figure 11). However, in the Fraser River watershed, recent sea-type salmon population increases relative to conspecifics with more typical lake-rearing life histories have been attributed to different sea-entry timing combined with changing nearshore ocean conditions (Beamish et al. 2010a, 2010b, 2016). The change in abundance of sea-type Sockeye Salmon relative to other Sockeye Salmon stocks in the Nass River may reflect changing rearing conditions in the marine environment. More research is needed to understand the differences between Nass River sea-type and lake-type Sockeye Salmon stocks.

4.0 CONCLUSIONS

4.1 GINGIT CREEK

1. A beaver dam near the confluence of Gingit Creek and Ksi Sii Aks blocks passage of Sockeye Salmon during the spawning period in most years; this dam may not have been removed in 1998 (no record exists) leading to the lowest recorded escapement (333) in 2002. High harvests in the marine and in-river fisheries could also have contributed to the poor 2002 escapement.
2. Escapement estimates for Gingit Creek since 2002 were recalculated using a standardized AUC methodology. In 10 of 14 years, spawning ground observations of tags applied at the Gitwinksihlkw test fishery fishwheels facilitated calculation of annual survey life estimates; a mean of these survey life values was used to calculate AUC estimates in four years with inadequate tag observations.
3. Since 2011, AUC escapement estimates have been derived for jack Sockeye Salmon (<45 cm) in Gingit Creek (mean = 2,164).
4. Gingit Creek Sockeye Salmon spawn much earlier than most other Nass populations, with a mean spawning ground peak count date of 13 August.
5. Gingit Creek adult escapement has increased dramatically during the reporting period to a maximum of 20,228 in 2015 (2002–2015 average = 6,086).

6. Alternative escapement estimates derived by dividing the peak live count and same day carcass count at Gingit Creek by 58% are highly correlated with AUC based escapement estimates (R^2 = 0.88; n = 14; intercept = 0).
7. Peak count methodology was used to derive an escapement estimate of 930 spawners in 2000.
8. Historical and recent biological sampling at Gingit Creek confirm that the vast majority of Gingit Sockeye Salmon go to sea in their first year (sea-type) and return as 3- or 4-year-olds, with a component of 2-year-old jacks.
9. Sockeye Salmon biosampled at the Gitwinksihlkw fishwheels provide a complete time series of sea-type age and size distribution data since 1994.
10. An annual fishwheel based index of the escapement of Nass River sea-type Sockeye Salmon was calculated by multiplying the sea-type proportion of fish biosampled at the fishwheels by the net aggregate escapement estimate for Nass Sockeye Salmon. Dividing this fishwheel based sea-type Sockeye Salmon escapement index by 207% resulted in fishwheel based Gingit Creek escapement estimates that correlate well with AUC estimates (R^2 = 0.85; n = 14; intercept = 0).
11. The escapement estimate currently in the NuSEDS database for 2001 was based on a count of Sockeye Salmon through the dam on the day that is was broken. Based on the run timing of Gingit Sockeye in subsequent years, it is unlikely that this estimate accurately reflects escapement; the fishwheel based escapement estimate (2,053) is a better estimate for this year.
12. Twenty-four percent of 3-year-old sea-type Sockeye Salmon are <45 cm NFL, suggesting that visual spawning ground surveys may slightly underestimate adult abundance and overestimate jack abundance.
13. The proportion of 4-year-old sea-type Sockeye Salmon is higher in odd numbered years and corresponds to larger escapements; this likely reflects two dominant run cycles with the majority of fish from all run cycles returning as 4-year-olds.

4.2 OTHER LOWER NASS SYSTEMS

1. Escapement surveys targeting Chum and Pink salmon have identified mid-summer (August) “Gingit-type” Sockeye Salmon spawning in Gitzyon Creek and a groundwater fed channel flowing into Tseax Slough; other sea-type Sockeye Salmon spawning sites may also exist in the Lower Nass River.
2. Escapement estimates have been calculated for Gitzyon Creek since 2013 and in a groundwater fed channel flowing into Tseax Slough in since 2012. The high escapement estimates observed in 2015 (1,360 and 289, respectively) are consistent with peaks in the Gingit Creek estimate and the fishwheel based sea-type Sockeye Salmon escapement index in 2015.
3. Successfully aged scales collected from Sockeye Salmon in Gitzyon Creek in 2013 and 2014 (n = 23) confirmed that these fish went to sea in their first year (sea-type), as in Gingit Creek.
4. Genetic distance analysis has confirmed that Gitzyon and Gingit Creek Sockeye Salmon are genetically very similar.

5. It seems likely that all mid-summer spawning Sockeye Salmon in Lower Nass River tributaries constitute a genetically distinct and predominately sea-type population. This population has experienced a dramatic recent increase in abundance.
6. Zolzap Creek Sockeye Salmon have historically been considered a separate river-type population represented by a genetic baseline collected from juveniles at the Zolzap Creek Coho Salmon smolt fence in 1996 and adults collected at the adult Coho Salmon fence in 1997. Ages and microsatellite allele frequencies of smolts and adults captured at this fence suggest that in fact they likely represent more than one stock, including at least some Gingit-like sea-type Sockeye Salmon. Juvenile Sockeye Salmon collected in 1996 were genetically similar to the Gingit Creek population, while adults collected in 1997 were similar to the Brown Bear Creek population.

5.0 RECOMMENDATIONS

5.1 FISH PASSAGE

1. The beaver dam at the mouth of Gingit Creek should be breached no later than 17 July and should be rechecked several times to ensure it remains passable during the Sockeye Salmon spawning migration.

5.2 GINGIT CREEK SEA-TYPE SOCKEYE SALMON ASSESSMENT

1. If possible, all eight reaches of Gingit Creek should be surveyed at least five times starting within one week of breaking the dam and continuing to the beginning of September; at least one survey should be in mid-August to assess peak abundance.
2. On each survey, crews should record reach-specific counts of total live adults, dead adults, and live jacks and reach and colour specific counts of tags on live fish, carcasses, and found lying alone in the stream or on the bank.
3. Surveys should be timed to avoid periods of very low visibility (due to rain). If visibility is low for an extended period, surveys of all reaches should still be conducted to obtain tag counts (for survey life calculation). Crews can omit total live counts in reaches where observer efficiency is estimated to be less than 25% but should always conduct complete live counts in as many of the upper reaches as possible.
4. Annual AUC estimates of jack Sockeye Salmon abundance should be calculated to determine utility for predicting future returns.
5. If time or funds are limiting, five surveys of the head pond and top one or two reaches (500–1,000 m) could provide adequate data for a low quality estimate. Alternatively, one complete survey timed to coincide with the peak of spawning (mid-August) could also be used.
6. Peak count and the fishwheel based Gingit Creek Sockeye Salmon escapement estimates should continue to be refined using annual AUC escapement estimates in case AUC surveys cannot be completed in the future.
7. Reconnaissance surveys of other potential spawning sites for sea-type Sockeye Salmon should occur concurrent with peak spawning in Gingit Creek

(mid-August). If spawning fish are located, scales should be collected to confirm life history and for genetic analysis. Target locations for surveys include the Ksi Sii Aks, Tseax Slough, and Vetter Creek water fed channels flowing from the lava beds into the Nass River; reconnaissance surveys should focus on groundwater fed watercourses.

8. The revised escapement estimates presented in this document should be used to update the NuSEDS escapement database for Gingit Creek, with this document provided as a supporting reference. This includes the low quality fishwheel based escapement estimates for 1994, 1996 to 1999, and 2001.

5.3 LOWER NASS SOCKEYE SALMON STOCK STATUS

1. We recommend that “Zolzap Creek Juveniles” not be considered a distinct stock in any further Nass River Sockeye Salmon genetic stock identification.
2. Reconnaissance surveys of potential Sockeye Salmon spawning areas in Zolzap Creek should be conducted prior to fence installation (late July to mid-August) and adults should be sampled for age to confirm the life history type of Zolzap Sockeye Salmon.

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TABLES

Table 1. Escapement estimates and associated data for Gingit Creek Sockeye Salmon, 1994–2015.

Year	Number of surveys	Observer efficiency[a]	Tags in survey area[b]	Area under the curve: Survey life[c]	Area under the curve: Lower 90%CI	Area under the curve: Adult esc.	Area under the curve: Upper 90%CI	Area under the curve: Jack esc.	Peak date	Peak live + dead	Ratio of peak count to AUC	Expanded peak count[d]	Fishwheel based sea-type esc. index[e]	Final esc. est.	Quality of est.[f]	Aggregate mark rate[g]	Gingit mark rate[h]	Comments[i]
1994													2,628	**2,628**	5			
1995	4													**1,800**	4			Estimate derived from 4 inspections; method unknown
1996													1,370	**1,370**	5			
1997													5,731	**5,731**	5			
1998													3,868	**3,868**	5			
1999													3,074	**3,074**	5			
2000	2	80%							11-Aug	537		930	1,998	**930**	4	2.2%	3.6%	Final estimate uses expanded peak count
2001													2,072	**2,072**	5	2.6%	4.6%	1,500 observed when BD breached
2002	3	80%		*14.7*	258	333	462		08-Aug	249	75%	432	1,493	**333**	4	1.8%		MSL (14.7) and SD (2.3) used for AUC
2003	3	80%		*14.7*	1,652	2,172	2,998		07-Aug	1,119	52%	1,937	2,672	**2,172**	4	2.4%	2.8%	MSL (14.7) and SD (2.3) used for AUC
2004	6	95%	15	17.3	695	851	1,093		07-Aug	512	60%	887	1,277	**851**	3	3.1%	2.0%	
2005	6	83%		*14.7*	1,999	2,619	3,645		22-Aug	1,563	60%	2,706	3,391	**2,619**	3	2.7%	2.9%	MSL (14.7) and SD (2.3) used for AUC
2006	5	88%		*14.7*	808	1,040	1,426		01-Aug	643	62%	1,113	1,773	**1,040**	4	3.2%		MSL (14.7) and SD (2.3) used for AUC
2007	5	77%	49	17.9	5,227	6,743	9,066		23-Aug	3,903	58%	6,757	2,964	**6,743**	3	3.9%	1.0%	
2008	3	71%	64	14.0	3,166	4,516	6,821		19-Aug	2,426	54%	4,200	4,345	**4,516**	4	3.3%	2.0%	
2009	5	80%	149	14.3	4,882	6,491	9,099		23-Aug	3,831	59%	6,633	8,705	**6,491**	3	2.9%	3.2%	
2010	5	72%	48	13.0	1,821	2,540	3,758		11-Aug	1,551	61%	2,685	4,137	**2,540**	3	1.7%	2.9%	
2011	8	73%	241	12.6	9,651	12,941	18,785	1,961	08-Aug	7,335	57%	12,699	8,893	**12,941**	3	2.5%	3.0%	
2012	9	64%	117	11.5	5,270	7,381	11,248	1,356	23-Aug	3,321	45%	5,749	5,295	**7,381**	3	4.2%	2.8%	
2013	7	85%	122	15.9	7,840	9,862	13,036	2,402	16-Aug	7,049	71%	12,203	6,333	**9,862**	3	2.2%	1.6%	
2014	9	83%	76	17.2	6,005	7,493	9,757	2,343	17-Aug	5,032	67%	8,712	8,881	**7,493**	3	2.0%	2.3%	
2015	8	74%	384	12.9	15,001	20,228	29,518	2,760	11-Aug	7,973	39%	13,804	21,256	**20,228**	3	2.1%	3.1%	
Average	6	79%	127	14.7	4,591	6,086	8,622	2,164	13-Aug	3,136	58%	5,430	5,343	4,849	4	2.7%	2.7%	
SD[i]	2	8%	111	2.3	4,121	5,504	7,973	534		2,656	10%	4,599	5,004	4,729	1	0.7%	0.9%	

[a] Derived from survey specific estimates of observer efficiency (OE) weighted by the estimated number of fish in each survey; generated in turn from reach specific estimates of OE weighted for the number of fish estimated to be in each reach.

[b] Estimated minimum total number of tags in the survey area calculated from the maximum live and dead count for each tag colour for each survey added to all tags of that colour recovered on previous surveys.

[c] Calculated by dividing the area under a tag-life curve generated from counts of live tagged fish by the estimated minimum total number of tags in the survey area. Average survey life (italicized) was used for years without estimates.

[d] Calculated by multiplying the peak live plus dead count by the average peak count to AUC escapement estimate ratio for all years with high quality AUC estimates (Quality ≤3).

[e] Aggregate Nass Sockeye Salmon escapement estimate (NJTC 2015) multiplied by the proportion of sea-type Sockeye Salmon in the catch (corrected for unequal sampling between fishwheels in the month of June) and divided by the average ratio of this value to the AUC escapement estimates for all years with high quality AUC estimates (Quality ≤3). No estimate could be calculated in 1995 as only Fishwheel 2 operated in June. See Appendix F for details.

[f] Escapement estimate reliability classification assigned using the Fisheries and Oceans Canada system (Appendix G).

[g] Overall spaghetti tag mark rate for all Sockeye Salmon counted at the Meziadin fishway over the course of the season.

[h] Estimated by dividing the number of tags observed on live Sockeye Salmon during all Gingit Creek surveys in a year by the sum of the counts of live Sockeye Salmon (before expanding for observer efficiency) on those surveys.

[i] BD = beaver dam; MSL = mean survey life; SD = standard deviation.

Table 2. Proportion of sea-type Sockeye Salmon captured at fishwheel 2 (FW2) between 13–30 June and the proportion of tags recovered during Gingit Creek surveys that were applied at FW2, 1994–2015.

	Aged Sockeye Salmon (FW1 & FW2)				Gingit Creek tag recoveries[a]	
	All		Sea-type			
Year	n	Sampled at FW2	n	Sampled at FW2	n	Applied at FW2
1994	293	72.7%	33	97.0%		
1995	363	100.0%	77	100.0%		
1996	252	58.3%	17	82.4%		
1997	80	62.5%	62	79.0%		
1998	403	89.6%	62	95.2%		
1999	224	59.8%	63	95.2%		
2000	263	76.0%	39	94.9%		
2001	172	90.7%	58	100.0%	1	100.0%
2002	483	60.5%	13	76.9%	1	0.0%
2003	356	43.8%	30	63.3%	7	85.7%
2004	277	68.6%	21	90.5%	7	100.0%
2005	303	43.6%	39	71.8%	26	80.8%
2006	155	44.5%	18	61.1%	15	73.3%
2007	306	35.6%	39	87.2%	38	81.6%
2008	306	49.3%	50	76.0%	78	69.2%
2009	427	48.7%	83	89.2%	168	92.3%
2010	178	47.8%	28	78.6%	49	95.9%
2011	205	50.2%	80	88.8%	258	93.0%
2012	196	31.1%	74	74.3%	122	89.3%
2013	658	53.6%	71	73.2%	91	74.7%
2014	321	50.5%	74	73.0%	54	85.2%
2015	327	55.0%	229	70.7%	363	86.5%
Average[b]	298	58.8%	57	76.9%	85	85.2%

[a] Refers to tags applied in the year specified and subsequently recovered during Gingit Creek surveys in all years to date.

[b] Only years in which 50 ± 10% of the successfully aged fish were sampled at FW2 were included in the average for total % sea-type Sockeye Salmon sampled at FW2.
Only 2003–2015 included in the average FW2 proportion for recovered tags due to low recoveries in 2001 and 2002.

Table 3. Ages of adult and juvenile Sockeye Salmon sampled in Lower Nass River tributaries, 1987–2015.

			Age (Gilbert-Rich notation)														
Stream	**Life stage**	**Year**	**1_1**	**2_1**	**2_2**	**3_1**	**3_2**	**3_3**	**4_1**	**4_2**	**4_3**	**5_1**	**5_2**	**5_3**	**6_2**	**6_3**	**Proportion sea-type[a]**
Gingit Creek	Adult[b]	1987							37	1							97%
	Adult[b]	1988				25			55								100%
	Adult[c]	2003							1								100%
	Adult[c]	2005				1			1								100%
	Adult[c]	2007							3							1	75%
	Adult[c]	2008				3			2								100%
	Adult[c]	2011				4			20				2				92%
	Adult[b]	2011		6		6			69								93%
	Adult[c]	2012				3			8					1			92%
	Adult[c]	2013				2			7			1		2			83%
	Adult[c]	2014				7											100%
	Adult[c]	2015		1		7			40								100%
Gitzyon Creek	Adult	2013				6			6	1			1				86%
	Adult	2014				8			0	1			0				89%
Zolzap Creek	Adult	1995								1				1			0%
	Juvenile	1997	24														Unknown
	Adult	1997								9			3				0%
	Adult	1998									1		1	1			0%
	Adult	1999					1										0%
	Adult	2001											1				0%
	Juvenile	2010			16												0%
	Juvenile	2011	69		21												Unknown
	Adult	2011								2			1				0%
	Adult	2012								1			1				0%
	Juvenile	2013	1		70			2									Unknown
	Adult	2013					1			1							0%
	Adult	2014								11			2		1		0%
	Juvenile	2015			8												0%
	Adult	2015				2				7			6				13%

[a] The life-history type of age 1_1 fish is unknown. They could be smolts (sea-type) or resident (river-type).

[b] Ages are from Sockeye Salmon sampled in Gingit Creek.

[c] Ages are for fish sampled at the Gitwinksihlkw fishwheels for which tags were subsequently recovered in Gingit Creek.

Table 4. Stock composition estimates for Sockeye Salmon returns to Gitwinksihlkw on the Nass River in 2000–2002, 2005, 2009–2011, and 2013–2015.

Year	Run-size to Gitwinksihlkw	Proportion of run-size to Gitwinksihlkw by stock[a]					
		Gingit Ck.	Damdochax Ck.	Kwinageese R.	Bell-Irving R.	Meziadin R.	Brown Bear Ck.
2000	243,584	3.11	1.91	0.80	2.18	73.79	18.20
2001	206,033	6.89	5.58	3.22	2.72	71.66	9.94
2002	470,083	0.02	0.05	2.83	1.47	90.75	4.87
2005	285,916	2.88	1.07	3.76	2.03	81.00	9.26
2009	281,235	11.75	2.22	2.31	1.80	75.60	6.33
2010	261,597	9.23	2.15	4.87	3.24	65.44	15.06
2011	308,625	10.40	3.54	4.96	3.41	69.54	8.14
2013	248,513	6.82	3.42	1.17	2.73	82.84	3.02
2014	301,072	5.75	5.17	0.05	4.46	76.28	8.28
2015	469,466	10.09	3.27	6.92	2.64	68.08	9.00
Mean	307,612	6.69	2.84	3.09	2.67	75.50	9.21
Min	206,033	0.02	0.05	0.05	1.47	65.44	3.02
Max	470,083	11.75	5.58	6.92	4.46	90.75	18.20

[a] Genetic stock composition analyses included Brown Bear Creek, an Upper Nass river-type stock.

FIGURES

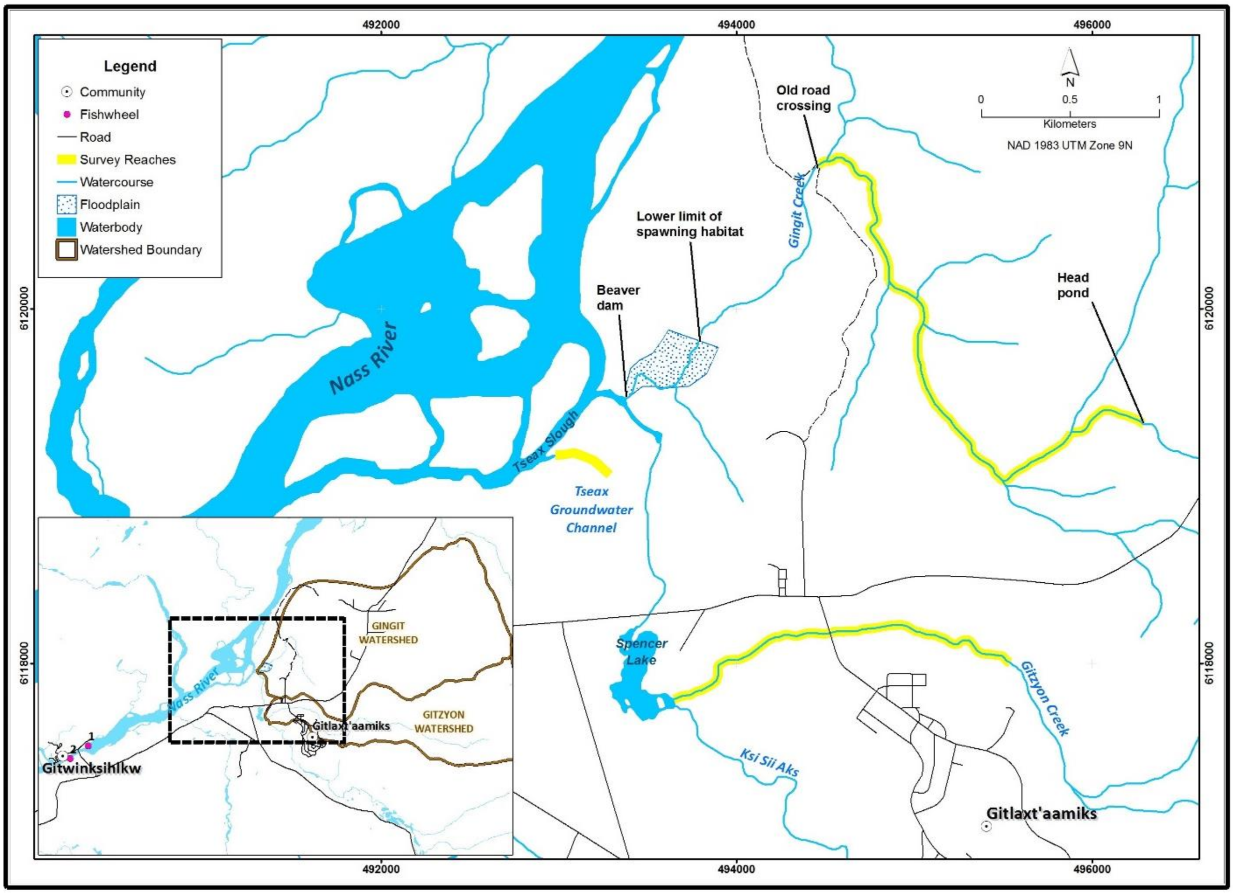

Figure 1. Location of Sockeye Salmon ground survey reaches in Gingit Creek, Gitzyon Creek, and the Tseax groundwater channel. The inset map shows the location the Lower Nass River fishwheels at Gitwinksihlkw relative to Gingit Creek.

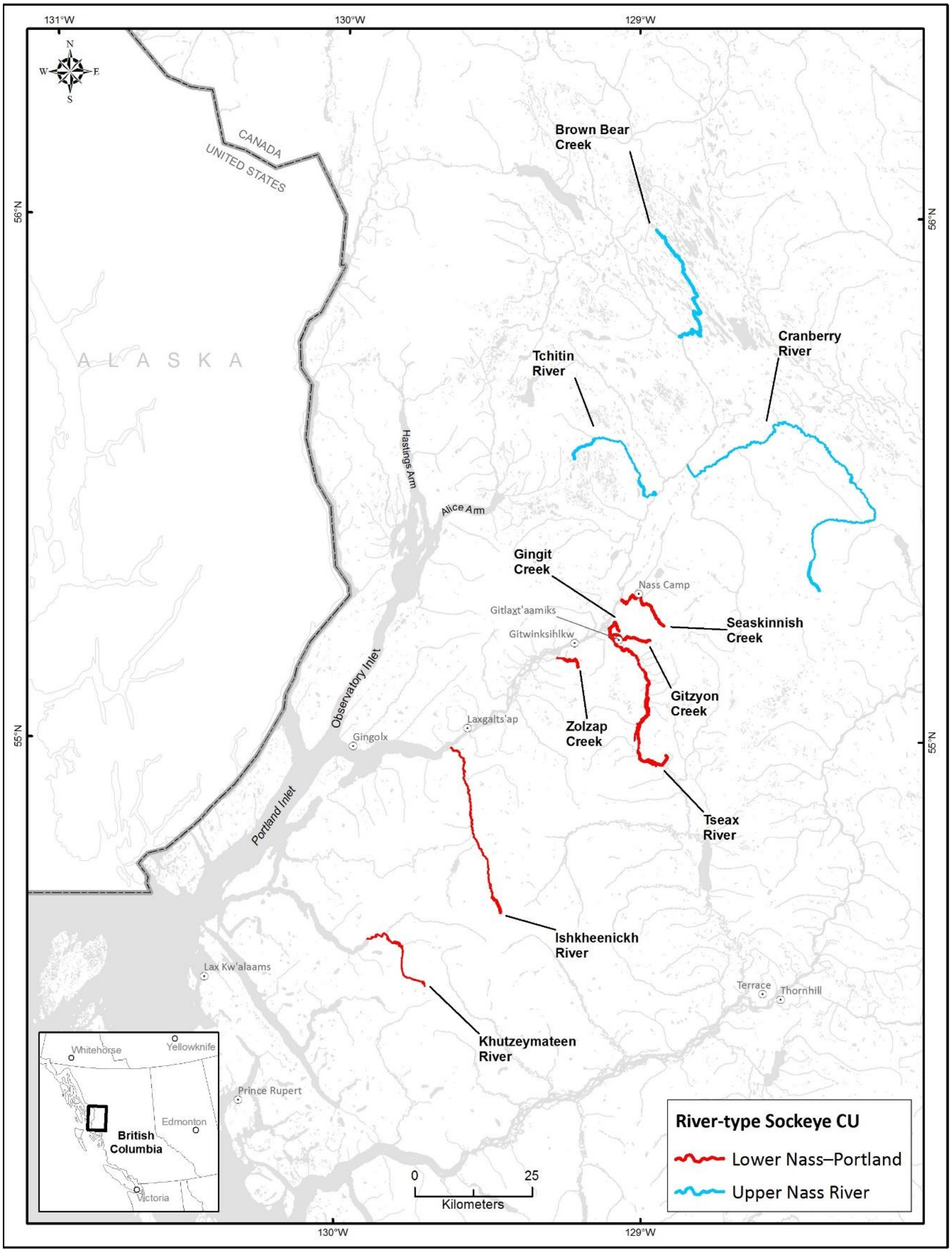

Figure 2. Sockeye Salmon streams in the Lower Nass–Portland river-type and Upper Nass river-type conservation units. Note that shading is used to denote the CU streams and not spawning locations.

Figure 3. Images from Gingit Creek, including: (A) large beaver dam near the creek mouth; (B) beaver dam after being opened by NFWD crew; (C) Sockeye Salmon swimming through opened beaver dam; (D) tagged (arrows) and untagged Sockeye Salmon in the head pond; (E) pitching a carcass out of the creek during a stream survey; and (F) a blue spaghetti tag found on a carcass on the streambank.

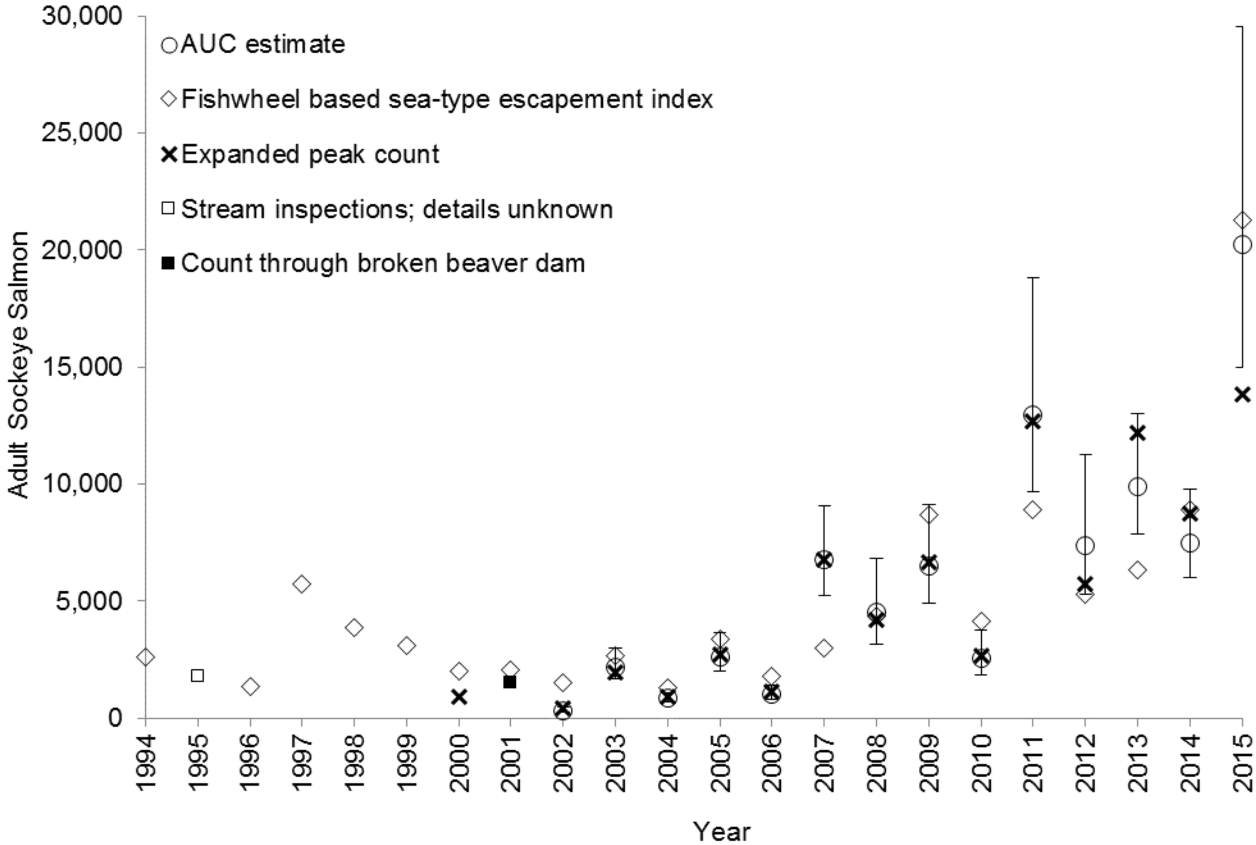

Figure 4. Alternative escapement estimates for Gingit Creek sea-type Sockeye Salmon, 2000–2015. Error bars show the 90% confidence intervals for the AUC estimates.

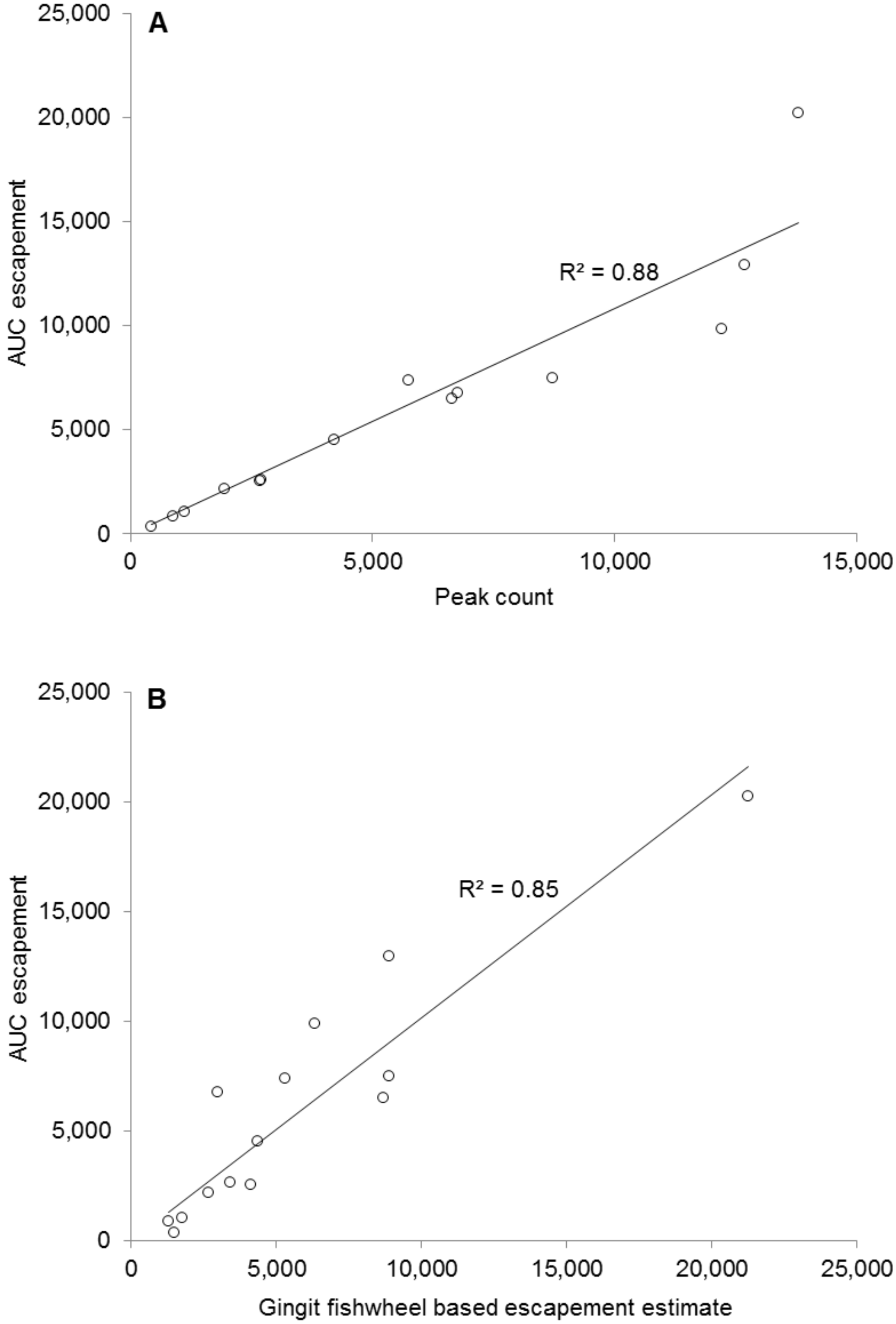

Figure 5. The relationship between Gingit Creek AUC escapement estimates and (A) peak count (expanded peak live plus same day carcass count divided by 58%) estimates and (B) the Gingit Creek fishwheel based Sockeye Salmon escapement estimate. Both estimates are highly correlated with the AUC escapement estimates.

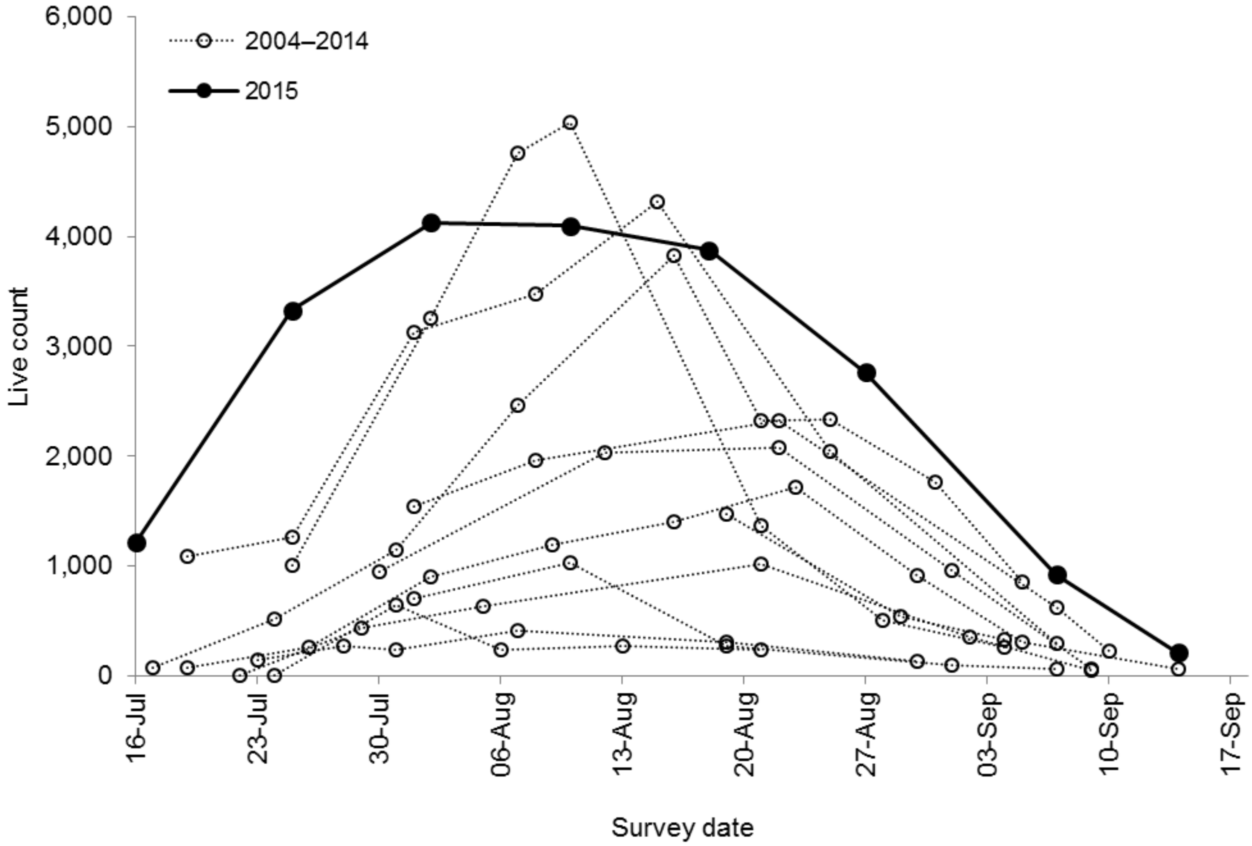

Figure 6. Prolonged high live Gingit Creek Sockeye Salmon counts in 2015 relative to counts from 2004 to 2014.

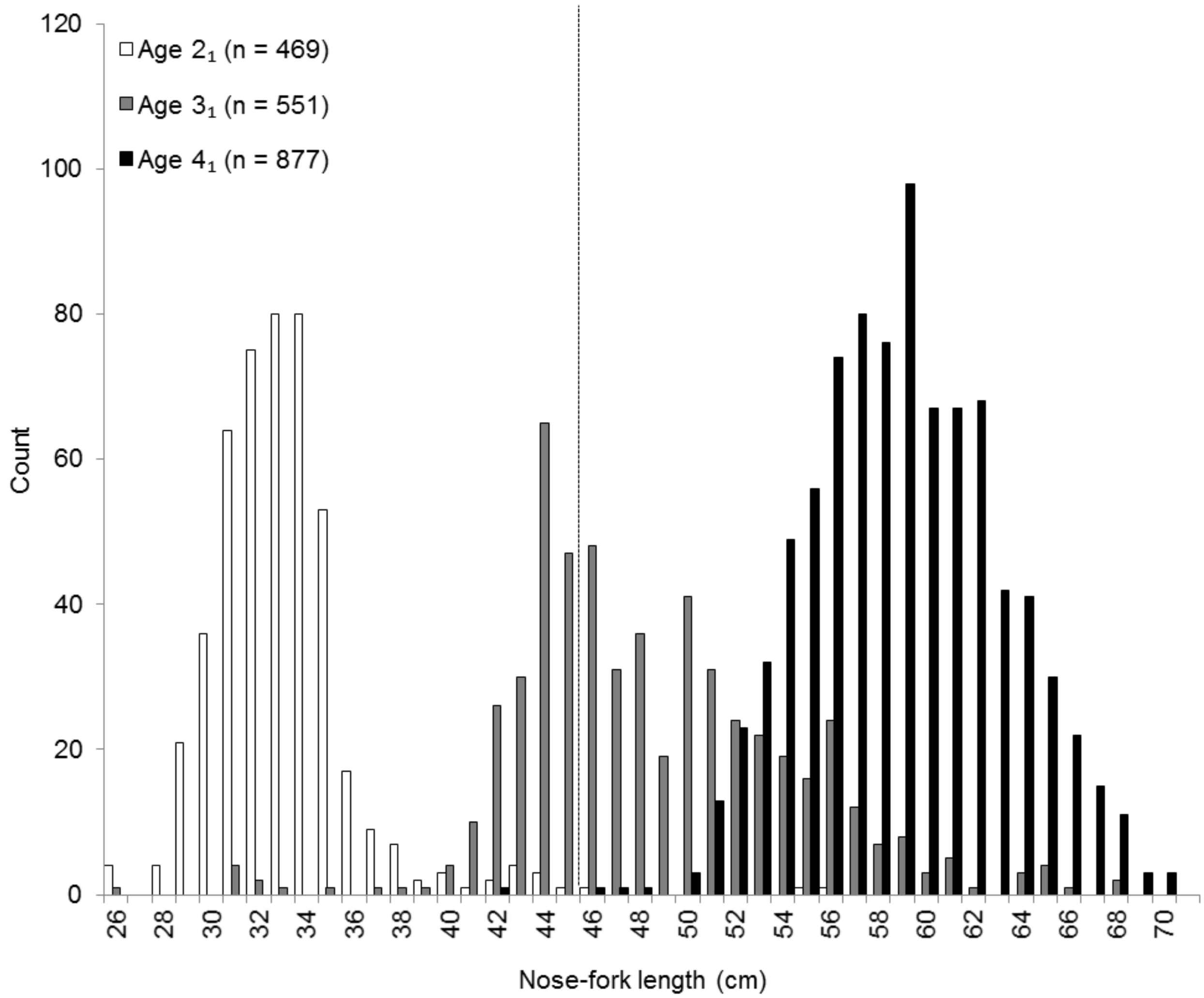

Figure 7. Size frequency distribution for age 2_1, 3_1, and 4_1 sea-type Sockeye Salmon sampled at the Gitwinksihlkw fishwheels, 2000–2015. The dashed vertical line is the fishwheel size cut-off for jacks (<45 cm) and adults (≥45 cm).

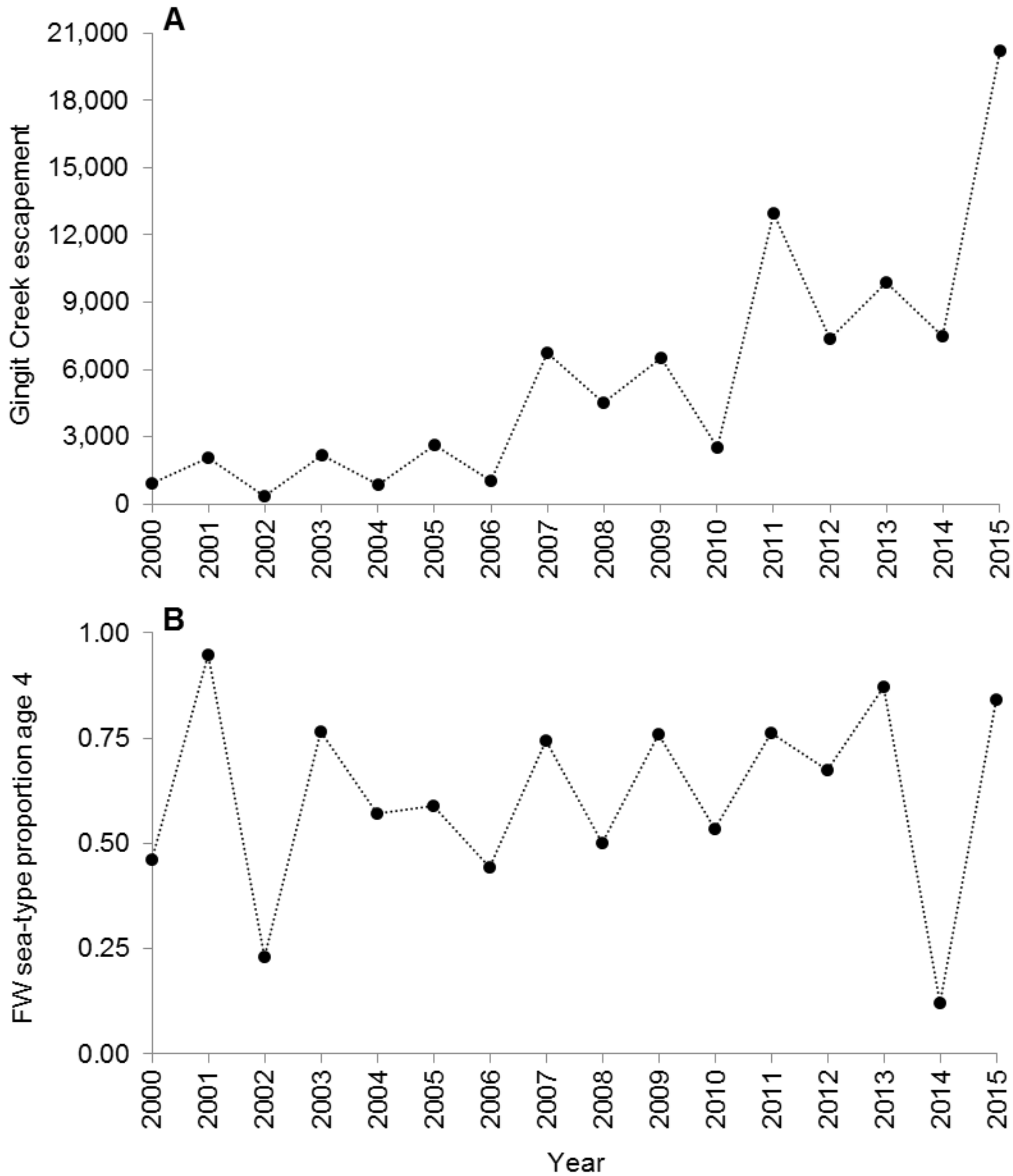

Figure 8. Gingit Creek Sockeye Salmon escapement (A) and the proportion of the fishwheel (FW) sea-type catch (ages 3_1 and 4_1) that was aged 4_1 (B), 2000–2015. A higher proportion of age 4_1 fish at the fishwheels corresponds to larger escapements to Gingit Creek in odd years relative to even years.

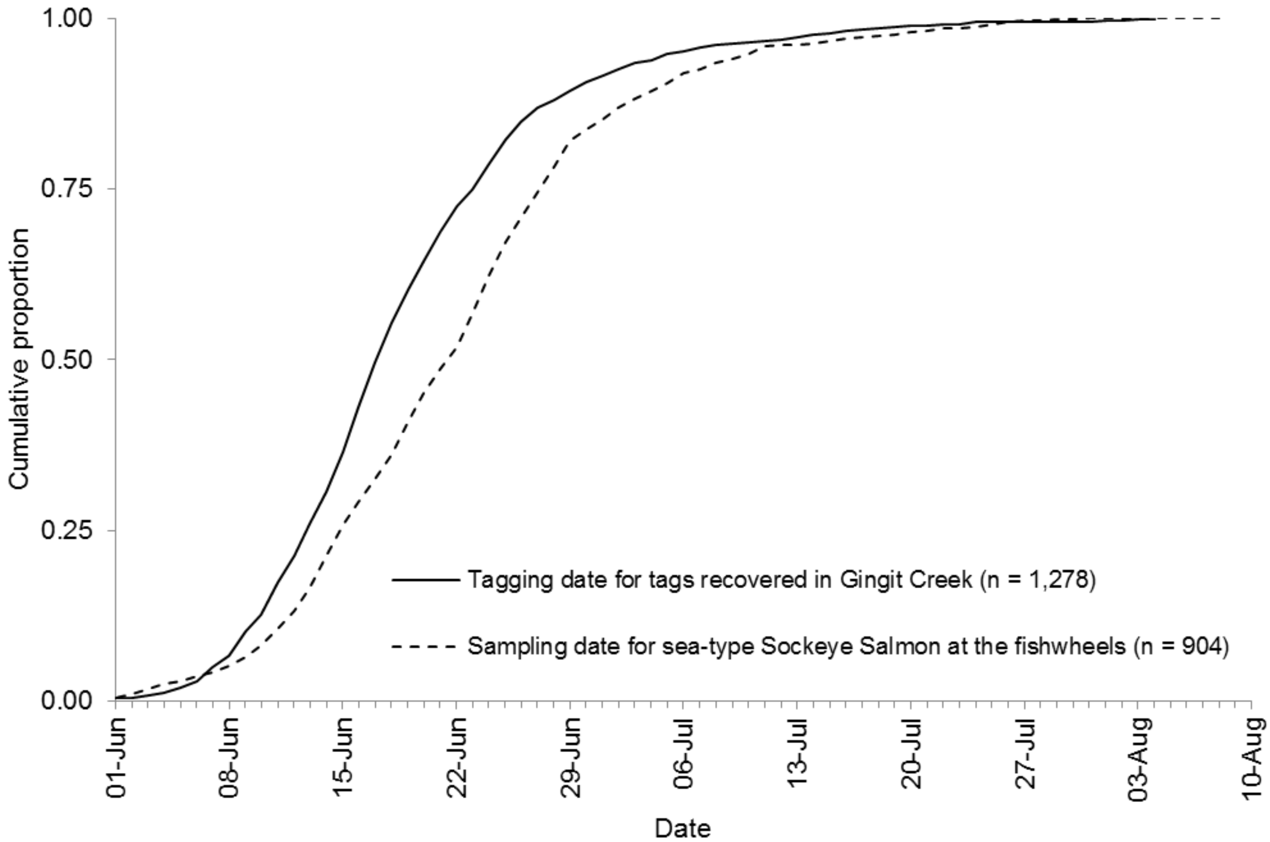

Figure 9. Cumulative proportional run timing of sea-type Sockeye Salmon sampled at the Gitwinksihlkw fishwheels (dashed line) and the fishwheel tagging date for tags recovered in Gingit Creek (solid line), 2001–2015.

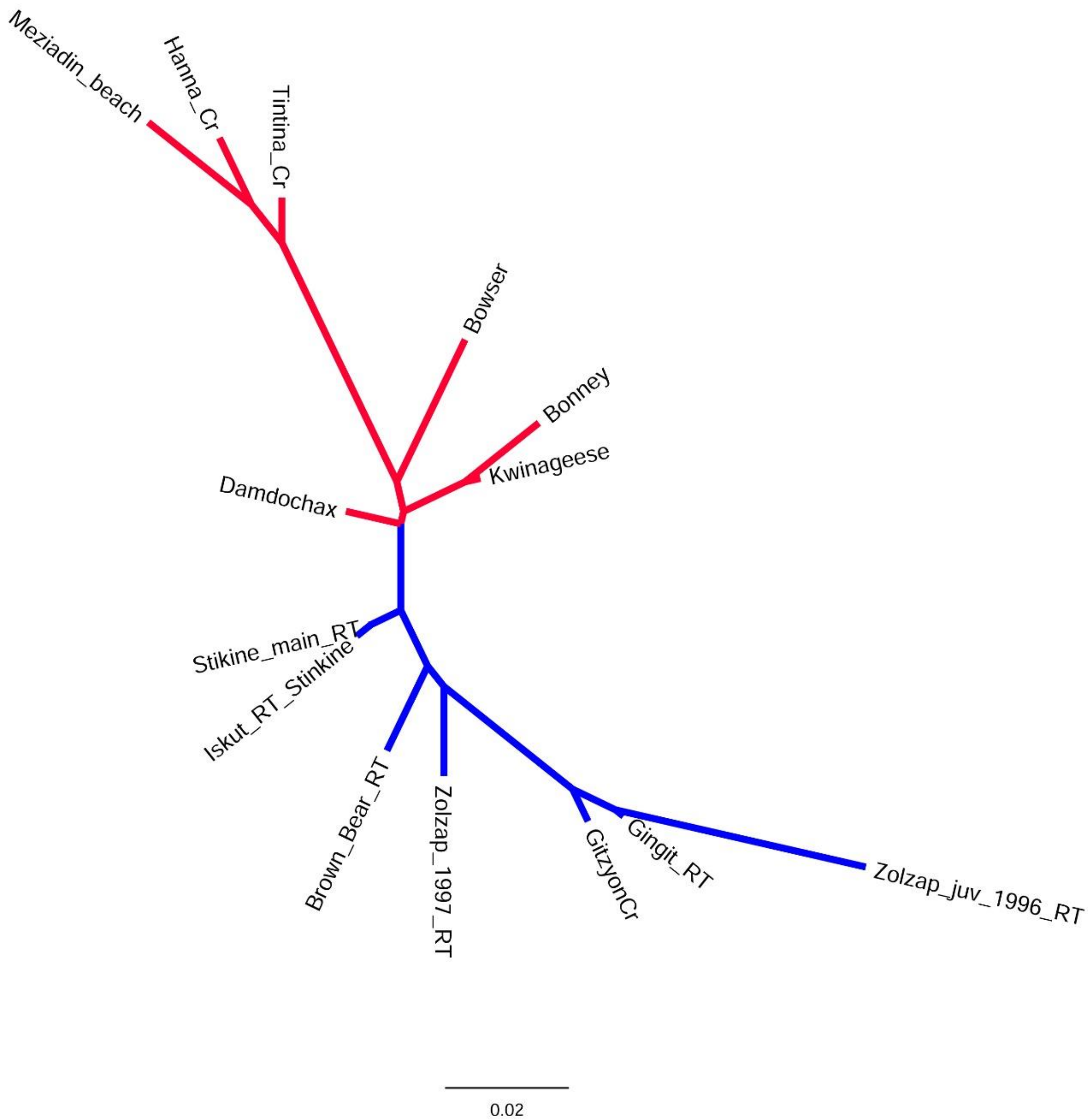

Figure 10. Neighbour joining tree of genetic distance (F_{ST}; Weir and Cockerham 1984) averaged across 14 highly variable microsatellite loci (as described by Beacham et al. 2005), for Nass River lake-type and river-type and Stikine River river-type Sockeye Salmon. Sea-type Sockeye Salmon (Gingit and Gitzyon creeks) are genetically very similar and are also the nearest neighbours of a collection of juvenile Sockeye Salmon from the Zolzap Creek smolt fence in 1996.

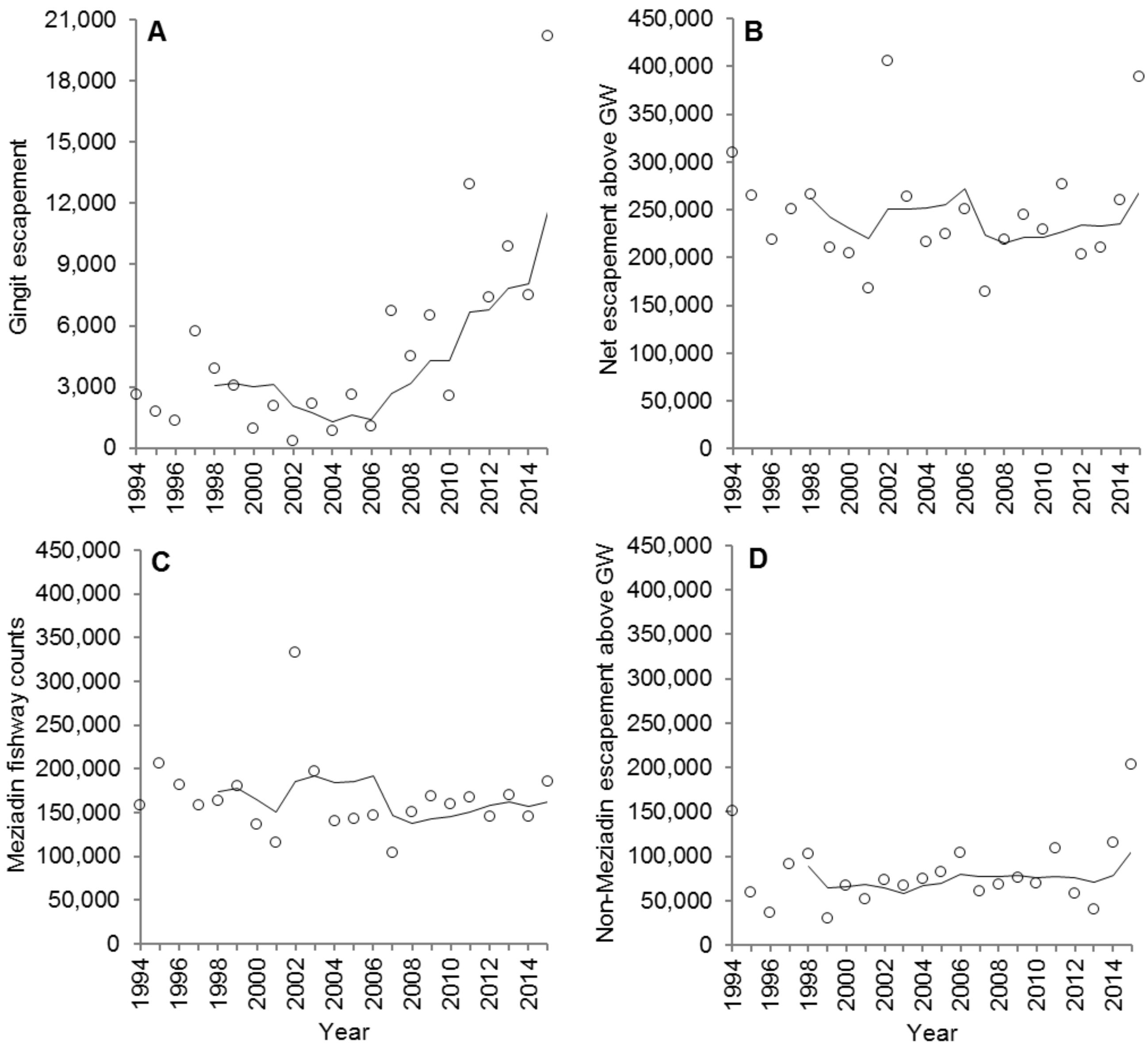

Figure 11. Sockeye Salmon escapement trends from 1994 to 2015 for: (A) Gingit Creek; (B) net aggregate above Gitwinksihlkw (GW); (C) Meziadin fishway; and (D) the non-Meziadin component of the net aggregate escapement above GW. Trend lines are five year moving averages. The pronounced increase in Gingit Creek escapement has not been matched by the net aggregate escapement, the Meziadin population, and the non-Meziadin component of the net aggregate escapement. The relative genetic contribution of Lower Nass sea-type stocks has been relatively stable since 2009 (average = 9%).

APPENDICES

Appendix A – Nisg̲a’a Fisheries and Wildlife Department survey forms

Table A - 1. Datasheet used by NFWD to record Gingit Creek Sockeye Salmon counts and physical data, 2015.

NFWD SOCKEYE COUNT and PHYSICAL SUMMARY FORM	Stream Name:	Crew:
Date (YYYY/MM/DD):	Start Time (00:00):	End Time (00:00):
Precipitation (circle): None Light Moderate Heavy Very Heavy		
% Overcast:	Air Temp (°C):	Water Temp (°C):

Reach: Start Time	Live Adult Count (Incl. Tagged)	Jacks (< 45 cm)	Observer Efficiency %	Carcass Count	% Spawning	Instream Visibility (m)	Turbidity (circle)	Photo #	Reach Comments
1:							Clear Tea Slight Muddy Glacial		
2:							Clear Tea Slight Muddy Glacial		
3:							Clear Tea Slight Muddy Glacial		
4:							Clear Tea Slight Muddy Glacial		
5:							Clear Tea Slight Muddy Glacial		
6:							Clear Tea Slight Muddy Glacial		
7:							Clear Tea Slight Muddy Glacial		
8:							Clear Tea Slight Muddy Glacial		
Total									
Comments:									

Table A - 2. Datasheet used by NFWD to record reach specific counts of tags on live fish, carcasses, and found alone during Gingit Creek Sockeye Salmon surveys, 2015.

GINGIT CREEK: TAG COLOUR COUNT FORM														
Date (yyyy/mm/dd):								**Crew:**						
		Sockeye Tag Identifier												
Rch	Rec. Type	OR	BRN	YEL	BLUE	DULL PK	LIGHT GREEN	DK/FOR GREEN	RED	FL. PINK	FL. GREEN	WH.	UNK.	**Total**
# 1	Live													
	Carcass													
	Tag Only													
# 2	Live													
	Carcass													
	Tag Only													
# 3	Live													
	Carcass													
	Tag Only													
# 4	Live													
	Carcass													
	Tag Only													
# 5	Live													
	Carcass													
	Tag Only													
# 6	Live													
	Carcass													
	Tag Only													
# 7	Live													
	Carcass													
	Tag Only													
# 8 HP	Live													
	Carcass													
	Tag Only													
Daily Total														

Notes/Comments: Tagged live Sockeye and carcasses should also be included in counts on count forms.

Table A - 3. Datasheet used by NFWD to record tag recovery data during Gingit Creek Sockeye Salmon surveys, 2015.

GINGIT CREEK TAG RECOVERY FORM

Date (YYYY-MM-DD):___________________________ Crew:________________________

Reach #	Tag #	Tag Colour	Tag on Carcass (C) or Found Alone (FA)	Old Tag (OT) or Current Year *	Comments

* To be completed in office

Appendix B – Gingit Creek survey count expansion factors

Table B - 1. Expansion factors (*a*) for expanding raw counts from a subset of successfully surveyed reaches to the entire Gingit Creek survey area. Expansion factors were based on linear regressions through the origin (y = *a*x) of observer efficiency expanded counts for successful surveys of all reaches between 2004 and 2015.

Reaches counted	2004–2010 (n = 21)		2004–2012 (n = 30)		2004–2013 (n = 36)		2004–2014 (n = 45)		2004–2015 (n = 51)	
	a	R^2	***a***	R^2	***a***	R^2	***a***	R^2	***a***	R^2
2-head pond	1.10	0.99	1.11	0.99	1.10	1.00	1.12	0.99	1.11	0.99
3-head pond	1.26	0.96	1.26	0.96	1.24	0.98	1.29	0.98	1.27	0.98
4-head pond	1.41	0.93	1.44	0.92	1.43	0.96	1.50	0.94	1.47	0.95
5-head pond	1.67	0.88	1.78	0.84	1.80	0.92	1.90	0.91	1.82	0.92
6-head pond	1.94	0.86	2.11	0.79	2.21	0.88	2.35	0.86	2.27	0.89
7-head pond	2.50	0.82	2.74	0.70	3.03	0.78	3.25	0.77	3.16	0.82
Head pond	3.85	0.47	4.27	0.39	5.16	0.38	5.69	0.42	6.03	0.54
1–6	1.55	0.93	1.43	0.93	1.43	0.93	1.43	0.93	1.43	0.93

Appendix C – Gingit Creek Sockeye Salmon survey count data

Table C - 1. Live, dead, and tag counts from Gingit Creek Sockeye Salmon surveys, 2000–2015. Not all counts (e.g., jacks) were made each year.

Date			Counts									Tags				
Year	Beaver dam breached	Survey	Live adult	Jack	Carcass[a]	Weighted observer efficiency[b]	Reaches successfully counted[c]	Surveyed reaches expansion factor[d]	Adult count expanded to all reaches	Observer efficiency exp. adult count	Jack count expanded to all reaches[e]	Live observed[f]	Live tags expanded to all reaches[g]	Recovered[h]	Estimated mark rate	Comments
2000		11-Aug	401		36	80%				501		12		2	3.0%	Peak live and dead = 537
		23-Aug	261		66	80%				326		12		0	4.6%	
2001	30-Jul	30-Jul	1,356		0							63			4.6%	Fish counted passing through beaver dam when dam broken
		30-Jul	150													Estimated fish still below beaver dam at end of count
2002	20-Jul	31-Jul	29		3	80%				36						
		08-Aug	181		23	80%				226						Peak live and dead = 249
		14-Aug	137		13	80%				171						
		20-Aug	68		6	80%				85						No count - assumed 1/2 of 14 Aug count
2003	15-Jul	25-Jul	35		0	80%				44		1		0	2.9%	
		31-Jul	755		7	80%				944		18		1	2.4%	
		07-Aug	872		29	80%				1,090		27		0	3.1%	Peak live and dead = 1,119
		20-Aug	436		15	80%				545						No count - assumed 1/2 of 7 Aug count
2004	15-Jul	23-Jul	39	0	1	100%	HP	3.85	150	150	0	0	0	0	0.0%	
		28-Jul	71	0	0	100%	HP	3.85	273	273	0	1	4	0	1.4%	
		31-Jul	241	10	6	91%	All		241	265	11	5	5	0	2.1%	
		07-Aug	371	25	55	89%	2 to HP	1.10	409	457	31	11	12	0	3.0%	Peak live and dead = 510
		19-Aug	308	0	61	97%	All		308	318	0	9	9	5	2.9%	
		30-Aug	36	1	20	100%	HP	3.85	139	139	4	0	0	1	0.0%	
2005	15-Jul	23-Jul	8		3	80%	All		8	10		0	0	1	0.0%	
		30-Jul	436		27	80%	All		436	545		21	21	0	4.8%	
		06-Aug	636		59	80%	All		636	795		18	18	2	2.8%	
		22-Aug	1,016		293	80%	All		1,016	1,270		25	25	7	2.5%	Peak live and dead = 1,563
		03-Sep	92		21	100%	HP	3.85	354	354		2	8	0	2.2%	
		10-Sep	13		40	100%	HP	3.85	50	50		0	0	1	0.0%	
2006	18-Jul	25-Jul	1			80%	All		1	1						
		01-Aug	167			100%	HP	3.85	643	643						Peak live and dead = 862
		07-Aug	236			80%	All		236	295						
		14-Aug	277			80%	All		277	346						
		22-Aug	242			80%	All		242	303						

Table C - 1 continued.

Date			Counts									Tags				
Year	Beaver dam breached	Survey	Live adult	Jack	Carcass[a]	Weighted observer efficiency[b]	Reaches successfully counted[c]	Surveyed reaches expansion factor[d]	Adult count expanded to all reaches	Observer efficiency exp. adult count	Jack count expanded to all reaches[e]	Live observed[f]	Live tags expanded to all reaches[g]	Recovered[h]	Estimated mark rate	Comments
2007	15-Jul	02-Aug	1,541		98	88%	All	1.00	1,541	1,745		24	24	0	1.6%	
		09-Aug	1,964		51	81%	All	1.00	1,964	2,432		15	15	2	0.8%	
		23-Aug	2,328		587	70%	All	1.00	2,328	3,316		26	26	2	1.1%	Peak live and dead = 3,903
		08-Sep	627		979	69%	All	1.00	627	905		3	3	17	0.5%	
		11-Sep	223		916	68%	All	1.00	223	328		0	0	9	0.0%	
2008	15-Jul	19-Aug	1,340		433	74%	2-HP	1.10	1,476	1,993		33	36	30	2.5%	Peak live and dead = 2,416
		29-Aug	540		277	70%	All	1.00	540	775		8	8	13	1.5%	
		04-Sep	334		87	63%	All	1.00	334	531		2	2	8	0.6%	
2009	16-Jul	31-Jul	949		96	92%	All	1.00	949	1,029		27	27	5	2.8%	
		13-Aug	2,027		364	75%	All	1.00	2,027	2,715		75	75	21	3.7%	
		23-Aug	2,082		1,111	77%	All	1.00	2,082	2,720		71	71	37	3.4%	Peak live and dead = 3,831
		02-Sep	964		1,956	92%	All	1.00	964	1,044		19	19	46	2.0%	
		10-Sep	68		700	84%	All	1.00	68	81		1	1	10	1.5%	
2010	21-Jul	02-Aug	702		77	83%	All	1.00	702	847		24	24	5	3.4%	
		11-Aug	1,026		0	66%	All	1.00	1,026	1,551		25	25	5	2.4%	Peak live and dead = 1,551
		20-Aug	269		88	68%	All	1.00	269	398		10	10	16	3.7%	
		02-Sep	52		0	79%	6 to HP	1.94	101	127		2	4	5	3.8%	
		08-Sep	42		4	83%	1–6	1.55	65	78		0	0	3	0.0%	
2011	17-Jul	26-Jul	919	24	137	79%	2 to HP	1.10	1,012	1,284	34	46	46	12	4.5%	
		03-Aug	2,315	67	242	71%	4 to HP	1.41	3,256	4,560	132	115	115	22	3.5%	
		08-Aug	2,841	194	423	69%	5 to HP	1.67	4,752	6,912	472	148	148	31	3.1%	Peak live and dead = 7,865
		11-Aug	3,581	321	376	76%	4 to HP	1.41	5,037	6,646	596	139	139	26	2.8%	
		19-Aug			295		None					19		11		Only 1-3 surveyed 9
		22-Aug	547	181	1,558	72%	7 to HP	2.50	1,367	1,906	631	11	27	48	2.0%	
		29-Aug	361	466	953	73%	4 to HP	1.41	508	693	895	13	13	36	2.6%	
		05-Sep	67	43	15	100%	HP only	3.85	258	258	166	0	0	4	0.0%	
2012	12-Jul	19-Jul	80	13	4	90%	All	1.00	80	89	14	3	3	3	3.8%	
		26-Jul	264	18	12	77%	All	1.00	264	341	23	16	16	2	6.1%	
		02-Aug	902	105	39	64%	All	1.00	902	1,400	163	35	35	6	3.9%	Some reaches had OE <50%
		09-Aug	1,191	220	177	61%	All	1.00	1,191	1,939	358	31	31	20	2.6%	Some reaches had OE <50%
		16-Aug	1,400	333	334	68%	All	1.00	1,400	2,065	491	34	34	14	2.4%	Some reaches had OE <50%
		23-Aug	1,716	350	466	60%	All	1.00	1,716	2,855	582	40	40	18	2.3%	Some reaches had OE <50%
		30-Aug	911	160	389	62%	All	1.00	911	1,474	259	26	26	16	2.9%	Some reaches had OE <50%
		05-Sep	312	37	190	85%	All	1.00	312	367	44	9	9	11	2.9%	
		14-Sep	58	13	9	84%	All	1.00	58	69	16	0	0	8	0.0%	

Table C - 1 continued.

Date			Counts						Adult			Tags				
Year	Beaver dam breached	Survey	Live adult	Jack	Carcass[a]	Weighted observer efficiency[b]	Reaches successfully counted[c]	Surveyed reaches expansion factor[d]	count expanded to all reaches	Observer efficiency exp. adult count	Jack count expanded to all reaches[e]	Live observed[f]	Live tags expanded to all reaches[g]	Recovered[h]	Estimated mark rate	Comments
2013	18-Jul	20-Jul	1,088	124	27	70%	All	1.00	1,088	1,550	177	24	24	3	2.2%	
		26-Jul	1,265	100	163	85%	All	1.00	1,265	1,486	117	24	24	3	1.9%	
		02-Aug	3,124	359	335	89%	All	1.00	3,124	3,521	405	48	48	4	1.5%	Reach 1 had OE <50%
		09-Aug	3,473	693	770	82%	All	1.00	3,473	4,261	850	48	48	11	1.4%	
		16-Aug	4,310	1,262	1,939	84%	All	1.00	4,310	5,110	1,496	70	70	25	1.6%	
		26-Aug	2,038	815	2,126	93%	All	1.00	2,038	2,198	879	37	37	28	1.8%	
		08-Sep	243	133	1,638	96%	3-HP	1.24	302	313	172	0	0	7	0.0%	Grizzly bear in Reach 1
2014	16-Jul	18-Jul	70	10	3	90%	All	1.00	70	78	11	0	0	0	0.0%	
		25-Jul	521	39	32	76%	All	1.00	521	688	52	13	13	1	2.5%	
		01-Aug	1,142	118	105	69%	All	1.00	1,142	1,663	172	17	17	3	1.5%	
		08-Aug	2,458	699	260	79%	All	1.00	2,458	3,113	885	32	32	5	1.3%	
		17-Aug	3,826	657	422	83%	All	1.00	3,826	4,610	792	46	46	8	1.2%	
		22-Aug	2,319	1,091	372	85%	All	1.00	2,319	2,732	1,285	32	32	8	1.4%	
		26-Aug	2,333	1,360	425	87%	All	1.00	2,333	2,692	1,569	31	31	8	1.3%	
		01-Sep	1,761	976	397	89%	All	1.00	1,761	1,971	1,093	20	20	12	1.1%	
		06-Sep	858	398	430	90%	All	1.00	858	953	442	20	20	5	2.3%	Grizzly bear in Reach 5
2015	15-Jul	17-Jul	1,216	3	15	77%	All	1.00	1,216	1,588	4	46	46	0	3.8%	
		26-Jul	3,328	32	262	82%	All	1.00	3,328	4,080	39	157	157	4	4.7%	
		03-Aug	3,718	105	815	67%	2 to HP	1.11	4,127	6,166	174	153	170	35	4.1%	Reach 1 OE = 20%; very turbid
		11-Aug	4,098	260	1,778	66%	All	1.00	4,098	6,195	393	133	133	65	3.2%	
		19-Aug	3,875	422	5,300	77%	All	1.00	3,875	5,063	551	79	79	118	2.0%	
		28-Aug	2,760	372	3,412	86%	All	1.00	2,760	3,210	433	34	34	84	1.2%	
		08-Sep	506	425	699	69%	5 to HP	1.82	922	1,339	1,125	5	9	21	1.0%	Reaches 1–4 muddy, 5% OE
		15-Sep	215	397	215	84%	All	1.00	215	255	470	2	2	26	0.9%	

[a] Carcass counts are not expanded for unsurveyed reaches and may be less complete on some days when crews focussed on counting live fish; large numbers also consumed by predators or dragged into forest.

[b] This is the average of reach-specific estimates of observer efficiency (OE) for all reaches successfully surveyed weighted by the estimated number of fish in each reach.

[c] Only reaches where the estimated OE was ≥25% are considered to have been successfully counted; where OE <25% or reaches are not surveyed, fish numbers are estimated by other means. HP = head pond.

[d] Derived from linear regressions of estimates of adult Sockeye Salmon for a subset of reaches against estimates for all reaches for dates between 2004 and 2015 on which all reaches were surveyed (n = 51).

[e] Except for 2004, jacks were not separately enumerated prior to 2011. The expanded jack count utilizes the same observer efficiency and unsurveyed reach expansion factors applied to adults and should be treated cautiously.

[f] Assumes that all live tagged fish are observed in each surveyed reach, regardless of estimated observer efficiency for untagged fish.

[g] For dates when not all reaches are surveyed, the estimated number of live tags is calculated by multiplying the number of live tags observed by the expansion factor for unsurveyed reaches.

[h] Only includes tags applied in the survey year that are recovered from either carcasses or that were found lying on the bank or streambed.

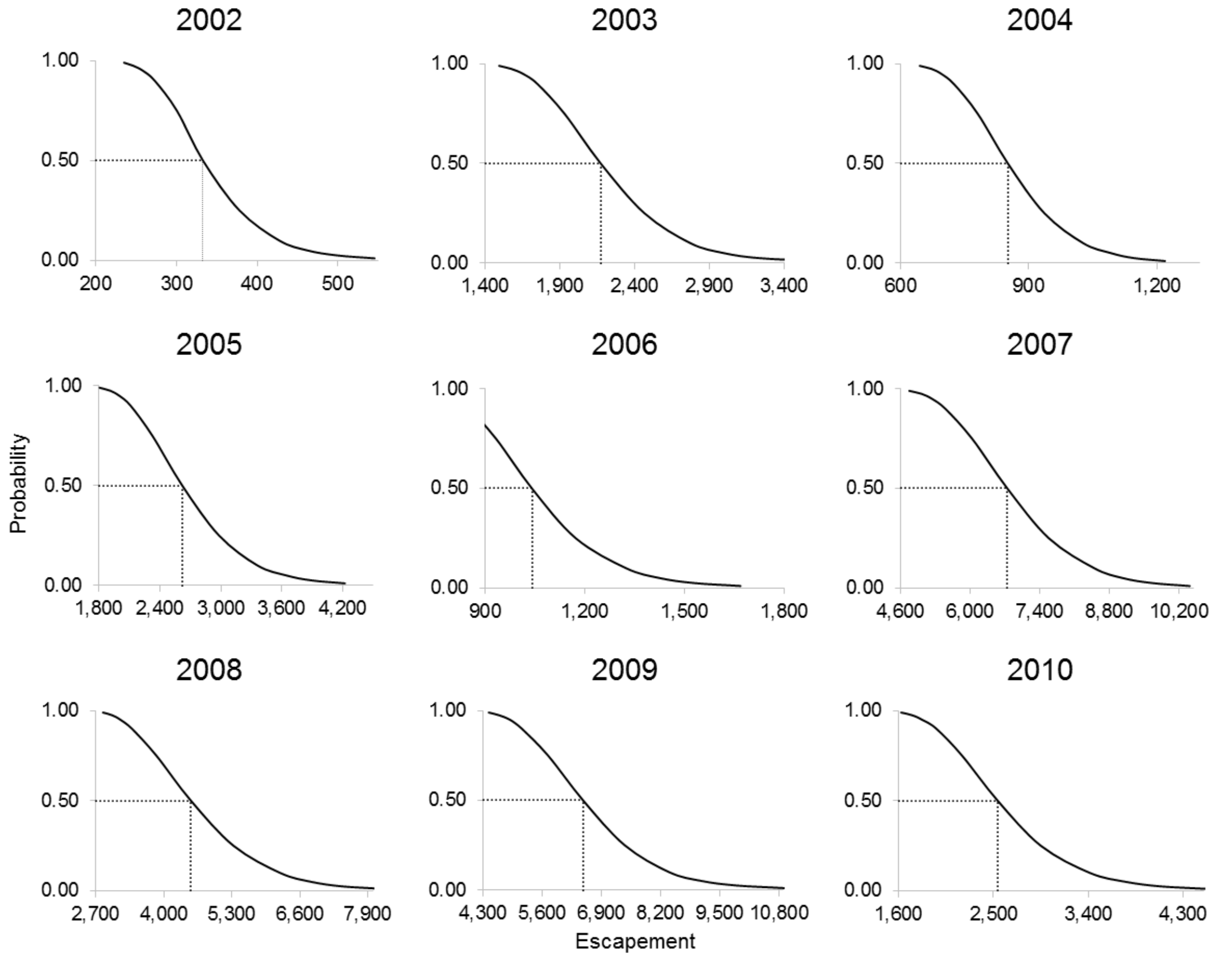

Figure C - 1. Probability distribution of retrospective AUC escapement estimates for Gingit Creek adult Sockeye Salmon, 2002–2010. Probability distributions were generated using AUCmonteMASTER 2.04 and the dashed lines show the escapement estimate for each year.

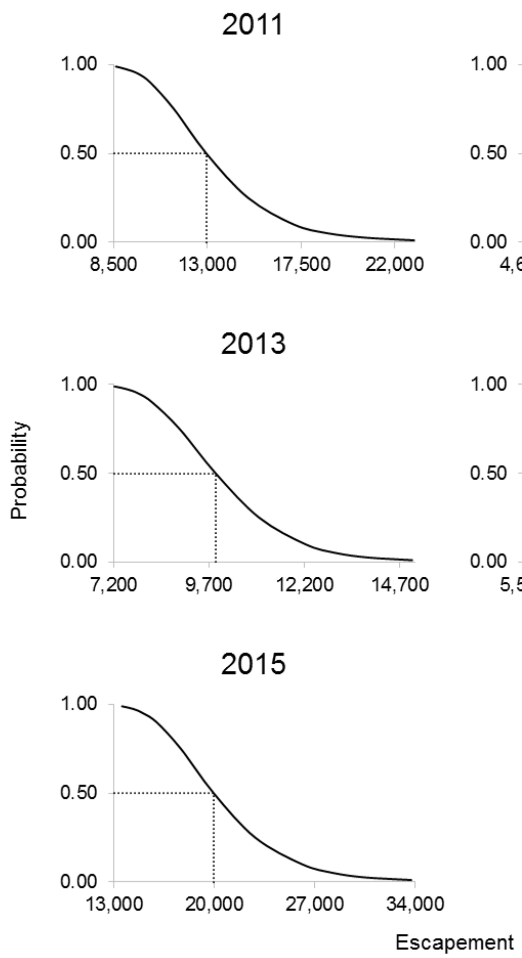

Figure C - 2. Probability distribution of AUC escapement estimates for Gingit Creek adult Sockeye Salmon, 2011–2015. Probability distributions were generated using AUCmonteMASTER 2.04 and the dashed lines show the escapement estimate for each year.

Appendix D – Gitzyon Creek and Tseax side (groundwater) channel survey Sockeye Salmon counts and escapement estimates

Table D - 1. Live and dead Sockeye Salmon counts from surveys in the Tseax Side Channel, 2012–2015.

			Raw count					AUC		
Year	Survey date	Section surveyed	Adult	Jack	Carcass	Weighted OE	OE expanded adult count	Survey life	Escapement estimate	Comments
2012	13-Aug	All (380 m)	22	0	1	0.90	24			
	20-Aug	All (380 m)	25	2	1	0.90	28			
	27-Aug	All (380 m)	9	2	0	0.90	10			
	03-Sep	All (380 m)	17	1	0	0.90	19			
	13-Sep	All (380 m)	11	0	0	0.90	12			
	18-Sep	All (380 m)	16	0	0	0.90	18			
	25-Sep	All (380 m)	2	0	0	0.90	2	11.5	94	Survey life = 2012 Gingit survey life
2013	01-Aug	All (380 m)	766	0	0	0.95	806			Large school at mouth; not included in AUC
	11-Aug	All (380 m)	375	0	0	0.95	395			Large school at mouth; not included in AUC
	19-Aug	All (380 m)	5	2	0	0.83	6			
	27-Aug	All (380 m)	26	10	0	0.96	27			
	03-Sep	All (380 m)	59	5	0	0.92	64			
	12-Sep	All (380 m)	16	4	0	0.89	18			
	23-Sep	All (380 m)	16	0	0	0.94	17	15.9	78	Survey life = 2013 Gingit survey life
2014	07-Aug	All (380 m)	0	0	0	0.75	0			
	14-Aug	All (380 m)	71	0	0	0.90	79			
	21-Aug	All (380 m)	5	0	0	0.90	6			
	27-Aug	All (380 m)	24	17	0	0.90	27			
	05-Sep	All (380 m)	36	0	0	0.90	40			
	13-Sep	All (380 m)	0	0	0	0.90	0	14.6	83	Survey life = 2000−2013 Gingit average survey life
2015	06-Aug	All (380 m)	122	NR	2	0.90	136			
	15-Aug	All (380 m)	149	NR	0	0.90	166			
	24-Aug	All (380 m)	13	NR	0	0.93	14			
	01-Sep	All (380 m)	15	NR	0	0.83	18			
	14-Sep	All (380 m)	17	NR	0	0.94	18			
	23-Sep	All (380 m)	11	NR	0	0.92	12	14.7	289	Survey life = 2000−2015 Gingit average survey life

NR = not recorded

Table D - 2. Live and dead Sockeye Salmon counts from surveys in Gitzyon Creek, 2012–2015.

			Raw count					Peak count		
Year	Survey date	Section surveyed	Adult	Jack	Carcass	Weighted OE	OE expanded adult count	Expansion factor[a]	Escapement estimate[b]	Comments
2012	27-Aug	NR	24	1	1	0.95	25	NA	NA	Reconnaissance survey
2013	04-Aug	Mouth to 2 km	326	9	20	0.94	348	0.58	634	
	10-Aug	Mouth to 2 km	210	4	18	0.95	220			
2014	06-Aug	Mouth to 2 km	280	0	5	0.83	356	0.59	612	
	16-Aug	Mouth to 2 km	60	2	7	0.89	67			
2015	07-Aug	Mouth to 2 km	470	NR	187	0.80	588	0.57	1,360	
	16-Aug	Mouth to 2 km	0	NR	0	0.83	0			Weighted OE based on Pink Salmon counts
	25-Aug	Mouth to 2 km	0	NR	0	0.90	0			Weighted OE based on Pink Salmon counts
	02-Sep	Mouth to 2 km	0	NR	0	0.50	0			Weighted OE based on Pink Salmon counts

[a] Calculated by applying the average (2004 to escapement year) ratio of peak live plus dead to robust AUC escapement estimates from Gingit Creek (see Table 1).

[b] Peak count = expanded peak live plus dead.

NR = not recorded

Appendix E – Fisheries and Oceans Canada Lower Nass BC16 escapement data summary

Table E - 1. DFO BC16 escapement and peak spawning estimates for Sockeye Salmon streams in the Lower Nass–Portland river-type conservation unit, 1950–2008. Blanks in the table indicate years without BC16 records. Khutzeymateen River is excluded as it is outside of the Nass Area.

	Gingit Creek		Gitzyon Creek		Tseax River		Ishkheenickh River		Zolzap Creek		Seaskinnish Creek	
Year	BC16 esc.[a]	Peak spawning	BC16 esc.	Peak spawning	BC16 esc.	Peak spawning	BC16 esc.	Peak spawning	BC16 esc.	Peak spawning	BC16 esc.	Peak spawning
1950	500−1,000	30-Jul	No Est.		No Est.		No Est.					
1951	1000−2,000	15-Jul	No Est.		No Est.		No Est.				No Est.	
1952	10,000−20,000	15-Jul	No Est.		No Est.		No Est.				No Est.	
1953	5,000−10,000	25-Jul	No Est.		No Est.		No Est.				N/I	
1954	500−1,000	30-Jul	No Est.		1,000−2,000	30-Jul	No Est.					
1955	1,000−2,000	25-Jul	No Est.		No Est.		No Est.				No Est.	
1956	5,000−10,000	12-Jul	No Est.		No Est.		No Est.				500−1,000	14-Jul
1957	5,000−10,000	31-Jul	50−100	07-Aug	300−500	01-Jul	N/I				100−300	03-Aug
1958	2,000−5,000	01-Aug	N/I		750	10-Jul	N/I				1−50	05-Aug
1959	4,000	25-Jul	100	10-Aug	5,000−10,000	05-Aug	N/I		400	05-Aug	No Est.	
1960	6,000	20-Aug	N.O.		No Est.		No Est.		500	30-Jul	No Est.	
1961	3,000	20-Aug	No Est.		No Est.		N/I		900	01-Aug	No Est.	
1962	500−1,000	20-Aug	No Est.		No Est.		No Est.		No Est.		No Est.	
1963	1,000−2,000	15-Aug	No Est.		500−1,000	NR	N/I		300−500	10-Jul	No Est.	
1964	1,000−2,000	25-Jul	No Est.		500−1,000	05-Aug	N/I		No Est.		No Est.	
1965	2,000−5,000	31-Jul	No Est.		2,000−5,000	10-Aug	No Est.		No Est.		No Est.	
1966	2,000−5,000	05-Aug	50−100	25-Jul	2,000−5,000	01-Aug	No Est.		No Est.		100−300	10-Jul
1967	2,000−5,000	20-Jul	50−100	20-Jul	300−500	05-Aug	No Est.		No Est.		1−50	15-Jul
1968	2,000−5,000	20-Jul	No Est.		500−1,000	05-Aug	No Est.		100−300	30-Jul	1−50	20-Jul
1969	100−300	20-Aug	No Est.		No Est.		No Est.		100−300	05-Aug	No Est.	
1970	2,000−5,000	10-Aug	No Est.		N.O.		No Est.		No Est.		100−300	10-Aug
1971	1,000−2,000	30-Jul	N.O.		100−300	01-Aug			100−300	10-Aug	100−300	20-Aug
1972	N/I		N.O.		800	20-Jul	No Est.		50	05-Aug	500	01-Aug
1973	N/I		N.O.		100	15-Jul	No Est.		60	30-Jul	No Est.	
1974	N/I		N.O.		No Est.		No Est.		No Est.		No Est.	
1975	200	30-Jul	No Est.		No Est.		No Est.		No Est.		No Est.	
1976	1,100	05-Aug	No Est.		50	20-Jul	50	15-Jul	50	30-Jul	300−500	30-Jul
1977	8,000	05-Aug	No Est.		500	20-Jul	100	15-Jul	100	30-Jul	50	30-Jul
1978	2,500	early Aug	No Est.		10	mid Jul	N.O.		30	early Aug	20	early Aug
1979	2,500	early Aug	10	mid Aug	40	mid Jul	No Est.		20	early Aug	No Est.	
1980	3,000	late Jul	60	early Aug	1,000	late Jul	No Est.		No Est.		120	late Jul
1981	2,500	late Jul	50	early Aug	800	late Jul	No Est.		No Est.		100	late Jul
1982	1,000	late Jul	20	early Aug	25	late Jul	No Est.		No Est.		25	late Jul
1983	2,000	late Jul	50	early Aug	50	late Jul	No Est.		No Est.		200	late Jul
1984	5,800	late Jul	60	early Aug	200	late Jul	No Est.		No Est.		45	late Jul
1985	6,000	late Jul	N.O.		200	late Jul	No Est.		No Est.		N.O.	
1986	1,000	late Jul	N/I		10	late Jul	No Est.		No Est.		N.O.	
1987	1,000	late Jul	75	early Aug	No Est.		No Est.		No Est.		N.O.	
1988	1,000	late Jul	Unknown		No Est.		No Est.		No Est.		N.O.	
1989	1,200	late Jul	Unknown		200	late Jul	No Est.		No Est.		No Est.	
1990	500	late Jul	Unknown		25	late Jul	No Est.		No Est.		No Est.	
1991	500	late Jul	Unknown		100	late Jul	No Est.		No Est.		No Est.	
1992	200	late Jul	Unknown		100	late Jul	No Est.		No Est.		No Est.	
1993	400	late Jul	N/I		No Est.		N.O.		N/I		N/I	
1994	N/I		N/I		N/I		No Est.		No Est.		N/I	
1995	1,800	NR			N/I		N.O.		N/I		N.O.	
1996	N/I		N/I		N/I		N.O.		N/I		N/I	
1997	N/I		N/I		N/I		N.O.		N/I		N/I	
1998	N/I		N/I		N/I		N.O.		Unknown		N/I	
1999	Unknown		N/I		N/I		N/I		N/I		N/I	
2000	437	11-Aug	N/I		N/I		N/I		Unknown		N/I	
2001	1,500	NR	N/I		N/I		N/I		N/I		N/I	
2002	550	08-Aug	N/I		N/I		N/I		N/I		N/I	
2003	2,606	08-Aug	N/I		N/I		N/I		N/I		N/I	
2004	990	07-Aug	N/I		N/I		N/I		N/I		N/I	
2005	2,770	22-Aug			N/I				N/I			
2006	810	01-Aug							N/I			
2007	7,100	23-Aug					N/I		N/I		A/P	
2008	3,390	19-Aug			A/P		N/I		N/I		12	NR

[a] No Est. = no estimate; NR = not recorded; N.O. = none observed; N/I = not inspected; A/P = adults present.

Table E - 2. DFO BC16 escapement and peak spawning estimates for Sockeye Salmon streams in the Upper Nass river-type conservation unit, 1950–2008. Blanks in the table indicate years without BC16 records.

	Tchitin River		Cranberry River		Brown Bear Creek	
Year	BC16 esc.[a]	Peak spawning	BC16 esc.	Peak spawning	BC16 esc.	Peak spawning
1950						
1951						
1952						
1953						
1954						
1955						
1956						
1957						
1958						
1959						
1960						
1961						
1962						
1963						
1964						
1965			No Est.			
1966			No Est.			
1967			No Est.			
1968			No Est.			
1969			No Est.			
1970			No Est.			
1971			No Est.			
1972			No Est.			
1973			No Est.			
1974			No Est.			
1975			No Est.			
1976	No Est.		No Est.			
1977	No Est.		No Est.			
1978	No Est.		No Est.		50	mid Aug
1979	No Est.		No Est.		20	late Aug
1980	No Est.		No Est.		50	mid Sep
1981	No Est.		No Est.		400	15-Oct
1982	No Est.		No Est.		N.O.	
1983	No Est.		No Est.		300	06-Oct
1984	No Est.		No Est.		140	mid Oct
1985	N/I		No Est.		300	mid Oct
1986	N/I		No Est.		N/I	
1987	No Est.		No Est.		N/I	
1988	No Est.		No Est.		Unknown	
1989	N/I		75		Unknown	
1990	200		75		Unknown	
1991	200		Unknown		Unknown	
1992	500		Unknown		Unknown	
1993	450		No Est.		N/I	
1994	N/I		No Est.		N/I	
1995			N/I			
1996	N/I		N/I		N/I	
1997	N/I		No Est.		N/I	
1998	N/I		N/I		N/I	
1999	N/I		N/I		N/I	
2000	N/I		N/I		N/I	
2001	N/I		N/I		N/I	
2002	N/I		N/I		N/I	
2003	N/I		N/I		110	NR
2004	N/I		N/I		1,240	mid Oct
2005					680	mid Oct
2006					133	mid Oct
2007					162	mid Oct
2008					75	mid Oct

[a] No Est. = no estimate; NR = not recorded; N.O. = none observed; N/I = not inspected.

Appendix F – Calculation of a Nass sea-type Sockeye Salmon abundance index from fishwheel age data

As the catch rate for Gingit Creek Sockeye Salmon is higher at fishwheel 2 (FW2) than fishwheel 1 (FW1; see Results and Discussion section above), and as the number of samples obtained was not evenly distributed between fishwheels in some years, correction factors were applied to the raw number of sea-type Sockeye Salmon aged at each fishwheel to simulate even sampling between wheels. This corrected number of sea-type Sockeye Salmon aged was calculated as:

Corrected adult sea-type Sockeye Salmon aged =

$$S_{\text{fishwheel 1}}{*}0.5/(t_{\text{fishwheel 1}}/t_{\text{total}}) + S_{\text{fishwheel 2}}{*}0.5/(t_{\text{fishwheel 2}}/t_{\text{total}}),$$

where S is the number of sea-type Sockeye Salmon aged and t is the total number of Sockeye Salmon successfully aged during the month of June (when the majority of Gingit Creek Sockeye Salmon pass the fishwheels; see Figure 9). The correction factors used are summarized in Table F - 1.

Table F - 1. Numbers of successfully aged adult (≥45 cm nose-fork length) Sockeye Salmon at fishwheels 1 and 2 (the Gitwinksihlkw test fishery) used to calculate a corrected sea-type proportion of the aggregate Nass net escapement and in turn, a fishwheel based sea-type Sockeye Salmon escapement index.

	All sea-type aged		All Sockeye aged in June		Corrected sea-type aged						
Year	FW1	FW2	FW1	FW2	FW1	FW2	All Sockeye aged	Overall sea-type	Corrected sea-type	Aggregate Nass escapement	Sea-type escapement index[a]
1994	1	32	83	221	2	22	1,520	2.17%	1.57%	310,043	4,863
1995	0	77	0	377	N/A	N/A	1,652	4.66%	N/A	264,685	N/A
1996	3	14	105	193	4	11	1,296	1.31%	1.16%	218,116	2,536
1997	13	49	34	52	16	41	1,345	4.61%	4.23%	250,456	10,607
1998	3	59	43	367	14	33	1,759	3.52%	2.69%	266,458	7,159
1999	3	60	97	154	4	49	1,957	3.22%	2.70%	210,957	5,689
2000	2	37	63	204	4	24	1,573	2.48%	1.81%	204,407	3,697
2001	0	58	34	195	0	34	1,499	3.87%	2.27%	167,253	3,800
2002	3	10	191	292	4	8	1,770	0.73%	0.68%	405,473	2,764
2003	11	19	200	156	10	22	1,678	1.79%	1.88%	263,688	4,945
2004	2	19	95	202	3	14	1,561	1.35%	1.10%	215,857	2,364
2005	11	28	180	147	10	31	1,472	2.65%	2.79%	224,559	6,275
2006	7	11	86	76	7	12	1,399	1.29%	1.31%	250,642	3,282
2007	5	34	197	109	4	48	1,550	2.52%	3.33%	164,747	5,485
2008	12	38	184	168	11	40	1,391	3.59%	3.69%	218,375	8,052
2009	9	74	219	210	9	76	1,283	6.47%	6.58%	244,900	16,110
2010	6	22	97	106	6	21	818	3.42%	3.34%	229,010	7,655
2011	9	71	115	130	10	67	1,286	6.22%	5.95%	276,700	16,458
2012	19	55	167	96	15	75	1,871	3.96%	4.83%	203,028	9,799
2013	19	52	322	381	21	48	1,232	5.76%	5.58%	210,263	11,727
2014	20	54	177	193	21	52	1,150	6.43%	6.32%	260,102	16,435
2015	67	162	150	202	79	141	2,176	10.52%	10.10%	389,503	39,337

[a] This index of sea-type Sockeye Salmon abundance is corrected to an escapement estimate for Gingit Creek by dividing by the average ratio of this value to the AUC escapement estimates for all years with high quality AUC estimates (Quality ≤3); see Table 1.

Appendix G – Fisheries and Oceans Canada escapement estimate classification

Table G - 1. Fisheries and Oceans Canada classification system for Pacific salmon escapement estimate quality.

Escapement estimate class	Estimate quality	Description
1	High	An estimate of high resolution from an unbreached fence count. The estimate uncertainty is believed to be less than plus or minus 10% of the actual estimate.
2	High	An estimate of high resolution based on documented measured data.
3	High	An estimate of high resolution based on three or more documented inspections of walking, floating, or flying which clearly define the peak of spawning and contain high adult live estimates with high fish countabilities; or an estimate of medium resolution based on documented data from a mark & recapture study, fixed site method, or medium to high AUC calculation. The estimate uncertainty is believed to be less than plus or minus 25% of the actual estimate.
4	Medium	An estimate of medium resolution based on the documentation of two or more walking, floating, or flying inspections around the peak of spawning containing high adult live estimates with high fish countabilities; or possibly low reliable fence count records, mark & recapture data or low to medium AUC calculation. The estimate uncertainty is believed to be no better than plus or minus 25% of the actual estimate.
5	Low	Low resolution.
6	No Estimate	None Observed (NO); Adults Present (AP); Not Inspected (NI); Do Not Spawn (DNS); Fry Present (FP).

Appendix H – Genetic distance (F_{ST}) matrix for Nass River Sockeye Salmon stocks

Table H - 1. Genetic distance (F_{ST}) matrix for Nass River river-type (RT) and lake-type Sockeye Salmon stocks. Two Stikine river-type populations are included for comparison.

Genetic Stock	Zolzap_juv_ 1996_RT	Zolzap_ 1997_RT	Gingit_RT	GitzyonCr	Brown Bear_RT	Bonney	Bowser	Damdochax	Hanna_Cr	Kwinageese	Meziadin_ beach	Tintina_Cr	Iskut_RT_ Stikine	Stikine_ main_RT
Zolzap_juv_1996_RT		0.0862	0.0403	0.0432	0.1005	0.1607	0.1269	0.1172	0.1626	0.1369	0.2006	0.1607	0.0793	0.0789
Zolzap_1997_RT	0.0862		0.0554	0.0343	0.0309	0.0806	0.0803	0.0478	0.0859	0.0531	0.1303	0.0828	0.0333	0.0375
Gingit_RT	0.0403	0.0554		0.0010	0.0585	0.1051	0.0864	0.0733	0.1178	0.0854	0.1502	0.1157	0.0396	0.0355
GitzyonCr	0.0432	0.0343	0.0010		0.0422	0.0893	0.0878	0.0641	0.0960	0.0716	0.1377	0.0946	0.0326	0.0297
Brown_Bear_RT	0.1005	0.0309	0.0585	0.0422		0.0487	0.0666	0.0557	0.0849	0.0407	0.1154	0.0809	0.0430	0.0359
Bonney	0.1607	0.0806	0.1051	0.0893	0.0487		0.0558	0.0348	0.0651	0.0180	0.0958	0.0634	0.0572	0.0490
Bowser	0.1269	0.0803	0.0864	0.0878	0.0666	0.0558		0.0392	0.0651	0.0556	0.0960	0.0628	0.0503	0.0452
Damdochax	0.1172	0.0478	0.0733	0.0641	0.0557	0.0348	0.0392		0.0541	0.0255	0.0937	0.0529	0.0264	0.0269
Hanna_Cr	0.1626	0.0859	0.1178	0.0960	0.0849	0.0651	0.0651	0.0541		0.0530	0.0095	0	0.0694	0.0675
Kwinageese	0.1369	0.0531	0.0854	0.0716	0.0407	0.0180	0.0556	0.0255	0.0530		0.0884	0.0506	0.0430	0.0364
Meziadin_beach	0.2006	0.1303	0.1502	0.1377	0.1154	0.0958	0.0960	0.0937	0.0095	0.0884		0.0106	0.1044	0.1027
Tintina_Cr	0.1607	0.0828	0.1157	0.0946	0.0809	0.0634	0.0628	0.0529	0	0.0506	0.0106		0.0676	0.0658
Iskut_RT_Stikine	0.0793	0.0333	0.0396	0.0326	0.0430	0.0572	0.0503	0.0264	0.0694	0.0430	0.1044	0.0676		0.0026
Stikine_main_RT	0.0789	0.0375	0.0355	0.0297	0.0359	0.0490	0.0452	0.0269	0.0675	0.0364	0.1027	0.0658	0.0026	