Cheakamus River Project Water Use Plan

Cheakamus River Juvenile Salmon Outmigration Enumeration

Data Report: 2018

Implementation Year 11

Reference: CMSMON1a

Cheakamus River Juvenile Salmonid Outmigration Enumeration Assessment

Final Data Report 2018

Study Period: 2018

Prepared for:

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1.0 INTRODUCTION

1.1 *Background*

The Cheakamus River is a salmon bearing river in the south coast of British Columbia and is important ecologically, culturally and recreationally to multiple stakeholder groups. The Squamish Nation harvest salmon in the Cheakamus River for food, social and ceremonial purposes. The watershed also provides opportunities for commercial anglers, raft guiding outfitters and recreational users (i.e., anglers and water sports).

The Cheakamus River was dammed for power generation and flood control in 1957. The Cheakamus Generation Project consists of a 28 m high, 680 m long dam that impounds the Cheakamus River and creates Daisy Lake Reservoir. Daisy Lake Reservoir has a storage capacity of 55,000,000 m^3 of water. Water is diverted from Daisy Lake through an 11 km tunnel through Cloudburst Mountain to a powerhouse on the Squamish River (Figure 1). The maximum capacity of the diversion through Cloudburst to the Squamish River is 60 $m^3 s^{-1}$. No fish passage structures were constructed in Daisy Dam due to the anadromous migration barrier at river km 17.5, which is below the dam.

Prior to 1997, the water licence for the Cheakamus Generation Project specified that water must be released for fish. Post construction, minimum flows of 320 cubic feet per second (~9.5 m^3s^{-1}) between April and December and 200 cubic feet per second (~5.6 m^3s^{-1}) were recommended by Fisheries and Oceans Canada (DFO). However, there was no legal requirement for BC Hydro to meet these recommended minimum flows (Mattison et al. 2014). In 1997, Fisheries and Oceans Canada issued an Interim Flow Order (IFO) with specific minimum flows for the Cheakamus River. An Instream Flow Agreement (IFA) resulting from the order was implemented in 1999. The IFA specified that the greatest of either 5 $m^3 s^{-1}$ or 45% of the previous days' inflows to the lake be released from Daisy Dam (within a daily range of 37% to 52% and within 45% of the previous 7 days' average) (BC Hydro, 2005).

Uncertainties regarding the effects of the IFA on salmonid populations were identified in 1999 during the water use planning process (BC Hydro, 2005) and monitoring studies were initiated in the spring of 2000 to address the key uncertainties. In 2005, a matrix of minimum discharges was presented to the Water Comptroller in the Cheakamus River Water Use Plan (WUP) (BC Hydro, 2005). The WUP describes discharge rules for the Cheakamus River designed to balance environmental, social and economic values. An objective of the Cheakamus River WUP is to maximize the productivity of wild fish populations. The changes made to the IFA during the creation of the WUP flow structure were based on expected benefits to wild fish populations resulting from increases in available fish habitat (BC Hydro 2005). The new flow order (hereafter, WUP) for the Cheakamus River was approved by the Water Comptroller and implemented on February 26, 2006.

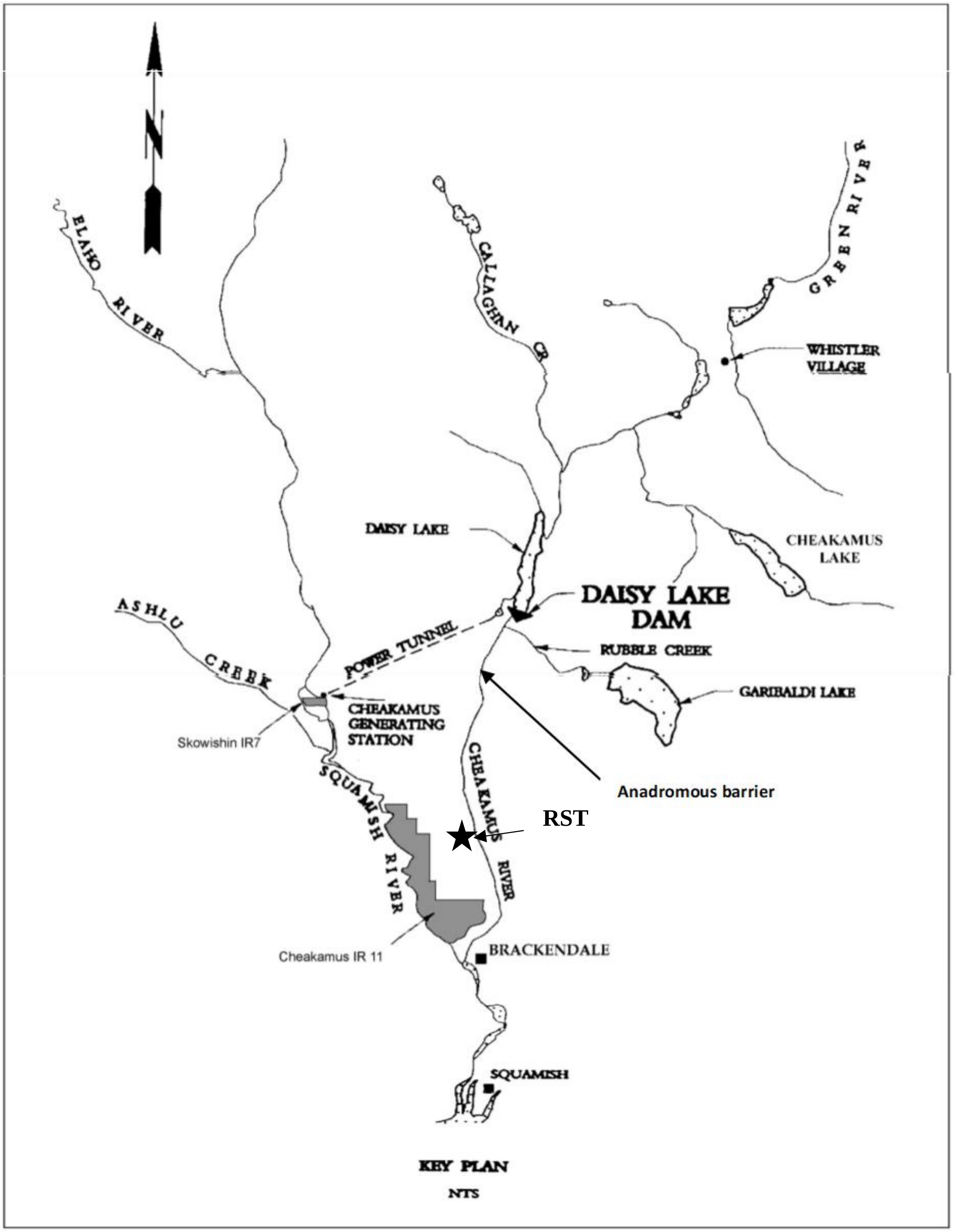

Figure 1. Map of the Cheakamus River and Daisy Generation Project in southwestern British Columbia.

Discharge requirements for operations under the implemented WUP were altered from the IFA to a required minimum flow at the following two locations:

1) Minimum flow required downstream of Daisy Lake Dam:

   i) 3 $m^3 s^{-1}$ from Nov 1 to Dec 31

   ii) 5 $m^3 s^{-1}$ from Jan 1 to Mar 31

   iii) 7 $m^3 s^{-1}$ from Apr 1 to Oct 31

2) Minimum flow required at the Brackendale Water Survey of Canada (WSC) Gauge:

   i) 15 $m^3 s^{-1}$ from Nov 1 to Mar 31

   ii) 20 $m^3 s^{-1}$ from Apr 1 to Jun 30

   iii) 38 $m^3 s^{-1}$ from Jul 1 to Aug 15

   iv) 20 $m^3 s^{-1}$ from Aug 16 to Aug 31[1]

   v) 20 $m^3 s^{-1}$ from Sep 1 to Oct 31

At the time of implementation, the effects of the WUP flow regime on fish populations were uncertain. Using relationships between fish habitat and fish production, Marmorek and Parnell (2002) outlined the expected benefits from the WUP flow regime. To assess the relationship between fish habitat and fish production, a study using rotary screw traps (RSTs) and mark-recapture methods to monitor juvenile salmonid production began in the spring of 2000 (Melville & McCubbing 2001) and has continued annually to 2018 following the terms of reference for Monitor 1a (hereafter, CMSMON1a). Data collection for CMSMON1a was scheduled to end in 2017. An additional year of data collection was approved for the spring of 2018 to generate a juvenile Chum Salmon abundance estimate for CMSMON1b (Chum Salmon Adult Escapement Monitor). The current data report summarizes field operations and abundance estimates for Pink and Chinook salmon young of the year collected concurrently with Chum Salmon which will be reported in the CMSMON1b annual report (Middleton in prep.).

[1]Unless directed to maintain 38 $m^3 s^{-1}$ for recreational purposes.

2.0 METHODS

Here we provide an annual update of juvenile fish abundance estimates and field operations for CMSMON1a. Detailed methods of annual data collection can be found in Lingard et al. (2016), or in previous annual reports at: (https://www.bchydro.com/about/sustainability/conservation/water_use_planning/lower_mainland/cheakamus.html).

2.1 *Site Description*

2.1.1 Study Area

The Cheakamus River is a major tributary of the Squamish Watershed and enters the Squamish River approximately 20 km north of Howe Sound (Figure 1). The Cheakamus Watershed covers an area of 1,010 km^2 in the coastal mountain range of southwestern British Columbia and is glacially fed. Annual water temperatures range from 0.5 to 15 ºC in the anadromous reach of the watershed. The Cheakamus River typically includes low-flow periods (15-20 $m^3 s^{-1}$) in both winter and late summer/early fall, and two high-flow periods resulting from spring snow melt (April to July) and fall storm events (October to November).

Daisy Dam is located on the Cheakamus River approximately 26 km upstream of the confluence with the Squamish River and impounds Daisy Lake Reservoir. A natural barrier to anadromous fish migration exists 9 km downstream of Daisy Dam at river km 17. The 17 km of the Cheakamus River below the natural barrier supports populations of anadromous salmon and trout. Ten species of salmonids are present in the Cheakamus Watershed: Pink, Coho, Chum, Chinook, Sockeye (*O. nerka*) and Kokanee (*O. nerka*) salmon as well as Rainbow and Steelhead Trout, Cutthroat Trout (*O. clarkii*), Bull Trout (*Salvelinus confluen*tus), and Dolly Varden (*S. malma*).

The mainstem habitat in the Cheakamus River is complimented by a large area of man-made restoration channels which are fed either by groundwater or surface water diverted from the mainstem river (Figure 2). The first restoration channel in the Cheakamus River was built in 1982 at the property now known as the Cheakamus Center. In the 1990s and early 2000s, a network of restoration channels was expanded as part of the Dave Marshall Salmon Reserve. Additional channels have been built upstream and downstream of the Cheakamus Center and include Mykiss Channel, BC 49 Channel, BC Rail Channel, Dave's Pond and Moody's Channel. In addition to the constructed channels, large woody debris structures were placed in the mainstem Cheakamus River to increase habitat complexity (Harper and Wilson 2007).

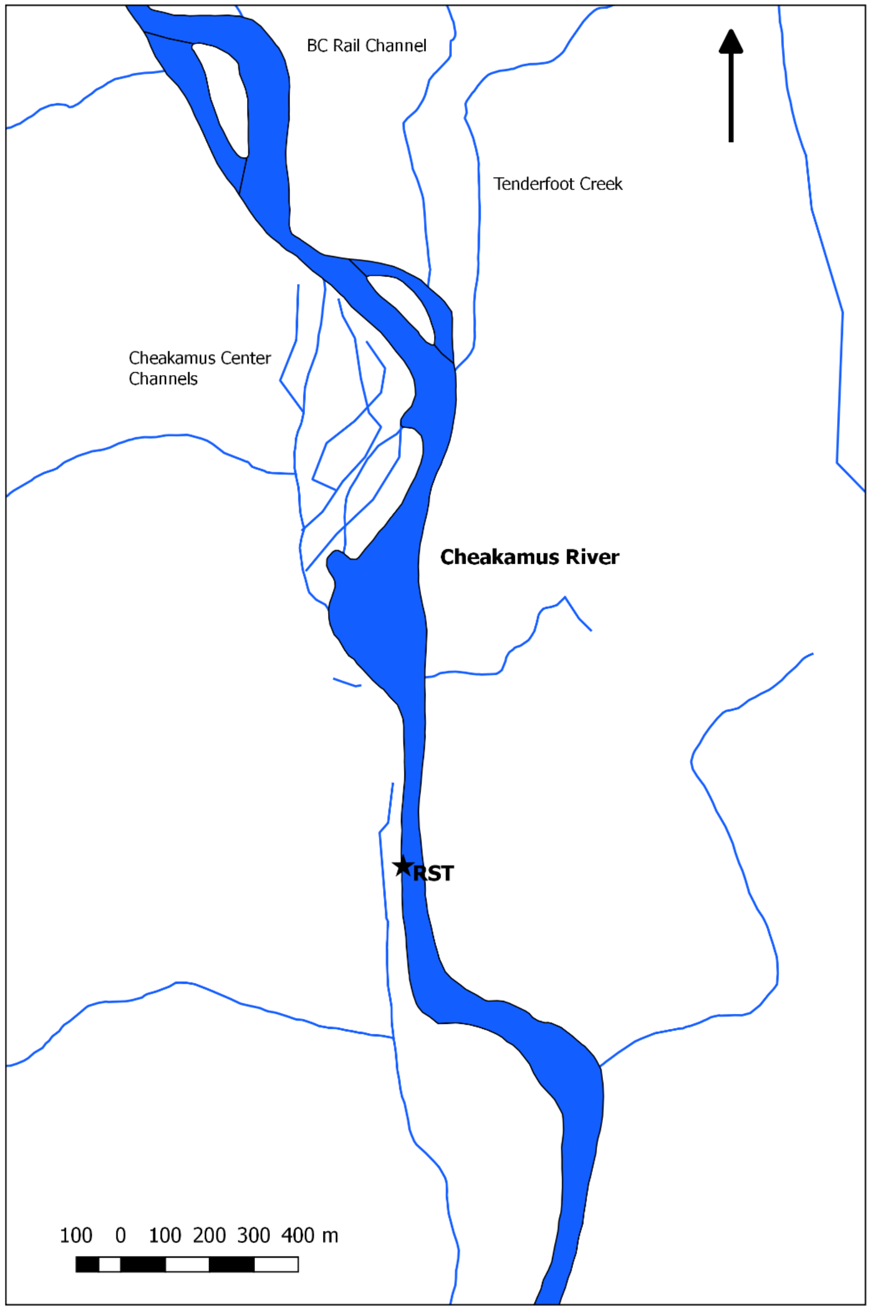

Figure 2. Map of the study area including the Cheakamus River and major side-channels.

2.2 Juvenile Abundance Estimation

2.2.1 Trapping Sites and Fish Capture Methods

Juvenile fish in the mainstem were enumerated by two six-foot RSTs operated adjacent to the Cheakamus Center (formerly NVOS) property (10U 0489141:5518035, Figure 2) at river km 5.5. Traps were operated between February 18th and April 28th in 2018. Fyke nets were operated in both groundwater and riveraugmented (flow through) side-channels in the Cheakamus Center complex, the BC Rail Channel and Tenderfoot Creek (Figure 2) over the same dates as the RSTs.

2.2.2 Mark-Recapture Abundance Estimation

A modified Petersen mark-recapture model was used to generate abundance estimates for juvenile salmon in the Cheakamus River. In traditional Petersen methods, data pooling between sampling events (or strata) is often required in the event of sparse data. Pooling strata assumes homogeneity in capture probabilities, which is often violated due to varying river discharge and capture effort throughout the run. When heterogeneity is present, pooled Petersen estimators can substantially underestimate uncertainty in abundance estimates. A Bayesian Time-Stratified Spline Model (BTSPAS) was used to estimate annual fish abundance (Bonner & Schwarz, 2011). The BTSPAS model is a modified Petersen mark-recapture model that estimates weekly abundance using splines to model the general shape of the run. The Bayesian hierarchical method shares information on catchability among strata when data are sparse (Bonner and Schwarz 2011). See Bonner and Schwarz (2011) for a detailed explanation of the model and its development.

Abundance estimates were generated for weekly strata for both the RSTs and fyke nets in side-channels. Weekly strata for young of the year (YOY) Chinook, Chum and Pink Salmon ran from Tuesday to Monday. Fish captured between Monday and Thursday were marked with a biological stain and released upstream of the RSTs or fyke net. Fish were not marked between Friday and Sunday to allow the mark group to move past the trap before the next strata began (Lingard et al., 2016). Note that Chum Salmon data collected under this project are discussed in CMSMON1b (Middleton et al., in progress).

Estimates generated from the RSTs represented the combined mainstem and side-channel estimate. Estimates generated from side-channel traps were subtracted from the RST estimate to determine comparative production from side-channel and mainstem habitat. Operations were suspended during hatchery releases; therefore, hatchery production totals are not included in the population estimates generated from this study.

3.0 RESULTS

3.1 Pink Salmon

A total of 261,693 YOY Pink Salmon were captured between February 18th and April 28th, 2018. Of the total catch, 71,301 fry were marked across 11 strata. The total estimated abundance of juvenile Pink Salmon migrating past the Cheakamus River RSTs in 2018 was 3,921,349 (SD 126,521). The 2018 estimate was the second lowest abundance observed since the implementation of the WUP flow regime in 2007 (Table 1, Figure 3).

An estimate of YOY Pink Salmon was also generated for the Cheakamus Center side-channels. A total of 43,791 juveniles were captured and 28,546 were marked over 11 strata. The total estimated abundance of Pink Salmon leaving the Cheakamus River side-channels was 1,144,735 (SD 40,254). Of the total abundance estimated from the RST, Cheakamus Center channels contributed approximately 29%.

Table 2. Annual abundance estimates of young of the year (YOY) Pink Salmon in the Cheakamus River from 2002 to 2018. Estimates were generated using the BTSPAS mark-recapture model. Capture of YOY Pink Salmon in odd years were near zero in the Cheakamus River.

Year	Mean abundance	SD	97.5% Lower	97.5% Upper	*cv*	Annual catch	Percent counted in side-channels
2002	1,671,625	286,619	1,274,882	2,303,970	0.17	27,038	Not assessed
2004	82,834	13,474	60,785	113,686	0.16	2,742	Not assessed
2006	303,488	9,817	285,605	323,715	0.03	41,336	Not assessed
2008	2,060,948	89,979	1,898,856	2,247,535	0.04	41,873	57%
2010	6,157,377	606,896	5,191,698	7,547,475	0.10	238,730	10%
2012	29,314,436	630,824	28,145,838	30,583,733	0.02	1,447,749	11%
2014	25,387,473	31,4061	24,782,837	26,014,983	0.01	1,900,820	14%
2016	5,491,140	260,514	5,032,642	6,046,211	0.05	258,353	19%
2018	3,921,349	126,521	3,700,595	4,183,279	0.03	261,693	29%

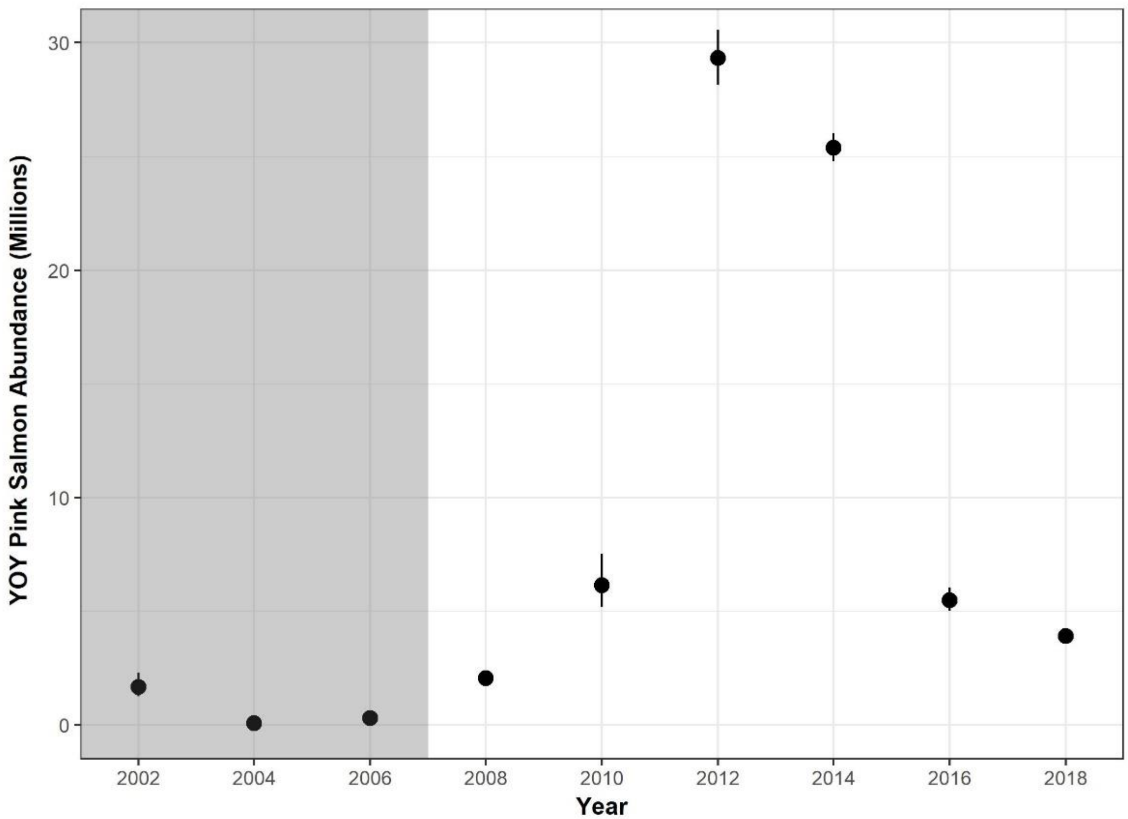

Figure 3. Annual abundance estimates, with 95% CI, of YOY Pink Salmon in the Cheakamus River.

3.2 Chinook Salmon

A total of 3,659 YOY Chinook Salmon (<50 mm) were captured at the RSTs in 2018. Of the total catch, 1,142 fish were marked across 11 strata. The total estimated abundance of YOY Chinook Salmon migrating past the RSTs in the Cheakamus River in 2018 was 60,931 (SD 15,408). The 2018 estimate of Chinook Salmon abundance was the fifth lowest observed since the implementation of the WUP flow regime in 2007 (Table 2, Figure 4).

Table 3. Annual estimates of YOY Chinook Salmon abundance in the Cheakamus River. Abundance estimates were generated by the BTSPAS mark-recapture model. No abundance estimate was generated in 2006 due to insufficient catch.

Year	Mean abundance	SD	97.5% Lower	97.5% Upper	*cv*	Annual catch
2001	167,946	39,688	180,674	333,839	0.16	8,578
2002	131,623	18,966	107,404	181,068	0.14	7,567
2003	385,534	98,652	225,488	600,794	0.25	5,859
2004	204,896	159,17	76,061	657,876	0.67	1,232
2005	211,909	154,69	83,365	605,230	0.65	1,107
2006	NA	NA	NA	NA	NA	499
2007	198,588	27,475	193,121	299,055	0.12	8,737
2008	564,313	132,30	378,680	876,185	0.23	5,127
2009	157,151	21,335	130,562	217,512	0.14	8,039
2010	60,040	7,799	47,132	77,166	0.13	3,649
2011	874,946	46,220	790,305	970,473	0.05	31,933
2012	323,375	32,315	269,226	392,903	0.10	8,787
2013	352,356	14,881	325,128	382,873	0.04	22,248
2014	39,001	9,413	27,941	59,812	0.24	3,154
2015	16,484	3,100	12,062	24,014	0.19	1,111
2016	56,470	8,474	41,910	74,511	0.15	1,922
2017	114,146	20,781	87,365	157,560	0.18	6,477
2018	60,931	15,408	42,317	97,189	0.25	3,659

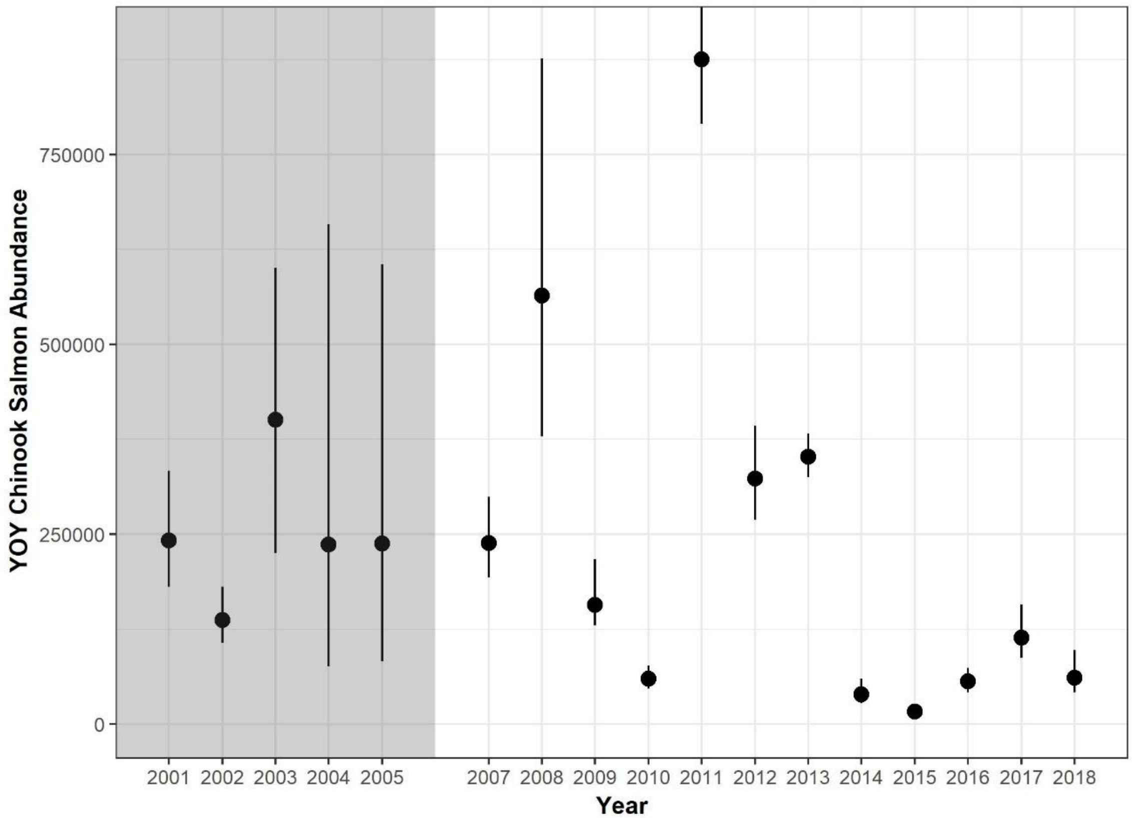

Figure 4. Annual abundance estimates, with 95% CI, of YOY Chinook Salmon in the Cheakamus River.

4.0 DISCUSSION

Field operations ran smoothly throughout the 2018 field season. Minimal high-water events were experienced between February 18th and April 28th, 2018. In total, eleven days were missed due to high water events and hatchery releases. Overall, the season was six weeks shorter than in previous years due to a change of scope following the completion of the scheduled 10-year WUP monitoring process. Due to the shortened season, it was not possible to derive estimates of Coho and Steelhead smolt abundance.

The 2018 estimate for YOY Pink Salmon, indicates the abundance of juveniles of this species continues to decline following the period of high abundance in 2012 and 2014. The 2018 estimate was the third lowest since implementation of the WUP, and fourth lowest of all estimates generated since 2001. High water events, a reduction in adult abundance, and fishing pressure in the fall of 2017 may have contributed to the reduction in Pink Salmon abundance.

The Chinook Salmon abundance estimate for 2018 added to a consistently low series of estimates. Out of the seventeen years abundance estimates have been generated for Chinook Salmon, the three lowest have occurred since 2014. The 2018 abundance estimate was the fifth lowest since the implementation of the WUP as well as the fifth lowest of all years since 2001.

Many factors, in both marine and freshwater environments are likely affecting Cheakamus River Chinook Salmon. Georgia basin Chinook are experiencing a decline in through-out their range (Slaney et al. 1996; Heard *et al.* 2007; Irvine and Fukuwaka 2011; Beamish et al. 2012; Neuswanger et al. 2015; Shields et al. 2018). However, water temperature and discharge in August have been identified as potential factors within the Cheakamus that may affect Chinook Salmon productivity (Lingard et al. 2018).

5.0 REFERENCES

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