Cheakamus River Project Water Use Plan

Cheakamus River Juvenile Salmonid Outmigration Enumeration Monitoring

Data Report: 2019

Reference: CMSMON1a

Cheakamus River Juvenile Salmonid Outmigration Enumeration Monitoring

Study Period: 2019

Prepared for:

BC Hydro

6911 Southpoint Dr, 11th floor

Burnaby, BC V3N 4X8

Prepared by:

Stephanie Lingard

InStream Fisheries Research, Inc. 1211A Enterprise Way Squamish, BC V8B 0E8

T: +1 (604) 892-4615

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1.0 INTRODUCTION

The Cheakamus River, located in the south coast of British Columbia, is important ecologically and culturally to multiple stakeholder groups and the Squamish Nation. The Squamish Nation harvests salmon in the Cheakamus River for food, social and ceremonial purposes and the watershed provides opportunities for commercial anglers, raft guiding outfitters and recreation.

The Cheakamus River was dammed for power generation and flood control in 1957. The 28 m high and 680 m long dam impounds the Cheakamus River and creates Daisy Lake Reservoir, which has a water storage capacity of 55,000,000 m^3. 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 $m^3 s^{-1}$.

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 $m^3 s^{-1}$) between April and December and 200 cubic feet per second (~5.6 $m^3 s^{-1}$) year-round 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, DFO 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. Discharge requirements for operations under the implemented WUP were altered from the IFA. As detailed in the Water Use Plan (BC Hydro 2005) required minimum flows downstream of Daisy Lake Dam and at the Brackendale Water Survey of Canada Gauge ranged from 3 to 7 $m^3 s^{-1}$ and 15 to 38 $m^3 s^{-1}$, respectively.

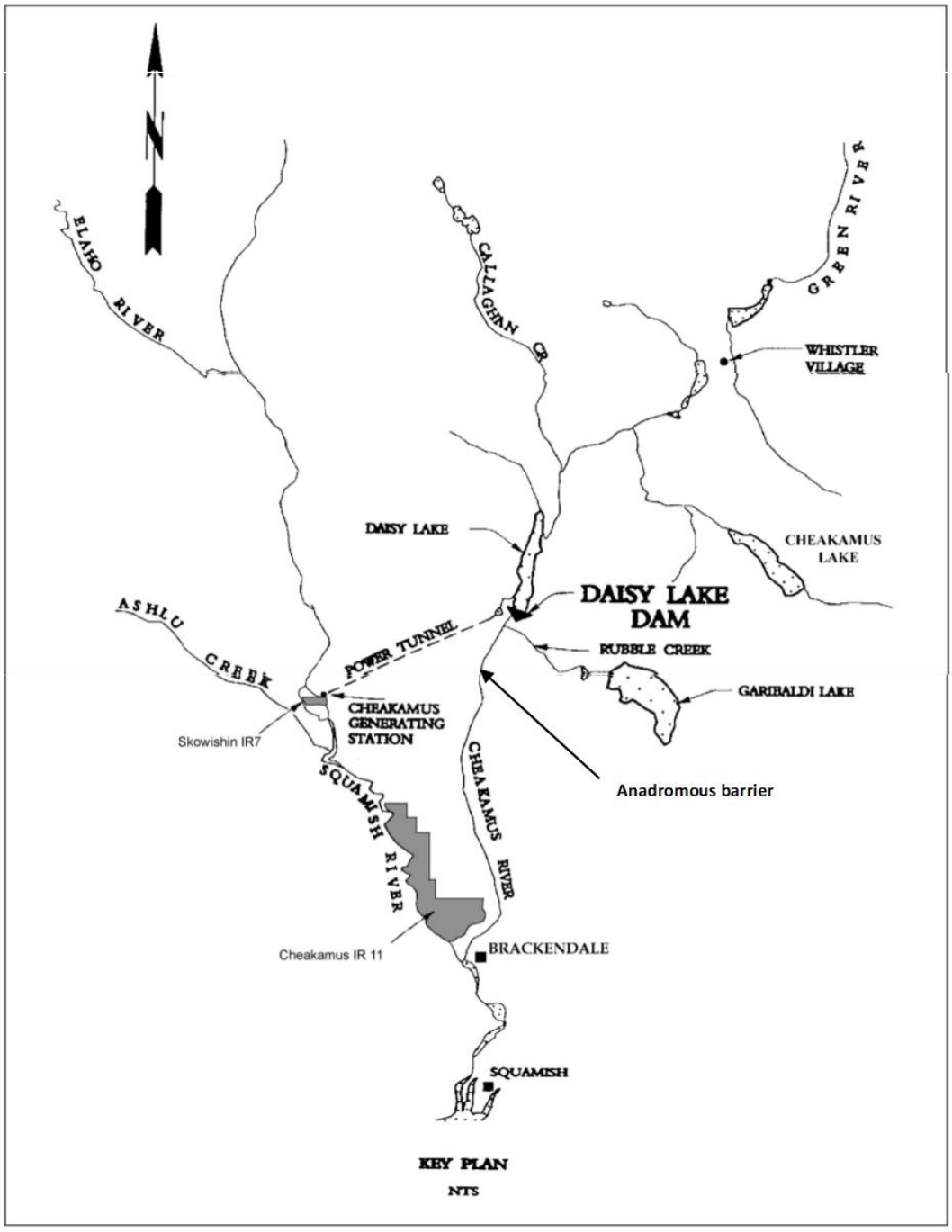

Figure 1. Map of the Cheakamus River and Daisy Generation Project in southwestern British Columbia.

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 continued annually until 2017 following the terms of reference for Monitor 1a (hereafter, CMSMON1a). Following the completion of the scheduled 10-year WUP monitoring process, an additional two years of data collection were approved for Spring of 2018 and 2019 to generate a juvenile Chum Salmon abundance estimate for CMSMON1b (Chum Salmon Adult Escapement Monitor). The current data report summarizes field operations of the RSTs and the abundance estimate for Chinook Salmon young of the year (YOY) collected concurrently with Chum Salmon in 2019. The change in scope resulted in a reduced monitoring period that precluded estimating Coho and Steelhead smolt abundance. Chum salmon abundance will be reported in the CMSMON1b annual report (Middleton et al. in progress).

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*

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 river. 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 (*O. mykiss*), 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 and the network of restoration channels was expanded in the 1990s and early 2000s.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).

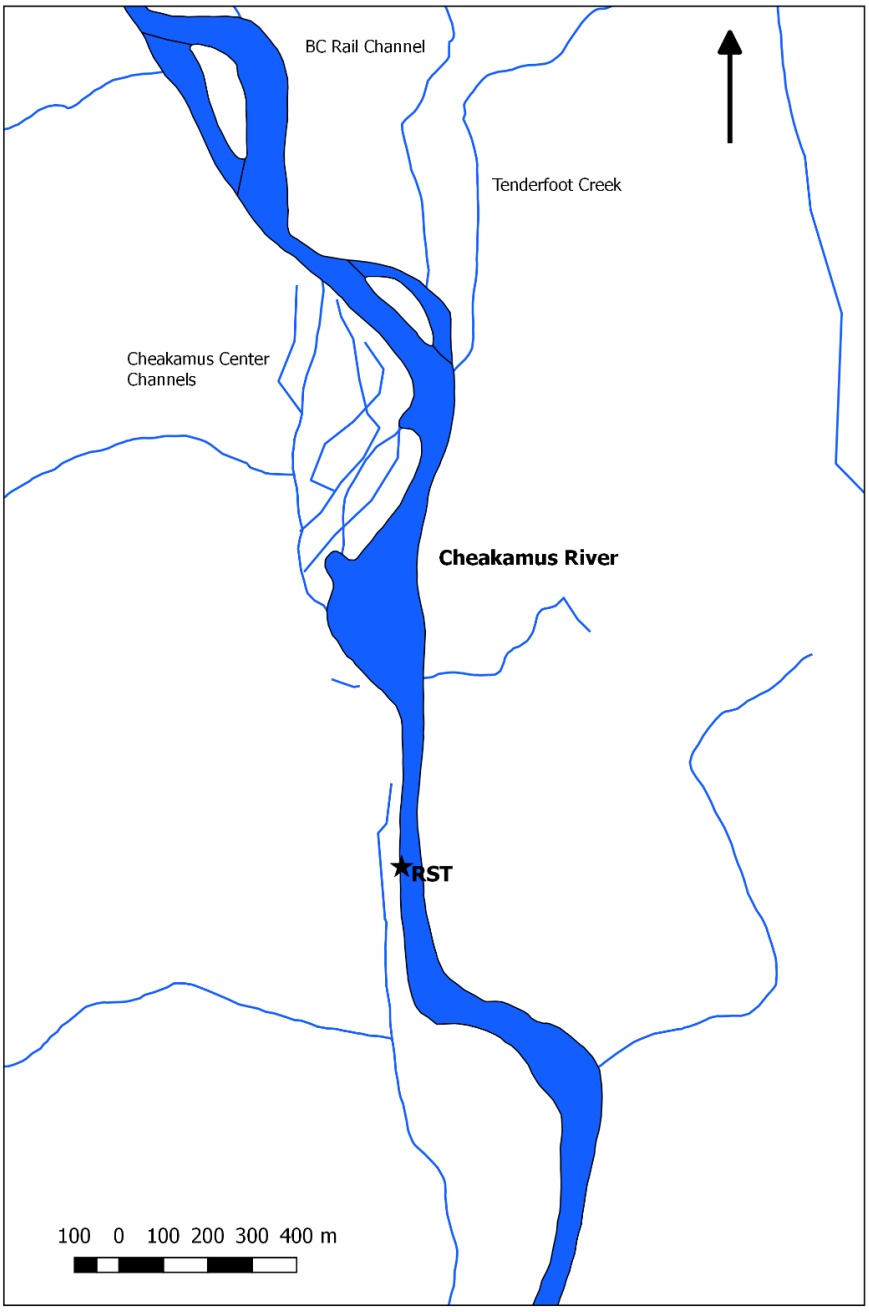

Figure 2. Map of the study area including the Cheakamus River and major side-channels.

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 25th in 2019. Fyke nets were operated in both groundwater and river-augmented (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 with 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 YOY Chinook and Chum 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).

Estimates generated from the RSTs represent the combined mainstem and side-channel estimates. 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. Note that Chum Salmon data collected under this project are discussed in CMSMON1b (Middleton et al., in progress).

3.0 RESULTS

A total of 7,786 YOY Chinook Salmon (< 50 mm) were captured at the RSTs in 2019. No Chinook Salmon were captured in the side channel traps. Of the total catch, 3,463 fish were marked across 11 strata. The total estimated abundance of YOY Chinook Salmon migrating past the RSTs in the Cheakamus River in 2019 was 205,127 (SD 34,350). Of the 12 years Chinook Salmon abundance has

been estimated since implementation of the WUP flow regime in 2007, the 2019 estimate was the fifth largest (Table 3, Figure 4).

Table 1. 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
2019	202,127	34,350	155,042	284,848	0.16	7,786

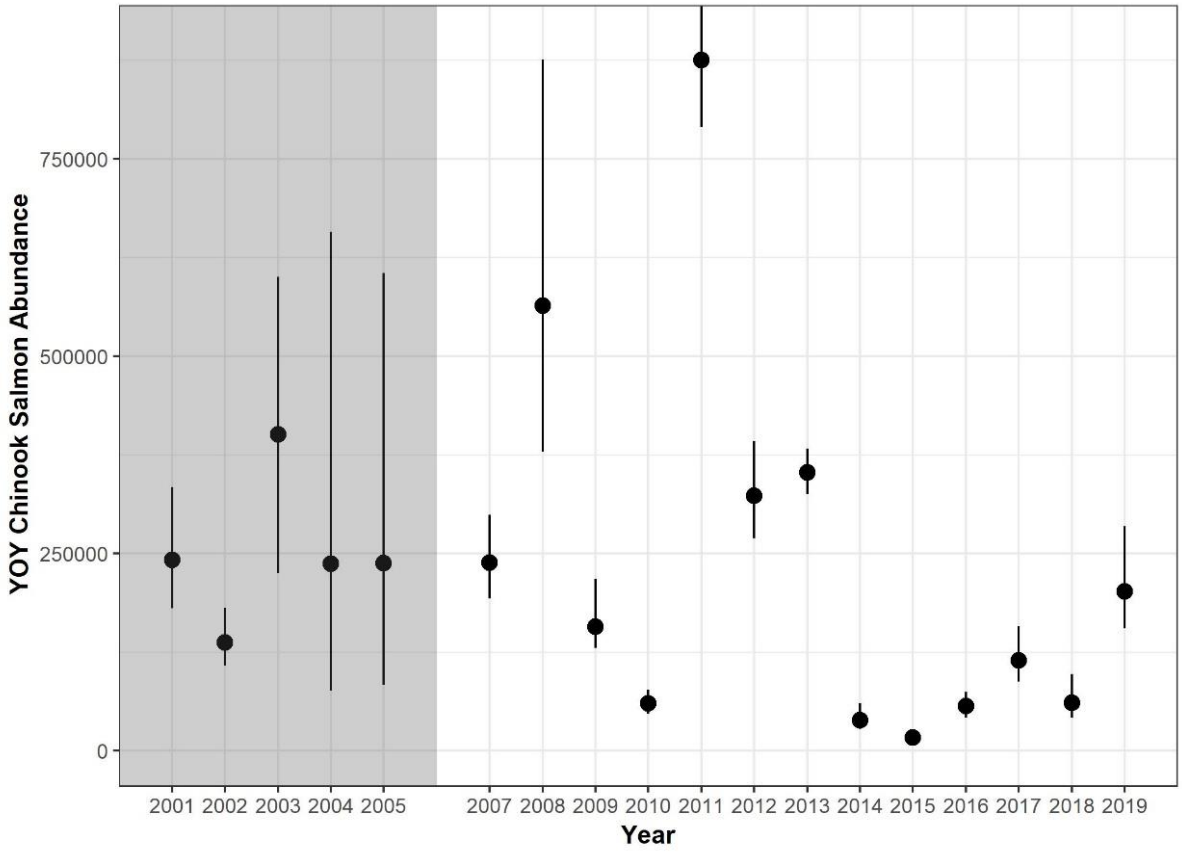

Figure 3. Annual abundance estimates, with 95% CI, of YOY Chinook Salmon in the Cheakamus River. Grey shading indicates years of study under IFA flow conditions.

4.0 DISCUSSION

There were no major disruptions to field operations throughout the 2019 field season. Minimal high-water events were experienced between February 19th and April 25th, 2019. In total, four days were missed due to high discharges and hatchery releases. As in 2018, the 2019 season was six weeks shorter than WUP monitoring conducted between 2000 and 2017; however, monitoring of the YOY Chinook migration was conducted for the same period as all previous years. Thus, the reduced timeframe does not affect comparability of YOY Chinook abundance among study years.

The YOY Chinook Salmon estimate for 2019 ended a five-year trend of low abundance. The 2019 estimate of 202,127 YOY exceeded the median of all WUP years (157,151). In 2019, a surge (roughly 20% of overall abundance) was observed in the final strata, at the end of April, indicating the migration

was not over when trapping ended. Upticks in abundance during the last strata (last week of April) have been observed in approximately 35% of all study years (2011, 2012, 2014, 2016, 2017, 2018).

The estimates generated for Cheakamus River YOY Chinook Salmon have had a wide range of precision associated with them over the 18-year study period. Prior to 2008 low catches and few re-captures resulted in large estimates with relatively low precision (2003-2005 & 2008). Since 2009, the precision of estimates has increased. Although estimates have generally been reliable in terms of precision, the timing of the CMSMON1a program has not been sufficient to evaluate all juvenile life history strategies. Chinook Salmon have incredibly diverse life histories with fish leaving through-out the year on more of a continuum rather than expressing distinct life history types (Volk et al. 2015). The factors that determine the life histories choices of individual fish are not well understood at this juncture in time, therefore, it is unclear whether estimates generated for Chinook Salmon since 2001 represent a consistent portion of the juvenile population. The reliability of abundance estimates and how the weaknesses in the CMSMON1a data affect inferences regarding water management on Chinook Salmon will be discussed in detail in the updated final report for CMSMON1a (Lingard et al. in progress).

The Cheakamus River Pink Salmon population is an odd-year spawning population. In odd-year populations juveniles are typically only present the subsequent even-year spring. As 2019 was an off year for Pink Salmon juveniles, an estimate could not be derived.

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