Campbell River Project Water Use Plan

JHTMON-15 Elk Canyon Smolt and Fall Spawner Enumeration Assessment

Implementation Year 7

Reference: JHTMON-15

JHTMON-15 Year 7 Monitoring Report

Study Period: 2020-2021

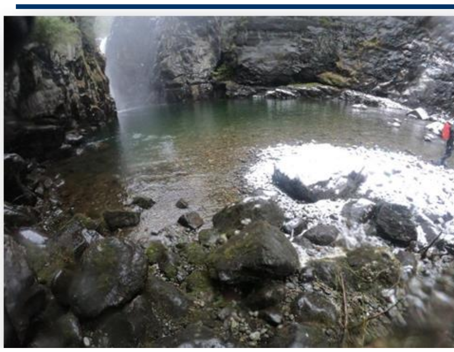
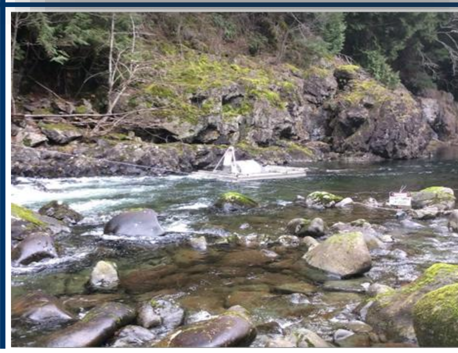
Laich-Kwil-Tach Environmental Assessment Ltd. Partnership and Ecofish Research Ltd.

July 25, 2022

JHTMON-15: Elk Canyon Smolt and Fall Spawner Enumeration Assessment

Year 7 Annual Monitoring Report



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Top left: Fisheries technicians conducting fall spawner survey in the Elk Falls Canyon.

Top right: Coho Salmon juvenile captured during RST sampling.

Bottom left: Looking upstream at upper extent of fall spawner surveys.

Bottom right: Rotary screw trap operating in the 4 CMS spill position.

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Certification: *Certified – stamped version on file.*

Senior Reviewer:

Morgan Hocking, Ph.D., R.P.Bio. No. 2752

Senior Environmental Scientist

Technical Leads:

Matthew Thornton, B.Sc., Dip. Tech, R.P. Bio. No. 3567

Fisheries Biologist

Alejandro Buren, Ph.D.

Senior Fisheries Biologist

Jaewoo Kim, Ph.D.

Senior Fisheries Scientist

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EXECUTIVE SUMMARY

The Elk Canyon on the lower Campbell River is used by seven salmonid species for at least part of their life history. The Campbell River Water Use Plan (WUP) prescribed a flow regime with the intent of maximizing fish habitat in Elk Canyon, including:

1) A minimum base flow of 4 m^3/s;
2) 2-day pulse flows of 10 m^3/s every two weeks in spring (February 15 to March 15) as an attraction flow, primarily for spawning Steelhead;
3) A two-week minimum spawning flow of 7 m^3/s (April 1-15); and
4) 2-day pulse flows of 7 m^3/s every week in the fall (September 15 to November 15) as an attraction flow for all fall spawners that could potentially use this reach.

There remains uncertainty over the extent to which fish use of the canyon by juveniles and spawners is affected by the implemented flow regime. The *Elk Canyon Smolt and Spawner Abundance Assessment* (JHTMON-15) is designed to assess the extent to which fish production is driven by flow in Elk Canyon and how this relates to BC Hydro operations. JHTMON-15 is scheduled for 10 years from 2014 to 2024 and is to be carried out as a series of interconnected parts, each focused on addressing a specific hypothesis and with different durations over the course of the monitor.

This report presents the results of Year 7 of the program. A number of components were completed in previous years, including an instream flow study (IFS), overwintering assessments, fall and spring pulse flow assessments, and a Steelhead spawning flow assessment. Reports that document these components can be found on the BC Hydro public website[1]. The components still being implemented are the smolt enumeration and the fall spawner enumeration associated with Management Questions 1 and 6 of JHTMON-15.

Smolt Enumeration

Similar to previous years, a rotary screw trap (RST) was installed in 2021 from March 1 (five days a week) to July 19. The RST was used to trap fish near the base of the canyon and allow quantification of salmonid outmigration from Elk Canyon. In 2021, captures in the RST were primarily composed of Chinook Salmon (48.2%), Chum Salmon (35.5%), and Coho Salmon (10.9%). Pink Salmon and Steelhead/Rainbow Trout accounted for 1.4% and 0.23% of all captures, respectively. The combined catch of all salmonids (8,185 fish) accounted for 99.4% of the total catch, and key target species of Chinook Salmon, Coho Salmon, and Steelhead/Rainbow Trout (4,888 fish) accounted for 59.3% of the total catch.

[1]https://www.bchydro.com/toolbar/about/sustainability/conservation/water_use_planning/vancouver_island/campbell_river.html.

Total salmonid outmigration by species in Year 7 (2021) was estimated by standardizing the RST catch by the capture efficiency of the RST, which was determined from mark recapture trials conducted in previous years. Chinook Salmon outmigration was the highest of all salmonid species, with an estimated total outmigration of 87,480 fry and 660 age 0+ smolts. Coho Salmon total outmigration was estimated to be 20,953 fry and 116 age 0+ smolts, and 143 age 1+ smolts. Chum Salmon total outmigration was estimated to be 74,088 fry. Steelhead/Rainbow Trout outmigration was estimated to be 92 age 0+ fry, 49 age 1+ parr, 51 age 2+ parr, and four age 3+ smolts. Pink Salmon and Sockeye Salmon total outmigration was estimated at 3,335 and zero fry, respectively. Overall, outmigration estimates were variable among years, with no clear trends over the monitoring period, although smolt production generally decreased for Coho Salmon and Steelhead/Rainbow Trout. Two low years of production were observed for Chinook, Chum, Coho, and Pink Salmon fry, 2015 and 2017, and 2019 was a low year for Steelhead/Rainbow Trout.

Estimates of daily outmigration continue to show seasonal patterns. Daily estimates consistently showed two outmigration peaks for Chinook Salmon, one in early to mid March to early April and a second one in late May and early June. Daily outmigration for Pink, Coho, and Sockeye Salmon fry consistently peaked between mid March and early April. The majority of Coho Salmon smolts 0+ or older tended to leave the canyon by early June, although some individuals delayed outmigration until late July. Chum Salmon fry outmigration tended to peak annually in April, but some inter annual variability was apparent.

The outmigration timing of Steelhead/Rainbow Trout differed by age class. Steelhead/Rainbow Trout 0+ fry outmigration peaked during May during Year 1 (2015) and 2 (2016); however, from Year 3 onwards, outmigration peaks became less conspicuous, and outmigration was spread between April and June. Daily outmigration estimates for 1+ Steelhead/Rainbow Trout varied considerably between years with outmigration typically occurring between mid-March and mid-July with no apparent trend between years. Daily outmigration of 2+ Steelhead/Rainbow Trout occurred between mid-April and late-May in most years. Daily outmigration timing of 3+ Steelhead/Rainbow Trout was similar to 2+ Steelhead/Rainbow Trout, although it was typically spread out over a wider time period.

Fall Spawner Enumeration

Snorkel surveys and area under the curve methods were used to estimate the abundance of Chinook, Coho, Pink, Chum, and Sockeye Salmon fall spawners in Elk Canyon in fall 2020. Chinook and Coho Salmon adult abundance were estimated to be 279 and 2,276 individuals, respectively, with Chinook peak counts being the highest to date. Pink Salmon adult spawner abundance was estimated to be 456 individuals. A total of 151 Chum Salmon and seven Sockeye Salmon spawners were also estimated. Few Steelhead were observed in fall with a peak count of only three individuals.

As in previous years, Pink and Sockeye Salmon had the earliest peaks, with observed spawner counts peaking in late September and mid September, respectively. Chinook Salmon had a peak in mid to late October. Chum and Coho Salmon had the latest peak in spawning in late October/early November. A maximum of three Steelhead were observed in mid-November.

Chinook, Chum, Coho, Pink, and Sockeye Salmon redds were documented during fall spawning surveys. The greatest numbers of redds were counted for Pink, followed by Coho and Chinook Salmon, (96, 39, and 19 redds, respectively), while four Chum Salmon redds and zero Sockeye Salmon redds were observed.

Comparison of Fall Spawner Abundance to Outmigration

The estimated fry and smolt production from counted redds in fall 2020 (based on egg to fry and egg to smolt survival rates from the literature) were compared to the estimated outmigration from the RST catch data in 2021. Estimates of fry outmigration based on redd production were lower than estimates derived from RST captures for Chum and Chinook Salmon, higher for Pink Salmon, and similar for Coho Salmon. These differences in outmigration estimated based on redd production versus RST catch are similar to previous years for each species. The differences are likely related to multiple factors, including coarse estimates of fecundity and survival, misidentification of redds, redd superimposition, and movements of adults prior to spawning. For Chum Salmon, redds counts may have been missed and/or egg-to-fry survival may have been high. For Pink Salmon, redd superimposition is a potential explanation for higher outmigration estimated from redd counts than from captures, given that the species is the earliest spawner.

Considering all years of the program to date, fall spawner abundance estimates appear to be positively correlated to 0+ fry and 0+ smolt outmigration estimates for most species. A notable exception was that there was relatively low outmigration estimated in 2017 regardless of the number of fall spawners in 2016. A large spill event occurred in November 2016 during which many redds were likely lost, which may demonstrate effects of a flow change on productivity. Pink Salmon outmigration was not related to spawner abundance potentially due, at least in part, to redd superimposition.

Considerations for Year 8

<u>Smolt Enumeration</u>

1. The RST is an effective method to inventory juvenile salmonids (fry and smolts) that are migrating out of Elk Canyon and provides valuable life history information. RST sampling should continue in Year 8 using the same methodology as Year 7 and outmigration estimates should continue to be calculated using the capture efficiency calculations developed from the mark-recapture trials implemented in Years 1, 2, 3, 5 and 6.

2. Based on the catch results of the target fish species to date, the RST sampling period should remain open until late July in Year 8 to ensure that the Coho and Chinook Salmon outmigration periods are adequately documented.

Fall Spawner Enumeration

1. Snorkel surveys continue to be an effective way to enumerate adult salmonids and redds. These surveys should continue using the same methodology employed in Year 7. The benefit of the comparison of estimated juvenile salmon production from RST catches to estimates of production predicted from redd counts by species in Elk Canyon should be evaluated as this comparison has highlighted that identification of species-specific redds is challenging resulting in high variability.

Management Questions, Hypotheses and Status after Year 7.

Management Questions	Management Hypothesis	Year 7 Status
MQ 1. Is the prescribed 4 m^3/s base flow sufficient to increase juvenile rearing habitat to near maximum values? If not, by how much should the base release increase (or decrease) and what would be the expected gain in habitat area?	**H01**: Carrying capacity of the Elk Canyon reach, as measured by annual smolt out-migrant counts, does not vary as a function of discharge. **H02**: The number of rearing residents deemed likely to smolt the following spring, as measured during late summer, is not significantly different from the abundance estimate obtained in late winter just prior to the onset of their outmigration. **H09**: Annual abundance of 'resident' smolts is not correlated with an index of steelhead spawner abundance.	Management question #1 and associated hypotheses are being addressed through several project components: a) An instream flow study (IFS); b) Smolt enumeration; c) Fall spawner abundance; d) Spring spawner abundance; and e) Juvenile overwintering assessment. The IFS was completed in Year 3 and Year 4 to determine the amount of habitat available to salmon at different flows (Healey *et al.* 2018). Results suggest that habitat carrying capacity of Elk Canyon does vary as a function of discharge, which is a rejection of H01. A summary analysis for the overwintering assessment was completed in Year 5 confirming H02 for Steelhead/Rainbow Trout and rejecting H02 for Coho Salmon. Steelhead/Rainbow Trout overwinter in Elk Canyon with little immigration or emigration between the fall and early spring period. In contrast, very few Coho Salmon overwinter in Elk Canyon. The remaining components (b and c) are being conducted each year until 2023 and 2024 respectively to determine fish productivity of Elk Canyon. Hypothesis H09 cannot be adequately addressed due to low Steelhead counts (≤10) and inconsistency of survey dates due to restricted access to the Elk Canyon due to spill events. Fall spawners (e.g., Coho, Chinook, Chum) were examined in relation to smolt outmigration estimates since we have much better spawning and outmigration data for these species.

Management Questions	Management Hypothesis	Year 7 Status
MQ 2. Does the 2-day 10 m^3/s pulse release every two weeks trigger the upstream migration of spring spawners as expected? If not, is this the result of inadequate pulse magnitude, duration, or some combination of both attributes? Or conversely, is the pulse attraction release unnecessary?	**H03**: The rate of spawning salmonid in migration (No./day) during the 2-day pulse flow release operation is not significantly different from that during the base flow operation. **H04**: The rate of spawning salmonid in-migration (No./day) during the first day of the pulse flow release operation is not significantly different from that during the second day. **H05**: The estimated number of spawning salmonids following pulse flow release operation is not significantly different from that just prior to the release.	Management question #2 and associated hypotheses were addressed through the spring pulse flow assessment component: Based on a synthesis analysis in Year 5, there is no evidence that the 10 m^3/s pulse flows are attracting Steelhead into Elk Canyon. The rate of Steelhead in-migration per day was significantly higher during the base flow than during the pulse flow, which is a rejection of H03, and the relationship was in fact opposite to that predicted. Because the WUP pulse flow prescription does not vary in magnitude or duration, we will be unable to determine if upstream migration of spring spawners would be improved if an alternate flow pulse prescription is used. Hypothesis H04 is not testable using the current sampling method of snorkel surveys immediately prior to and after the pulse flows. The count of Steelhead in Elk Canyon in the spring was not significantly different the day after the 2 day 10 $m^{3/s}$ spring pulse releases compared to the day prior to the pulse releases, which retains H05.
MQ 3. Is the two weeklong 7 m^3/s spawning flow effective at increasing available spawning habitat for spring spawners? If not, by how much should the spawning release increase (or decrease) and what would be the expected gain in habitat area?	**H06**: The estimated number of spawning steelhead during the two-week, 7 m^3/s spawning release period in spring is not significantly different from that observed just prior to the operation.	Management question #3 and associated hypothesis are being addressed through: a) The IFS; and b) The Steelhead spawning flow assessment. The IFS was completed in Year 3 and Year 4 to determine the amount of habitat available to salmon at different flows (Healey *et al.* 2018). The IFS predicts that more Steelhead spawning habitat is available at 7 m^3/s (96-97% of maximum) compared to 4 m^3/s (69-71% of maximum). Using snorkel survey methodology, the abundance of Steelhead in Elk Canyon was found to be not significantly different prior to the two-week spawning flow release than during the release across all three years of data collection (2016, 2017, 2019), which retains null hypothesis H06.

Management Questions	Management Hypothesis	Year 7 Status
MQ 4. Does the resumption of base flows following the spawning release keeps redds adequately wetted throughout the egg incubation period as expected? If not, what should the spawning release be to ensure all redds are wetted at the base flow?	**H07**: The number of redds found above the base flow water level (minus a nominal depth to take into account that steelhead will not spawn in very shallow water, e.g., 10 cm) following the two-week spawning release is not considered significantly different when compared to the total number of redds in the reach. **H08**: Following resumption of base flow operations, the number of steelhead redds found above the water line and therefore, at risk of egg mortality from stranding, is not considered significant compared to the total number of redds in the reach.	Management question #4 and associated hypotheses are being addressed through: a) The IFS; and b) The spring spawner abundance assessment. The IFS was completed in Year 3 and Year 4 to determine the amount of habitat available to salmon at different flows (Healey *et al.* 2018). The IFS predicts that the majority of redds (97-99%) will remain wetted when flows return to 4 m^3/s from 7 m^3/s. Five Steelhead redds were observed during 2019 and none were observed in previous years. Redds observed during the 7 m^3/s spawning flow remained wetted when flows were reduced to baseline flows (4 m^3/s). Observational and habitat modelling results suggest that the majority of redds will remain wetted at 4 m^3/s, which retains the null hypotheses of H07 and H08.
MQ 5. Does the 2-day 7 m^3/s pulse release every week trigger the upstream migration of fall spawners as expected? If not, is this the result of inadequate pulse magnitude, duration, or some combination of both attributes? Or conversely, is the pulsed attraction release unnecessary?	**H03**: The rate of spawning salmonid in-migration (No./day) during the 2-day pulse flow release operation is not significantly different from that during the base flow operation. **H04**: The rate of spawning salmonid in-migration (No./day) during the first day of the pulse flow release operation is not significantly different from that during the second day. **H05**: The estimated number of spawning salmonids following pulse flow release operation is not significantly different from that just prior to the release.	Management question #5 and associated hypotheses are being addressed through the fall pulse flow assessment component. The rate of fall spawning salmonid in-migration per day did not differ between periods of pulse flows and periods of base flows for all fall spawners, which retains H03 for Coho Salmon, Chinook Salmon, and Chum Salmon. These results were confirmed in a supplemental analysis where only counts during the buildup to peak abundance were considered. Because the WUP pulse flow prescription does not vary in magnitude or duration, we will be unable to determine if upstream migration of fall spawners would be improved if an alternate flow pulse prescription is used. Hypothesis H04 is not testable using the current sampling method of snorkel surveys immediately prior to and after the pulse flows. The abundance of all fall spawners in Elk Canyon measured using snorkel surveys pre- and post pulses, did not differ the day after the 2-day 7 m^3/s fall pulse release compared to the day prior the pulse release. This means that the null hypothesis H05 is retained for all fall spawning species including Coho Salmon, Chinook Salmon, and Chum Salmon.

Management Questions	Management Hypothesis	Year 7 Status
MQ 6. Following implementation of the WUP flow prescription to the Elk Canyon reach, has the general fish productivity of the reach increased as expected? If a change is apparent, whether positive or negative, can it be attributed to WUP operations? Conversely, if no change is apparent, are some or all elements of the flow prescription still necessary?	This management question is a synthesis question associated with all of the hypotheses and project components listed above.	Since there are no fish population data available before the WUP was implemented, it will not be possible to address these questions directly in terms of fish productivity. The IFS was completed in Year 3 and Year 4 to determine the amount of habitat available to salmon at different flows (Healey *et al.* 2018). Results suggest that the carrying capacity of Elk Canyon does vary as a function of discharge. Other components of JHTMON-15 (e.g., the RST study) will provide important measures of fish productivity that will allow informed discussions of the benefits of the WUP operations and will establish a productivity reference point for these discussions. A full synthesis analyses will be presented in Year 10 to address this management question.

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1. INTRODUCTION

1.1. Background to Water Use Planning

Water use planning exemplifies sustainable work in practice at BC Hydro. The goal is to provide a balance between the competing uses of water that include fish and wildlife, recreation, and power generation. Water Use Plans (WUPs) were developed for many of BC Hydro's hydroelectric facilities through a consultative process involving local stakeholders, government agencies, and First Nations. The framework for water use planning requires that a WUP be reviewed on a periodic basis and there is expected to be monitoring to address outstanding management questions in the years following the implementation of a WUP.

As the Campbell River Water Use Plan (BC Hydro 2012) process reached completion, a number of uncertainties remained with respect to the effects of BC Hydro operations on aquatic resources. A key question throughout the WUP process was the question of the mechanisms that limit fish abundance. For example, it is uncertain whether fish abundance and biomass in the Campbell system are limited by flow. Resolving this uncertainty is important for better understanding how human activities in a watershed affect fish, and for effectively managing water uses to protect and enhance aquatic resources. To address this uncertainty, monitoring programs were designed to assess whether benefits to fish are being realized under the WUP operating regime and to evaluate whether limits to fish production could be improved by modifying operations in the future.

The Elk Canyon on the lower Campbell River is used by all salmonid species for at least part of their life history. The WUP prescribed a flow regime with the intent of maximizing fish use in the canyon. However, there remains uncertainty over the extent to which the use of the canyon by juvenile and spawning fish is affected by the implemented flow regime. JHTMON-15, the *Elk Canyon Smolt and Spawner Abundance Assessment*, is part of wider monitoring of the Campbell River WUP. JTHMON-15 is designed to assess the extent to which fish production is driven by flows in Elk Canyon, and how this relates to BC Hydro operations. This report presents methods and results from Year 7 of the JHTMON-15 study which was implemented between September 2020 to July 2021.

1.2. BC Hydro Infrastructure, Operations, and the Monitoring Context

The Campbell River WUP project area is complex and includes facilities and operations in the Campbell and Quinsam watersheds. In addition to the mainstem rivers, there are three large reservoirs, nine diversion lakes influenced by water diverted from the Quinsam River (and until 2017, the Salmon River), and many tributaries and small lakes in these watersheds that are not directly affected by operations (Map 1). Details of BC Hydro's Campbell River infrastructure and operations are provided in the Campbell River System WUP report (BC Hydro 2012).

1.2.1. Elk Canyon

Elk Canyon is a section of the Lower Campbell River that extends from Elk Falls below the John Hart Dam to just upstream of the new tailrace of the John Hart generating station (Map 2). The tailrace had been moved to a new location, slightly upstream of the old location, in 2018. Water in John Hart Reservoir is diverted to the John Hart Generating Station, with water returning to the Lower Campbell River below Elk Canyon; flows to the canyon are released through the John Hart Dam spillway gates. The value of Elk Canyon as fish habitat was not fully appreciated until a base flow of 3.5 m^3/s was provided as part of an interim flow management strategy developed in 1997 (Campbell River Hydro/Fisheries Advisory Committee 1997). Field investigations since the flow release have shown an increase in the juvenile rearing and salmonid spawning habitat (Healey *et al.* 2018). Given this increase in the use of the canyon by salmonids, it was hypothesized that further increases in habitat were possible with additional flow releases. Therefore, during the Campbell River WUP process, a flow prescription was developed for Elk Canyon based primarily on the professional opinion of several biologists (all members of the Fish Technical Subcommittee or FTC). Recognizing that the release of water to the canyon reach comes at considerable cost in terms of lost power generation, the FTC recommended that the flow prescription be the start of a long term 'titration' study with the aim of modifying the prescription at regular intervals (i.e., WUP Review intervals) based on the results of the preceding interval's monitoring program.

Based on the available information at the time, the FTC recommended that the following flow prescriptions be implemented as an attempt to maximize fish use in the canyon:

1) A minimum base flow of 4 m^3/s;
2) 2-day pulse flows of 10 m^3/s every two weeks in spring (February 15 to March 15) as an attraction flow, primarily for spawning Steelhead (though other spring spawners may benefit);
3) A two-week minimum spawning flow of 7 m^3/s in spring (April 1-15); and
4) 2-day pulse flows of 7 m^3/s every week in the fall (September 15 to November 15) as an attraction flow for all fall spawners that could potentially use this reach.

The prescriptions above were considered by the FTC as a starting point in a titration type study that would progressively change the flow regime as new information is gathered; alterations are only to be considered during WUP reviews when trade-offs with other values in the system can be examined. To successfully conduct this titration approach to flow setting, it was recommended that a monitoring program be developed and implemented to track the success or failure of the flow prescription in meeting its management objectives. JHTMON-15 is the monitoring study program implemented to increase the knowledge and understanding of flow relationships with fish in the Elk Canyon reach.

1.3. Management Questions and Hypotheses

There are six key management questions (or sets of questions) to be addressed by JHTMON-15:

1) Is the prescribed 4 m^3/s base flow sufficient to increase juvenile rearing habitat to near maximum values? If not, by how much should the base release increase (or decrease) and what would be the expected gain in habitat area?

2) Does the 2-day 10 m^3/s pulse release every two weeks trigger the upstream migration of spring spawners as expected? If not, is this the result of inadequate pulse magnitude, duration, or some combination of both attributes? Or conversely, is the pulse attraction release unnecessary?

3) Is the two-week long 7 m^3/s spawning flow effective at increasing available spawning habitat for spring spawners? If not, by how much should the spawning release increase (or decrease) and what would be the expected gain in habitat area?

4) Does the resumption of base flows following the spawning release keep redds adequately wetted throughout the egg incubation period as expected? If not, what should the spawning release be to ensure all redds are wetted at the base flow?

5) Does the 2-day 7 m^3/s pulse release every week trigger the upstream migration of fall spawners as expected? If not, is this the result of inadequate pulse magnitude, duration, or some combination of both attributes? Or conversely, is the pulsed attraction release unnecessary?

6) Following implementation of the WUP flow prescription to the Elk Canyon reach, has the general fish productivity of the reach increased as expected? If a change is apparent, whether positive or negative, can it be attributed to WUP operations? Conversely, if no change is apparent, are some or all elements of the flow prescription still necessary?

The following hypotheses were developed to answer these management questions:

$H_0$1: Carrying capacity of the Elk Canyon reach, as measured by annual smolt out-migrant counts, does not vary as a function of discharge.

$H_0$2: The number of rearing residents deemed likely to smolt the following spring, as measured during late summer, is not significantly different from the abundance estimate obtained in late winter just prior to the onset of their outmigration.

$H_0$3: The rate of spawning salmonid in-migration (No./day) during the 2-day pulse flow release operation is not significantly different from that during the base flow operation.

$H_0$4: The rate of spawning salmonid in-migration (No./day) during the first day of the pulse flow release operation is not significantly different from that during the second day.

$H_0$5: The estimated number of spawning salmonids following pulse flow release operation is not significantly different from that just prior to the release.

$H_0 6$: The estimated number of spawning Steelhead during the two-week, 7 m^3/s spawning release period in spring is not significantly different from that observed just prior to the operation.

$H_0 7$: The number of redds found above the base flow water level (minus a nominal depth to take into account that Steelhead will not spawn in very shallow water, e.g., 10 cm) following the two-week spawning release is not considered significantly different when compared to the total number of redds in the reach.

$H_0 8$: Following resumption of base flow operations, the number of Steelhead redds found above the water line and therefore, at risk of egg mortality from stranding, is not considered significant compared to the total number of redds in the reach.

$H_0 9$: Annual abundance of 'resident' smolts is not correlated with an index of Steelhead spawner abundance.

1.4. Scope of the JHTMON-15 Study

1.4.1. Overview

The study area for JHTMON-15 consists of the Elk Canyon reach of the Lower Campbell River from its entrance by the John Hart generating station (at the first riffle above the pedestrian bridge) to Elk Falls below John Hart Dam. The species of primary concern are Chinook Salmon, Coho Salmon, and Steelhead, although other salmonid species known to use the system are also monitored.

JHTMON-15 is scheduled for 10 years and is being carried out as a series of interconnected components, each focused on addressing a specific hypothesis and with different durations over the course of the monitoring period. The eight components, along with associated hypotheses being tested, are shown in Table 1. Two components (smolt enumeration and spawner enumeration) were addressed in Year 7 (September 2020 to July 2021) and are presented in this report; the remaining components had been completed in previous years (Table 1). Overview summaries of the monitoring components in relation to the management hypotheses they address are given in the sub-sections below.

Table 1. Summary of TOR components and program years implemented.

Component	Time of Year	Hypothesis Tested	Program Year									
			1	2	3	4	5	6	7	8	9	10
			2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Instream Flow Study	January to May, August, October to December	$H_0$1, $H_0$6, $H_0$7, $H_0$8			✓							
Smolt Enumeration	March to July	$H_0$1	✓	✓	✓		✓	✓	✓	✓	✓	✓
Overwintering Assessment	September and February	$H_0$2	✓	✓	✓	✓	✓					
Fall Pulse Flow Assessment	September to November	$H_0$3, $H_0$5	✓	✓		✓						
Spring Pulse Flow Assessment	February to April	$H_0$3, $H_0$5		✓	✓		✓					
Steelhead Spawning Flow Assessment	March to April	$H_0$6, $H_0$7, $H_0$8		✓	✓		✓					
Spring Spawner Enumeration	February to April	$H_0$9	✓	✓	✓	✓	✓	✓				
Fall Spawner Enumeration [1]	September to November	$H_0$9	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

[1] All fall spawner enumeration surveys were completed the previous year (i.e., Year 1 fall spawner enumeration surveys were completed in 2014).

1.4.2. Instream Flow Study

An instream flow study (IFS) was conducted to test how the carrying capacity of the habitat in Elk Canyon varies with flow; this addresses hypotheses H_01, H_06, H_07 and H_08 of the TOR. The IFS fieldwork was completed in 2017 and included a Fish Habitat Assessment Procedure, habitat suitability criteria validation, empirical habitat modelling, and habitat simulation modelling at different flows. This study has been prepared as an independent report and was submitted to BCH in August 2018 (Healey *et al.* 2018). Overall, IFS results suggested that habitat carrying capacity of Elk Canyon does vary as a function of discharge and that the prescribed flow regime has increased habitat available to salmon compared to pre-WUP conditions.

1.4.3. Smolt Enumeration

The carrying capacity of the Elk Canyon reach is hypothesized to be affected by the magnitude of base flows (e.g., 4 m^3/s) provided in the flow prescription (H_01). This hypothesis is being addressed in part by monitoring salmon fry and smolt production from Elk Canyon using a rotary screw trap (RST) from March to July each year. Priority species for monitoring are Steelhead/Rainbow Trout, Chinook Salmon, and Coho Salmon, although sampling is also providing information for Chum Salmon, Pink Salmon, and Sockeye Salmon that have incubated in Elk Canyon.

Enumeration of outmigrating fry and smolts of all salmon species was conducted in Year 7 and was conducted in all previous years except Year 4. The smolt enumeration component of JHTMON-15 was not completed in Year 4 due to commissioning and construction related activities that prevented access into the Elk Canyon.

In previous years, in addition to reporting outmigrating numbers of fish captured in the RST, mark-recapture trials were conducted to provide estimates of capture efficiency. This allowed the conversion of capture numbers to actual outmigration estimates, taking capture efficiency into account. Mark-recapture sampling with the RST was completed between March and May in years 1, 2, 3, 5, and 6 and summarized in Thornton *et al.* 2021. Mark-recapture was not conducted in Year 7, given that an adequate estimate of capture efficiency had already been generated. Thus, results from previous years were used to adjust Year 7 captures to outmigration estimates. An age analysis of captured fish, which allows assignment of captured fish to age classes based on fork length, was also conducted in previous years, and not in Year 7. Thus, captured fish in Year 7 were assigned to age classes based on the relationship between age and length determined in previous years.

1.4.4. Overwintering Assessment

The overwintering assessment component of JHTMON-15 was developed to test if juvenile fish rear for their entire life history in Elk Canyon or if a portion of the population consists of immigrant juveniles. The overwintering assessment fieldwork was completed in 2019 which consisted of night snorkeling mark/re-sight methods used to estimate Steelhead/Rainbow Trout and Coho Salmon parr densities in fall and in early spring, which were then compared to determine the extent of parr overwintering in Elk Canyon. A synthesis analysis was completed across all four years of data collection (Year 2, 3, 4, and 5) to address Management Question#1 and H_02 of the TOR. Results showed that Steelhead/Rainbow Trout overwinter in Elk Canyon with little immigration or emigration between the fall and early spring period. In contrast, few Coho Salmon overwinter in Elk Canyon (Thornton *et al.* 2020).

1.4.5. Fall and Spring Pulse Flow Assessment

The pulse flow assessment component of JHTMON-15 was developed to test the effectiveness of pulse flows in attracting spawning salmonids and attracting and retaining Steelhead in Elk Canyon. The pulse flows consisted of 2-day pulse flows of 7 m^3/s every week in the fall (September 15 to November 15) and 2-day pulse flows of 10 m^3/s every two weeks in the spring (February 15 to March 15). The pulse flow assessment fieldwork consisted of snorkel surveys scheduled pre- and post-pulses and was completed in 2019. A synthesis analysis was completed in Year 5 to address H_03 and H_05 of the TOR. There was no evidence that the 10 m^3/s pulse flows attracted Steelhead into Elk Canyon. The rate of Steelhead in-migration per day was significantly higher during the base flow than during the pulse flow; H_03 was rejected, and the relationship was in fact opposite to that predicted. The rate of fall spawning salmonid in-migration per day did not differ between periods of pulse flows and periods of base flows for all fall spawners (i.e., H_03 rejected for Coho Salmon, Chinook Salmon, and Chum Salmon; Thornton *et al.* 2020).

1.4.6. Steelhead Spawning Flow Assessment

The flow prescription for Elk Canyon includes a two-week long 7 m^3/s spring spawning flow (April 1-15) aimed at increasing available spawning habitat for Steelhead. The Steelhead spawning flow assessment was completed using snorkel surveys and redd surveys prior to, during, and after the spawning flows in Year 2, 3, and 5. A synthesis analysis was completed after three years of data collection to address H_06, H_07, and H_08 of the TOR. Abundance of Steelhead in Elk Canyon was found to be not significantly different prior to the two-week spawning flow release than during the release across all three years of data collection (2016, 2017, 2019); thus, the null hypothesis H_06 was not rejected. Observational and habitat modelling results suggest that the majority of redds will remain wetted at 4 m^3/s, which retains the null hypotheses of H_07 and H_08 (Thornton *et al.* 2020).

1.4.7. Spring and Fall Spawner Enumeration

Spawner counts in both fall and spring are to be conducted annually for the full JHTMON-15 program through snorkel surveys. Area under the curve (AUC) estimates of abundance was calculated and used to test if the annual abundance of 'resident' smolts is not correlated with an index of Steelhead spawner abundance (H_09) (note that the H_09 hypothesis is concerned only with that portion of the total smolt count that has spent their entire freshwater lifecycle in the Elk Canyon reach). However, it was determined that this hypothesis cannot be adequately addressed due to low adult Steelhead counts in Year 1 through 6 (≤ 10) and inconsistency of survey dates which resulted from restricted access to the Elk Canyon owing to spill events. As a result, spring spawner surveys were discontinued after Year 6. However, fall spawner (e.g., Coho, Chinook, Chum) abundance is being examined in relation to smolt outmigration the following spring to determine whether the abundance of fall spawners is correlated with the abundance of outmigrating smolts. This is expected to provide information on relationships between productivity and flows. It could also be linked to potential bottlenecks to productivity; for example, if not correlated, this may indicate that spawners are habitat limited in which case managing flows to increase the number of spawners may not result in increased productivity. Additionally, productivity of fall spawners is being directly measured, and related to outmigrating smolts, through observations/enumeration of redds, from which the number of eggs, fry, and smolt production is estimated.

2. METHODS

The sections below provide the methods for the two components addressed in Year 7. Additionally, flow data for Year 7 were compiled to demonstrate the flow prescriptions (Section 1.2.1) implemented to investigate the improvement of fish use in the canyon.

2.1. Flows in Year 7

Flow conditions are an important consideration for spawning migration, habitat availability, and smolt outmigration. Flows conditions were summarized for the Year 7 period based on data provided by BC Hydro for the Elk Falls Canyon from August 2020 through to the end of July 2021.

2.2. Smolt Enumeration

2.2.1. RST Captures

Year 7 represented the sixth year of smolt enumeration activities in Elk Canyon for JHTMON-15 (Table 1). In all years, smolt enumeration was carried out using a single 1.2 m rotary screw trap (RST) (a floating fish trap anchored with steel cables to both stream banks; Figure 1, Figure 2) located near the base of the canyon, in the first run type mesohabitat (Figure 1) upstream of the new tailrace of the John Hart generating station (Map 2).

The RST install equipment was designed with the help of a qualified rigging professional. The rigging allowed adjustment of fishing position and included a mechanism for moving the trap if necessary (e.g., in the event of a planned spill) and a breakaway mechanism for recovering the trap safely in the event that it broke free. Use of the RST followed a standard protocol (U.S. Fish and Wildlife Service 2008).

In Year 7, the RST was installed March 1, 2021, and was kept operational five days a week (excluding most weekends) until July 19, 2021, for a total effort of 80.69 days (Table 2). The RST was first installed in 2015 and has operated between late February/early March and late July for every year of the smolt enumeration component for the JHTMON-15 study (i.e., except Year 4; Table 1). By the end of Year 7 (2021), a total of 639 trap days had been accumulated (i.e., more than 15,000 hours of trapping) (Table 2).

There were two main fishing positions for the trap in all years, including Year 7: Position #1 was for base flows of 4 m^3/s (Figure 1) and Position #2 was for pulse flows of 10 m^3/s and the prescribed spawning flow of 7 m^3/s (Figure 2). One difference in sampling conditions between years was related to the movement of the tailrace partway through the program (see Section 1.2.1). The tailrace, in its new location, causes significant backwatering compared to flow conditions created by the tailrace in the old location. In response to this increased backwatering, small adjustments were made to the placement of the RST according to tailrace flows. However, other than moving the trap between its two positions, and the minor adjustments that were made related to backwatering, the position of the RST in the Elk Canyon has been relatively consistent throughout the duration of the monitoring program.

Crews serviced the trap daily, or every other day depending on total catches. A crew of two accessed the trap to record trap orientation and rotation, water velocity at the trap, and the debris present in the trap. The trap was cleaned, serviced, and all fish were removed for sampling.

All fish caught in the trap were removed and identified to species prior to release. A small, semi-permanent fish sampling station was constructed to increase sampling efficiency and allow for fish to be sampled on shore, outside of the active channel. On each catch date, a maximum of ten fish per species and size class were measured for fork length and weight. If more than ten fish per size class and species were captured, the surplus fish were identified to species in a fish viewer. All fish were released back to the river downstream of the trap.

The condition of the trap was also monitored continuously by a remote camera, which took a series of still pictures each morning (at first light) and evening. Pictures were emailed automatically to the trapping crew, so they were aware of any potential issues with the trap prior to arriving onsite. For site security, the camera was also programmed to be motion activated to detect tampering or vandalism.

Table 2. RST trap effort in Years 1, 2,3, 5, 6, and 7.

Year	Total Effort (h:mm:ss)	Total Effort (hrs)	Total Effort (days)
2015	2624:17:00	2624.28	109.35
2016	1952:06:00	1952.1	81.34
2017	3571:32:00	3571.53	148.81
2019	3110:29:00	3110.48	129.6
2020	2144:53:00	2144.88	89.37
2021	1936:28:48	1936.48	80.69

Figure 1. Rotary Screw Trap (RST) during operation in 2021 at base of Elk Canyon at 4 m^3/s (Position #1).

Figure 2. Rotary Screw Trap (RST) during operation in 2021 at base of Elk Canyon at 10 m^3/s (Position #2).

2.2.2. Fish Scale Age Analysis

Results from previous years were used to classify fish captured in Year 7 to age class, according to fork length. No scale samples were collected or aged in Year 7, and no additional samples will be collected in subsequent years.

Fish scale age analysis was completed using samples from RST captured Steelhead/Rainbow Trout, Chinook Salmon, and Coho Salmon from ears 1, 2, 3, 5, and 6. In total, 279 scale samples from Steelhead/Rainbow Trout, 362 scale samples from Chinook Salmon, 138 scale samples from Coho Salmon, and 53 scale samples from Cutthroat Trout were collected in these years. Of these, 80 Steelhead/Rainbow Trout, 43 Coho Salmon, and 33 Chinook Salmon scales were aged. This was conducted in the Ecofish laboratory, where scales were examined under a dissecting microscope. Three representative scales from each sample were photographed and annuli were noted on a digital image. Scales were aged by two independent observers, following Ecofish in-house QA protocols. Where discrepancies were noted, they were discussed, and a final age determination was made based on professional judgment of the senior biologist). Species specific age data were then used to create discrete fork length bins, that were associated with age.

Results from the age analysis conducted with all data combined (Year 6) are presented fully in Thornton *et. al* 2021. The resultant species-specific length age relationships and size at age classification (i.e., determined in Year 6) are reproduced in Figure 3 and Table 3 below.

Figure 3. **Length at age graphs determined from scale samples taken from fish in years 1, 2, 3, 5, and 6 for a) Chinook Salmon, b) Coho Salmon, and c) Steelhead/Rainbow Trout.**

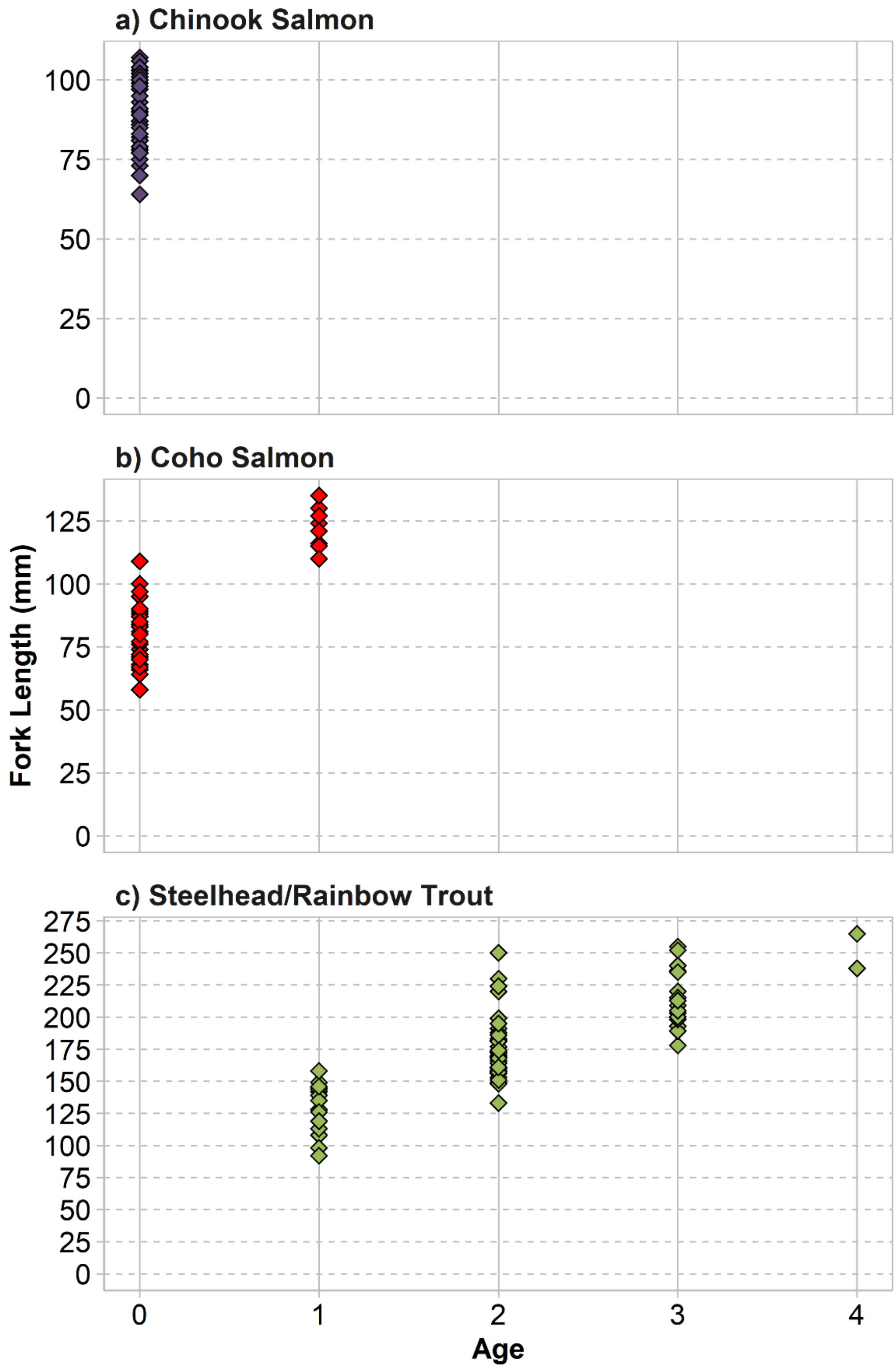


Table 3. Estimated size at age classification for juvenile Chinook Salmon, Coho Salmon, and Steelhead/Rainbow Trout based on captures in years 1, 2, 3, 5, and 6.

Species	**Age Class**	**Fork Length (mm)**
Chinook Salmon	0+	≤111
Coho Salmon	0+	30-109
	1+	110+
Steelhead/Rainbow Trout	0+	≤85
	1+	92-150
	2+	151-199
	3+	200-255
	Adult >3+	265+

2.2.3. Estimating Capture Efficiency and Outmigration

Mark-recapture trials for salmon fry and smolts were used to estimate the capture efficiency of the RST and to ultimately generate outmigration estimates from Elk Canyon. Mark-recapture trials were completed between March and May in Years 1, 2, 3, 5 and 6. Trials were conducted by marking a target of 200 fish (hatchery fish, or wild fish captured in the RST) either by immersion in Bismarck Brown or a unique ventral fin clip and releasing them approximately 225 m upstream of the RST. The number of recaptures in the two days following the release per trial were recorded to calculate a capture efficiency. Additional detail on the trials is provided in Thornton *et. al.* 2021. Results of these mark-recapture trials allowed calculation of two capture efficiency estimates (capture efficiency by trial, and capture efficiency by species and life stage) based on recaptures of the marked and released fish. The capture efficiency estimates were then used with the capture data to estimate daily salmonid outmigration abundances. Outmigration in Year 7 was therefore estimated from RST captures in Year 7, adjusted for capture efficiency as determined in previous years. Field methods from the mark recapture trials and additional detail on fish captured during these trials are provided in Years 1, 2, 3, 5, and 6 annual monitoring reports which can be found on the BC Hydro website (BC Hydro 2022).

To estimate capture efficiency from mark-recapture data from Years 1, 2, 3, 5, and 6 (that were used to calculate Year 7 outmigration from Year 7 RST capture data), we first calculated the trial capture efficiency based on recapture rates calculated for each trial, through the following equation:

$$CEt_{t,i,s,y} = \frac{RR_{t,i,s,y}}{r_{t,i,s,y}}$$

Where $Cet_{t,I,s,y}$ is the trial capture efficiency of trial *t* at year *y* for species *i* at life stage *s*, $RR_{t,i,s,y}$ is the total number of recaptured fish of species *i* at trial *t* in year *y* at life stage *s*, and $r_{t,i,s,y}$ is the number of released fish of species *i* at trial *t* in year *y* at life stage *s*. In total, we performed 82 mark-recapture trials from Years 1 to 6, although no marked fish were captured in 11 trials. These 11 trials were not considered for the subsequent analysis.

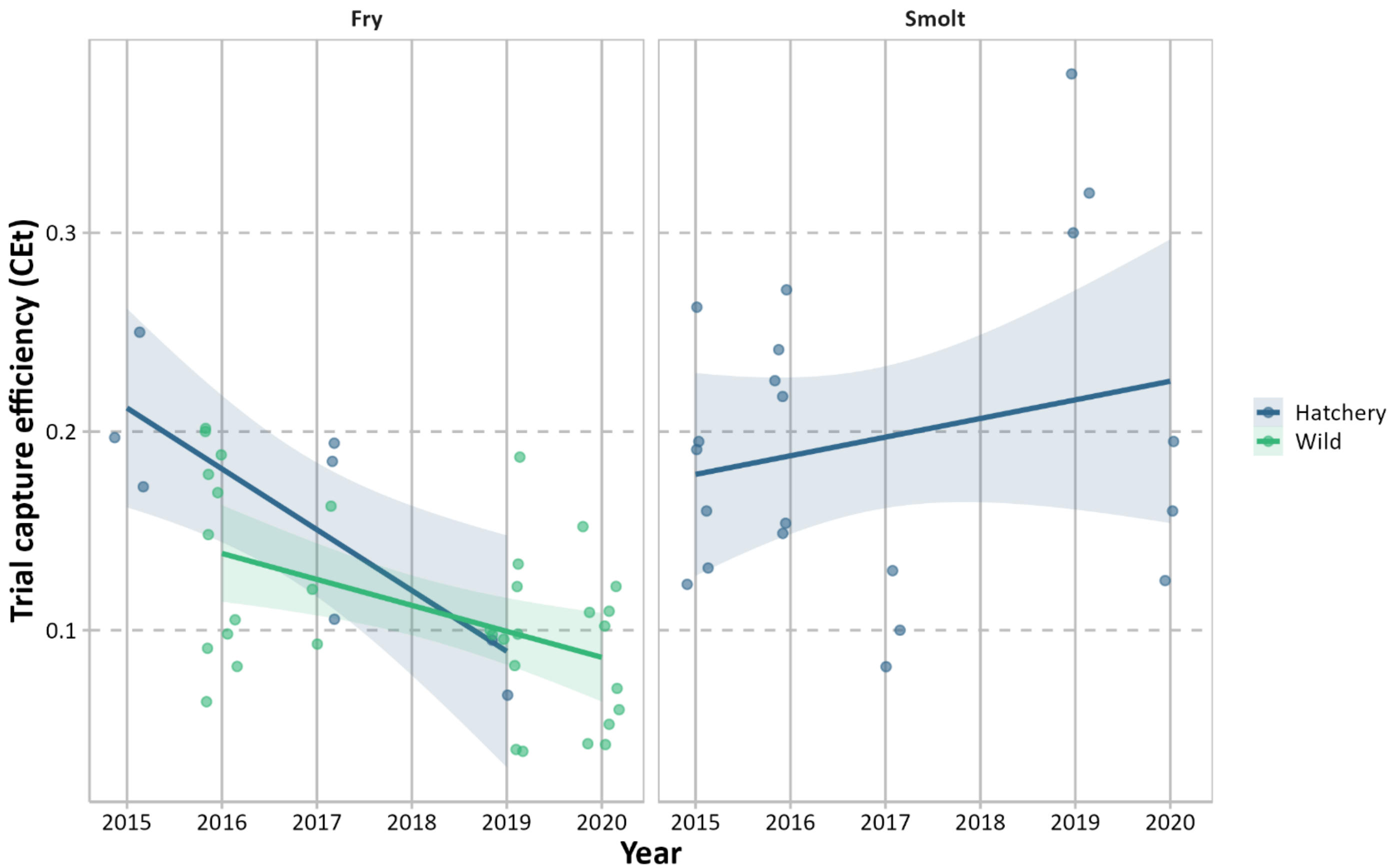
We next calculated an overall capture efficiency based on the combined information from 71 trials for each species and life stage weighted by the number of fish released per trial, through the following equation:

$$CEo_{s,y} = \frac{\sum(r_{t,s,y}\, CEt_{\,t,i,s,y})}{\sum r_{s,y}}$$

Where $CEo_{s,y}$ is the annual weighted average capture efficiency of salmonid life stage *s* at year *y*, $r_{t,s,y}$ is the total number of salmonids released at trial *t,* in life stage *s* at year *y*, $CEt_{t,i,s,y}$ is the trial capture efficiency at life stage *s* at year *y*, and the denominator, $\sum r_{s,y}$, represents the total number of fish released at life stage *s* at year *y*. This resulted in two overall capture efficiencies per year, one for fry and one for parr/smolts.

In total, 82 mark-recapture trials were conducted in five previous years of the monitoring program (not in Year 7). Methods and results are fully presented in Thornton *et. al.* 2021. In summary, capture efficiencies differed by year and life stage for both fry and smolts/parr (Figure 4 – reproduced from Thornton *et. al.* 2021) and there was an overall decreasing trend in capture efficiency for fry but not for smolts/parr. Because the new tailrace location caused a backwatering effect, which may have influenced capture efficiency in recent years, capture efficiencies in 2019 and 2020 were averaged to predict outmigration estimates in years since 2019, including Year 7. These capture efficiency values will also be applied to subsequent monitoring years.

Figure 4. Trial capture efficiencies (CEt) for salmonid a) fry and b) smolts/parr in Year 1 (2015), Year 2 (2016), Year 3 (2017), Year 5 (2019), and Year 6 (2020) of the mark-recapture experiments. Blue coloured points (hatchery origin) and green coloured points (wild origin) depict the overall capture efficiency per year of monitoring (weighted averages of trial capture efficiencies; CEo) used to estimate total outmigration of salmonids from the Elk Canyon.



2.3. Fall Spawner Enumeration

2.3.1. Fall Spawner Abundance

Full canyon snorkel surveys were used to enumerate fall spawners in reaches one to six of the Elk Canyon (Map 2). The snorkel counts were carried out by a crew of two snorkelers swimming in tandem with a third crew member recording data onshore. In Year 7, a total of eight snorkel surveys were conducted in 2020 on September 11 and 25, October 6, 16, and 27, November 6 and 23, and December 4 to inventory fall spawning Coho Salmon, Chinook Salmon, Chum Salmon, Pink Salmon, Sockeye Salmon, and Steelhead in the Elk Canyon. In each reach, total counts of all species, their spawning condition, and the presence of redds were recorded.

Spawner abundance for each salmon species was estimated using an area under the curve (AUC) analysis with the DFO AUC calculator tool. The AUC calculator uses the survey abundance estimates, along with estimates of fish residence time and observer efficiency, to estimate the total spawner abundance. Estimates of fish residence times are provided in Perrin and Irvine (1990) (Table 4). Observer efficiency was assumed to be 100%.

2.3.2. Fall Spawner Productivity

The production of fry and smolts was estimated based on the maximum number of redds observed for Chinook, Coho, Chum, Pink, and Sockeye salmon spawners. Assuming that a female would spawn in a single redd, we estimated the number of eggs produced per redd based on average female fecundity by salmon species (Bradford 1995). We then estimated fry and smolt production by salmon species based on the egg to fry and egg to smolt survival rates provided in Quinn (2005). For egg to smolt survival, only Coho and Chinook salmon were considered as the remaining species outmigrate as fry. These estimates of fry and smolt production from observed salmon redds were compared against the fry and smolt outmigration estimates generated from the RST data. In addition, fall spawner abundance estimates were compared to smolt enumeration data to test if the annual abundance of smolts is correlated with spawner abundance.

Table 4. Fall spawner residence times (source Perrin and Irvine 1990).

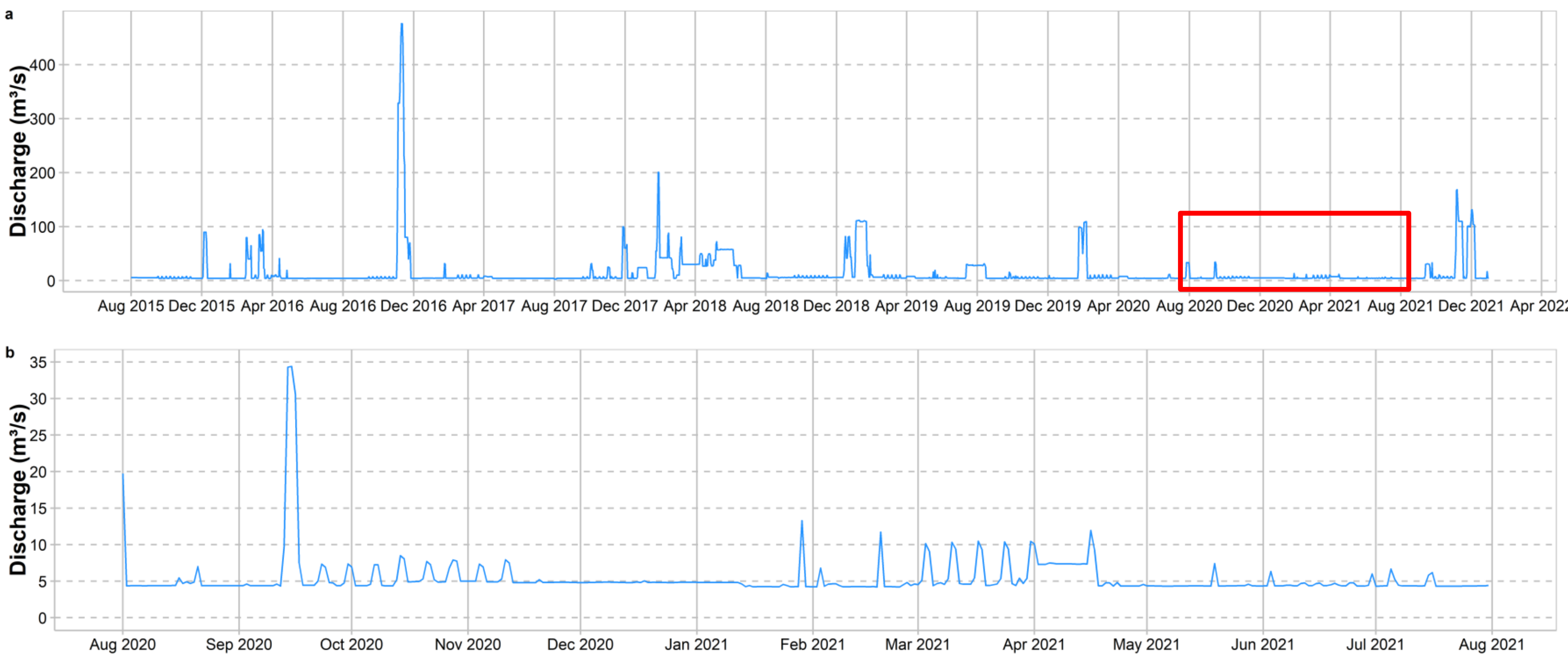
Fish Species	Residence Time (days)
Coho Salmon	11.4
Chum Salmon	11.9
Pink Salmon	17.3
Chinook Salmon	12.1
Sockeye Salmon	13.2

3. RESULTS

3.1. Flows in Year 7

Figure 5a shows measured flow in Elk Canyon from September 2015 through to the end of December 2021. Figure 5b shows the measured flow in Elk Canyon from August 2020 through to the end of July 2021. The 7 m^3/s pulse flows in September through November are evident, as are the 10 m^3/s pulse flows and 7 m^3/s spawning flow in February to March and April, respectively. Also evident is the ~35 m^3/s flow that occurred during an operational change in mid-September 2020.

Figure 5. Discharge (m^3/s) in Elk Canyon for (a) August 2015 to January 2022; and (b) August 2020 to August 2021. Note different y-axis scales in panels a and b. Rectangle in b) shows period covered in a).



3.2. Smolt Enumeration

3.2.1. RST Captures

In Year 7 (2021), the RST operated for approximately 81 days (approximately 1,936 hours) between March 1 to July 19, 2021 (Table 2). In total, 8,237 fish were captured in the RST (Figure 6). Similar to previous RST sampling years, the catches in 2021 were primarily composed of Chinook Salmon (48.2%), Chum Salmon (35.5%), and Coho Salmon (10.9%). Pink Salmon and Steelhead/Rainbow Trout accounted for 1.4% and 0.23% and of all captures, respectively. The combined catch of all salmonids (8,185 fish) accounted for 99.4% of the total catch in 2021, whereas the catch of the key target species of Chinook Salmon, Coho Salmon, and Steelhead/Rainbow Trout (4,888 fish) accounted for 59.3% of the total catch.

Of the 8,185 salmonids caught in the RST in 2021, 1,301 fish were measured for fork length. The fork lengths of these fish were used to age them and determine if outmigration timing varied by the size and/or age cohort of fish (Figure 7, Appendix A; see Section 2.2.2 for aging fish based on size).

Chinook were captured from March through July in 2021. Recently emerged Chinook fry were captured from March to early May, with average fork length ranging from 37 to 52 mm. From late May to the end of July, the majority of the Chinook captured had average fork lengths between 64 to 88 mm (Figure 7, Appendix A); most of these fish were assumed to be age 0+ smolts that had reared for several months in Elk Canyon prior to their outmigration.

Coho Salmon were also captured from March through July in 2021. Recently emerged Coho fry were captured from March to early May, with average in fork length ranging from 37 to 52 mm.

Both Chum Salmon fry and Pink Salmon fry were captured only early in the year in 2021: Chum Salmon were captured only until April 30, and Pink Salmon were captured only until April 9. No Sockeye Salmon were captured in the RST.

Steelhead/Rainbow Trout fry were captured later in the year (July) and smolts were captured between March and May in 2021. The peak in Steelhead/Rainbow Trout outmigration occurred at end of May (Figure 6, Appendix A). In total, only 19 individual fish were captured between March and July. Most of the captured Steelhead/Rainbow Trout were age 1+ (~37%; 92-150 mm) and age 2+ (~37%; 151-199 mm), which were captured between March and July. Small 0+ (≤85 mm) and 3+ (200-256 mm), made up small proportions of RST captures (~21% and ~5% respectively).

Over all six years of monitoring (2015, 2016, 2017, 2019, 2020, and 2021), the RST captured a total of 68,821 fish in the Elk Canyon, with salmonids representing over 90% of the total catch (64,431 fish) (Figure 8). Chum Salmon fry were most abundant in the RST catch across all years except Year 1 and Year 7 (average catch = 7,705), followed by Chinook Salmon (average catch = 1,784), and Coho Salmon (average catch = 429). In Year 3 (2017), we observed a substantial decrease in all salmonids captured (Figure 8 and Figure 9). The low capture numbers in 2017 are likely the result of a large spill event between November 4 and 24, 2016 (Section 3.4), which could have scoured redds within Elk Canyon (Figure 5b). The number of Steelhead/Rainbow Trout and Sockeye Salmon individuals caught during RST operations appear to show a decreasing trend over the years of the study so far, having decreased from 93 and 78 in Year 2 to 19 and 0 in Year 7, for Steelhead/Rainbow Trout and Sockeye Salmon, respectively.

The seasonal patterns of salmonids captured by the RST has remained relatively consistent for each species throughout the monitoring program (Figure 9). Daily catch averages consistently showed two outmigration peaks for Chinook Salmon, one in early to mid March and a second one in late May and early June. Similarly, Coho Salmon catch peaked yearly around mid to late March and later between June and July. Chum, Pink, and Sockeye Salmon RST catch peaked between mid March and early April. Steelhead/Rainbow Trout peaked each year in May, although some differences were noted by age class (see also Figure 7).

Figure 6. Daily RST catches of key salmonid species in Elk Canyon in 2021.

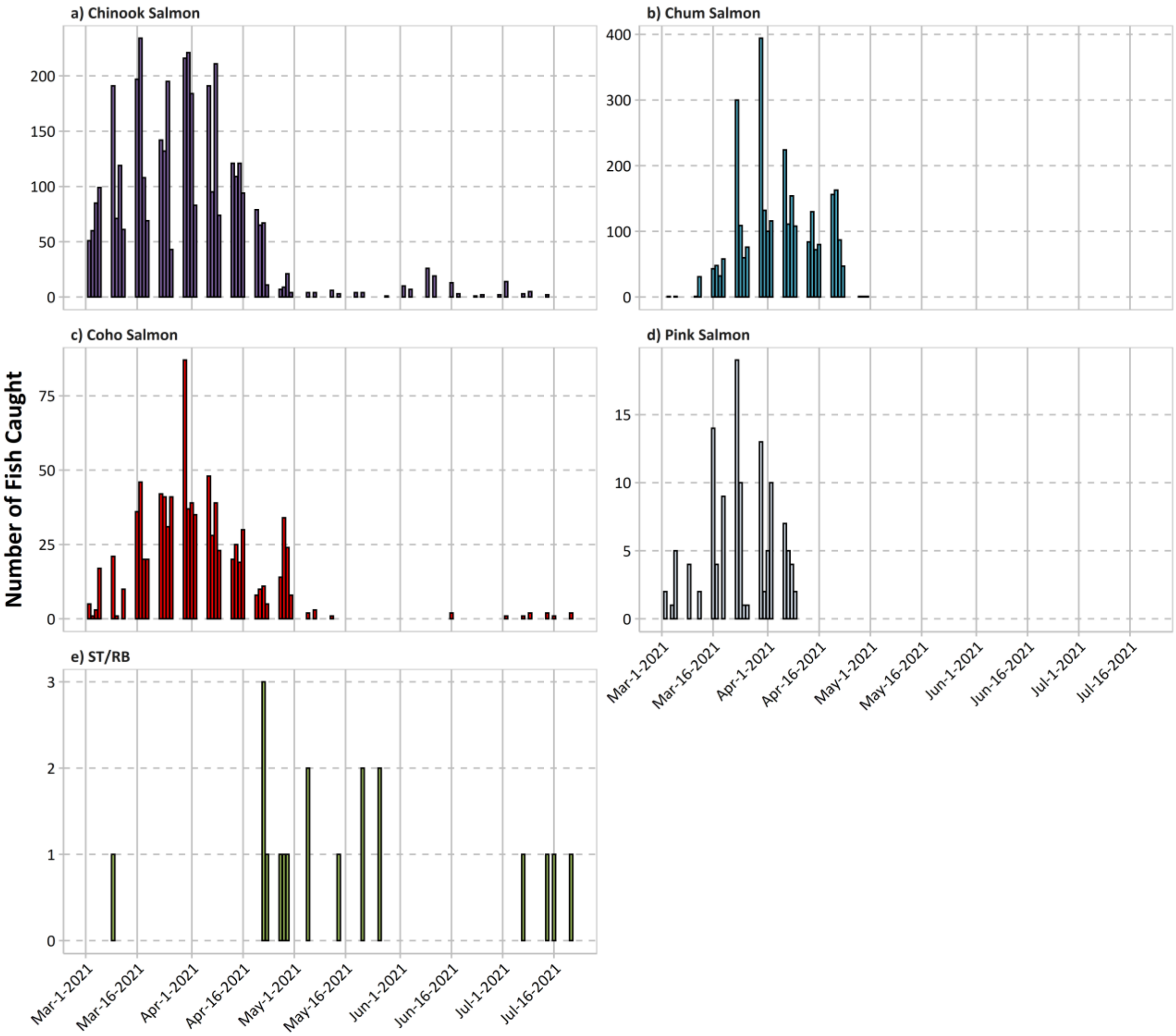


Figure 7. Average fork length of key salmonid species captured in the RST in the Elk Canyon between March 1 and July 19, 2021. Error bars represent standard deviations.

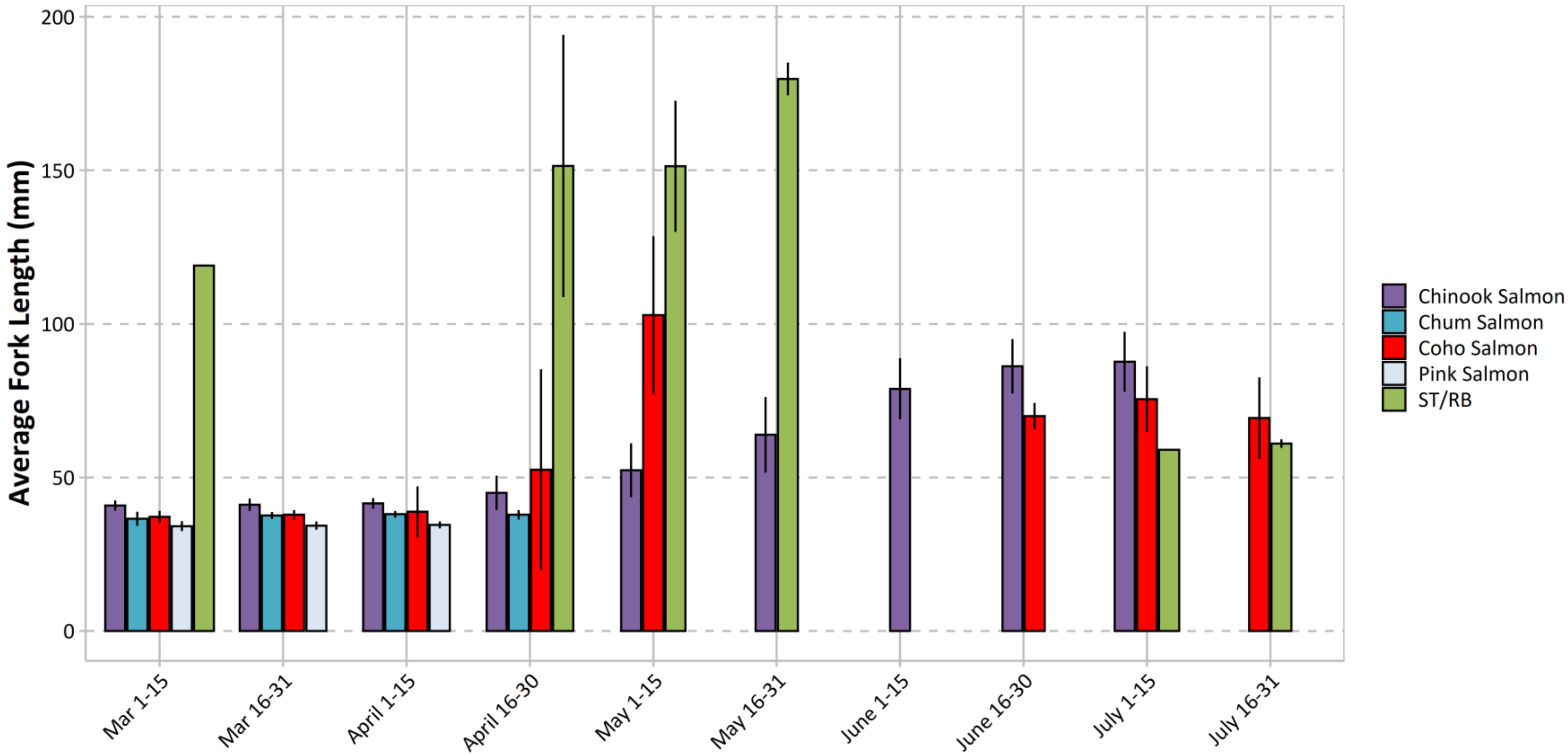


Figure 8. Total number of RST fish captures by species in Elk Canyon during the monitoring program to date (ST/RB = steelhead/Rainbow Trout, CO = Coho Salmon, CH = Chinook Salmon, CM = Chum Salmon, PK = Pink Salmon, SK = Sockeye Salmon, CT = Cutthroat Trout, CAL = Coastrange Sculpin, CCG = Slimy Sculpin, CAS = Prickly Sculpin, CC = sculpin (*Cottus* spp.), DV = Dolly Varden, PL = Pacific Lamprey, L = Lamprey, CRAY = Crayfish, TSB = Threespine Stickleback, SB = Stickleback, SA = Unknown Salmon species, TR = unknown trout spp., UNK = unknown fish species (fry mortalities that were too damaged to identify to species in the field)).

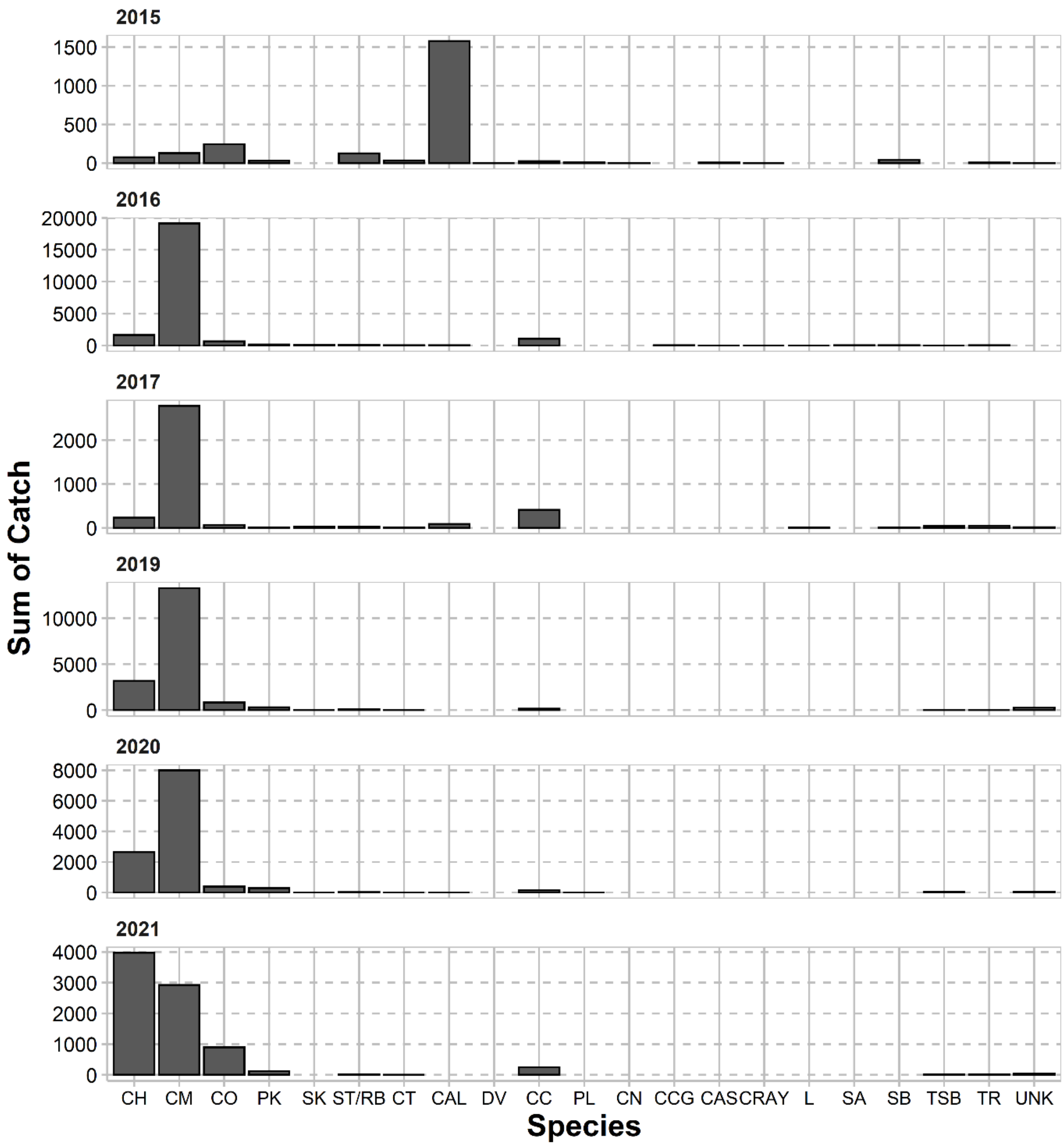


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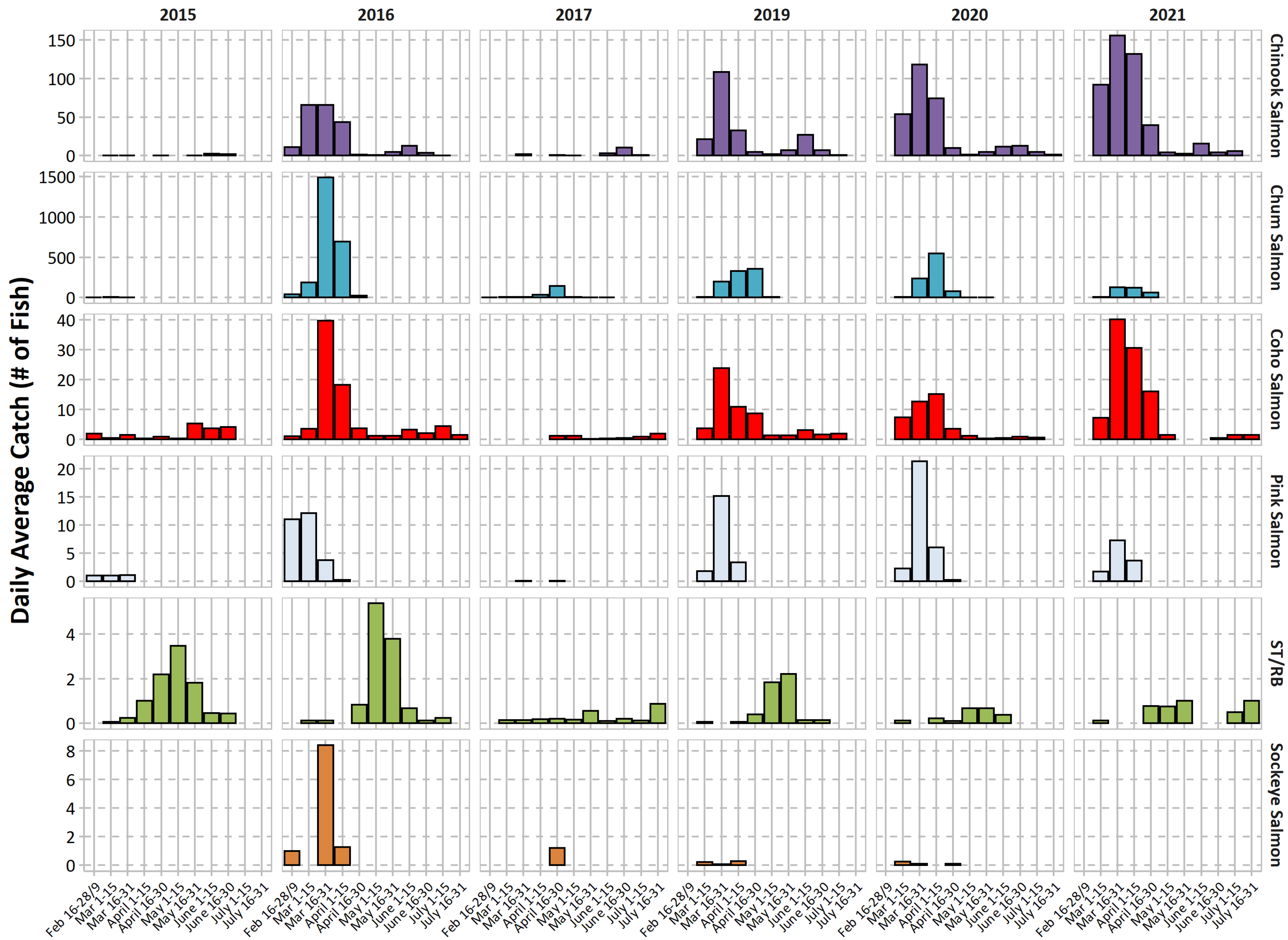
Figure 9. **Daily average RST catch of key salmonid species per sampled day by half-month periods for Year 1 (2015), 2 (2016), 3 (2017), 5 (2019), 6 (2020), and 7 (2021) of the monitoring program in Elk Canyon.**



3.2.2. Juvenile Salmonid Outmigration

In general, total fry and smolt outmigration from Elk Canyon, which was calculated by species based on RST catches (Section 3.2.1) adjusted for capture efficiency (Section 2.2.3), were variable among years with no clear trends over the monitoring period, although smolt production generally decreased for Coho Salmon and Steelhead/Rainbow Trout (Figure 10, Table 5). Two low years of production were generally observed for Chinook, Chum, Coho, and Pink Salmon fry, 2015 and 2017, and 2019 was a low year for Steelhead/Rainbow Trout. Estimated fry outmigration was highest in Year 7 (2021) for Coho and Chinook Salmon and Steelhead/Rainbow Trout and was highest in Year 2 (2016) for Chum and Sockeye Salmon. Outmigration was highest for Pink Salmon in Year 6 (2020).

Estimated numbers of fry outmigrating from the Elk Canyon were also highly variable by species (Table 5). Estimated numbers of Chum Salmon fry were the highest of all species reaching a maximum of 278,482 individuals in 2016. Estimated numbers of Chinook Salmon and Coho Salmon 0+ fry also reached high numbers in some years (87,480 and 20,953, both in 2021). Numbers were generally low in 2015 (e.g., 643, 52, and 193 for Chum, Chinook, and Coho Salmon). Estimated Sockeye and Pink Salmon fry numbers were intermediate, and Steelhead/Rainbow Trout fry outmigration estimates were the lowest of all species in most years, ranging from 11 in Year 5 (2019) to 89 in Year 2 (2016).

Smolt outmigrating numbers were similarly variable among years for species were smolt were captured (Chinook and Coho Salmon and Steelhead/Rainbow Trout) (Figure 10, Table 5). Outmigration of smolts decreased between years 1 and 7 for Coho Salmon and Steelhead/Rainbow Trout, although 1+ Coho smolts had the highest outmigration estimates in Year 6 (Table 5). Chinook Salmon smolt outmigration estimates increased between Year 1 and 6, and then decreased in Year 7.

In general, relatively consistent seasonal patterns were documented by species across the years of the monitoring program to date (Figure 11, Figure 12). As noted for RST capture (Section 3.2.1), 2017 was an anomalous year for outmigration for all species, likely due to the large spill event between November 4 and 24, 2016.

For Chinook Salmon, two outmigration peaks were documented, a large peak of recently emerged fry in March and early April and a second smaller peak in late May and early June composed of larger individuals (0+ smolts). The majority of Chinook 0+ fry left the canyon by early April (Figure 13), while the majority of smolts 0+ migrated later in the season, by early to mid-June (Figure 14).

Coho Salmon exhibited three main peaks in outmigration: outmigration of Coho fry occurred from early March until early May; within this time period two peaks were evident: late March and early to mid April (Figure 11, Figure 13). A third peak of Coho Salmon in late June through July consisted primarily of 0+ smolts; 50% of estimated Coho smolts 0+ or older tended to leave the canyon by early June (Figure 14). The outmigration for Coho 0+ smolts was extended relative to that of Chinook smolts, which is evident in Figure 14. For example, in Year 2 (2016), Coho outmigration started in April and 50% of the estimated numbers of 0+ smolts had left the canyon by early July. In contrast, approximately 50% of the estimated numbers of Chinook smolts outmigrated within June.

Chum Salmon outmigration began in early March and typically peaked in early April, but there was slightly more inter annual variability in timing than for Chinook and Coho Salmon (Figure 11). For example, the majority of Chum Salmon 0+ fry had outmigrated by early March in Year 1 (2015) and by early April in Year 3 (2017).

Sockeye Salmon estimated outmigration varied considerably between years; in Year 5 most of the estimated 0+ fry migrated as early as early March while in Year 3, most outmigrated in mid-April (Figure 12, Figure 13). Pink Salmon outmigration began in early March and peaked late March to early April (Figure 12, Figure 13).

The outmigration timing of Steelhead/Rainbow Trout differed by year and age class. In general, outmigration occurred from mid-April through July with a peak occurring around the end of May (Figure 12). Steelhead/Rainbow Trout 0+ fry estimated outmigration peaked during May in years 1 (2015) and 2 (2016); however, from Year 3 onwards, outmigration peaks became less conspicuous, and outmigration was spread between April and June (Figure 12, Figure 13). Daily outmigration estimates for 1+ Steelhead/Rainbow Trout varied considerably between years with outmigration typically occurring between mid-March and mid-July (Figure 15). The timing of outmigration of 2+ Steelhead/Rainbow Trout was similar among years, with most outmigration consistently occurring between mid-April and late-May. Daily outmigration timing of 3+ Steelhead/Rainbow Trout was similar to that of 2+ Steelhead/Rainbow Trout, although it was typically spread out over a wider time period.

Table 5. Total RST catch, estimated total outmigration, and overall capture efficiencies (CEo) for key salmonid species between Year 1 (2015) and 7 (2021) of the monitoring program in the Elk Canyon.

Species	Life Stage	2015			2016			2017			2019			2020			2021		
		RST Catch	CEo	Total Outmigration	RST Catch	CEo	Total Outmigration	RST Catch	CEo	Total Outmigration	RST Catch	CEo	Total Outmigration	RST Catch	CEo	Total Outmigration	RST Catch	CEo	Total Outmigration
Chinook Salmon	Fry 0+	10	0.209	53	1,424	0.141	19,936	77	0.152	584	2,861	0.091	31,563	2,452	0.066	54,687	3,880	0.074	87,480
	Smolt 0+	64	0.177	362	188	0.210	1,663	153	0.104	1,571	318	0.333	1,028	200	0.160	2,257	93	0.247	660
Coho Salmon	Fry 0+	36	0.209	193	533	0.141	7,838	38	0.152	295	743	0.091	8,246	358	0.066	8,472	863	0.074	20,953
	Smolt 0+	203	0.177	1,164	94	0.210	903	27	0.104	412	90	0.333	292	18	0.160	187	16	0.247	116
	Smolt 1+	7	0.177	49	2	0.210	16	0	0.104	0	4	0.333	11	8	0.160	89	17	0.247	143
Steelhead/Rainbow Trout	0+	4	0.209	18	6	0.141	89	4	0.152	40	1	0.091	11	2	0.066	30	4	0.074	92
	1+	12	0.177	73	16	0.210	135	8	0.104	85	6	0.333	20	8	0.160	69	7	0.247	49
	2+	77	0.177	461	66	0.210	587	9	0.104	132	30	0.333	101	6	0.160	75	7	0.247	51
	3+	33	0.177	247	5	0.210	72	5	0.104	62	27	0.333	93	1	0.160	6	1	0.247	4
	Adults	0	0.177	0	0	0.210	0	1	0.104	9	0	0.333	0	0	0.160	0	0	0.247	0
Chum	Fry 0+	130	0.209	643	19,132	0.141	278,482	2,784	0.152	19,456	13,274	0.091	147,785	7,991	0.066	207,373	2,921	0.074	74,088
Pink Salmon	Fry 0+	31	0.209	194	140	0.141	1,865	2	0.152	13	315	0.091	3,467	287	0.066	6,963	120	0.074	3,335
Sockeye Salmon	Fry 0+	0	0.209	0	78	0.141	1,177	18	0.152	119	8	0.091	94	4	0.066	131	0	0.074	0

Figure 10. **Yearly estimations of total outmigration of a) fry and b) smolts of key salmonid species from Elk Canyon. Note that the y axis is in $\log_{10}$ scale and that no sampling was conducted in 2018.**

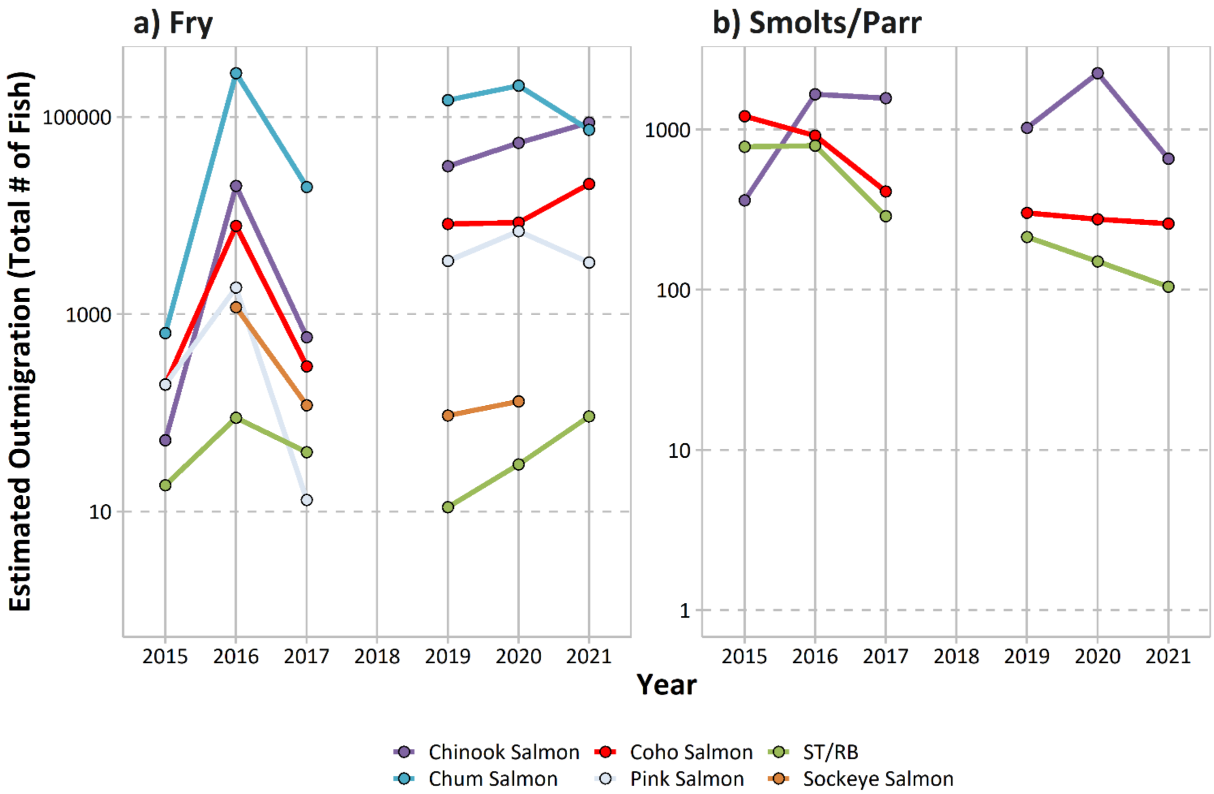


Figure 11. Daily estimated outmigration for Chinook, Chum, and Coho Salmon species for Year 1 (2015), Year 2 (2016), Year 3 (2017), Year 5 (2019), Year 6 (2020), and Year 7 (2021) in the Elk Canyon. Note 2017 was an anomalous year for outmigration for all species, likely due to the large spill event in November 2016.

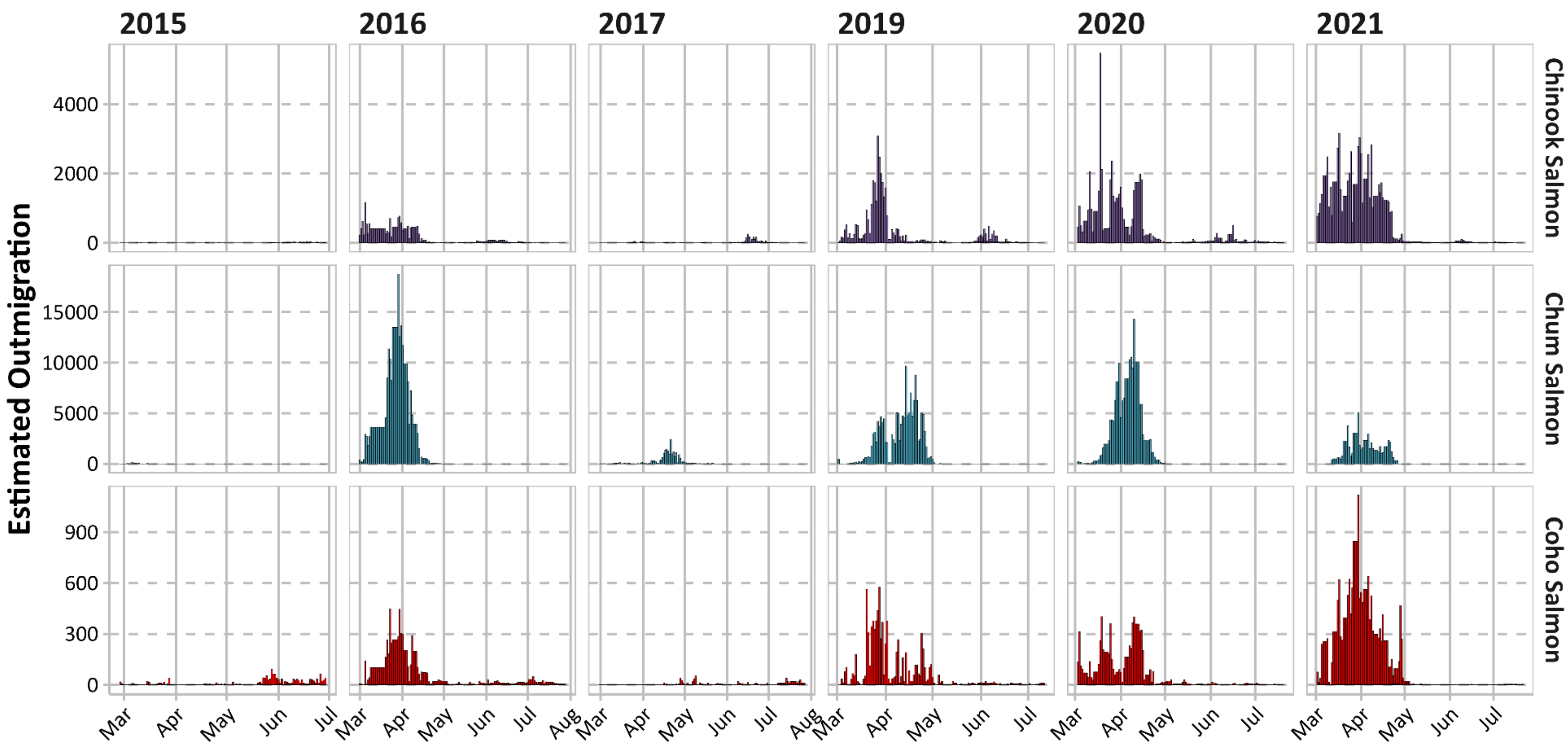


Figure 12. Daily estimated outmigration for Pink Salmon, steelhead/Rainbow Trout, and Sockeye Salmon for Year 1 (2015), Year 2 (2016), Year 3 (2017), Year 5 (2019), Year 6 (2020), and Year 7 (2021) in the Elk Canyon.

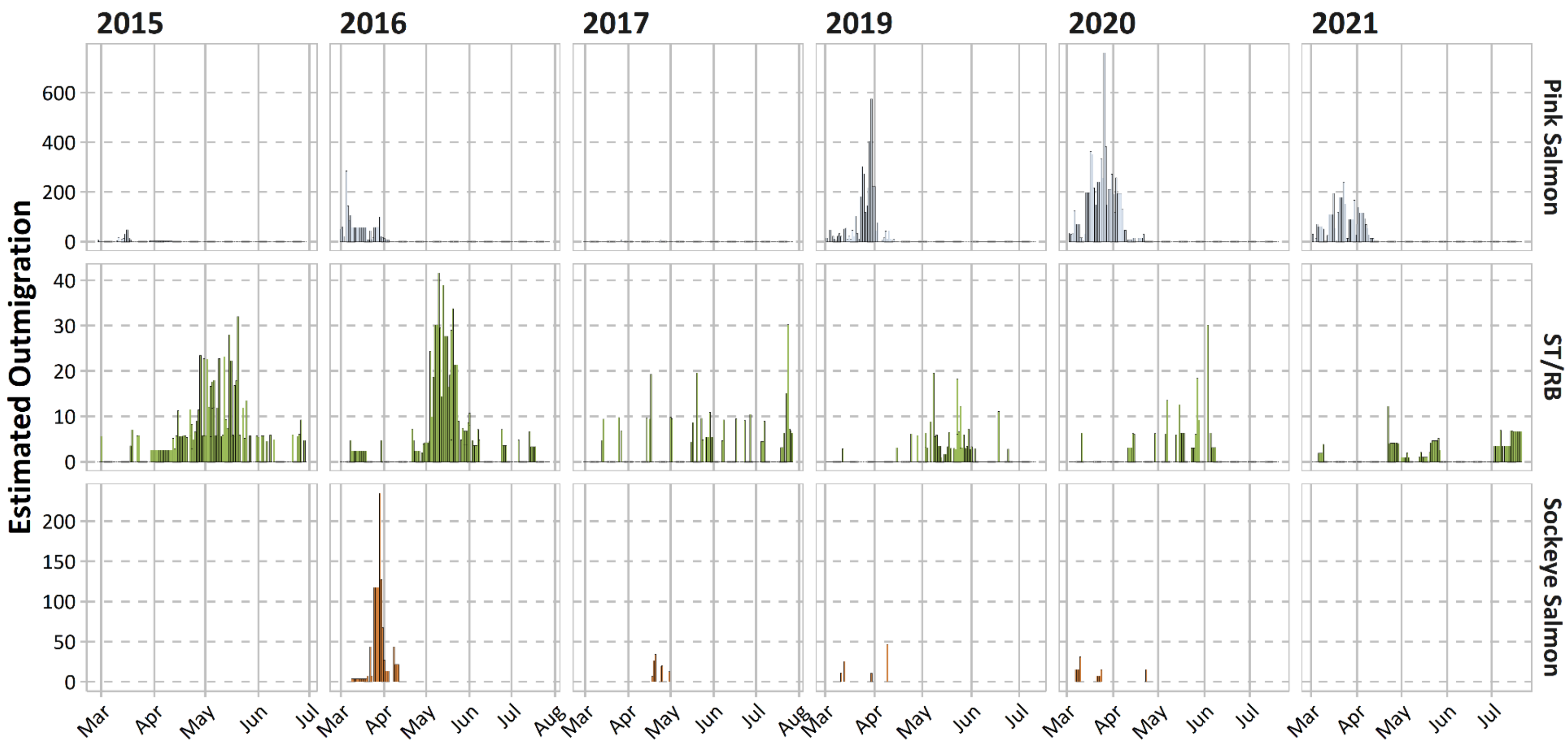


Figure 13. Cumulative daily outmigration of 0+ fry for key salmon species in the Elk Canyon relative to outmigration date.

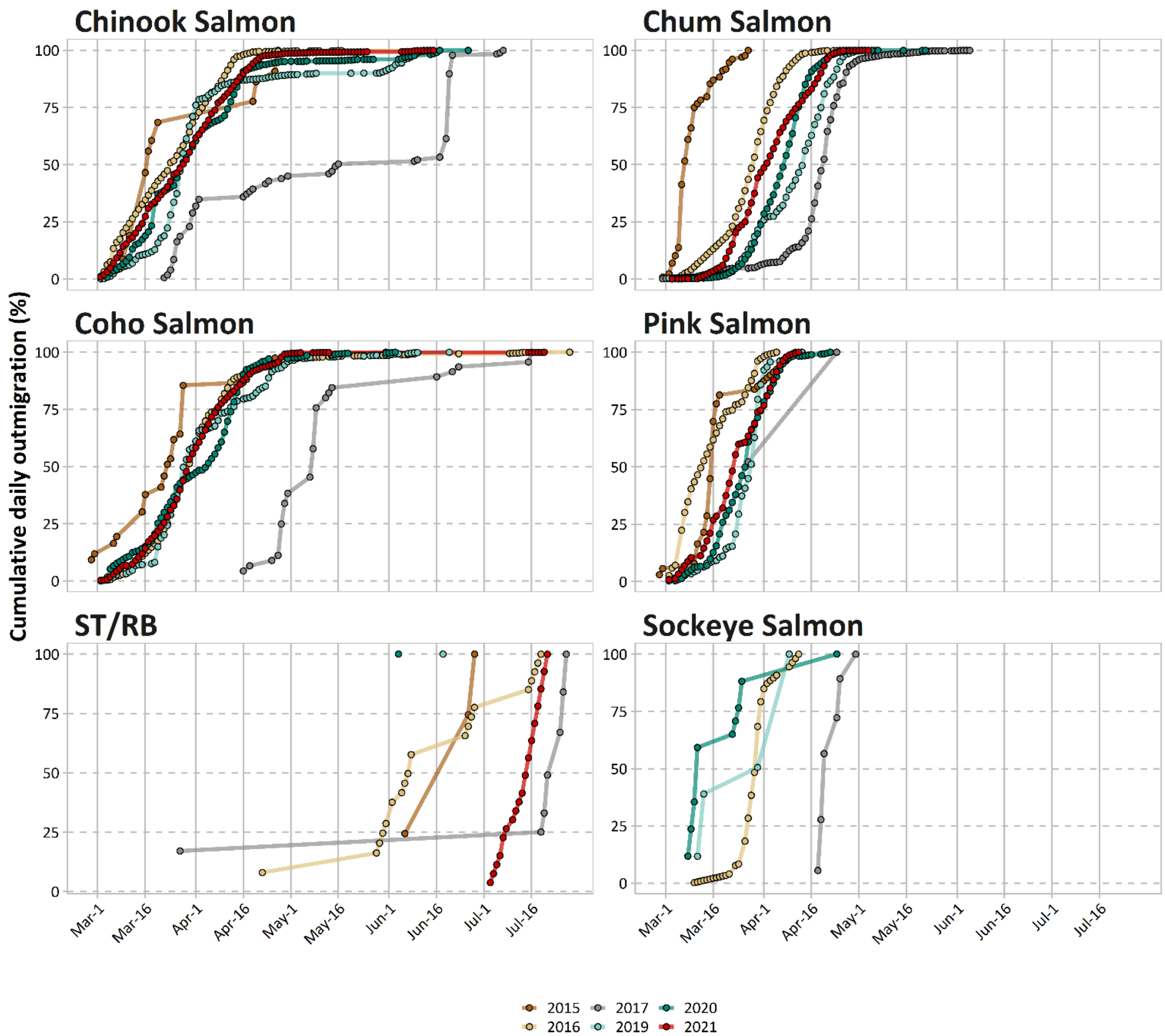


Figure 14. Cumulative daily outmigration of Chinook and Coho salmon smolts (0+ and 1+) from the Elk Canyon by date and year.

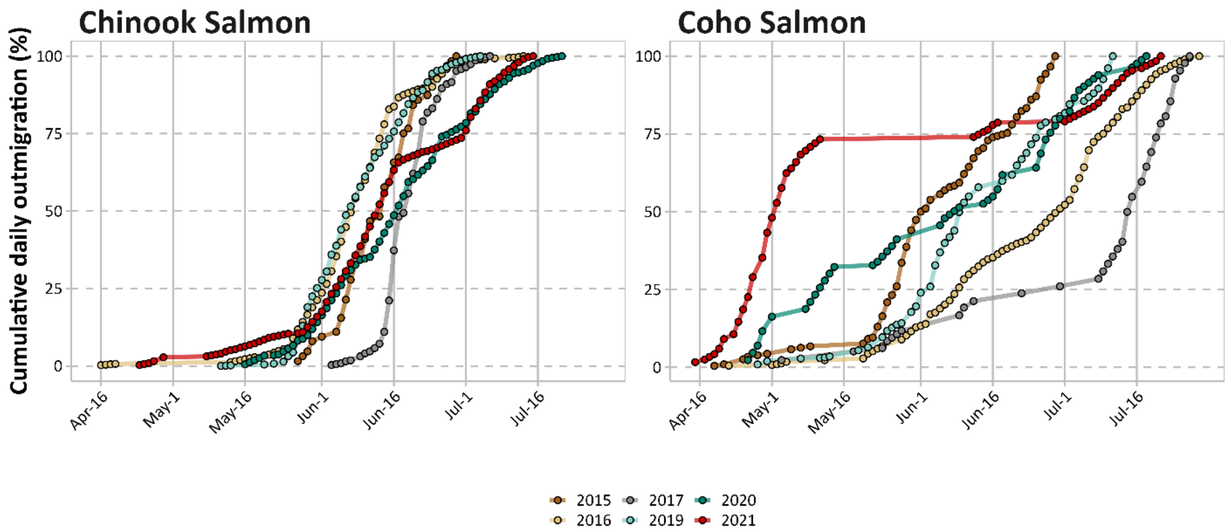
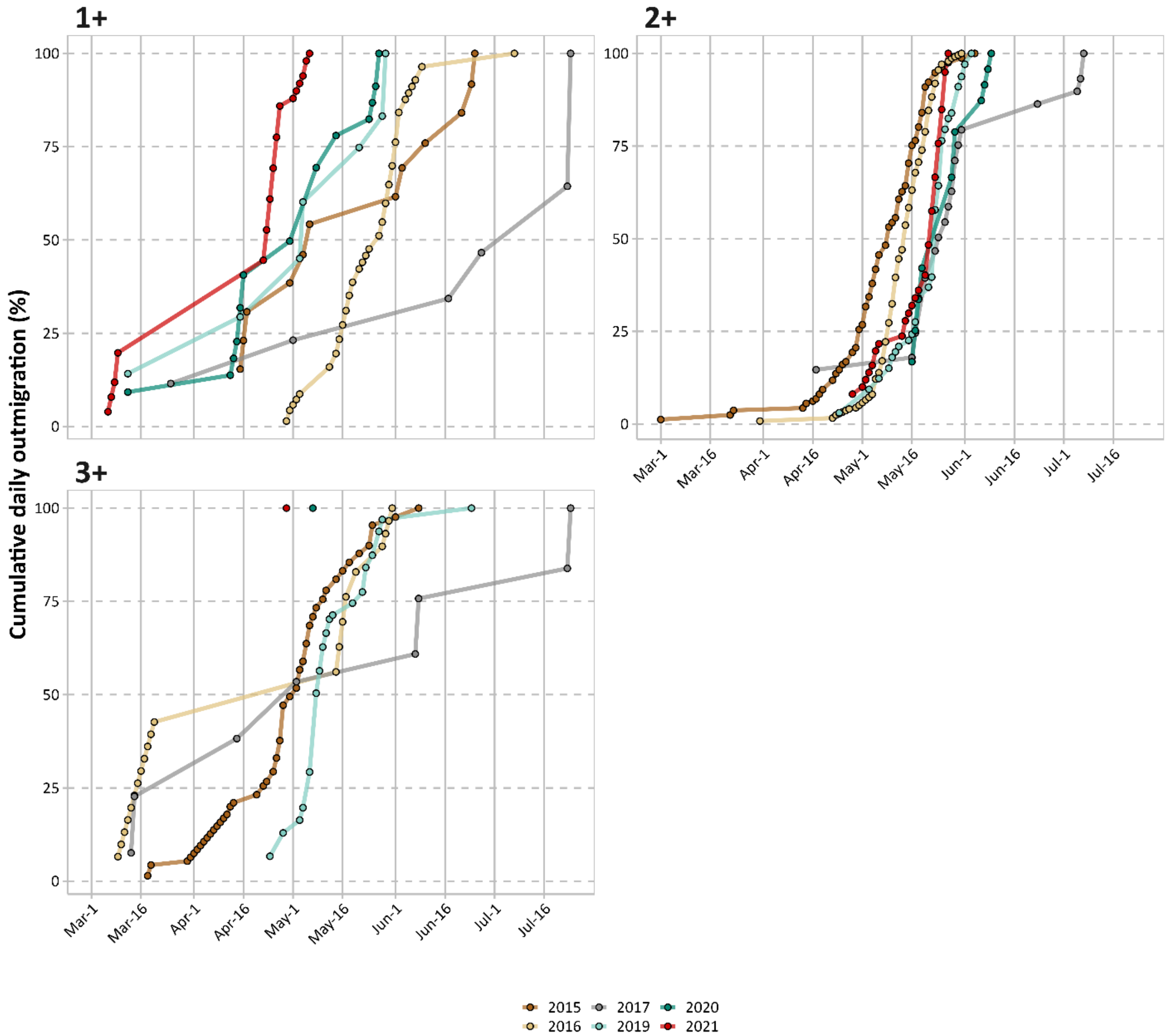


Figure 15. Cumulative daily outmigration of Steelhead/Rainbow Trout from the Elk Canyon by outmigration date, age class, and year.



3.3. Fall Spawner Enumeration

3.3.1. Fall Spawner Abundance

Fall spawner abundance, estimated from snorkel surveys using the area under the curve method, differed substantially among species in 2020 (Table 6). Coho Salmon adult spawner abundance was greatest in fall 2020, with 2,276 individuals estimated to be spawning in Elk Canyon. Pink Salmon had next highest estimated numbers (456). Numbers were lowest for Sockeye Salmon (7) and Steelhead/Rainbow Trout (3), and Chinook and Chum numbers were intermediate (279 and 151, respectively).

For both Chinook and Coho Salmon, counts in 2020 were the highest observed to date (Figure 16, Figure 17). Chinook observations peaked in mid to late-October over an approximate three-week period (Table 6), similar to previous years (Figure 16). Peak spawn for Coho occurred in mid-October in 2020, whereas it occurred early to mid-November in previous years (Figure 17). Spawning periodicity was similar to previous years, occurring over an approximate 6-week period.

Peak Chum counts in 2020 were lower than all previous years except for 2014 (Figure 18). However, in 2014, snorkel surveys were not conducted around typical peak Chum spawn timing and thus many spawners were likely missed. Chum spawn timing was similar among all years with peak counts occurring in late October and early November.

Pink Salmon counts in 2020 were similar to those observed in 2017 and 2018, but much lower than peak counts observed in 2014 and 2015 (Figure 19). Pink Salmon spawning peak has been in mid to late September in all years, which is earlier that the other fall spawning salmonid species present in the Elk Canyon.

Sockeye counts in 2020 were notably lower than in all previous years: the peak count was only two individuals (Table 6). Sockeye observations peaked mid-October in 2020, whereas in other years the peak typically occurred late September early October (Figure 20). However, sample size was small in 2020.

Counts of Steelhead were also relatively low in 2020 (Figure 21). A maximum of three individuals were observed in mid-November 2020 (Table 6). Observations were scattered throughout the fall survey periods in all years.

Table 6. Fall salmon spawner counts in 2020 by species and estimates of abundance.

Date	Count of Adult Fish Observed[1]					
	ST	**CH**	**CM**	**CO**	**PK**	**SK**
11-Sep-2020	1	3	0	0	23	1
25-Sep-2020	0	5	0	12	346	0
06-Oct-2020	0	45	0	446	240	0
16-Oct-2020	0	241	19	657	0	2
27-Oct-2020	0	25	45	578	0	0
06-Nov-2020	0	2	81	376	0	0
23-Nov-2020	3	1	5	187	0	0
04-Dec-2020	0	0	0	64	0	0
Abundance Estimate[2]	**3**	**279**	**151**	**2,276**	**456**	**7**

[1] ST = Steelhead Trout, CH = Chinook Salmon, CM = Chum Salmon, CO = Coho Salmon, PK = Pink Salmon, and SK = Sockeye Salmon.

[2] Abundance estimate of salmon species are based on an area under the curve analysis while the abundance estimate of Steelhead Trout are based on maximum observed fish.

Figure 16. Adult Chinook Salmon counts in Elk Canyon by date and year.

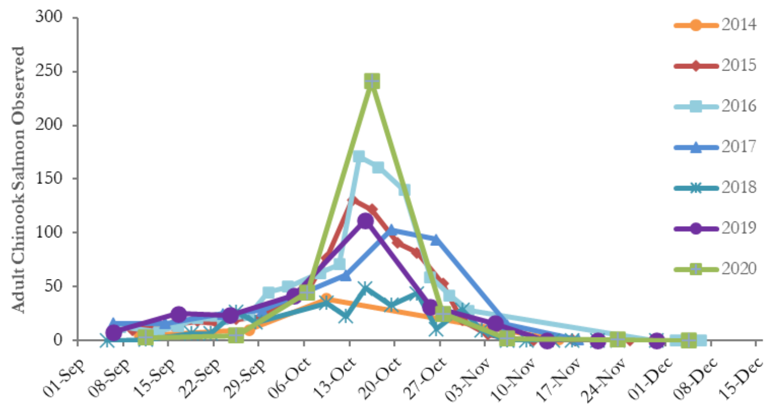


Figure 17. Adult Coho Salmon counts in Elk Canyon by date and year.

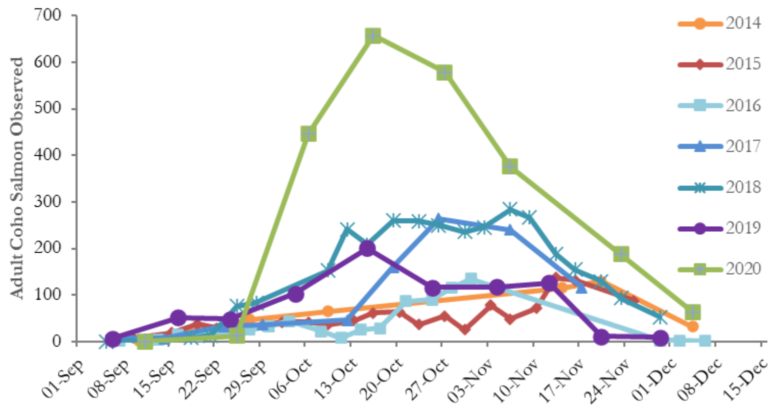


Figure 18. Adult Chum Salmon counts in Elk Canyon by date and year.

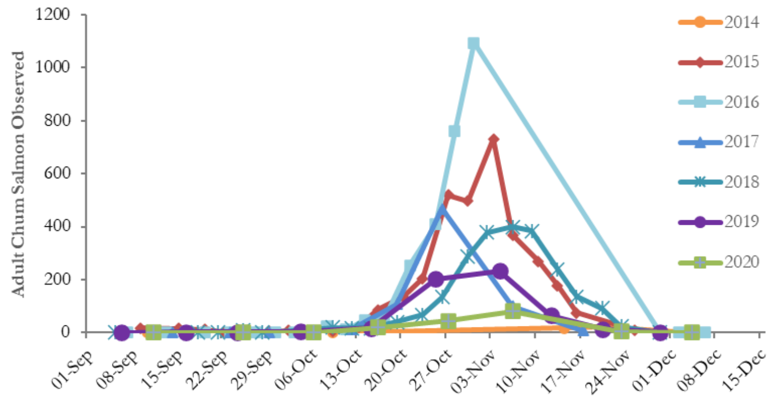


Figure 19. Adult Pink Salmon counts in Elk Canyon by date and year.

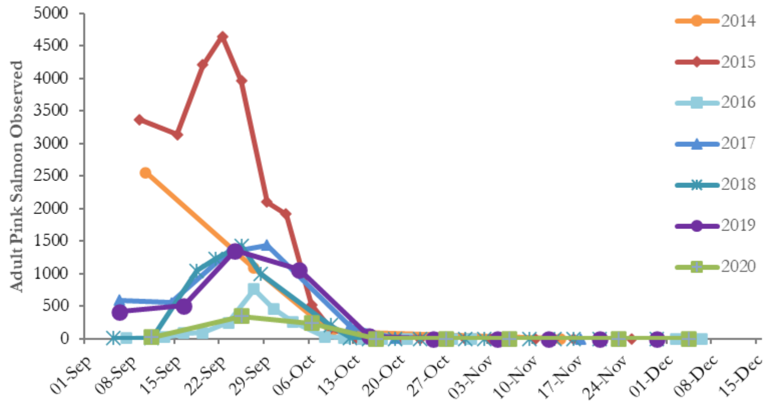


Figure 20. Adult Sockeye Salmon counts in Elk Canyon by date and year.

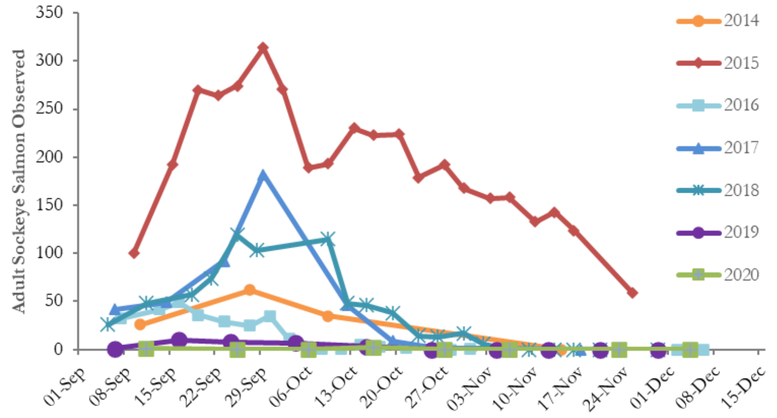
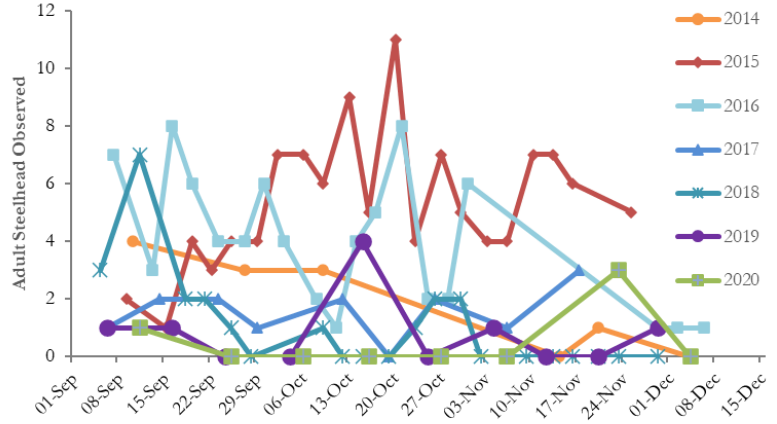


Figure 21. Adult Steelhead counts in Elk Canyon by date and year.



3.3.2. Fall Spawner Productivity

The maximum number of redds observed during fall snorkels are summarized in Table 7. Pink Salmon, followed by Coho and Chinook Salmon, had the highest numbers of redds (96, 39, and 19 redds, respectively). Four Chum Salmon redds and no Sockeye Salmon redds were observed. Similar to spawner counts, redd counts peaked for Pink Salmon in late September and early October, for Chinook in mid to late October, and for Chum and Coho in November.

Table 7. Salmon redds counted during snorkel surveys in 2020 by species.

Date	Count of Trout/Salmon Redds[1]					
	ST	CH	CM	CO	PK	SK
11-Sep-2020	0	3	0	0	0	0
25-Sep-2020	0	0	0	0	49	0
06-Oct-2020	0	4	0	0	96	0
16-Oct-2020	0	19	0	0	0	0
27-Oct-2020	0	10	0	3	0	0
06-Nov-2020	0	1	4	0	0	0
23-Nov-2020	0	0	0	39	0	0
04-Dec-2020	0	0	0	7	0	0
Max Observed	**0**	**19**	**4**	**39**	**96**	**0**

[1] ST = Steelhead Trout, CH = Chinook Salmon, CM = Chum Salmon, CO = Coho Salmon, PK = Pink Salmon, and SK = Sockeye Salmon.

3.4. Comparison of Fall Spawner Abundance to Outmigration

Salmon fry and smolt production from Elk Canyon were estimated based on the fall 2020 redd counts (Table 7) along with fecundity and egg-to-fry and egg-to-smolt survival values taken from the literature (Bradford 1995; Quinn 2005). These estimates were then compared to the 2021 outmigration predicted from capture numbers adjusted for capture efficiency (Section 3.2.2).

Estimates of outmigrating fry numbers in 2020 based on redd production were lower than estimates made from captures for Chum and Chinook Salmon, higher for Pink Salmon, and similar for Coho Salmon (Table 8). Estimates of outmigrating smolts for both Coho and Chinook Salmon based on redd production were substantially higher than estimates made from captures.

Fall spawner abundance (determined from snorkel surveys using the area under the curve method) was examined in relation to juvenile (fry and smolt) outmigration the following year (estimated from RST captures adjusted for capture efficiency). Figure 22 shows this relationship by species for all years of the program to date (note that year labels on Figure 22 indicate the adult spawning year, and the year for the associated juvenile outmigration is therefore in the following year). In general, fall spawner abundance estimates appear to be weakly positively correlated to 0+ fry and 0+ smolt outmigration estimates for most species with some exceptions (Figure 22). The strongest positive correlation was observed for Chum Salmon and there was little apparent relationship between Pink Salmon estimated outmigration and spawner abundance. The relationship between adult spawning abundance in 2016 and outmigration in 2017 was anomalous for all species where data exist: there was relatively little outmigration in 2017 regardless of the number of fall spawners in 2016. This anomalous relationship coincides with the large spill event that occurred in November 2016 (Figure 5, Section 3.1).

Table 8. Comparison of estimated juvenile salmon production (outmigration) by species in Elk Canyon based on redd counts in 2020 and capture numbers (RST catch adjusted by capture efficiency) in 2021.

Species	Mean Fecundity[1]	Max Redds Observed	Total Estimated Eggs	Survival[2]		Estimated Redd Production[3]		Estimated Outmigration[4]	
				Egg-Fry	Egg-Smolt	Fry	Smolt	Fry[5]	Smolt[6]
Pink	1,800	96	172,800	0.115	n/a	19,872	n/a	3,335	n/a
Chum	3,200	4	12,800	0.129	n/a	1,651	n/a	74,088	n/a
Sockeye	3,500	0	0	0.127	n/a	0	n/a	0	n/a
Coho	3,000	39	117,000	0.253	0.17	29,601	19,305	20,953	259
Chinook	4,300	19	81,700	0.38	0.10	31,046	8,252	87,480	660

[1] Information from Bradford (1995).

[2] Information from Quinn (2005).

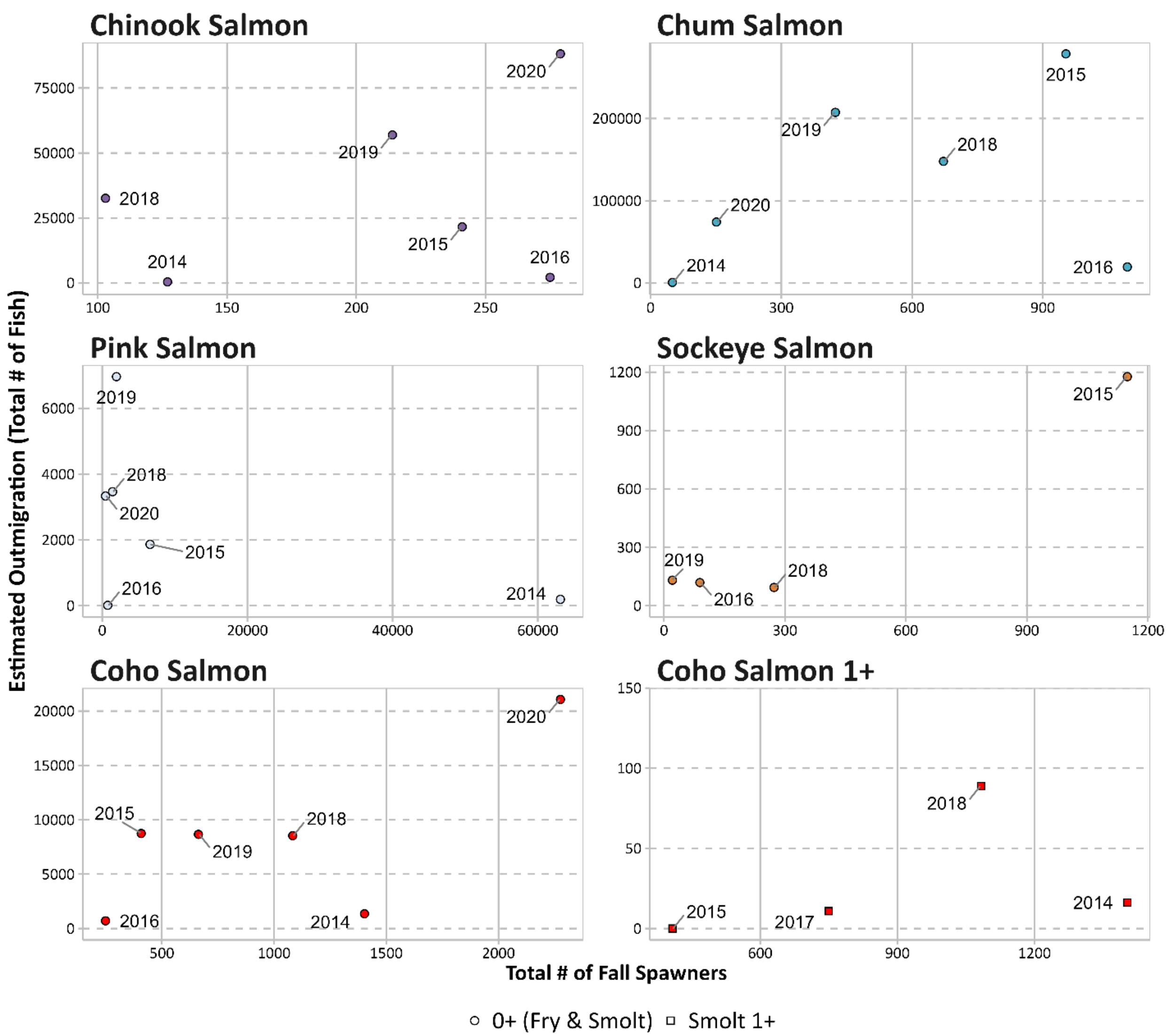
[3] Estimated redd production based on the total estimated eggs and literature survival rates.

[4] Estimated outmigration of fish based on the RST sampling results.

[5] Sockeye Salmon fry RST outmigration estimates are based on overall Capture efficiency of all species combined as no Sockeye Salmon fry were recaptured.

[6] Coho smolt RST outmigration estimates are based on the sum of the 0+ and 1+ smolt outmigration estimates.

Figure 22. Estimated annual outmigration by salmon species as a function of the abundance of adult fish spawners. Year labels indicate the adult spawning year; the associated juvenile outmigration is the following year.



4. DISCUSSION

Results from Year 7 of the JHTMON-15 study have provided another year of smolt enumeration and spawner enumeration data that can be used to address effects of flow on fish abundance, which contribute to addressing management questions 1 and 6. Management questions 2, 3, 4, and 5 and associated hypotheses have been addressed in earlier years of the program. Similar to previous years of the program, all BC coast salmonid species were observed using Elk Canyon for spawning and/or rearing during Year 7. Although many of these species occur in low abundance, this nevertheless indicates that habitats in Elk Canyon are used by a diversity of salmon and trout.

In Year 7, the RST operated for a total effort of approximately 81 days (1,936 hours) between March and July 19, 2021, capturing a total of 8,237 fish. Similar to previous years, the catches in 2021 were primarily composed of Chinook Salmon (48.2%), Chum Salmon (35.5%), and Coho Salmon (10.9%), and Pink Salmon and Steelhead/Rainbow Trout were captured in fewer numbers.

As was also done in previous years, total salmonid outmigration by species in Year 7 was estimated from the RST catch along with the capture efficiency of the RST, which was determined from mark-recapture trials. In Year 7 Chinook had the highest outmigration estimate of all species followed by Chum Salmon. Overall, outmigration estimates were variable among years of the program to date, with no clear trends over the monitoring period, although smolt production generally decreased for Coho Salmon and Steelhead/Rainbow Trout. Two years with generally low outmigration were observed, 2015 and 2017, and 2019 was a low year for Steelhead/Rainbow Trout. For all species, 2017 was an anomalous year for outmigration, likely due to the large spill event between November 4 and 24, 2016 that could have scoured redds within Elk Canyon (see also below).

In general, relatively consistent seasonal patterns were documented by species across the years of the monitoring program to date, with peak outmigration occurring at the same time of year, although seasonal patterns were less consistent for Sockeye Salmon and Steelhead/Rainbow Trout. Daily estimates consistently showed two outmigration peaks for Chinook Salmon, one in early to mid March to early April and a second one in late May and early June. Daily outmigration for Pink, Coho, and Sockeye Salmon fry consistently peaked between mid March and early April. The majority of Coho Salmon smolts 0+ or older tended to leave the canyon by early June, although some individuals delayed outmigration until late July. Chum Salmon fry outmigration tended to peak annually in April, but some inter annual variability was apparent. For Steelhead/Rainbow Trout, outmigration timing generally occurred from mid-April through July with a peak occurring around the end of May; however, timing differed by year and age class. The consistency and duration of outmigration is an important consideration for sampling. For example, for Coho outmigration is extended relative to species such as Chinook, which suggests that a longer sampling period may be necessary to fully enumerate Coho Salmon smolts.

Fall spawner abundance counts and productivity estimates (estimated from snorkel surveys conducted using the area under the curve method) were used to compare estimates of spawning effort with the longer-term goal of relating this to flows. In general, estimated abundance of spawners was related to redd counts in 2020. Excluding Pink Salmon, numbers of both (numbers of spawners and redds counted) were highest for Coho, intermediate for Chinook, and lowest for Chum (no Sockeye redds were observed). Pink Salmon were the exception: most redds counted were from Pink Salmon (96 Pink Salmon redds were counted, compared to 39 Coho Salmon redds), whereas most spawners were Coho Salmon (2,276 Coho Salmon spawners counted, compared to 456 Pink Salmon spawners). Timing of redd count peaks also generally coincided with observations of spawning adults. Peak counts of spawning adults were earliest for Pink Salmon in all years of the study to date (mid to late September), whereas peak numbers have been documented for the other species between mid-October to mid-November (Chinook, Coho, and Chum Salmon and Steelhead/Rainbow Trout) or late September to early October (Sockeye Salmon).

When outmigrating fry numbers were estimated based on redds counted, estimates differed substantially for some species relative to estimates made from RST captures (adjusted by capture efficiency) (Table 8). For Chum and Chinook Salmon, estimates of outmigration made from redds were lower than those made from captures, and for Pink Salmon the reverse was true. Estimates of outmigration based on method were similar for Coho Salmon. These discrepancies observed in Chum, Chinook, and Pink Salmon were similar to discrepancies observed in 2019. Differences in production (outmigration) estimates derived from redd surveys and the RST catch could be attributed to multiple factors, including our use of coarse estimates of fecundity and survival by species from the literature, the potential misidentification of redds, redd superimposition, and movements of adults prior to spawning. For Chum Salmon, the large discrepancy in estimation of outmigration (45 times more outmigration estimated from captures than from redds; Table 8) suggest that redds may have been missed or misidentified and/or that egg-to-fry survival was high. Chum and Coho Salmon have a similar spawn timing and similarly sized redds, and it can be difficult to distinguish redds from different species when multiple species are in the system at a given time; thus, it is possible that some redds identified as Coho redds were Chum redds. It is also possible that redd superimposition may explain some of the discrepancy in Chum and Coho Salmon outmigration estimates based on redd counts compared to estimates based on RST captures.

Redd superimposition may explain the discrepancy in Pink Salmon for which the estimation of outmigration based on redd counts was six times higher than the estimate based on captures in 2022. Pink Salmon counts of redds were highest of all species, whereas outmigration estimates were relatively low. Pink Salmon are the earliest spawner and therefore likely the most vulnerable to egg superimposition. Where estimates of outmigration are greater when calculated from RST captures are greater than those calculated from redds (e.g., Chum and Chinook Salmon), it is also possible that a high percentage of adult spawners hold in the Elk Canyon but then drop down to the lower river to spawn, to a location where redds are not counted during surveys.

The relationship between fall spawner abundance and outmigration the following year was examined to determine whether the abundance of fall spawners is correlated with the abundance of outmigrating smolts and if, not, identify potential causes of lack of discrepancy. This relationship as documented from the years of the program to date suggests that, in general, a larger number of spawners in fall is associated with larger numbers of outmigrating juveniles the following year (Figure 22). However, there was a notable exception in that relatively little outmigration was documented in 2017 regardless of the number of fall spawners in 2016. This anomalous relationship coincides with the large spill event that occurred in November 2016 during which many redds were likely lost. Thus, this may demonstrate effects of a flow change on productivity. In addition, Pink Salmon outmigration was not related to spawner abundance, potentially due, at least in part, to egg superimposition (discussed above). Additional data collected in subsequent years (2022 through 2024) will allow us to examine the relationship between flows and productivity in greater detail.

5. CONSIDERATIONS FOR YEAR 8

The following is a summary of considerations for Year 8, during which smolt enumeration and fall spawner enumeration components will continue (Table 1).

Smolt enumeration:

1. The RST is an effective method to inventory juvenile salmonids (fry and smolts) that are migrating out of Elk Canyon and provides valuable life history information. RST sampling should continue in Year 8 using the same methodology as Year 7 and outmigration estimates should continue to be calculated using the capture efficiency calculations developed from the mark-recapture trials implemented in Years 1, 2, 3, 5 and 6.
2. Based on the catch results of the target fish species to date, the RST sampling period should remain open in Year 8 until late July to ensure that the Coho and Chinook Salmon outmigration periods are adequately documented.

Fall spawner enumeration:

1. Snorkel surveys continue to be an effective way to enumerate adult salmonids and redds. These surveys should continue using the same methodology employed in Year 7. The benefit of the comparison of estimated juvenile salmon production from RST catches to estimates of production predicted from redd counts by species in Elk Canyon should be evaluated as this comparison has highlighted that identification of species-specific redds is challenging resulting in high variability.

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PROJECT MAPS

Map 1

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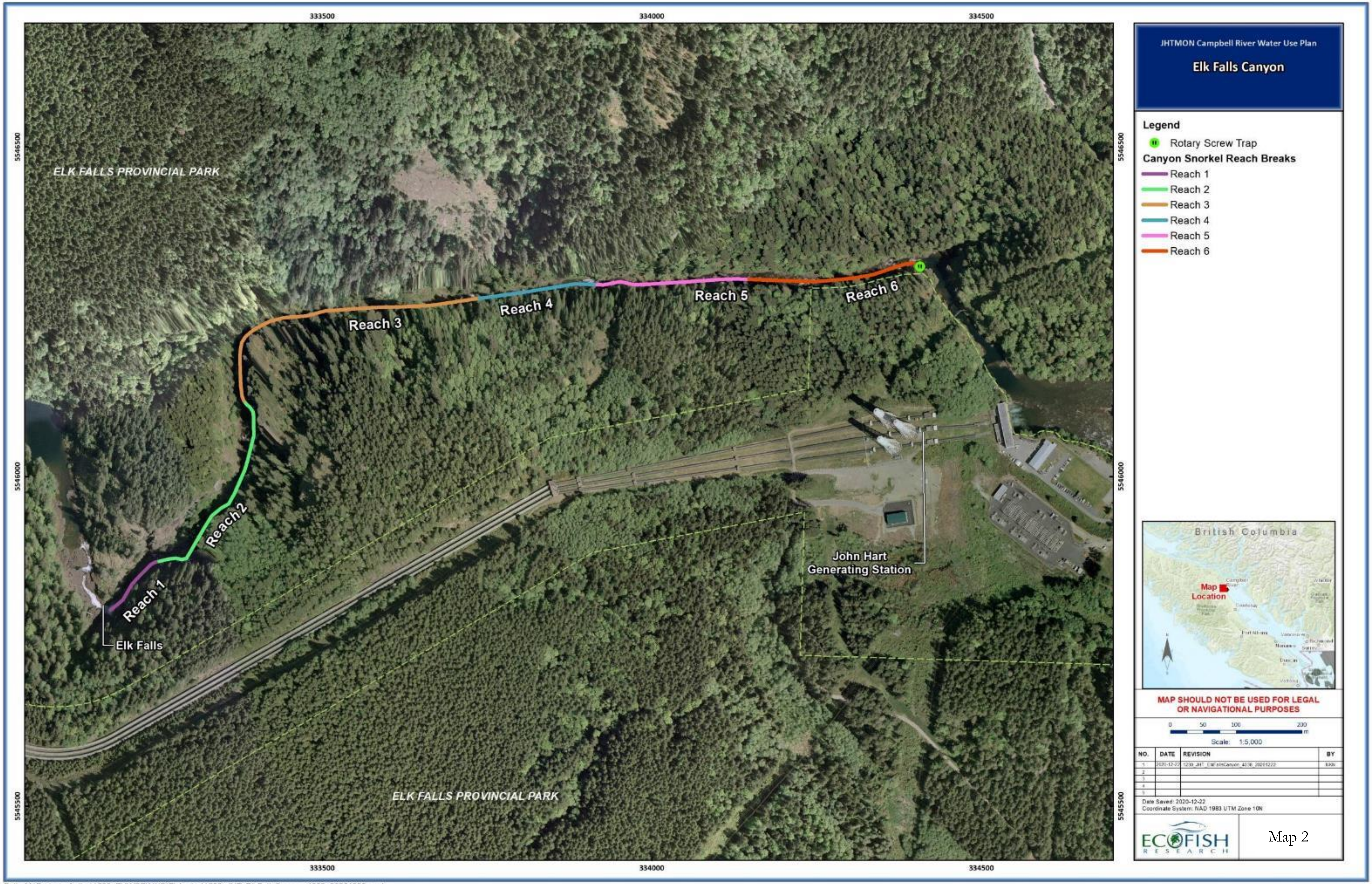

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APPENDICES

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Table 1. Daily average RST catch per operational day by half month periods for key salmonid species in Year 7.

Date	Chinook		Coho			Steelhead/Rainbow Trout				Chum	Pink	Sockeye
	Fry 0+	Smolt 0+	Fry 0+	Smolt 0+	Smolt 1+	0+	1+	2+	3+	Fry 0+	Fry 0+	Fry 0+
Mar 1-15	92.1	0.0	7.3	0.0	0.0	0.0	0.1	0.0	0.0	4.3	1.8	0.0
Mar 16-31	155.7	0.0	40.1	0.0	0.0	0.0	0.0	0.0	0.0	125.2	7.3	0.0
April 1-15	132.1	0.0	30.6	0.0	0.1	0.0	0.0	0.0	0.0	122.1	3.7	0.0
April 16-30	39.3	0.3	14.1	0.6	1.3	0.0	0.6	0.1	0.1	59.6	0.0	0.0
May 1-15	3.5	0.8	0.3	0.3	1.0	0.0	0.3	0.5	0.0	0.0	0.0	0.0
May 16-31	1.0	1.3	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
June 1-15	6.3	9.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
June 16-30	0.0	4.2	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
July 1-15	0.0	6.0	0.0	1.5	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0
July 16-31	0.0	0.0	0.5	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 1. Daily average RST catch of key salmonid species from March 1 to July 19, 2021.

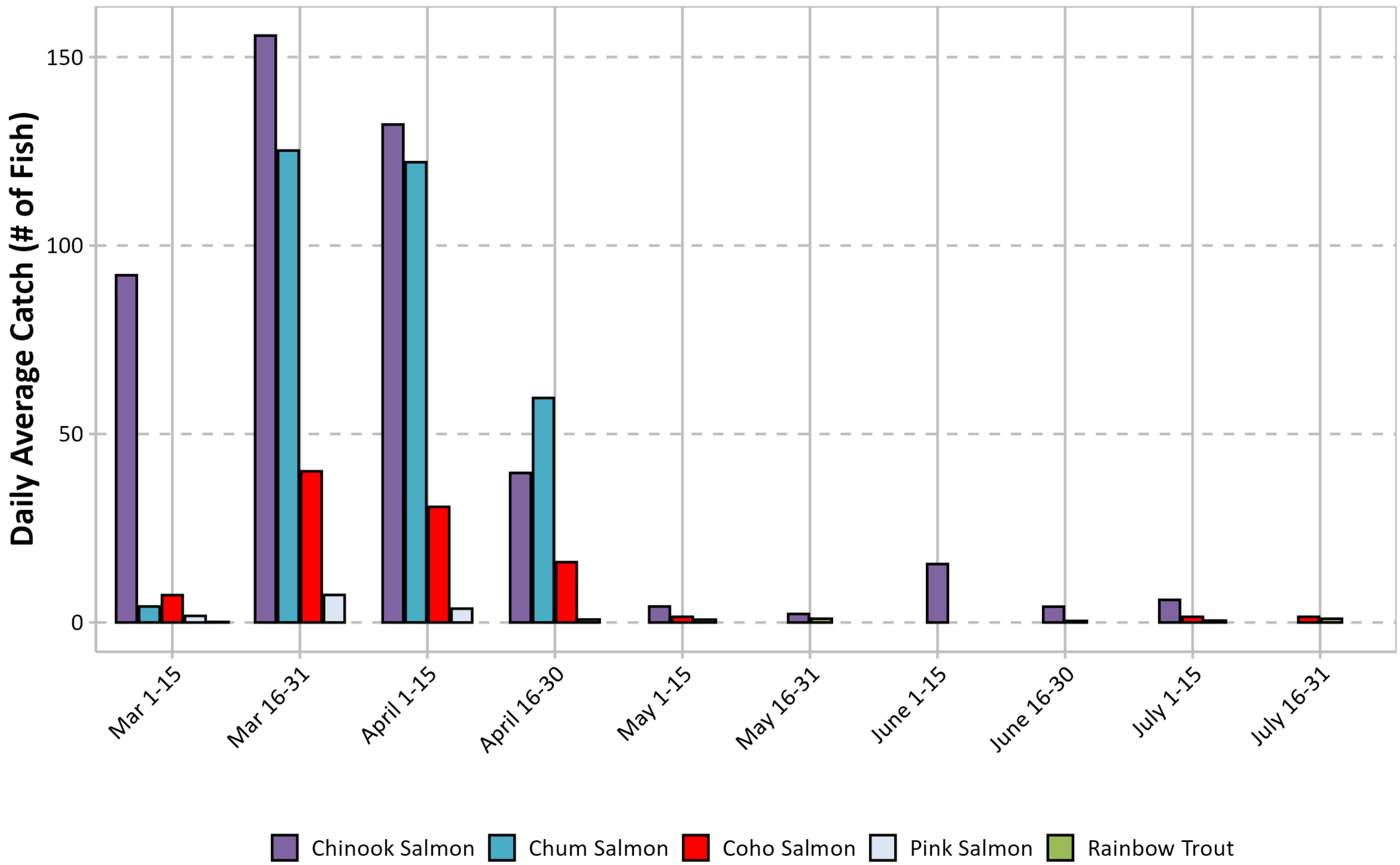

Figure 2. Daily average RST catch of key salmonid species (excluding Chum Salmon) from March 1 to July 19, 2021.

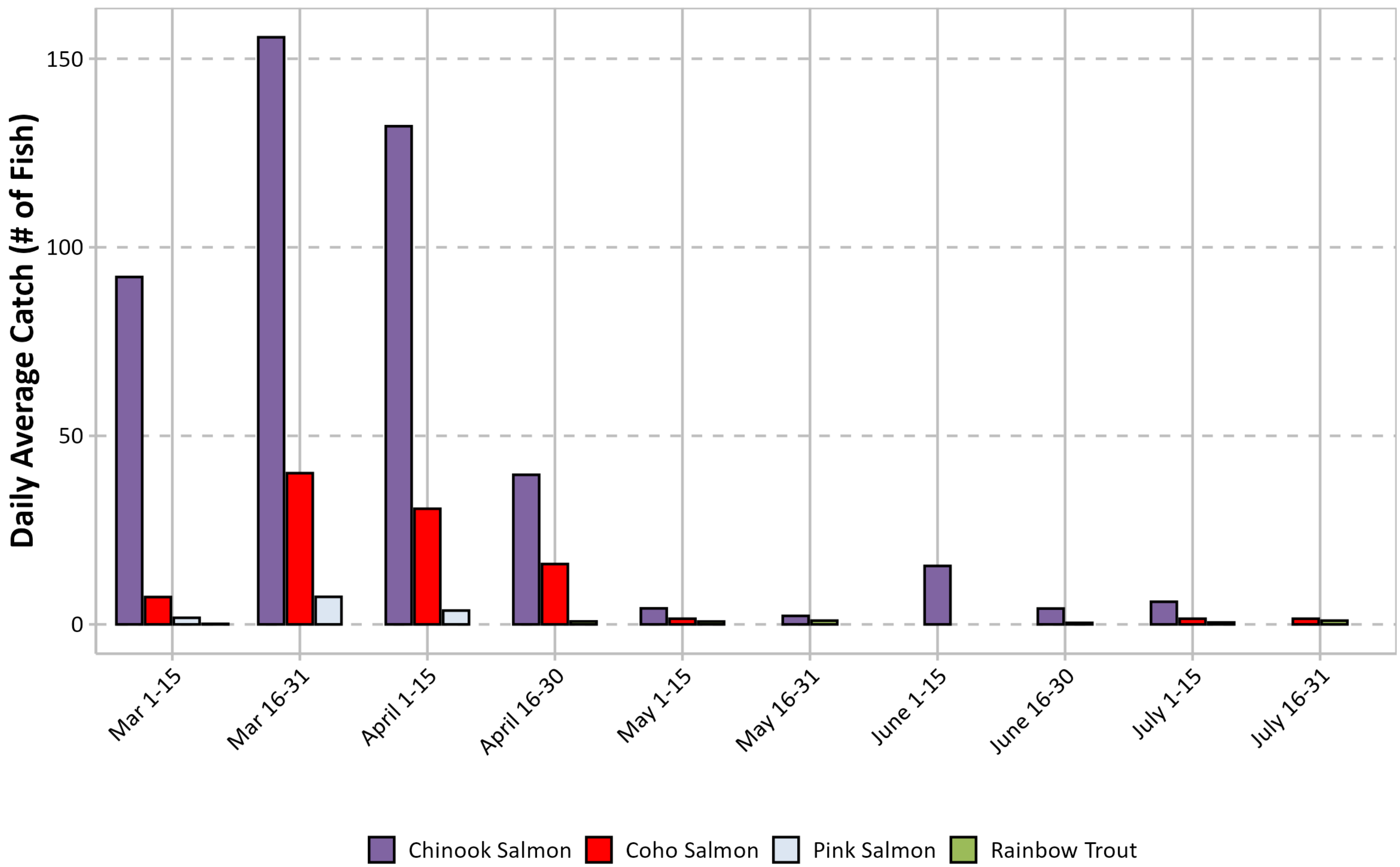

Figure 3. Length frequency histogram of Chum Salmon captured in the RST in 2021 by month.

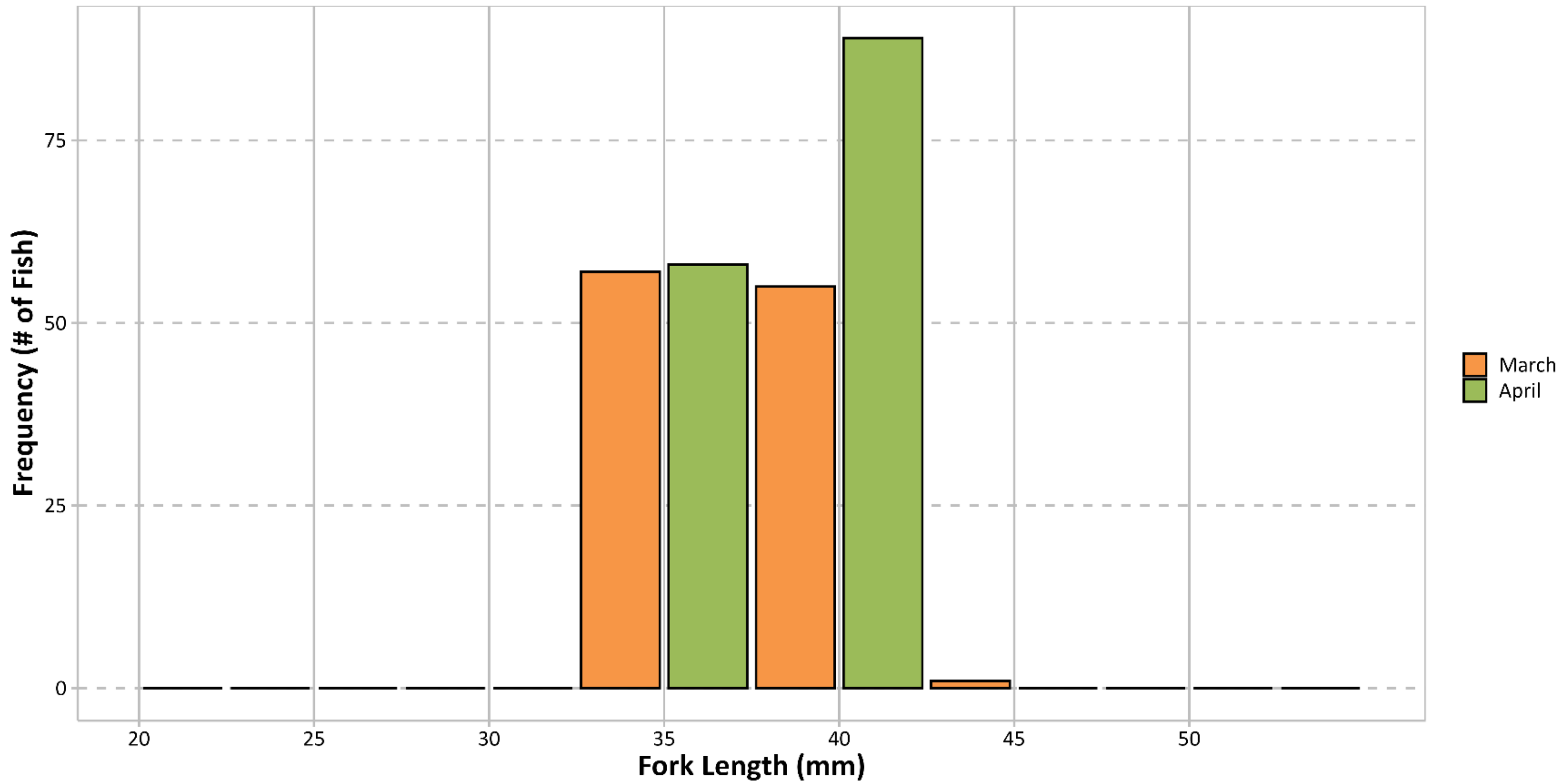

Figure 4. Length frequency histogram of Chinook Salmon captured in the RST in 2021 by month.

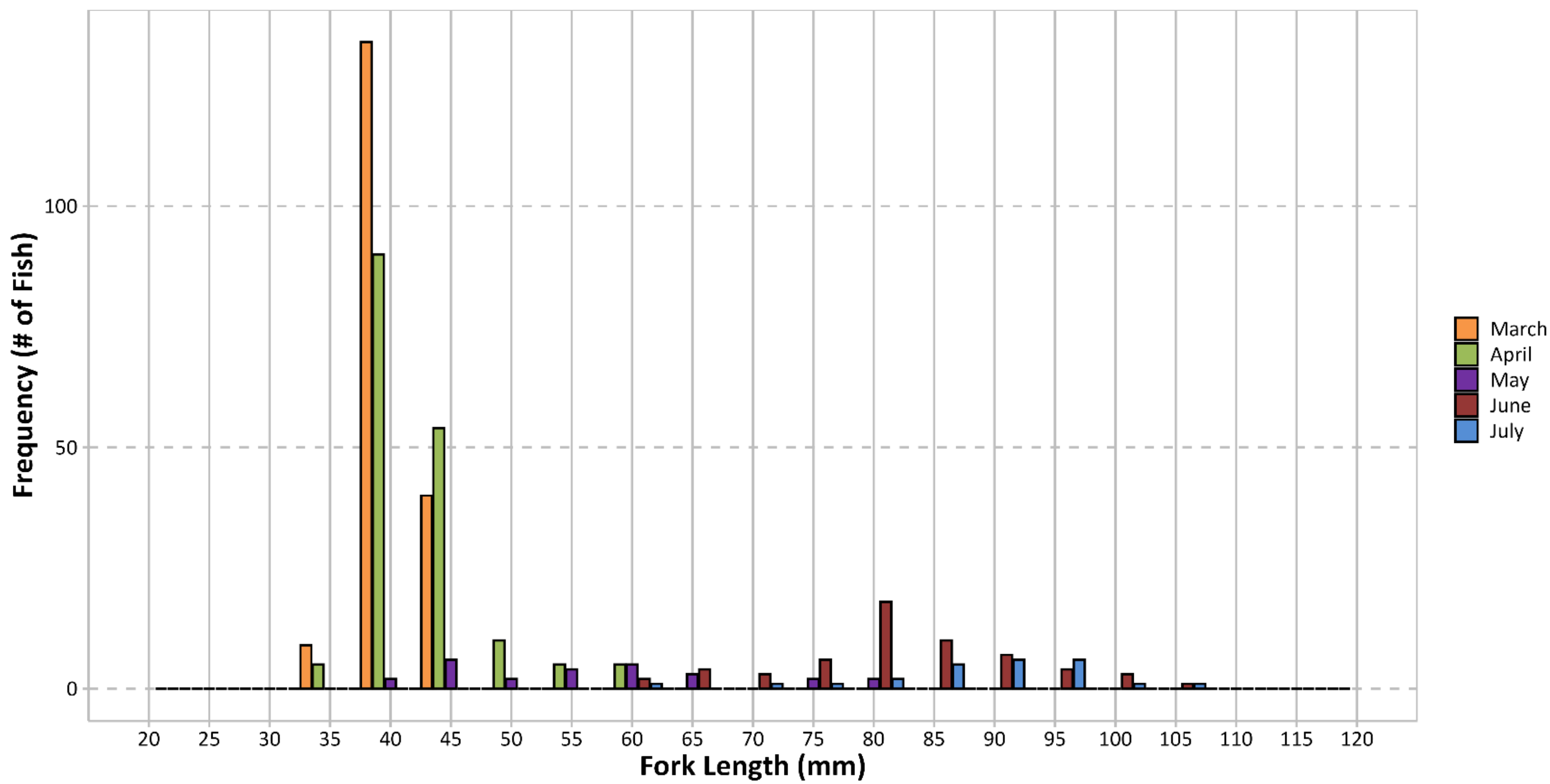

Figure 5. Length frequency histogram of Coho Salmon captured in the RST in 2021 by month.

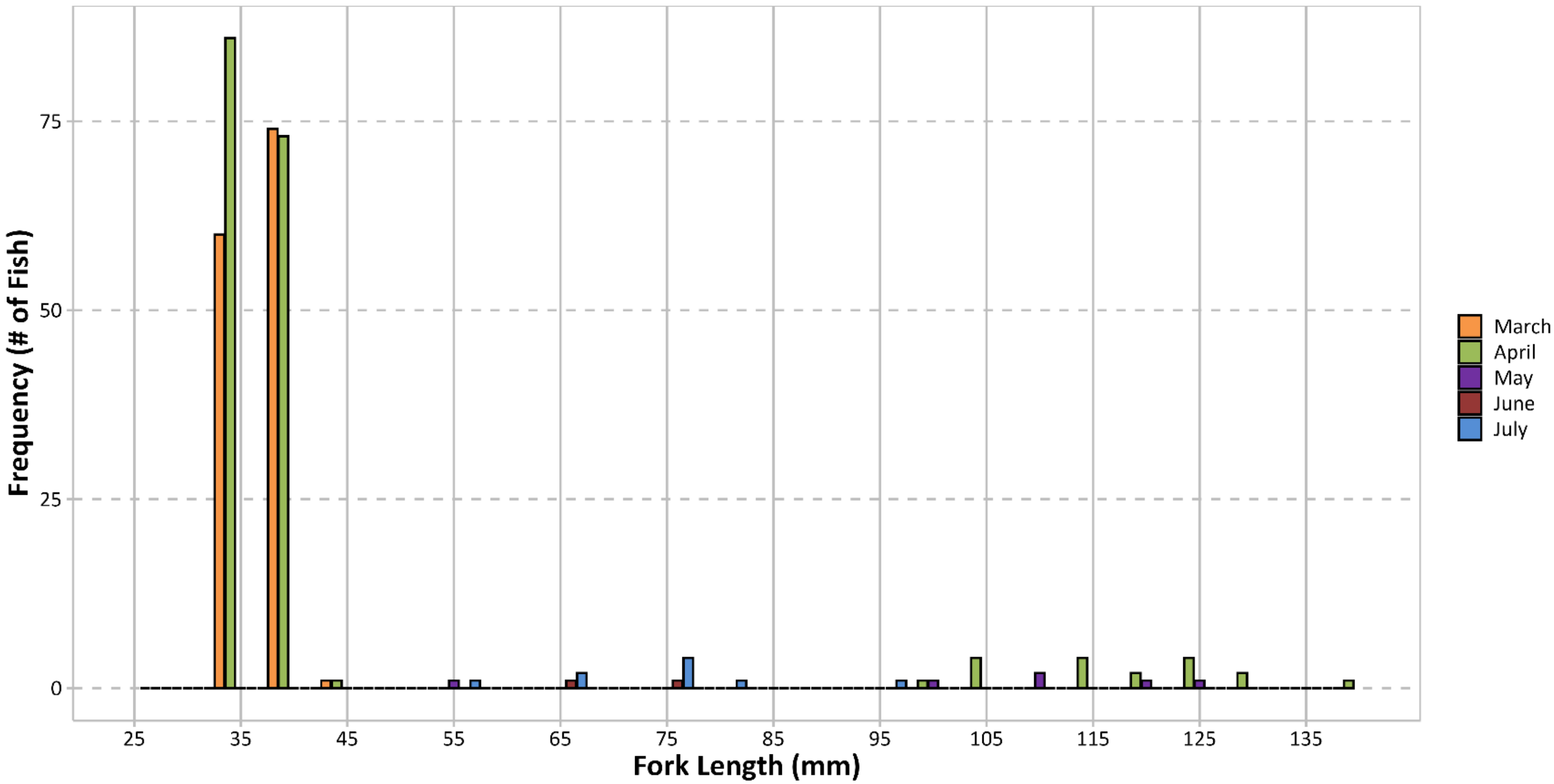

Figure 6. Length frequency histogram of Steelhead/Rainbow Trout captured in the RST in 2021 by month.