Campbell River Project Water Use Plan

JHTMON-15 Elk Canyon Smolt and Spawner Abundance Assessment

Implementation Year 6

Reference: JHTMON-15

JHTMON-15 Year 6 Monitoring Report

Study Period: 2019-2020

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

August 19, 2021

JHTMON-15: Smolt and Spawner Abundance Assessment

Year 6 Annual Monitoring Report




Prepared for:

BC Hydro Water License Requirements
6911 Southpoint Drive
Burnaby, BC, V3N 4X8

August 19, 2021

Prepared by:

Laich-Kwil-Tach Environmental Assessment Ltd. Partnership

Ecofish Research Ltd.

Published by Ecofish Research Ltd., 600 Comox Rd., Courtenay, B.C., V9N 3P6

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Citation:

Thornton, M., J. Braga, A. Buren, T. Hatfield, and M.D. Hocking. 2021. JHTMON-15: Smolt and Spawner Abundance Assessment Year 6 Annual Monitoring Report. Consultant's report prepared for BC Hydro by Laich-Kwil-Tach Environmental Assessment Ltd. Partnership and Ecofish Research Ltd., August 19, 2021.

Certification: *Certified – stamped version on file.*

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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.

A number of components were previously completed 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 remaining components involve snorkel swim counts of spawning adults and rotary screw trap (RST) enumerations of out-migrating fry and smolts.

Smolt Enumeration Year 6

Similar to previous RST sampling years, the catches in 2020 were primarily composed of Chum Salmon (69.0%), Chinook Salmon (22.9%), and Coho Salmon (3.3%). Steelhead/Rainbow Trout and Sockeye Salmon accounted for 0.15% and 0.04% of the catch, respectively. The combined catch of all salmonids (11,335 fish) accounted for 97.9% of the total catch, whereas the catch of the key target species of Chinook Salmon, Coho Salmon, and Steelhead/Rainbow Trout (3,053 fish) accounted for 26.4% of the total catch.

Total salmonid outmigration by species in Year 6 (2020) was estimated by standardizing the RST catch by the capture efficiency of the RST, which was determined from mark recapture experiments. As in Years 2, 3 and 5, Chum Salmon outmigration was the highest of all salmonid species, with an estimated total outmigration of 207,373 fry. Coho Salmon total outmigration was estimated to be 8,472 fry and 187 age 0+ smolts, and 89 age 1+ smolts. Chinook Salmon total outmigration was estimated to be

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

54,687 fry and 2,257 age 0+ smolts. Steelhead/Rainbow Trout outmigration was estimated to be 30 age 0+ fry, 69 age 1+ parr, 75 age 2+ parr, and six age 3+ smolts. Pink Salmon and Sockeye Salmon total outmigration was estimated at 6,963 and 131 fry, respectively. Overall, outmigration estimates in 2020 were similar to or higher than estimates since 2015.

Five-Year Smolt Outmigration Assessment

Over all five years of monitoring (2015, 2016, 2017, 2019, and 2020), the RST captured a total of 58,650 fish in the Elk Canyon and salmonids represented 92.8% of the total catch (54,432 fish). With the exception of Year 1, the most abundant fish species caught in the RST have been consistently Chum and Chinook Salmon. In Year 3 (2017), we observed a substantial decrease in all salmonids caught by the RST, likely the result of the large spill event between November 4 and 24, 2016, which likely scoured redds within Elk Canyon.

A total of 82 mark-recapture trials were conducted in five years of the RST monitoring program of which 71 trials were used to estimate overall capture efficiencies per salmonid life stage. These capture efficiencies were used to estimate total smolt outmigration by species, life stage and year.

Estimates of daily outmigration showed 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 Rainbow Trout differed by age class. 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+ 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+ Rainbow Trout occurred between mid-April and late-May in most years. Daily outmigration timing of 3+ Rainbow Trout was similar to 2+ Rainbow Trout, although it was typically spread out over a wider time period.

The outmigration timing of 0+ salmonid fry was examined in relation to the accumulated growing degree days (AGDD) between the fall peak spawning date to the date each individual fish was caught in the RST. For fry, AGDD measured the total number degrees (°C) that an individual accumulated between the fall peak spawning date to the date each individual fish was caught in the RST. This represents the AGDD during egg-to-fry development up to the date of fry outmigration. For smolts, accumulated degree days measured the total number degrees (°C) that an individual fish accumulated from March 1st each year to the date each individual was caught in the RST. This analysis is used to help determine whether water temperature was related to outmigration timing. For Chum, Coho, Chinook, and Sockeye Salmon, we observed that the majority of 0+ fry tended to migrate at similar levels of AGDD every year. This suggests that Chum, Coho, Chinook, and Sockeye salmon 0+ fry require a specific accumulation of thermal units during egg to fry development and to migrate out of the Elk Canyon.

For Rainbow Trout and Pink Salmon, we observed that cumulative daily 0+ fry migration was associated differently with AGDD every year. Rainbow Trout 0+ fry outmigration occurred between approximately 1,400 and 2,900 AGDD. The annual differences were even higher for Pink Salmon suggesting that Pink Salmon have a lower dependency on AGDD to migrate out of the Elk Canyon and rather are out-migrating on a consistent date each year.

Accumulated growing degree days to outmigration was also examined for Chinook, Coho, and Rainbow Trout smolts (0+, 1+, 2+ and 3+), which spent a month or more rearing in Elk Canyon prior to outmigration. The relationship observed between the annual cumulative daily outmigration and AGDD for smolts differed between salmonid species but was less apparent than trends for 0+ fry. For Coho smolts 0+ and older, the relationship between AGDD and outmigration had two outmigration peaks. For Rainbow Trout aged 1+, we observed no clear pattern between AGDD and estimated daily outmigration; however, for fish aged 2+ and 3+ we observed a clear peak of individuals leaving the canyon between 400 and 800 AGDD.

Fall and Spring 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 2019. Chinook and Coho Salmon adult abundance were estimated to be 214 and 663 individuals, respectively. Pink Salmon had the highest estimated abundance of 1,960 individuals. A total of 44 Chum Salmon and 21 Sockeye Salmon spawners were also estimated. Few Steelhead were observed in fall with a peak count of only four 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 four Steelhead were observed in mid-October.

Chinook, Chum, Coho, Pink and Sockeye Salmon redds were counted during fall spawning surveys. Pink, followed by Coho and Chum Salmon had the highest numbers of redds at 78, 65, and 46 redds, respectively; a maximum of 45 Chinook Salmon redds, and two Sockeye Salmon redds were observed.

The estimated fry and smolt production from these redds were compared to the estimated outmigration from the RST data. Chinook Salmon predictions for juvenile production based on redd counts were similar to outmigration estimates from the RST, whereas the other species' estimates diverged. The differences in production estimates derived from redd surveys and RST catch could be attributed to multiple factors, including our use of coarse estimates of fecundity and survival by species from the literature and redd superimposition.

For Chum Salmon, however, the results suggest that redd counts may have been underestimated, or, alternatively, that egg-to-fry survival was high. Chum and Coho salmon have a similar spawn timing and similarly sized redds, so it seems plausible that some redds identified as Coho were likely Chum redds.

Fall spawner abundance was examined in relation to outmigration estimates. Fall spawner abundance estimates were weakly positively correlated to 0+ fry and 0+ smolt outmigration estimates for most species with some exceptions. Chum Salmon saw the strongest positive correlation except for fall spawners from 2016, which were likely influenced by the large spill event in November 2016. Pink Salmon outmigration was not related to spawner abundance. This could be due to multiple factors including a high percentage of adult spawners holding in the Elk Canyon but dropping down to the lower river to spawn, and redd superimposition caused by later spawning Chum, Chinook, and Coho Salmon. Coho Salmon outmigration for 0+ and 1+ age classes showed a similar pattern with outmigration generally increasing with increased fall spawner abundance except for 2014, when fall spawner abundance was high, but outmigration numbers did not increase notably in response.

A single spring snorkel survey was conducted on March 10, 2020; no Steelhead, or redds were observed. Additional surveys were not possible due to COVID19 restrictions. Steelhead counts in previous years ranged from 1 to 10 fish.

The following is a summary of considerations for Year 7.

<u>Smolt enumeration component</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. In Year 6, the mark-recapture experiments included wild Chinook and Chum fry in addition to Quinsam hatchery Chinook fry and smolts. Year 6 represents the final year of the mark-recapture experiments. In subsequent years, outmigration estimates will be calculated using the same mark recapture efficiencies applied in the Year 6 summary analysis.
2. Based on the catch results of the target fish species, the RST sampling period should remain open until the end of July to ensure that the Coho and Chinook Salmon outmigration periods are measured sufficiently.
3. The assessment of accumulated growing degree days with outmigration timing provided a useful addition to the analysis and increases our understanding of the factors that influence salmonid productivity in Elk Canyon. A similar synthesis analysis will be completed after Year 10 to summarize the smolt enumeration component.

<u>Spawner enumeration component</u>:

1. Adult Steelhead, Chinook, Chum, Coho, Pink and Sockeye Salmon were all observed in Elk Canyon; Chinook, Chum, Coho, Pink and Sockeye redds were also counted. Year 6 was the fourth year when estimates of production derived from RST catches were compared to

estimates of production predicted from redd counts by species. This was a useful component of the analysis, which showed that egg-to-fry survival for Chum Salmon was high in 2019-2020. However, this component also highlighted that identification of species-specific redds is challenging, especially for species that construct similarly sized redds during the same time period. This is likely to remain a challenge for the program.

2. Steelhead counts during the spring snorkel surveys in Years 1 through 6 have been low (≤10). Such low Steelhead counts will not allow us to address Hypothesis $H_0$9 for Steelhead from the ToR, which states: *$H_0$9: Annual abundance of 'resident' smolts is not correlated with an index of Steelhead spawner abundance.*

Management Questions, Hypotheses and Status after Year 6.

Management Questions	Management Hypothesis	Year 6 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, c, and d) are being conducted each year to determine fish productivity of Elk Canyon. Year 6 results confirm that we are on track to address H01. 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 6 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 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. 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 but is opposite to the hypothesized effect direction. 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.
MQ 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?	**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 6 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.

Management Questions	Management Hypothesis	Year 6 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.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF MAPS

LIST OF APPENDICES

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 "what limits fish abundance?" For example, are fish abundance and biomass in the Campbell system limited by flow? Resolving this uncertainty is an important step to better understanding how human activities in a watershed affect fisheries, and to 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. The *Elk Canyon Smolt and Spawner Abundance Assessment* (JHTMON-15) is part of wider monitoring of the Campbell River WUP. JTHMON-15 and 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 results from Year 6 of the JHTMON-15 study and an interim summary of the Year 1, 2, 3, 5 and 6 smolt enumeration component.

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

The Elk Canyon consists of a reach of the Lower Campbell River from Elk Falls below the John Hart Dam to the John Hart generating station (Map 2). 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). Despite 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 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 (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 will also be considered.

JHTMON-15 is scheduled for 10 years 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. Two of the main sampling techniques to be employed in the monitor are snorkel swim counts of spawning adults and rearing juveniles and rotary screw trap enumerations of out-migrating smolts. The basic data requirements are summarized in Table 1.

Three components of JHTMON-15 were part of the data collection for Year 6 with the remaining components completed in Year 5 (Table 1).

Table 1. Summary of TOR data requirements.

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 and addresses hypotheses H_01, H_06, H_07 and H_08 of the TOR. The IFS fieldwork was completed in 2017 and includes 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 suggest 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 will be 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, Chinook Salmon, and Coho Salmon, although the RST will also capture information for Chum Salmon, Pink Salmon and Sockeye Salmon that have incubated in Elk Canyon. The RST was used successfully in Years 1, 2, 3, 5, and 6 to enumerate out-migrating fry and smolts of all salmon species. The smolt enumeration component of JHTMON-15 was not completed in Year 4 due to commissioning and construction related activities. This report includes Year 6 specific results and an interim summary analysis of smolt enumeration in the Elk Canyon using mark-recapture trials and RST capture data from Years 1, 2, 3, 4, and 6.

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 and address hypothesis H_02 of the TOR. 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. 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 was completed in 2019 which consisted of snorkel surveys scheduled pre- and post-pulses. A synthesis analysis was completed in Year 5 to address H_03

and $H_0$5 of the TOR. Results showed no evidence that the 10 m^3/s pulse flows attracted Steelhead into Elk Canyon, retaining $H_0$5. The rate of Steelhead in-migration per day was significantly higher during the base flow than during the pulse flow, rejecting $H_0$3 and was opposite to the hypothesized effect direction. 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, retaining $H_0$3 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 also 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 across three years of data collection to address $H_0$6, $H_0$7, and $H_0$8 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), which retains null hypothesis $H_0$6. 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_0$7 and $H_0$8 (Thornton *et al.* 2020).

1.4.7. Spawner Enumeration

Spawner counts in both fall and spring are to be conducted annually for the full JHTMON-15 program. Area under the curve (AUC) estimates of abundance are calculated and used to test if the annual abundance of 'resident' smolts is not correlated with an index of Steelhead spawner abundance ($H_0$9). This hypothesis cannot be adequately addressed due to low adult Steelhead counts in Year 1 through 6 (≤10), and inconsistency of survey dates due to restricted access to the Elk Canyon due to spill events. Fall spawner (e.g., Coho, Chinook, Chum) abundance will be examined in relation to smolt outmigration the following spring. Note that the $H_0$9 hypothesis is concerned only with that portion of the total smolt count that has spent their entire freshwater lifecycle in the Elk Canyon reach.

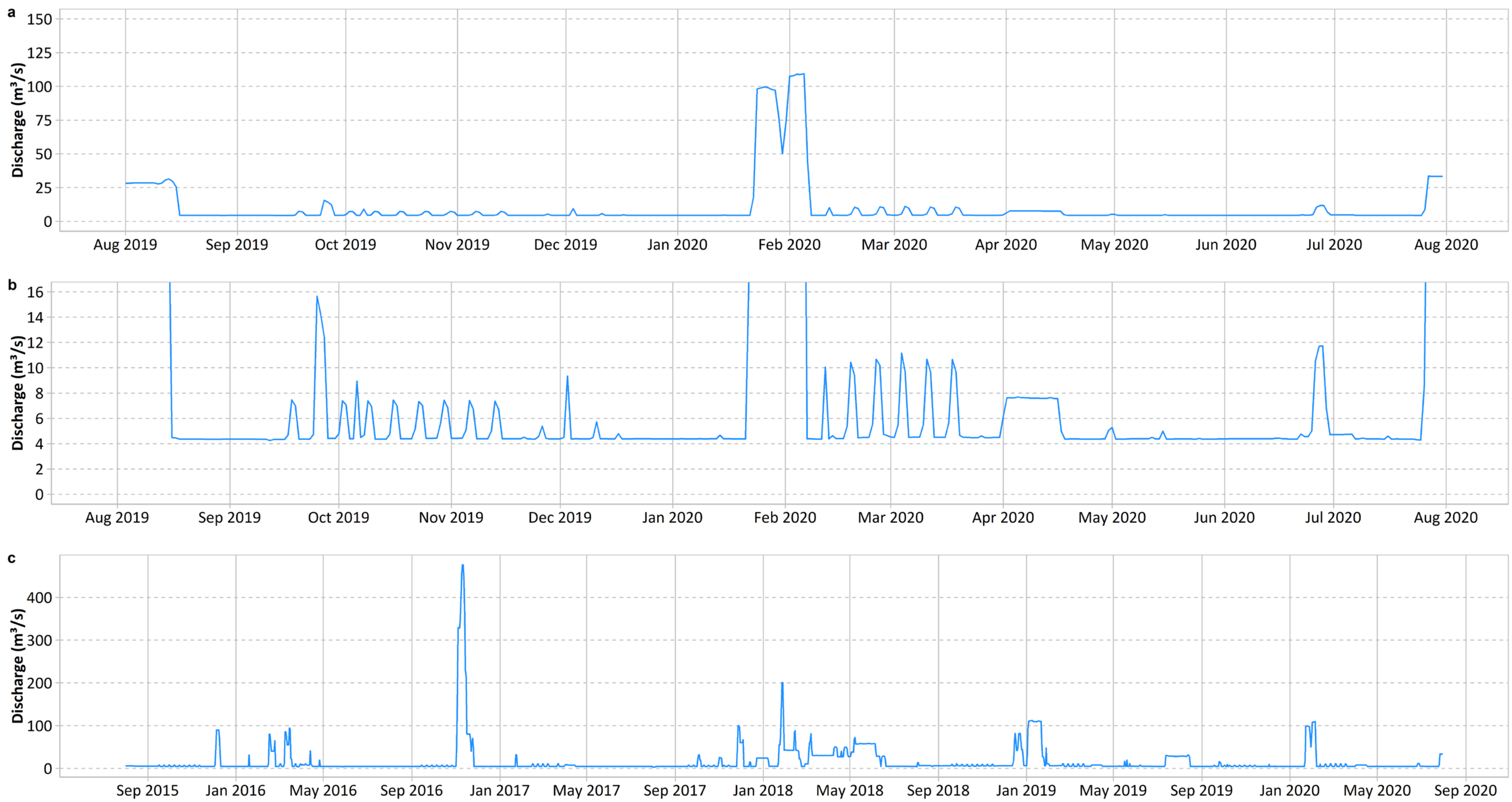
2. METHODS

2.1. Overview of Conditions in Year 6

The Elk Canyon smolt and spawner abundance program involves a series of interconnected components, each focused on addressing a specific hypothesis. The two main sampling techniques employed in Year 6 of the monitor were snorkel swim counts of adults and rotary screw trap enumerations of out-migrating juveniles.

Figure 1a and b show the measured flow in Elk Canyon from August 2019 through to the end of July 2020. The 7 m^3/s pulse flows in September through November are evident, as well as the 10 m^3/s pulse flows and 7 m^3/s spawning flow in March and April. Also evident are large spill events that occurred between January and February 2020 as well as the ~30 m^3/s flow that occurred during an outage in mid-August 2019 and 2020. Figure 1c shows measured flow in Elk Canyon from September 2015 through to the end of August 2020.

Figure 1. **Discharge (m^3/s) in Elk Canyon August 2019 to August 2020 (a and b) and September 2015 to August 2020 (c). Note different y-axis scales in panels a, b, and c which help view the 7 and 10 m^3/s pulses in fall and spring respectively relative to the larger spills in Elk Canyon.**



2.2. Smolt Enumeration

2.2.1. RST Setup and Operation

Year 6 represented the fifth year of smolt enumeration activities in Elk Canyon, including assessments in Years 1, 2, 3, 5 and 6 of JHTMON-15. Smolt enumeration is planned to occur for four more years from Years 7 to 10. No smolt enumeration was completed in Year 4 due to commissioning activities preventing access into the Elk Canyon.

Smolt enumeration was carried out using a single 1.2 m rotary screw trap (RST) located near the base of the canyon, in the first run type mesohabitat (Figure 2), just around the corner and upstream from the powerhouse at JHT-DVRST (Map 2). Use of the RST followed a standard protocol (U.S. Fish and Wildlife Service 2008).

The RST was secured 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. Operators were trained during the install to manage the rigging under a range of flow conditions.

The trap was installed March 3, 2020 and fished 5 days a week (excluding most weekends) until July 23, 2020 for a total effort of 89.4 days (Table 2). Crews serviced the trap daily each morning. In Year 6 there were 2 main fishing positions for the trap. Position #1 was for base flows of 4 m^3/s (Figure 2) and Position #2 for pulse flows of 10 m^3/s and the prescribed spawning flow of 7 m^3/s (Figure 3). The new tailrace location caused significant backwatering effect compared to flow conditions created by the old tailrace location. In response to this increased backwatering effect, small adjustments to the fishing location were required dependent on tailrace flows.

Table 2. RST Fishing Effort Years 1, 2,3, 5, and 6.

Year	Total Effort (h:mm)	Total Effort (hrs)	Total Effort (Days)
2015	2624:17	2624.3	109.3
2016	1952:06	1952.1	81.3
2017	3571:32	3571.5	148.8
2019	3110:29	3110.5	129.6
2020	2144:53	2144.9	89.4

Daily trap servicing consisted of a crew of two accessing 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 and sampled for DNA. Scale samples were also collected from a subset of captured fish, specifically targeting Rainbow Trout and larger Coho and Chinook Salmon. 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 afternoon. Pictures were emailed automatically to the trapping crew, so they were aware of any potential issues with the trap prior to arriving onsite. Afternoon pictures were emailed sufficiently early in the day so that any issues could be resolved prior to sunset. For site security, the camera was also programmed to be motion activated to detect tampering or vandalism.

Figure 2. Rotary Screw Trap (RST) during operation at base of Elk Canyon at 4 m^3/s (Position #1).

Figure 3. Rotary Screw Trap (RST) during operation at base of Elk Canyon at 7 m^3/s (Position #2).

2.2.2. Fish Scale Age Analysis

In Years 1, 2, 3, 5, and 6 scale samples were collected for age analysis from RST captured Steelhead/Rainbow Trout, Chinook Salmon, and Coho Salmon that were >50 mm fork length. 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. Of these, 80 Steelhead/Rainbow Trout, 43 Coho Salmon, and 33 Chinook Salmon scales were aged. Species specific age data were then used to create discrete fork length at age bins.

In the Ecofish laboratory, scales were examined under a dissecting microscope to determine age. 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.

2.2.3. Year 6 Mark Recapture Experiment

Mark-recapture experiments were completed to measure RST capture efficiency and ultimately to estimate total outmigration from Elk Canyon (Table 3). A total of 13 mark-recapture trials were completed over 13 release days from March 18 to May 13, 2020. The trials included: six trials of wild Chum fry, four trials of wild Chinook fry, and three trials of hatchery Chinook smolts. Chum and Chinook fry were marked by immersion in Bismarck Brown (0.8 g of in 38 L of water) for 1.25 hrs and Chinook Salmon smolts were marked using a unique ventral fin clip for each individual trial.

The number of fish targeted for release per trial (200 fish) was determined by an efficiency analysis conducted for the Year 1 report (Hocking *et al.* 2015). This analysis determined that with 200 fish released the RST catch efficiency is not expected to vary by more than 5% if an additional fish is captured during a given trial, a quality criterion described in U.S. Fish and Wildlife Service (2008).

The hatchery Chinook Salmon were driven to the upper laydown parking lot from the Quinsam hatchery and then transported into the canyon in buckets with battery-powered bubblers. All fish were released approximately 225 m upstream of the RST. The release site was consistent through all trials and was located at the top of a cascade which flowed into a pool, run, riffle, and then into the RST. In total, 600 hatchery Chinook Salmon smolts, and 3977 wild Chum Salmon fry were released over the course of the mark recapture experiment (Table 3).

Two different capture efficiency estimates were calculated based on recaptures of the marked and released fish. First, the trial capture efficiency was based on recapture rates calculated for each trial:

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

Where CE_t is the trial capture efficiency, $RR_{i,s,x}$ is the total number of recent recaptured fish of species *i*, in life stage *s* in trial *x*, and $r_{i,s,x}$ is the number of released fish for species *i*, in life stage *s* at trial *x*.

Second, because some marked and released fish may not immediately leave Elk Canyon, an overall capture efficiency was calculated based on a weighted average all trials for each species and life stage, weighted by the number of fish released:

$$CEo_s = \frac{\sum(r_{i,s,x}\, CEt_{i,s,x})}{\sum r_s}$$

Where CEo_s is the weighted average capture efficiency for life stage *s*, $CEt_{i,s,x}$ is the trial capture efficiency trial for species *i,* at life stage *s*, *r* is the weight based on the total number of fish released of species *i* of life stage s in trial *x*, and denominator $\sum r_s$ represents the total number of fish released at stage *s*. As a result, two overall capture efficiencies were determined, one for fry and one for parr/smolts.

Table 3. Mark-recapture experiment release date and fish numbers.

Species	Origin	Life Stage	Release Date	Number of Fish Marked	Number of Fish Released[1]
Chinook Salmon	Hatchery	Parr	29-Apr-20	200	200
	Hatchery	Parr	6-May-20	200	200
	Hatchery	Parr	13-May-20	200	200
	Wild	Fry	18-Mar-20	200	198
	Wild	Fry	26-Mar-20	255	254
	Wild	Fry	8-Apr-20	46	46
	Wild	Fry	15-Apr-20	266	266
Chum Salmon	Wild	Fry	18-Mar-20	75	73
	Wild	Fry	26-Mar-20	571	569
	Wild	Fry	1-Apr-20	200	200
	Wild	Fry	8-Apr-20	1370	1366
	Wild	Fry	15-Apr-20	773	770
	Wild	Fry	22-Apr-20	235	235

[1] Not all fish survived the marking and/or transport procedure. Only live marked fish were released.

2.2.4. Year 6 Salmonid Outmigration

Using estimates of overall capture efficiency (CEo) and catch per unit of effort (CPUE), we estimated daily outmigration for each salmonid species and life stage in Elk Canyon using the following formula:

$$Outmigration_{i,s,d} = \frac{CPUE_{i,s,d} \times T_d}{CEo_s}$$

Where $Outmigration_{i,s,d}$ is the estimated outmigration for species *i*, at life stage *s* in day *d*, $CPUE_{i,s,x}$ is the hourly average catch of a given species *i* at life stage *s* in day *d*, *T* is total number of hours of RST operation in day *d*, and *CEo* is the overall capture efficiency for life stage *s*.

The RST did not operate continuously from March 3 to July 23, which created 61 days without outmigration estimations. To fill those gaps, we averaged the estimated outmigration of the first available records before and after each gap for each salmonid species and respective life stages. In total, we estimated 140 days of salmonids outmigration for Chum, Coho, Chinook, Pink and Sockeye Salmon species and Rainbow Trout.

2.2.5. Five-Year Smolt Outmigration Assessment

A five-year smolt outmigration assessment summary analysis provides a mid-project summary examining any trends in outmigration for Years 1, 2, 3, 5 and 6 and factors such as temperature and seasonality and how they affect Elk Canyon productivity. Analyses included a synthesis of the mark-recapture trials and an assessment of trends in productivity and outmigration timing across all years of the study.

2.2.5.1. RST Mark-Recapture Summary

The objective of the RST Mark-Recapture summary is to assess the capture efficiency variation throughout the monitoring program duration. In total, 86 mark-recapture trials were completed between March and May in Years 1, 2, 3, 5 and 6.

Using mark-recapture trials from Years 1, 2, 3, 5, and 6, we calculated two different capture efficiency estimates based on recaptures of the marked and released fish. First, we calculated the trial capture efficiency based on recapture rates calculated for each trial:

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

Where *CEt* is the trial capture efficiency of trial *t* at year *y* for species *i* at life stage *s*, RR_x is the total number of recaptured fish of species *i* at trial *t* in year *y* at life stage *s* and r_x is the number of released fish of species *i* at trial *t* in year *y* at life stage *s*. In total, we performed 82 capture-recaptures trial from Years 1 to 6. However, no marked fish were caught in 11 trials. In detail, nine of those trials were from Year 2 (2016), one wild Chinook Salmon fry trial, five wild Coho Salmon fry trials, one wild Pink Salmon fry trial and two wild Sockeye Salmon fry trials. The remainder two trials were hatchery Coho Salmon parrs from Year 3 (2017). These 11 trials were not considered for the subsequent analysis.

Second, we calculated an overall capture efficiency based on combining the information of 71 trials for each species and life stage weighted by the number of fish released per trial:

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

Where CEo_s is the weighted average capture efficiency of salmonid life stage *s* at year *y*, $CEt_{t,i,s,y}$ is the trial capture efficiency at life stage *s* at year *y*, and denominator $\sum r_{s,y}$ represents the total number of fish released at stage *s* at year *y*. This resulted in two overall capture efficiencies per year, one for fry and one for parr/smolts. To estimate fry *CEo* we combined information from wild and hatchery Chinook fry trials, wild fry Chum salmon trials, hatchery and wild fry Coho salmon trials and wild fry Pink salmon trials. To estimate parr/smolt *CEo,* we used information from parr/smolt trials of Chinook and Coho Salmon species.

Mark-Recapture trials and RST capture data from years 1, 2, 3, 4, and 6 (this study), were used to estimate daily salmonid outmigration.

2.2.5.2. Five-Year Salmonid Outmigration Trends

The carrying capacity of Elk Canyon was assessed using daily estimates of salmonid outmigration, between March and July, for Years 1, 2, 3, 5 and 6. The RST was first installed in 2015 and operated between late February/early March and late July for every year of the project. By the end of Year 6 (2020) it accumulated 558 effort days (Table 2) or more than 13,000 hours of fishing. The annual total effort varied between years of operation, from 81.3 in Year 2 (2016) to 148.8 days in Year 3 (2017; Table 2). Note that, no smolt enumeration was completed in Year 4 (2018) due to commissioning activities preventing access into the Elk Canyon.

The RST position in the Elk Canyon was relatively consistent throughout the duration of the monitoring program with major adjustments occurring during pulse flows (7 m^3/s) where the trap was moved to location #2 (Figure 3). Due to a backwatering effect from the new tailrace, minor adjustments were required throughout the monitoring program to ensure the trap was effectively fishing.

Mark-Recapture trials and RST capture data from years 1, 2, 3, 4, and 6 (this study), were used to estimate daily salmonid outmigration. To estimate daily outmigration for years 1, 2, 3, 5 and 6, we used the estimated *CEo* from Section 2.2.5.1 and applied the outmigration formula in Section 2.2.4 per year. For more details on salmonid outmigration estimation see Section 2.2.4.

Estimates of daily outmigration were examined to determine if seasonal patterns exist within a given year, or if any patterns are apparent between years by species, life stage, and age class. In addition, outmigration timing was examined in relation to the accumulated growing degree days (AGDD). For fry, AGDD measured the total number degrees (°C) that an individual accumulated between the fall peak spawning date to the date each individual fish was caught in the RST. This represents the AGDD during egg-to-fry development up to the date of fry outmigration. For smolts, accumulated degree days measured the total number degrees (°C) that an individual fish accumulated from March 1 each year to the date each individual was caught in the RST. The annual timing of outmigration each year was then compared to the timing predicted by AGDD to help determine different dependencies on temperature for development for the salmonid species in the Elk Canyon. Water temperature data was obtained from BCH; however, no water temperature data was available after January 1, 2020. Therefore, no AGDD was calculated for 2020 fry and smolts.

2.3. Fall and Spring Spawner Enumeration

2.3.1. Fall Spawners

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 swimmers swimming in tandem with a third crew member recording data onshore. In total, 10 snorkel surveys were conducted on September 9, 16, 24, and October 4, 15, 25, and November 4, 12, 20, and 29, 2019 to inventory fall spawning Coho Salmon, Chinook Salmon, Chum Salmon, Pink Salmon, Sockeye Salmon, and Steelhead in Elk Canyon. In each reach, total counts of all species, their spawning condition, and the presence of redds were recorded. Spawning areas were also marked for future data collection.

Spawner abundance for each salmon species was estimated using an area under the curve (AUC) analysis using 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%.

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). 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

2.3.2. Spring Spawners

Snorkel surveys were also used to enumerate spring spawning Steelhead in reaches one to six of the Elk Canyon (Map 2). In total, one snorkel survey was conducted on March 10, 2020 following the same methods used in the fall spawner surveys. Additional snorkels surveys were proposed however COVID19 restrictions prevented these from happening. The maximum number of Steelhead observed in a single survey day was used as the spawner abundance estimate rather than using area under the curve.

3. RESULTS

3.1. Smolt Enumeration

3.1.1. Year 6 RST Captures

The RST operated for a total effort of approximately 89 days or approximately 2145 hours between from March 3 to July 23, 2020. In total, 11,576 fish were captured in the RST in 2020 (Figure 4, Appendix A). Similar to previous RST sampling years, the catches in 2020 were primarily composed of Chum Salmon (69.0%), Chinook Salmon (22.9%), and Coho Salmon (3.3%). Steelhead/Rainbow Trout and Sockeye Salmon account for 0.15% and 0.04%, respectively. The combined catch of all salmonids (11,335 fish) accounted for 97.9% of the total catch, whereas the catch of the key target species of Chinook Salmon, Coho Salmon, and Steelhead/Rainbow Trout (3,053 fish) accounted for 26.4% of the total catch.

Clear periods of outmigration were observed for Chinook Salmon, Coho Salmon, and Chum Salmon based on the RST catches (Figure 5, Figure 6, Appendix A). Chinook Salmon outmigration had two main peaks, including a large peak of recently emerged fry in late March and early April, and a second smaller peak in late May to early July of 0+ smolts. Coho Salmon outmigration occurred more intermittently than Chinook. Outmigration of fry occurred from early March until early May with two main peaks occurring late March and late April. Early June through July saw a second peak consisting primarily of 0+ smolts. Steelhead/Rainbow Trout outmigration was low and irregular from mid-April through to early June with a peak occurring around the end of May. Chum Salmon outmigration began in early March and peaked in mid April. Catches of Chum Salmon occurred until May 20, after which none were captured in the RST. Pink Salmon outmigration began in early March and peaked late March to early April. Catches of Pink Salmon occurred until April 21, after which none were captured in the RST. Only 4 Sockeye Salmon were captured in the RST with irregular outmigration occurring between early March and early April.

The Quinsam hatchery releases sub yearling Chinook and Coho Salmon smolts into the Quinsam River, which enters the Campbell River downstream of the RST. There is some uncertainty around whether the Chinook and Coho released from the hatchery could swim upstream and become captured in the RST. Fish origin could not be determined in the field; however, otolith analysis was conducted in Year 3 which resulted in only 1 of 29 fish sampled determined to be of hatchery origin (~3%) suggesting that hatchery fish do not make up a significant proportion of the Chinook outmigration from Elk Canyon.

Of the 11,335 salmonids caught in the RST, 1,504 fish were measured for fork length. The fork lengths of these fish were compared over time to determine if outmigration timing varied by the size and/or age Cohort of fish (Figure 7, Appendix A). Chum Salmon fry were captured throughout March to May (total of 303 fish measured), and Pink Salmon were captured in March and April (total of 166 fish measured) had a narrow range of fork lengths, roughly between 30 to 40 mm. Only 4 Sockeye Salmon were captured between March and April with a narrow fork length range between roughly 36 and 37 mm.

Chinook Salmon exhibited two main peaks in outmigration timing and size while Coho Salmon exhibited three main peaks in outmigration timing and size (Figure 5, Figure 6, Appendix A). Recently emerged Chinook and Coho fry were caught in the RST from March to early May, and ranged in fork length from 25 to 50 mm. For Chinook, a second peak in outmigration composed of larger individuals was observed for both species starting in mid-May until the end of the sampling period. From late May to the end of July, the majority of the Chinook caught in the RST ranged in fork length from 70 to 100 mm (Figure 7, Appendix A). Most of these fish are assumed to be age 0+ smolts that have reared for several months in Elk Canyon prior to their outmigration.

The peak in Steelhead/Rainbow Trout outmigration occurred between early May and mid-June (Figure 5, Figure 6, Appendix A). In total, only 17 individual fish were capture between March and June. Most of the captured Steelhead/Rainbow Trout were age 1+ (~47%; 92-150 mm;) and age 2+ (~35%; 151-199 mm), which were captured between March and June. Small 0+ (≤85 mm) and 3+ (200-256 mm), made up small proportions of RST captures (~12% and ~ 6% respectively). Average outmigration body size of Steelhead/Rainbow Trout declined steadily from mid-May to mid-June (Figure 7), which suggests that age 3+ smolts migrated earlier than 2+ smolts (Figure 7, Appendix A).

Figure 4. Total RST catch by species from March 3 to July 23, 2020. ST/RB = Steelhead/Rainbow Trout, CO = Coho Salmon, CH = Chinook Salmon, CM = Chum Salmon, PK = Pink Salmon, SK = Sockeye Salmon, CT = Cutthroat Trout, TR = unknown trout spp., CC = sculpin (*Cottus* spp.), TSB = Threespine Stickleback, UNK = unknown fish species (fry mortalities that were too damaged to identify to species in the field).

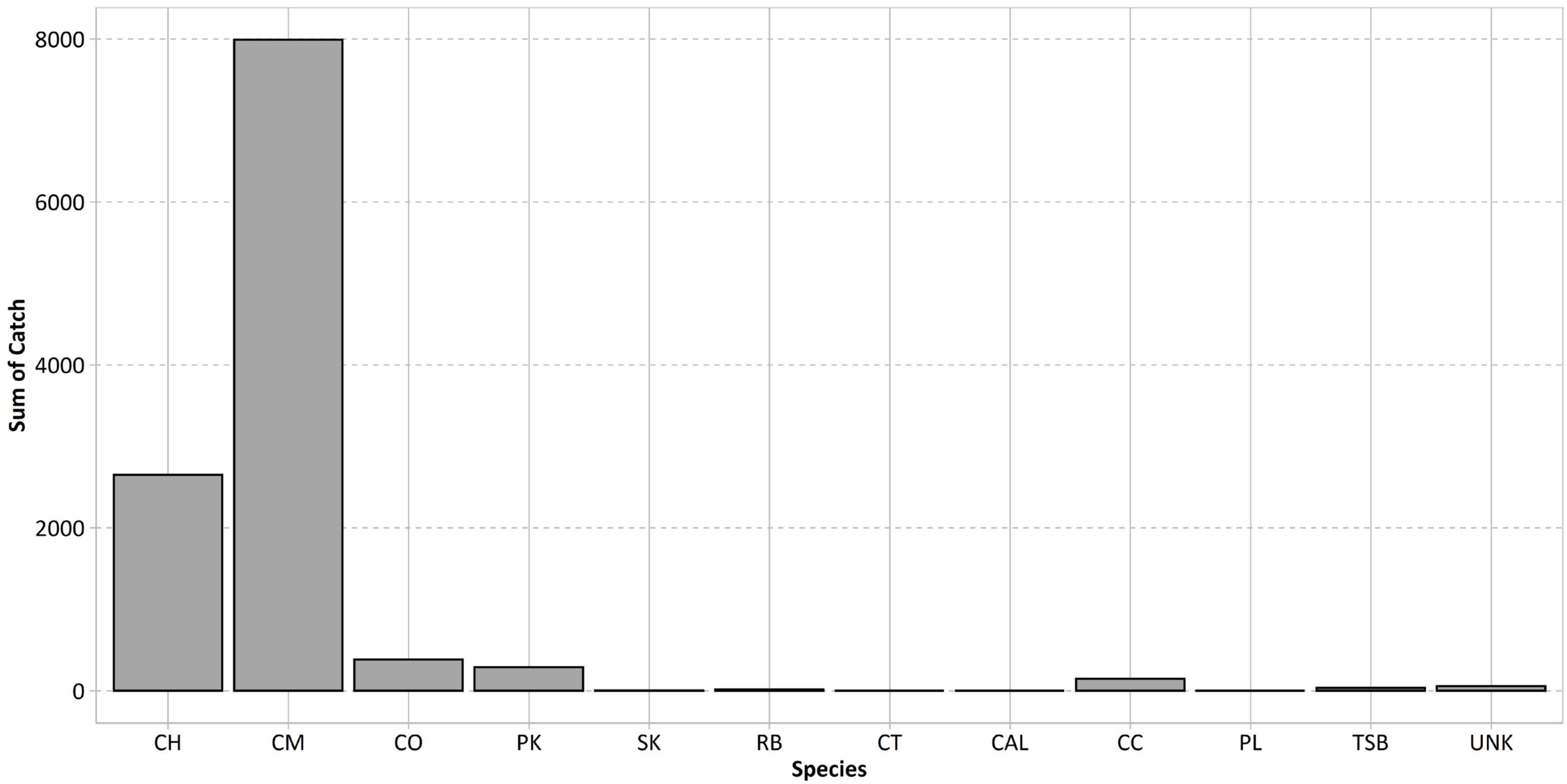


Figure 5. Daily average RST catch of key salmonid species from March 3 to July 23, 2020.

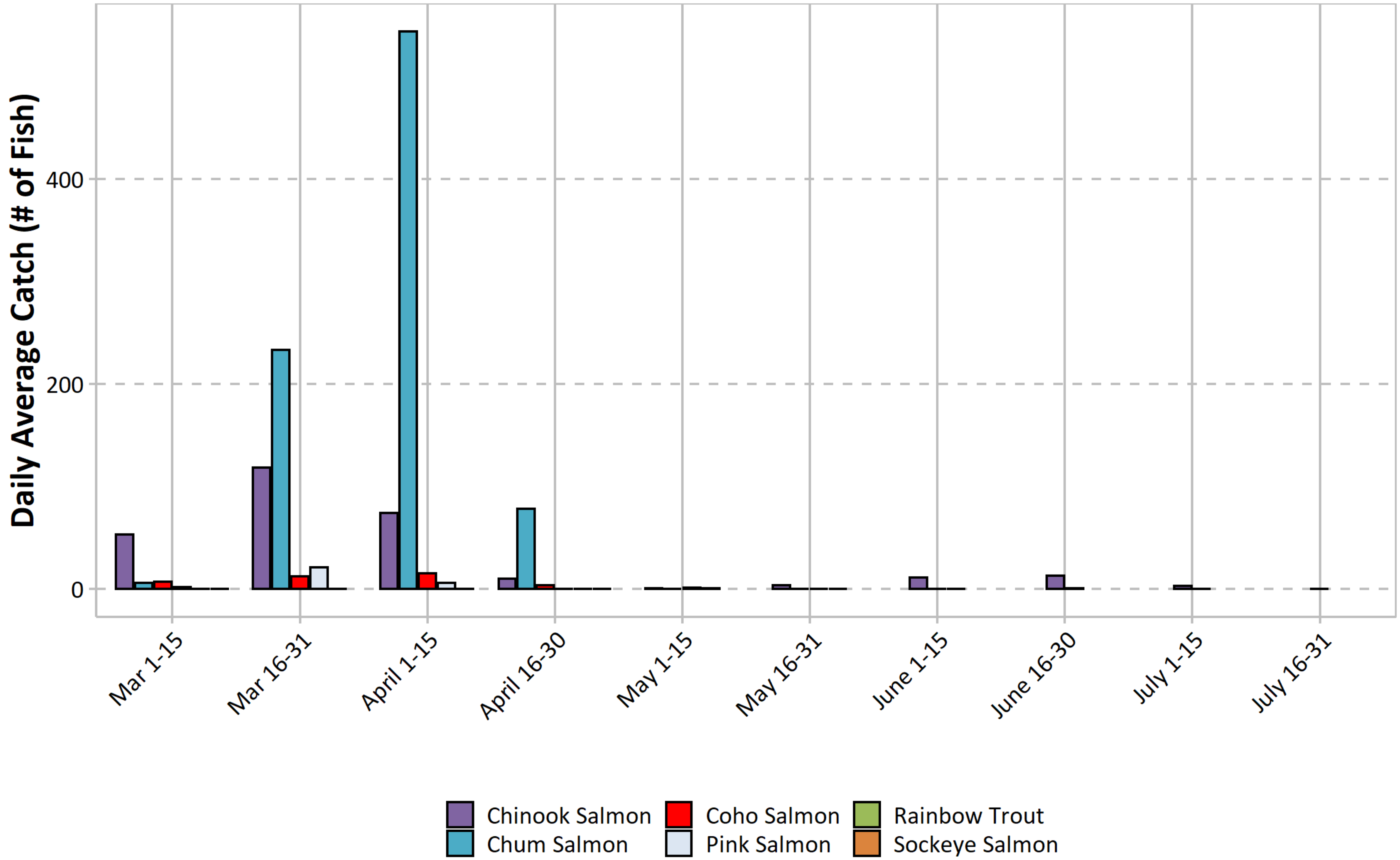


Figure 6. Daily RST catches of a) Chinook Salmon, b) Chum Salmon, c) Coho Salmon, d) Pink Salmon, e) Rainbow Trout, and f) Sockeye Salmon.

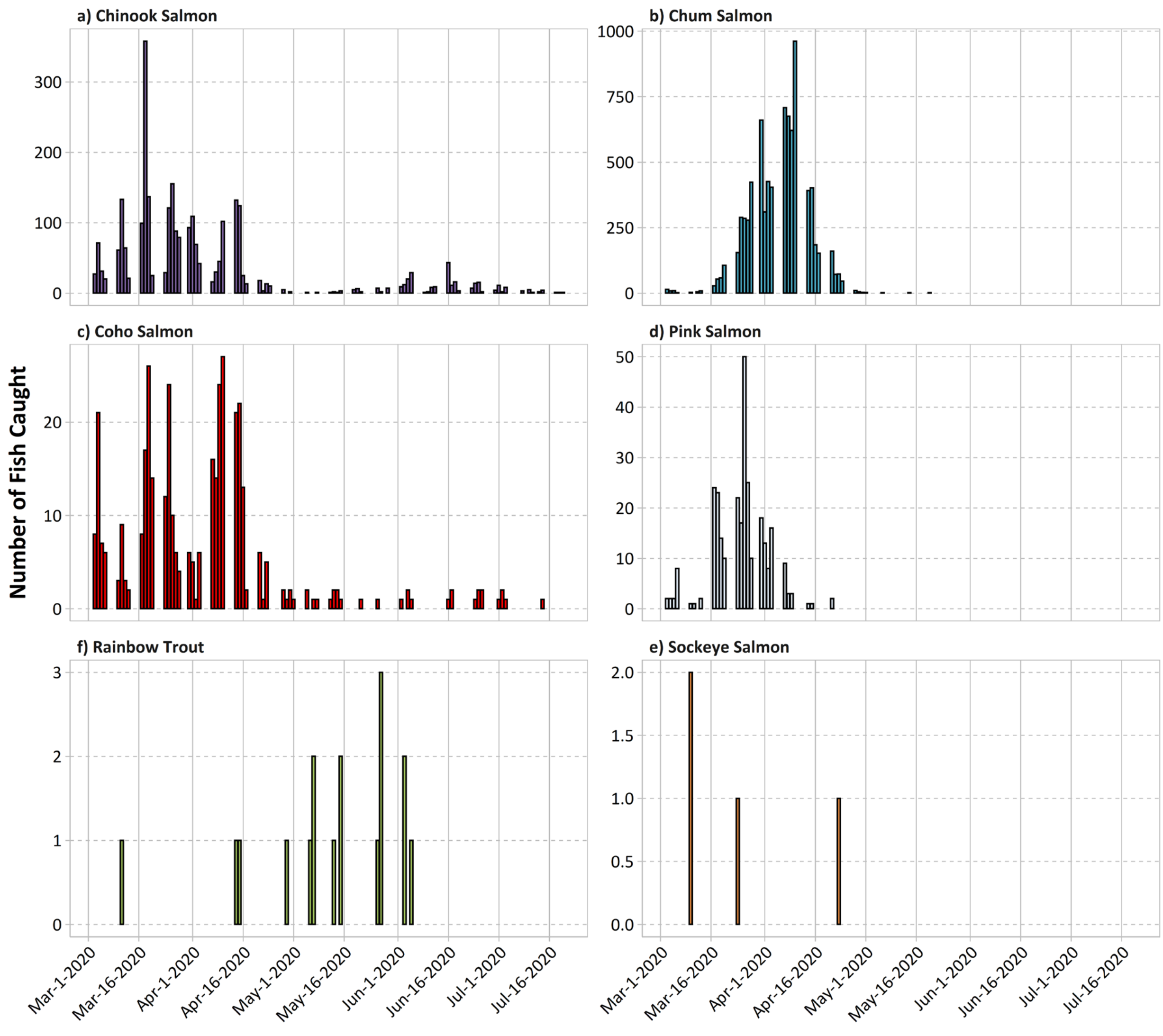
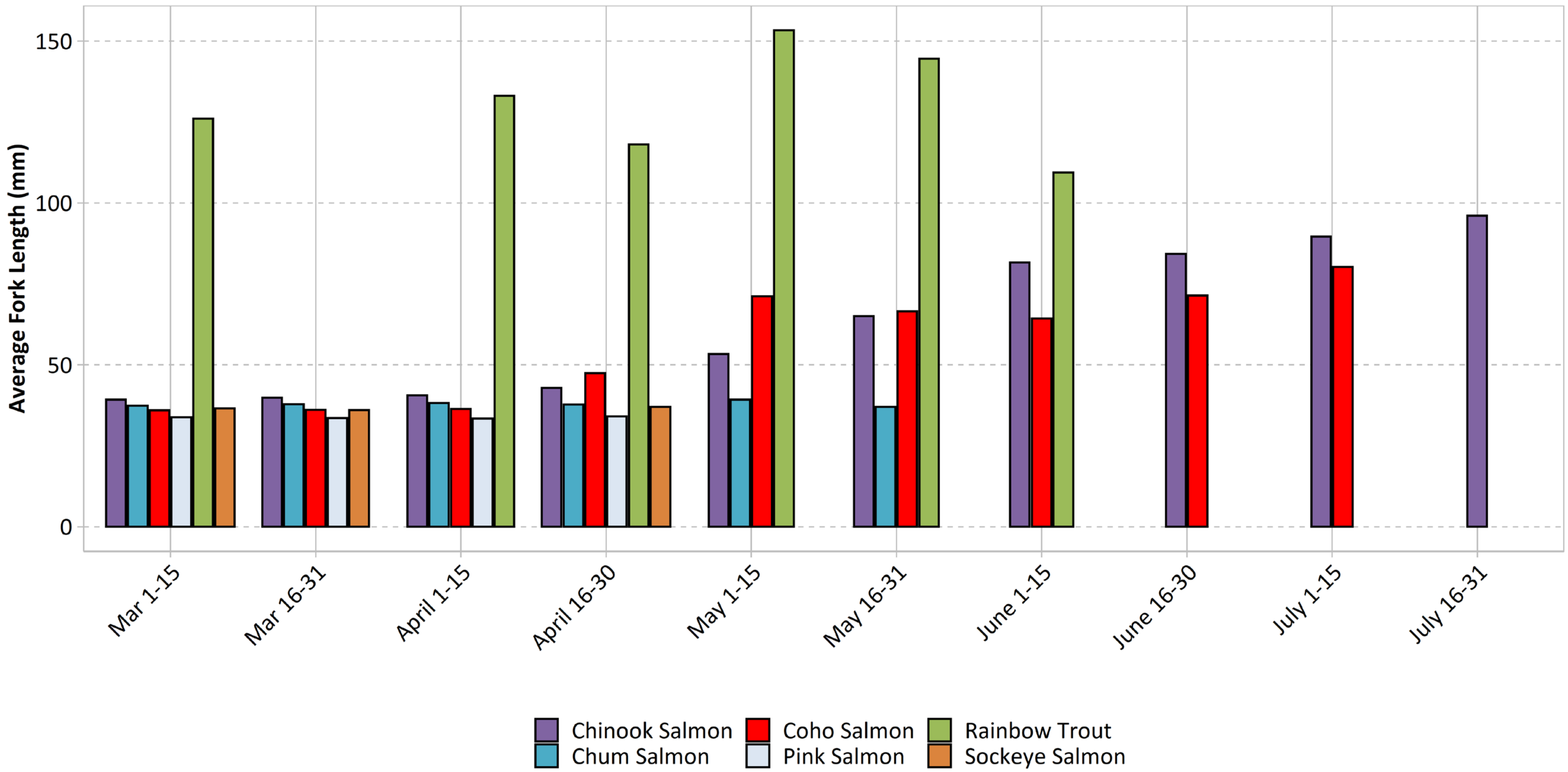


Figure 7. Average fork length of Coho Salmon, Steelhead/Rainbow Trout, Chum Salmon, Chinook Salmon, Pink Salmon, and Sockeye Salmon during RST sampling period, between March 3 and July 23, 2020.



3.1.2. Fish Scale Age Analysis

Chinook Salmon caught in the RST that were aged ranged in fork length from 64 mm to 107 mm. Of the 32 Chinook Salmon scales samples that were aged, all were aged as 0+ fish (Figure 8). Based on the size distribution of Chinook Salmon caught in the RST, it is concluded that all Chinook Salmon juveniles are 'ocean type' and likely leave Elk Canyon by the end of July.

Of the 43 Coho Salmon scales that were aged, 35 were aged as 0+ fish, and eight aged as 1+ (Figure 8, Table 5). Coho Salmon caught in the RST that were aged ranged in fork length from 58 mm to 135 mm. Based on the size distribution of Coho Salmon caught in the RST, it is concluded that most Coho Salmon juveniles caught in the RST in 2020 were 0+ fish. However, eight individuals were aged as 1+ confirming a small number of Coho Salmon juveniles overwinter in Elk Canyon.

Of the 81 Steelhead/ Rainbow Trout scales that were aged, 17 were aged as 1+, 44 were aged as 2+, 18 were aged as 3+, and two were aged as 4+ (Figure 8). Based on this aging data, and the length-frequency histograms from RST catch all fish ≤85 mm are assumed 0+, fish 92 to 150 mm are assumed 1+, fish 151 to 199 mm are assumed 2+, fish 200 to 255 mm assumed 3+, and all fish >265 mm assumed >3+ (Table 5). It is important to note the uncertainty associated with these age break classifications for Steelhead/Rainbow Trout, as the date of age sample collection varies significantly over the course of the RST monitoring period; therefore, this is a best estimate using all data collected to date.

Figure 8. Length at age graphs for all years for a) Chinook Salmon, b) Coho Salmon, and c) Steelhead/Rainbow Trout.

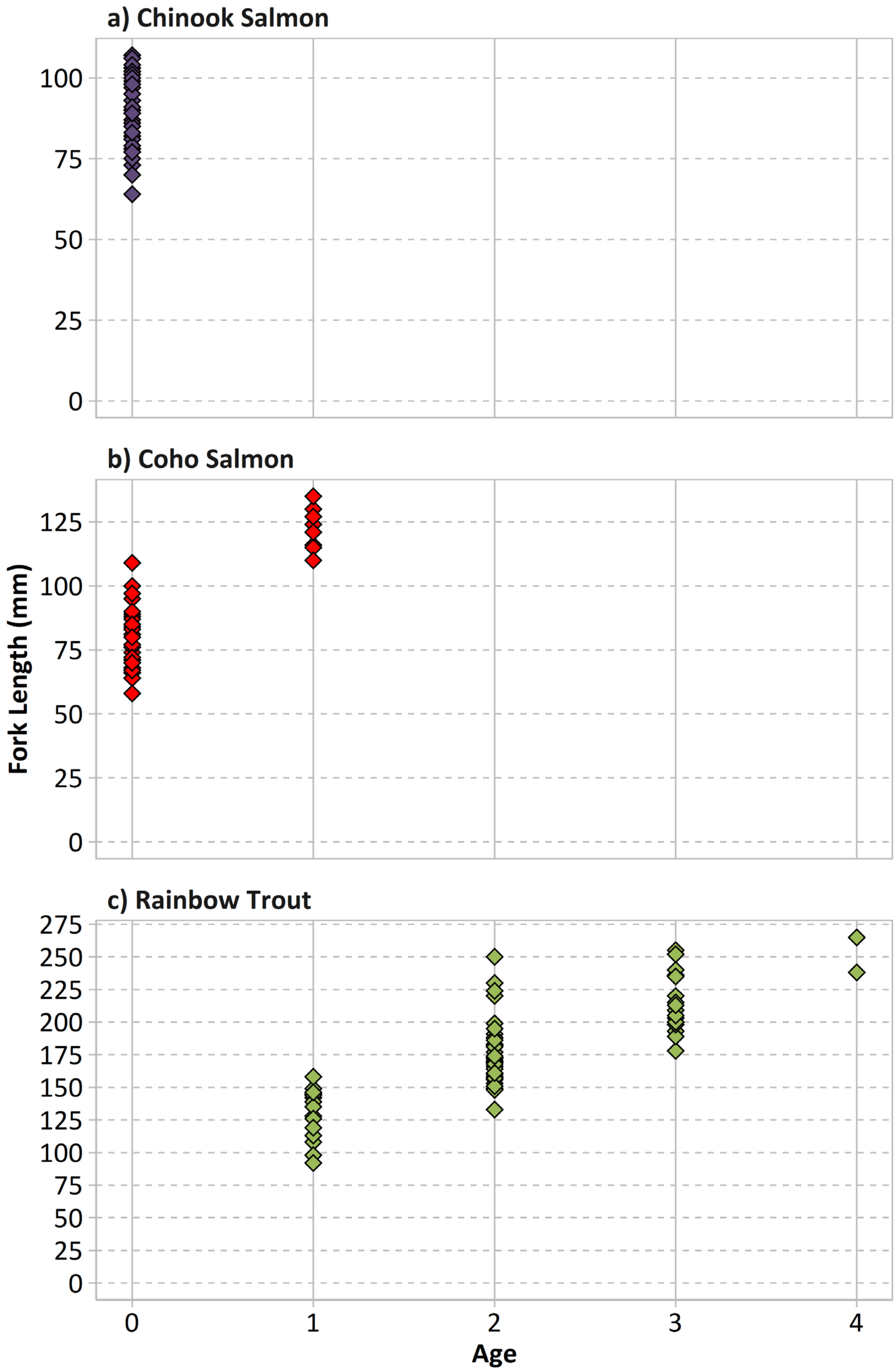


Table 5. Estimated size at age classification for juvenile Chinook Salmon, Coho Salmon, and Steelhead/Rainbow Trout.

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+

3.1.3. Year 6 Mark Recapture Experiment

The mark-recapture trials for salmon fry and smolts were used to estimate the capture efficiency of the RST and to ultimately generate outmigration abundance estimates from Elk Canyon. Of the total of 3,577 released fish, only 359 fish (~10.0%) were recaptured. The overall capture efficiencies differed by life stage with fry experiencing lower capture efficiencies (average = 0.066) than smolts/parr (average = 0.160; Table 6 and Table 7).

The trial capture efficiency estimates were based on recent recapture rates within the release periods (Table 6). Wild Chinook Salmon fry trial capture efficiencies ranged from 0.053 to 0.152 (mean = 0.099), while hatchery Chinook salmon parr/smolt capture efficiencies ranged from 0.125 to 0.195 (mean = 0.160). Wild Chum Salmon fry trial capture efficiencies ranged from 0.039 to 0.187 (mean = 0.090). No wild Coho Salmon mark recapture release was conducted in Year 6.

Table 6. Trial capture efficiency estimates for each corresponding release date during the Year 6 mark-recapture study.

Species[1]	Fish Lifestage	Origin	Release Date	Total Released Fish	Total Recaptured Fish	Trial Capture Efficiency
Chinook Salmon	Parr	Hatchery	29-Apr-20	200	32	0.16
			6-May-20	200	39	0.195
			13-May-20	200	25	0.125
					Average	**0.160**
	Fry	Wild	18-Mar-20	198	14	0.071
			26-Mar-20	254	31	0.122
			8-Apr-20	46	7	0.152
			15-Apr-20	266	14	0.053
					Average	**0.099**
Chum Salmon	Fry	Wild	18-Mar-20	73	8	0.110
			26-Mar-20	569	62	0.109
			1-Apr-20	200	12	0.060
			8-Apr-20	1366	58	0.042
			15-Apr-20	770	33	0.043
			22-Apr-20	235	24	0.102
					Average	**0.078**
					Overall Capture Efficiency Used (Fry)	**0.066**
					Overall Capture Efficiency Used (Parr/Smolt)	**0.160**

1 No Coho, Pink nor Sockeye Salmon species were marked in 2020.

Table 7. Overall capture efficiency estimates for the Year 6 mark-recapture study.

Species[1]	Total Number of Released Fish	Total Number of Recaptured Fish	Overall Capture Efficiency
Chinook Salmon Fry	764	66	0.086
Chinook Salmon Smolt	600	96	0.160
Chum Salmon Fry	3213	197	0.061
Overall Capture Efficiency Used (Fry)	**3977**	**263**	**0.066**
Overall Capture Efficiency Used (Parr/Smolt)	**600**	**96**	**0.160**

1 No Coho, Pink nor Sockeye Salmon species were marked in 2020.

3.1.4. Year 6 Salmonid Outmigration

Chinook Salmon outmigration was estimated to be 54,687 0+ fry and 2,257 age 0+ smolts. Coho Salmon outmigration was estimated to be 8,472 0+ fry, 187 age smolts 0+ and 89 smolts 1+. Steelhead/Rainbow Trout outmigration was estimated to be 30 individuals of age 0+ fry, 69 individuals of age 1+, 75 individuals of age 2+ and 6 individuals of age 3+. Chum Salmon outmigration was the highest of all salmonid species with an estimated outmigration of 207,373 0+ fry. Pink Salmon and Sockeye Salmon total outmigration was estimated at 6,963 and 131 fry, respectively (Table 8). Overall, outmigration estimates in 2020 were similar to or higher than estimates since 2015.

3.1.5. Five-Year Salmonid Outmigration Assessment

A five-year analysis was conducted to assess trends in Elk Canyon productivity and outmigration of key species across all years of RST operation. Over all five years of monitoring (2015, 2016, 2017, 2019, and 2020), the RST captured a total of 58,650 fish in the Elk Canyon, with salmonids representing 92.8% of the total catch (54,432 fish). Chum Salmon fry represent the most abundant species in RST catch across all years except Year 1 (average catch = 8,662), followed by Chinook Salmon (average catch = 1,549) and Coho Salmon (average catch = 432) (Figure 9). In Year 3 (2017), we observed a substantial decrease in all salmonids caught by the RST (Figure 9 and Figure 10). The low capture numbers in 2017 are likely the result of the large spill event between November 4 and 24, 2016, which likely scoured redds within Elk Canyon. The number of Rainbow Trout and Sockeye Salmon individuals caught during RST operations have progressively decreased from 78 and 126 in Year 2 to four and 17 in Year 6, for Rainbow Trout and Sockeye, respectively.

Temporal patterns of salmonids captured by the RST remained consistent throughout the monitoring program (Figure 11). 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. Lastly, Rainbow Trout peaked each year in May, although some differences were noted by age class.

Figure 9. Total number of fish capture by the RST in the Elk Canyon (2015-2017, 2019-2020; 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).

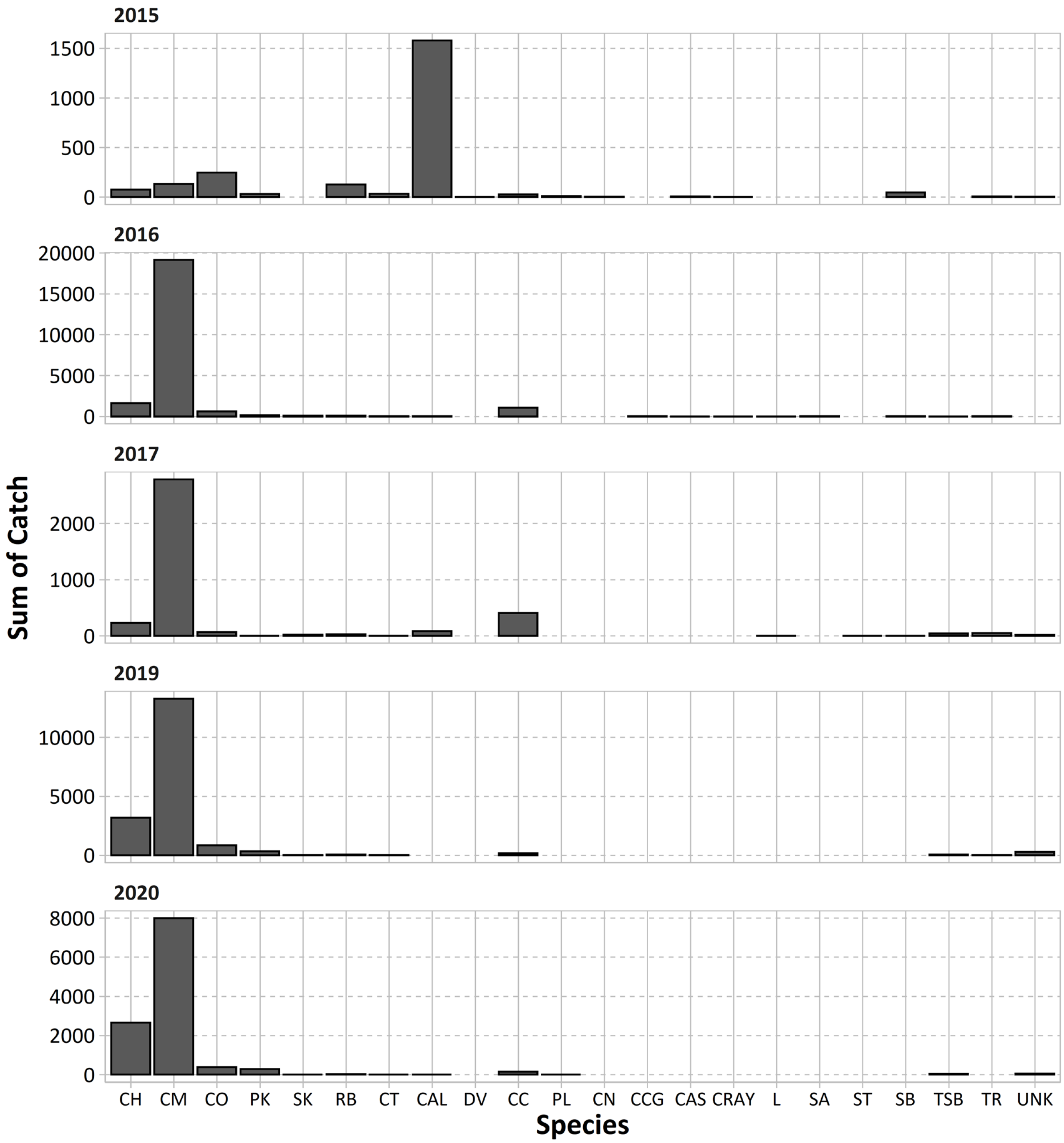


Figure 10. Salmonid catch per unit effort (# of Fish / Hour) in the RST for Year 1 (2015), 2 (2016), 3 (2017), 5 (2019), and 6 (2020) of the monitoring program in Elk Canyon. Note that sampling could not be completed in 2018.

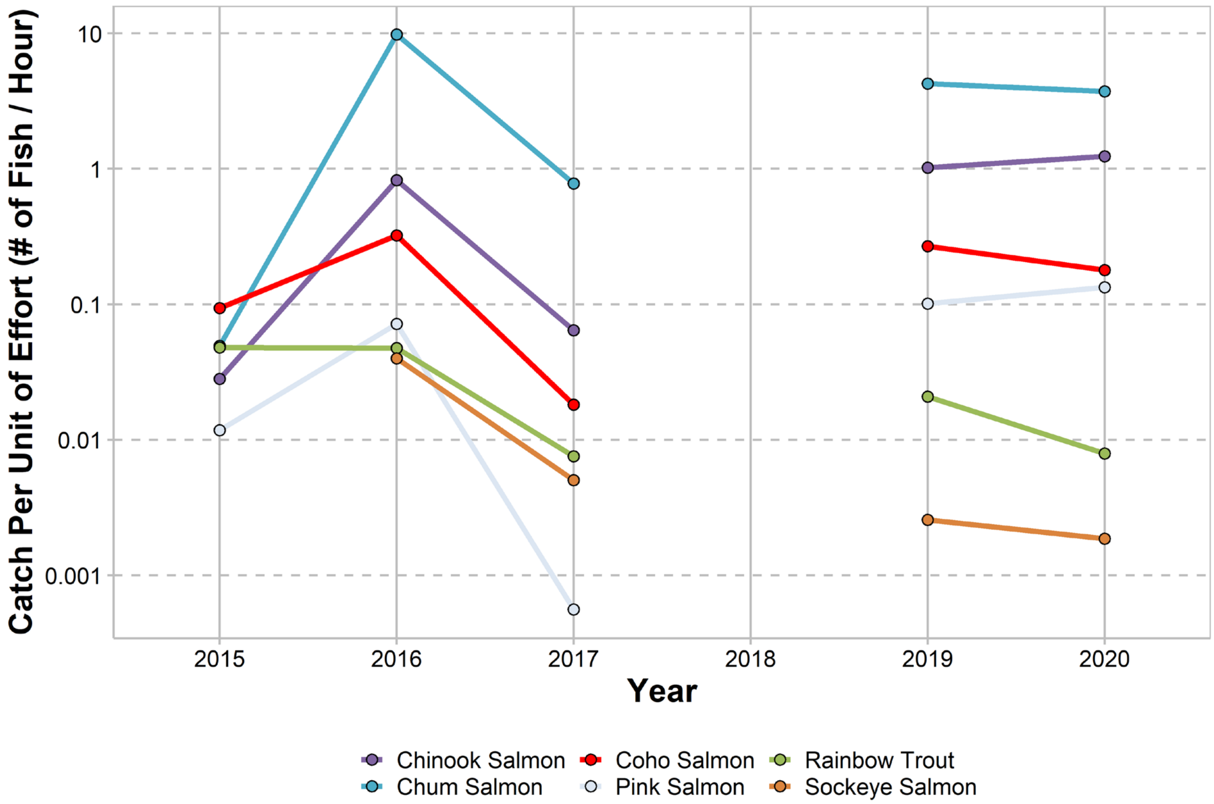
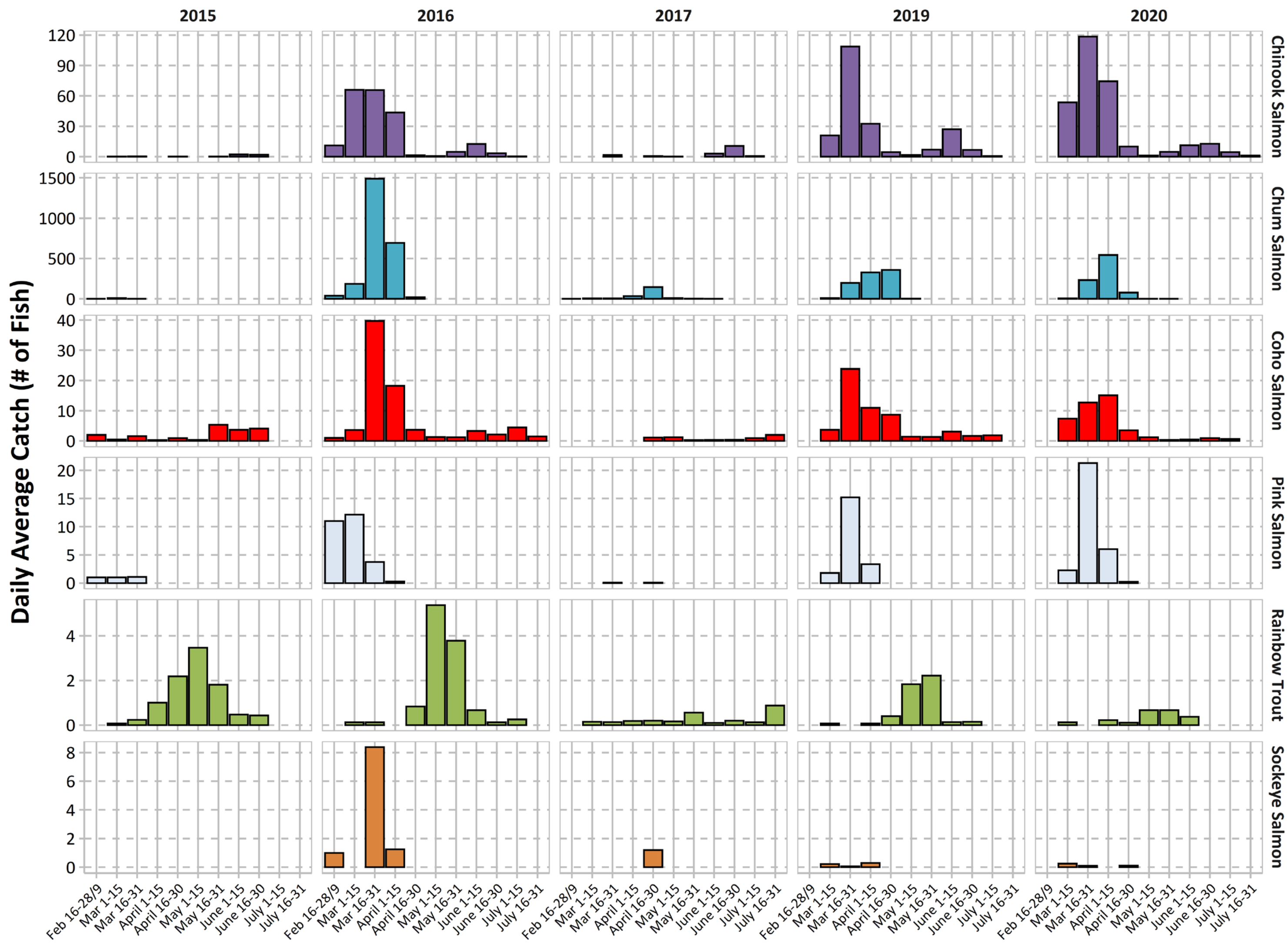


Figure 11. Daily average RST catch of key salmonid species per sampled day by half-month periods for Year 1 (2015), 2 (2016), 3 (2017), 5 (2019), and 6 (2020) of the monitoring program in Elk Canyon.

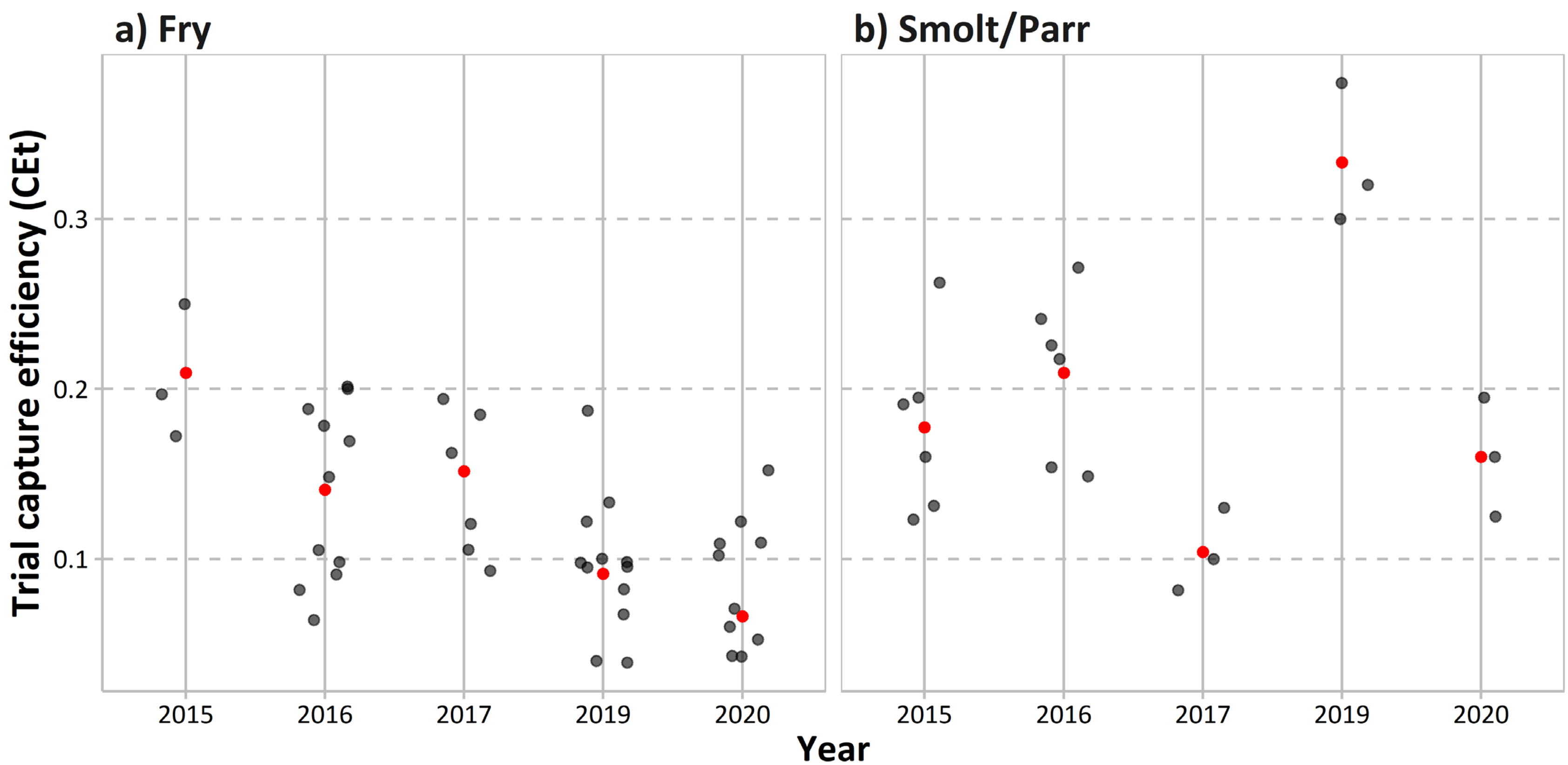


3.1.5.1. RST Mark-Recapture Summary

The mark-recapture trials for salmon fry and smolts were used to estimate the capture efficiency of the RST and to ultimately generate outmigration abundance estimates from Elk Canyon. In total, 82 mark-recapture trials were conducted in five years of the monitoring program. Note that we combined information from only 71 capture efficiencies from yearly mark-recapture trials to estimate overall capture efficiencies per salmonid life stage (see Section 2.2.5.1).

The capture efficiencies per trial differed year by year by life stage for both fry and smolts/parr (Figure 12). The average capture efficiency for fry was the highest in 2015 (~0.21) and lowest in 2020 (~0.06), while an overall decreasing trend. For smolts/parr the average capture efficiency was highest in 2019 (~0.33) and lowest in 2017 (~0.10) with no apparent trend. It is possible that the backwatering effect from the new tailrace location could be causing decreased capture efficiency of fry however this could not be determined based on available data.

Figure 12. Trial capture efficiencies (CE_t) 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. Red coloured points depict the overall capture efficiency per year of monitoring (weighted averages of trial capture efficiencies; CE_o) used to estimate total outmigration of salmonids from the Elk Canyon.



3.1.5.2. Five-Year Salmonid Outmigration

Apart from two low production years, total fry outmigration from Elk Canyon remained similar or increased for Coho, Chinook, Chum and Pink Salmon over the monitoring period (Figure 13, Table 8). Chum Salmon fry outmigration was the highest of all species and ranged from 643 in Year 1 (2015) and 278,482 in Year 2 (2016). Two low years of production were observed (2015 and 2017), with roughly equivalent higher production observed for Coho, Chinook, Chum and Pink Salmon in 2016, 2019 and 2020. The estimated number of Coho Salmon 0+ fry leaving the Elk Canyon, was predicted to vary between 193 in Year 1 (2015) and 8,472 in Year 6 (2020). Chinook Salmon 0+ fry outmigration varied between 53 in Year 1 (2015) and 54,687 in Year 6 (2020). Lastly, Pink Salmon 0+ fry leaving the Elk Canyon, varied between 13 in Year 3 (2017) and 6,963 in Year 6 (2020).

Sockeye Salmon and Rainbow Trout fry outmigration estimates were variable between years and tended to decrease in recent years compared to earlier in the monitoring period (Table 8, Figure 13). Sockeye Salmon fry estimates ranged between zero in Year 1 (2015) and 1,177 in Year 2 (2016). Rainbow Trout fry outmigration estimates were the lowest of all species in most years and ranged from 11 in Year 5 (2019) and 89 in Year 2 (2016).

The total outmigration of smolts leaving Elk Canyon appears to have decreased between Year 1 and 6 for Rainbow Trout and Coho Salmon except for 1+ Coho smolts, which saw the highest outmigration estimates in Year 6 (Table 8, Figure 13). In contrast to Rainbow Trout and Coho Salmon smolts, Chinook Salmon smolt outmigration estimates increased between Year 1 and 6. For Rainbow Trout smolts and parr combined, outmigration estimates ranged from 214 to 794 (Year 5 and 2 respectively). Coho Salmon smolts 0+ outmigration estimates ranged from 187 to 1,164 (Year 6 and 1 respectively). Coho Salmon smolts 1+ outmigration estimates ranged from zero to 89 (Year 3 and 6 respectively). Lastly, Chinook Salmon smolt outmigration estimates increased from 362 in Year 1 to 2,257 in Year 6.

Estimates of daily outmigration showed seasonal patterns (Figure 14, Figure 15). 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. In addition, the majority of Chinook 0+ fry left the canyon by early April, while the majority of smolts 0+ migrated later in the season, by early to mid-June. Daily outmigration estimates for Pink and Coho Salmon fry consistently peaked between mid-March and early April. Moreover, 50% of estimated Coho smolts 0+ or older tended to leave the canyon by early June. However, for Coho smolts 0+, migration lasted longer. For instance, in Year 2 (2016) migration started in April, and 50% of estimated smolt 0+ left the canyon by early July. This suggests that a longer sampling period may be necessary to fully enumerate Coho salmon smolts 0+. Chum Salmon migration typically peaked annually around April, but some inter annual variability was apparent. The majority of Chum Salmon 0+ fry migration varied between early March in Year 1 (2015) and early April in Year 3 (2017). Sockeye Salmon estimated outmigration varied considerably between years, where in Year 5 much of the estimated 0+ fry migrated as early as early March while in Year 3, this occurred in mid-April. The outmigration timing of Rainbow Trout differed by age class. Rainbow

Trout 0+ fry 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+ 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+ Rainbow Trout occurred consistently between years with most outmigration occurring between mid-April and late-May. Daily outmigration timing of 3+ Rainbow Trout was similar to 2+ Rainbow Trout although it was typically spread out over a wider time period.

The outmigration timing of 0+ salmonid fry was examined in relation to the accumulated growing degree days (AGDD) between the fall peak spawning date to the date each individual fish was caught in the RST (Figure 16, Figure 17) to help determine different dependencies on temperature for development for the salmonid species in the Elk Canyon. This represents the AGDD during egg-to-fry development up to the date of fry outmigration. The annual timing of outmigration each year was compared to the timing predicted by AGDD.

The majority of Chum, Coho, Chinook, and Sockeye Salmon 0+ fry tended to migrate at similar levels of AGDD every year with some exceptions (Figure 16b). The most apparent exception was Chum Salmon in Year 1 (2015) when the majority of outmigration occurred between 500 and 800 AGDD compared to 750 to 1,000 in all other monitoring years. Overall, outmigration patterns suggests that Chum, Coho, Chinook, and Sockeye salmon 0+ have specific dependencies on temperature to migrate out of the Elk Canyon. This pattern is also shown in Figure 17 where a single peak is observed for Chinook, Chum, Coho, and Sockeye Salmon 0+ fry. For Rainbow Trout and Pink Salmon, cumulative daily 0+ fry migration was associated differently with AGDD every year (Figure 16). Rainbow Trout 0+ fry outmigration occurred between approximately 1,400 and 2,900 AGDD (Figure 17). Pink Salmon 0+ fry saw two different outmigration peaks, one between 750 and 1,000 AGDD and the other between approximately 1,350 and 1,850 AGDD suggesting that Pink Salmon have a lower dependency on AGDD to migrate out of the Elk Canyon and rather are out-migrating on a consistent date each year as shown in Figure 16a.

Accumulated growing degree days to outmigration was also examined for Chinook, Coho, and Rainbow Trout smolts (0+, 1+, 2+ and 3+) who spent a month or more of time rearing in Elk Canyon prior to outmigration (Figure 18 though Figure 22). The AGDD for smolts was calculated as the AGDD from March 1st each year to the date of outmigration, and thus represent conditions for growth in the spring and early summer prior to outmigration. The relationship observed between the annual cumulative daily outmigration and AGDD for smolts differed between salmonid species but was less apparent than trends for 0+ fry. Chinook smolt 0+ outmigration typically occurred between 800 and 1,000 units of AGDD with a peak around 900 AGDD. For Coho smolts 0+ and older, there were two clear peaks, one at 850 AGDD units and another at 1,400 AGDD units. For Rainbow Trout aged 1+, there was no clear pattern between AGDD and estimated daily outmigration; however, for fish aged 2+ and 3+ we observed a clear peak of individuals leaving the canyon at approximately 600 and 500 units of AGDD, respectively.

Table 8. Total RST catch, estimated total outmigration and overall capture efficiencies (CEo) for key salmonid species between Year 1 and 6 of the monitoring program in the Elk Canyon.

Species	Life Stage	2015			2016			2017			2019			2020		
		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
	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
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
	Smolt 0+	203	0.177	1,164	94	0.210	903	27	0.104	412	90	0.333	292	18	0.160	187
	Smolt 1+	7	0.177	49	2	0.210	16	0	0.104	0	4	0.333	11	8	0.160	89
Steelhead/Rainbow Trout	0+	4	0.209	18	6	0.141	89	4	0.152	40	1	0.091	11	2	0.066	30
	1+	11	0.177	73	16	0.210	135	7	0.104	85	6	0.333	20	8	0.160	69
	2+	77	0.177	461	66	0.210	587	9	0.104	132	30	0.333	101	6	0.160	75
	3+	33	0.177	247	5	0.210	72	5	0.104	62	27	0.333	93	1	0.160	6
	Adults	0	0.177	0	0	0.210	0	1	0.104	9	0	0.333	0	0	0.160	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
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
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

Figure 13. 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 completed in 2018.

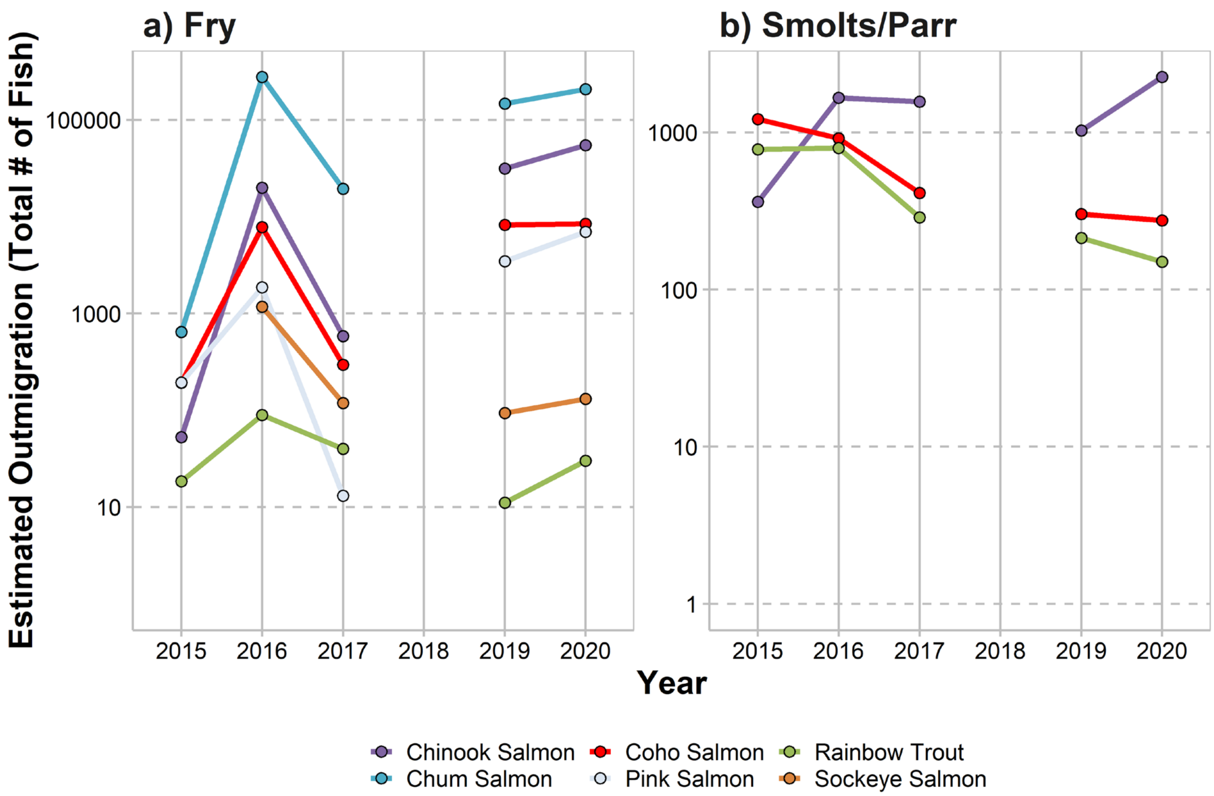


Figure 14. Daily estimated outmigration for Chinook, Chum and Coho Salmon species for Year 1 (2015), Year 2 (2016), Year 3 (2017), Year 5 (2019), and Year 6 (2020).

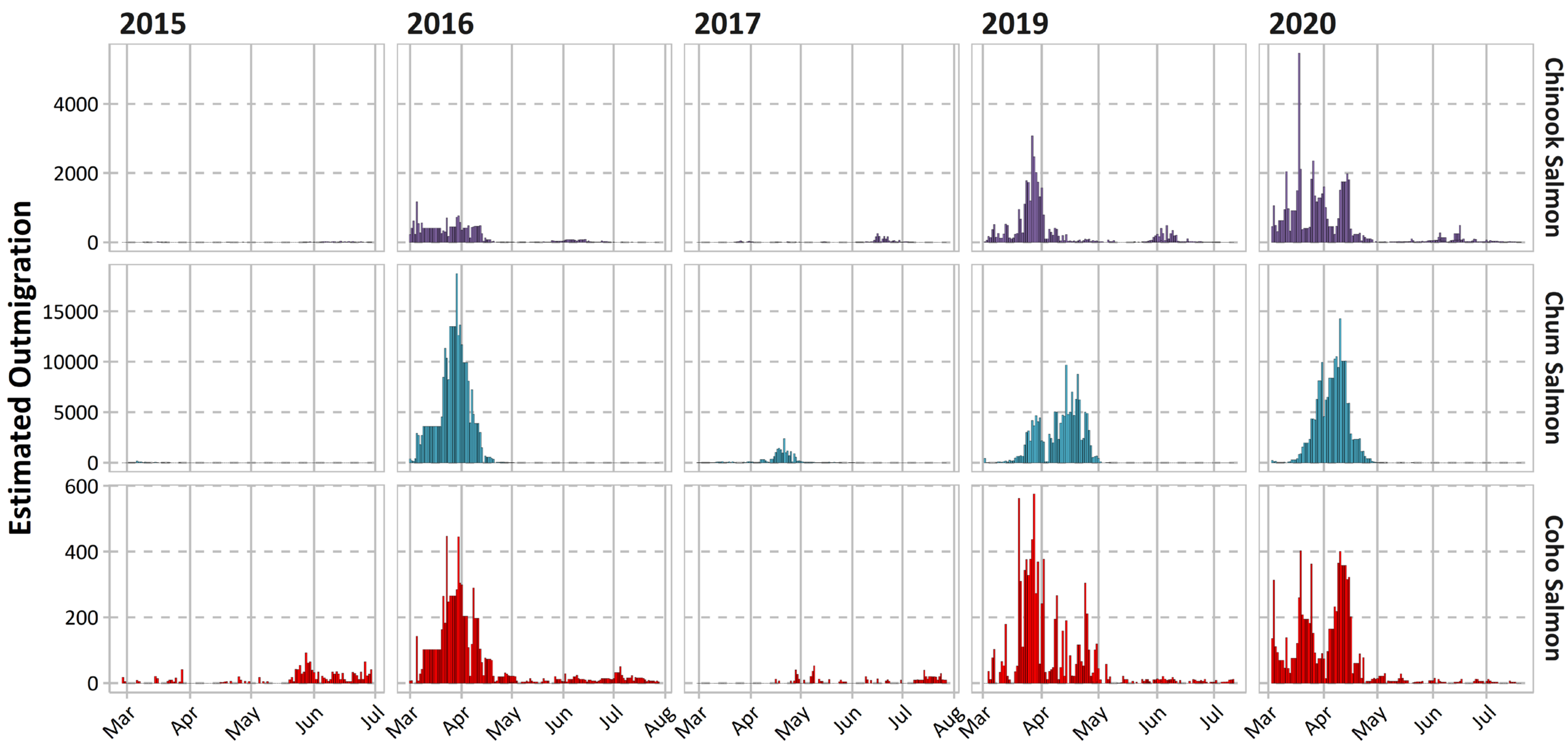


Figure 15. Daily estimated outmigration for Pink and Sockeye Salmon and Rainbow Trout for Year 1 (2015), Year 2 (2016), Year 3 (2017), Year 5 (2019), and Year 6 (2020).

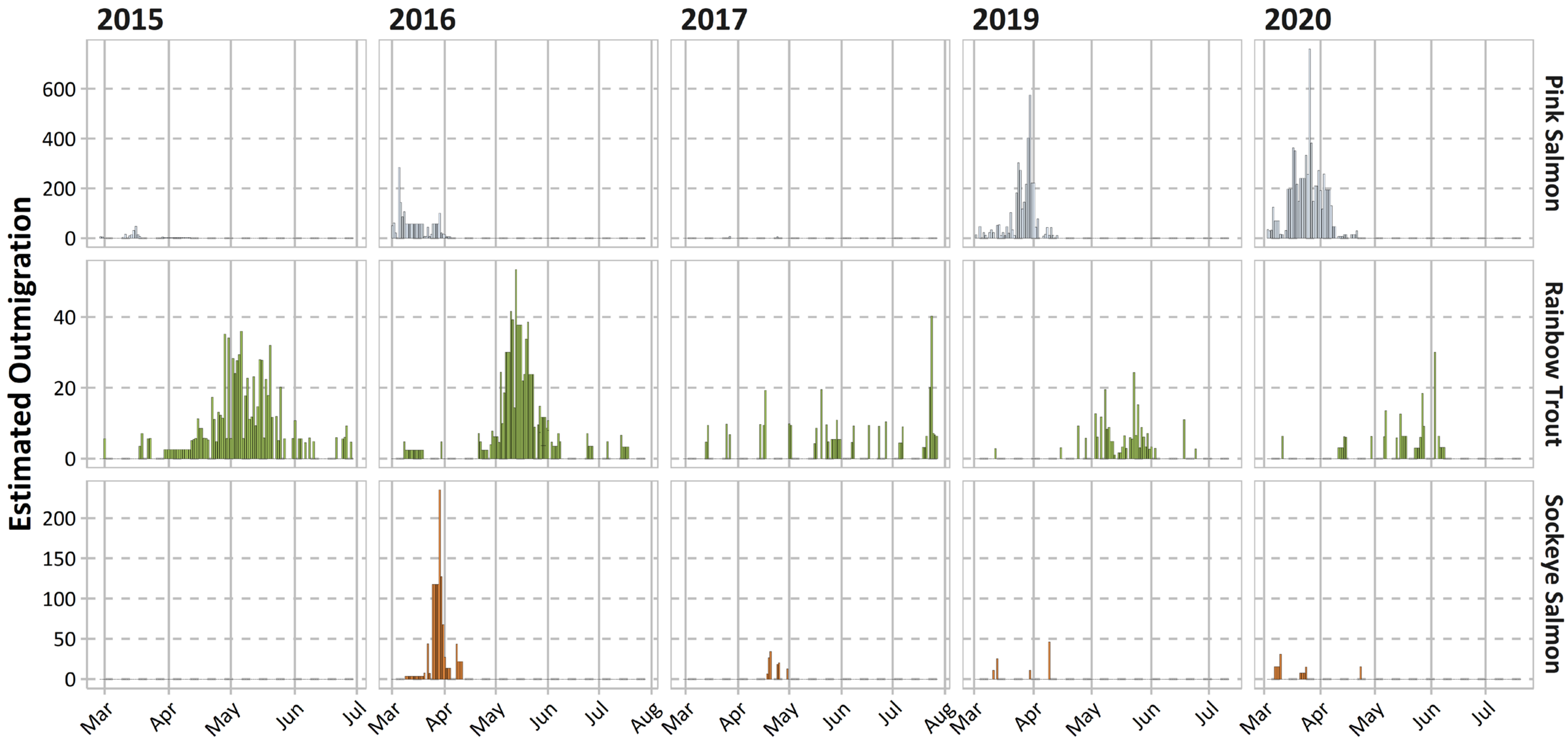


Figure 16. Cumulative daily outmigration of 0+ fry for key salmon species in the Elk Canyon outmigration date (a) and accumulated growing degree days from the peak spawning date each year (b).

a)

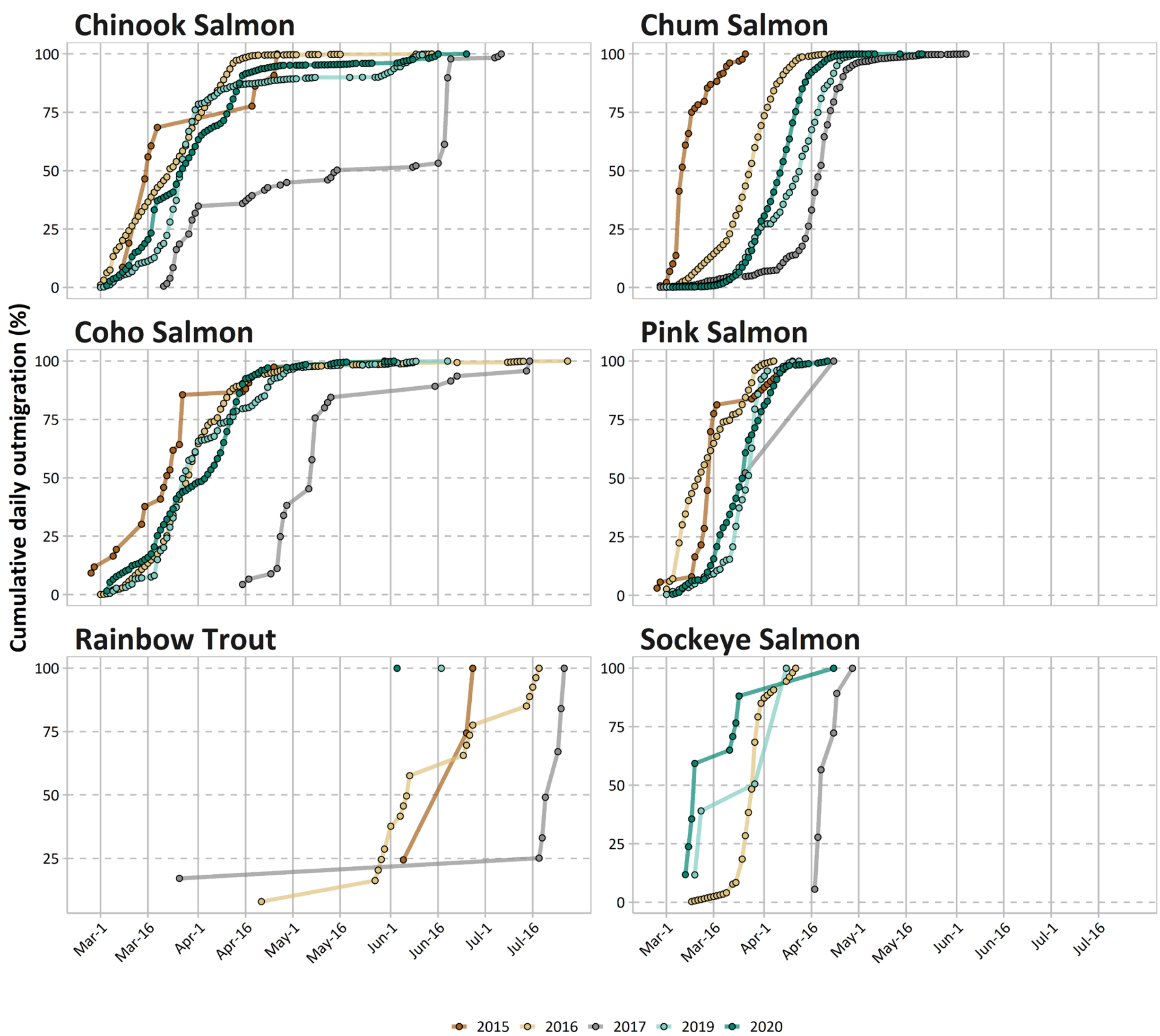


Figure 16. Continued (2 of 2).

b)

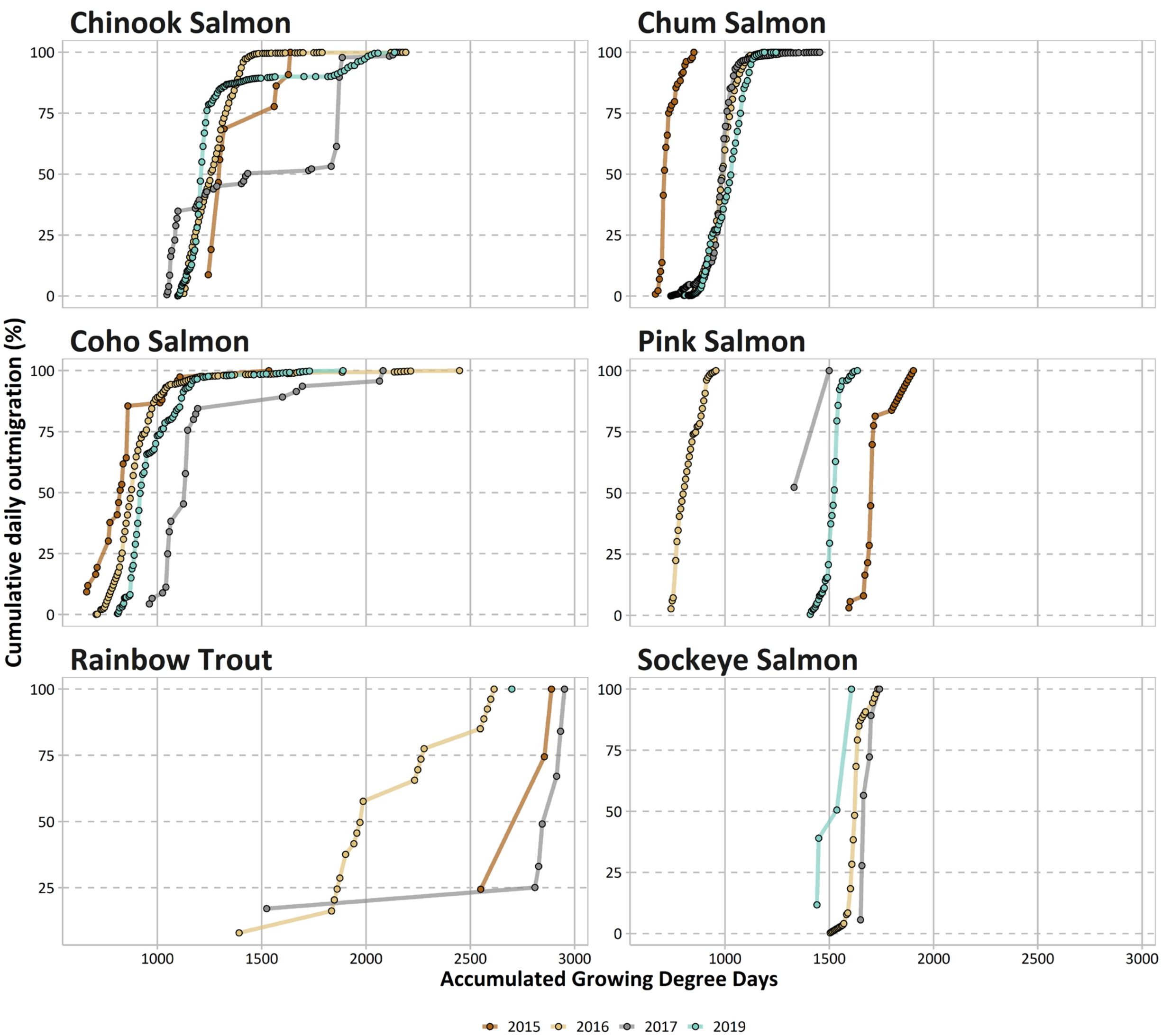


Figure 17. **Daily estimates of 0+ fry outmigration and accumulated growing degree days for key salmonid species. Note that no accumulated growing degree day was calculated for Year 6 (2020) due to lack of water temperature information. Lines are fitted using a generalized additive model to provide visual aid on the relationship between AGDD and outmigration.**

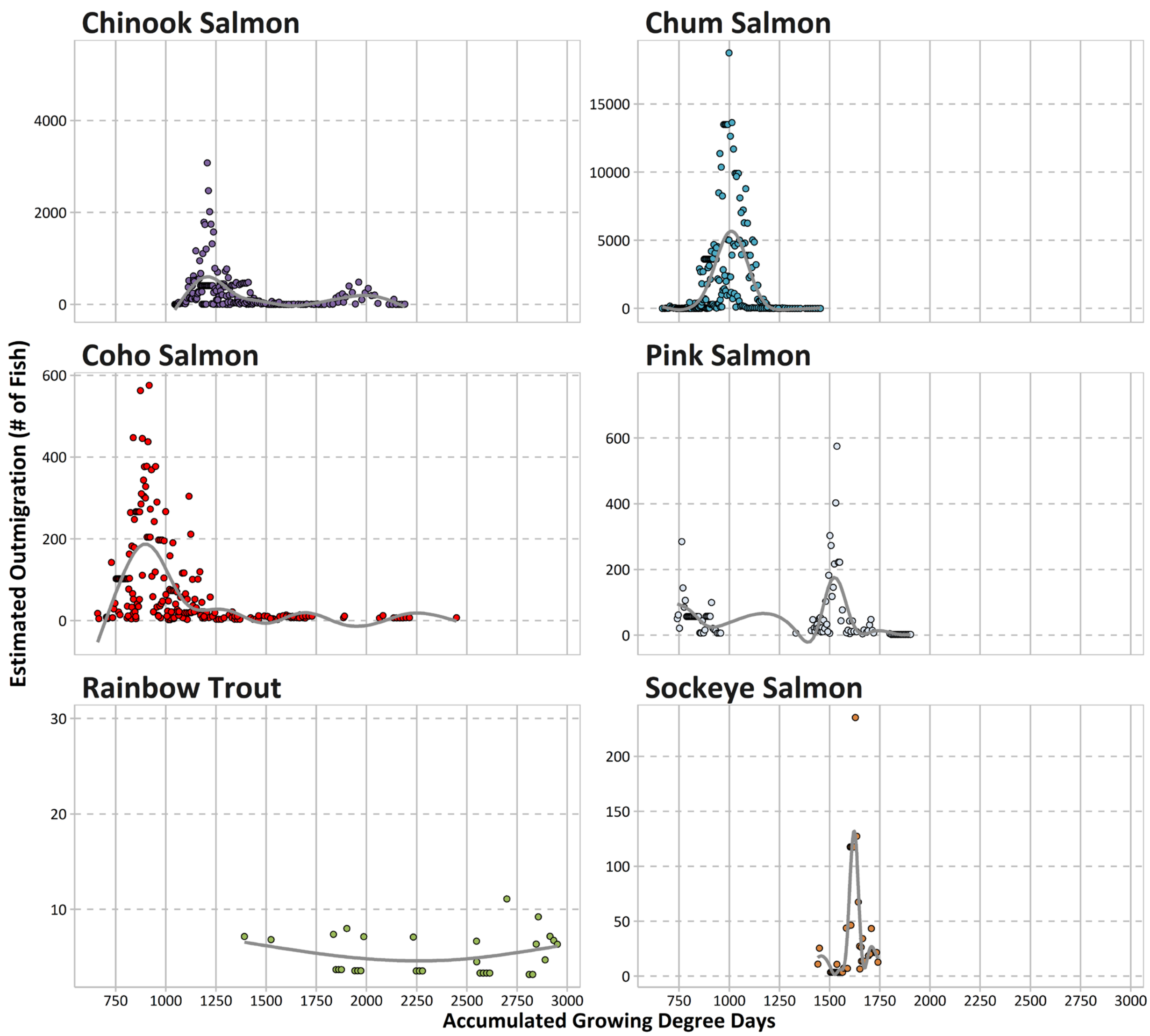


Figure 18. Cumulative daily outmigration of Chinook and Coho Salmon smolts (0+ and 1+) from the Elk Canyon by date of outmigration and year.

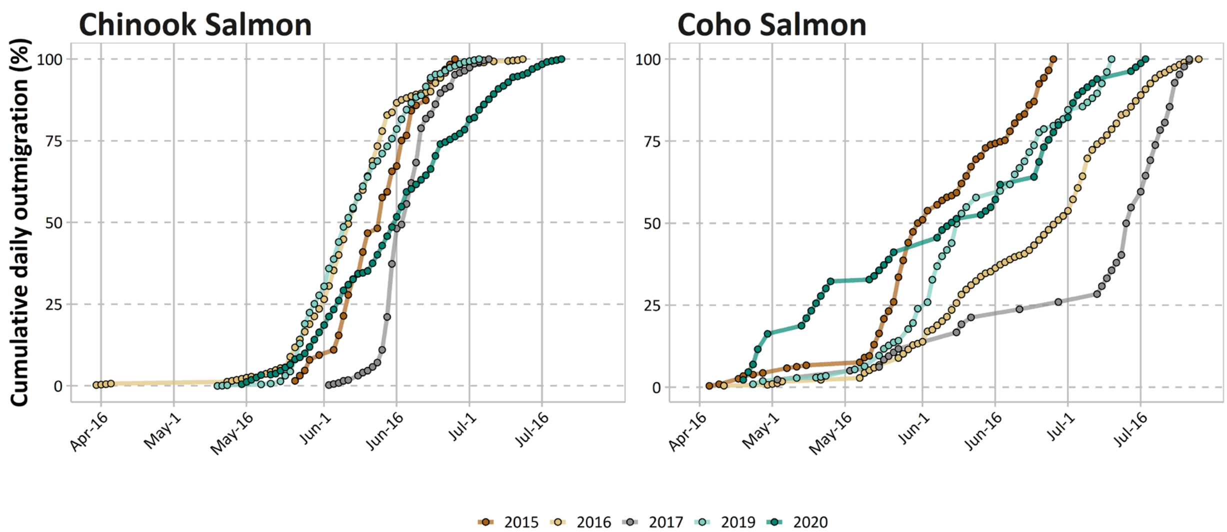


Figure 19. Cumulative daily outmigration of Chinook and Coho Salmon smolts (0+ and 1+) from the Elk Canyon by the accumulated growing degree days from March 1 onwards each year.

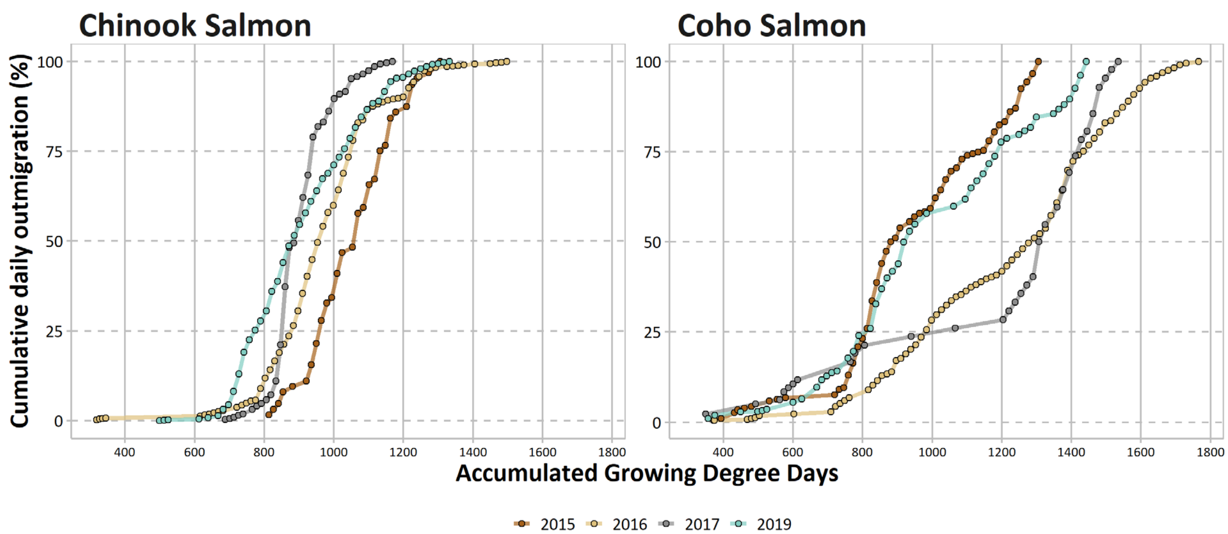


Figure 20. Daily estimates of outmigration for Chinook and Coho salmon smolts (0+ and 1+) by accumulated growing degree days after March 1 each year. Lines are fitted using a generalized additive model to provide visual aid on the relationship between AGDD and outmigration.

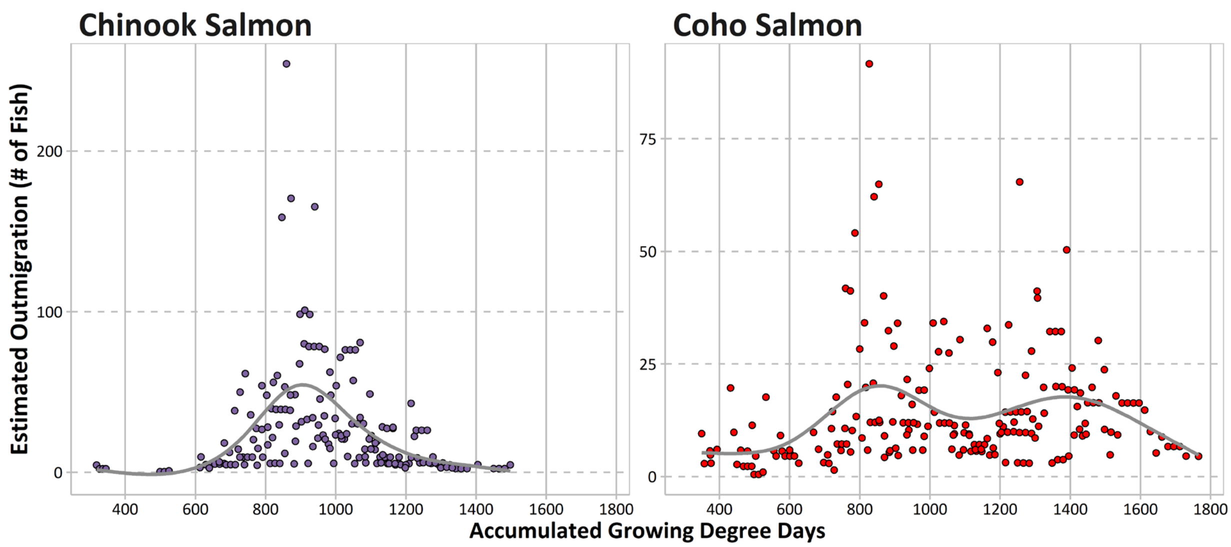


Figure 21. Cumulative daily outmigration of Rainbow Trout from the Elk Canyon by outmigration date, age class and year (a) and accumulated growing degree days (b). Note that no accumulated growing degree days were calculated for Year 6 (2020) due to lack of water temperature information. Note that fish age 1+ and older start to accumulate growing degree days from March 1 onwards.

a)

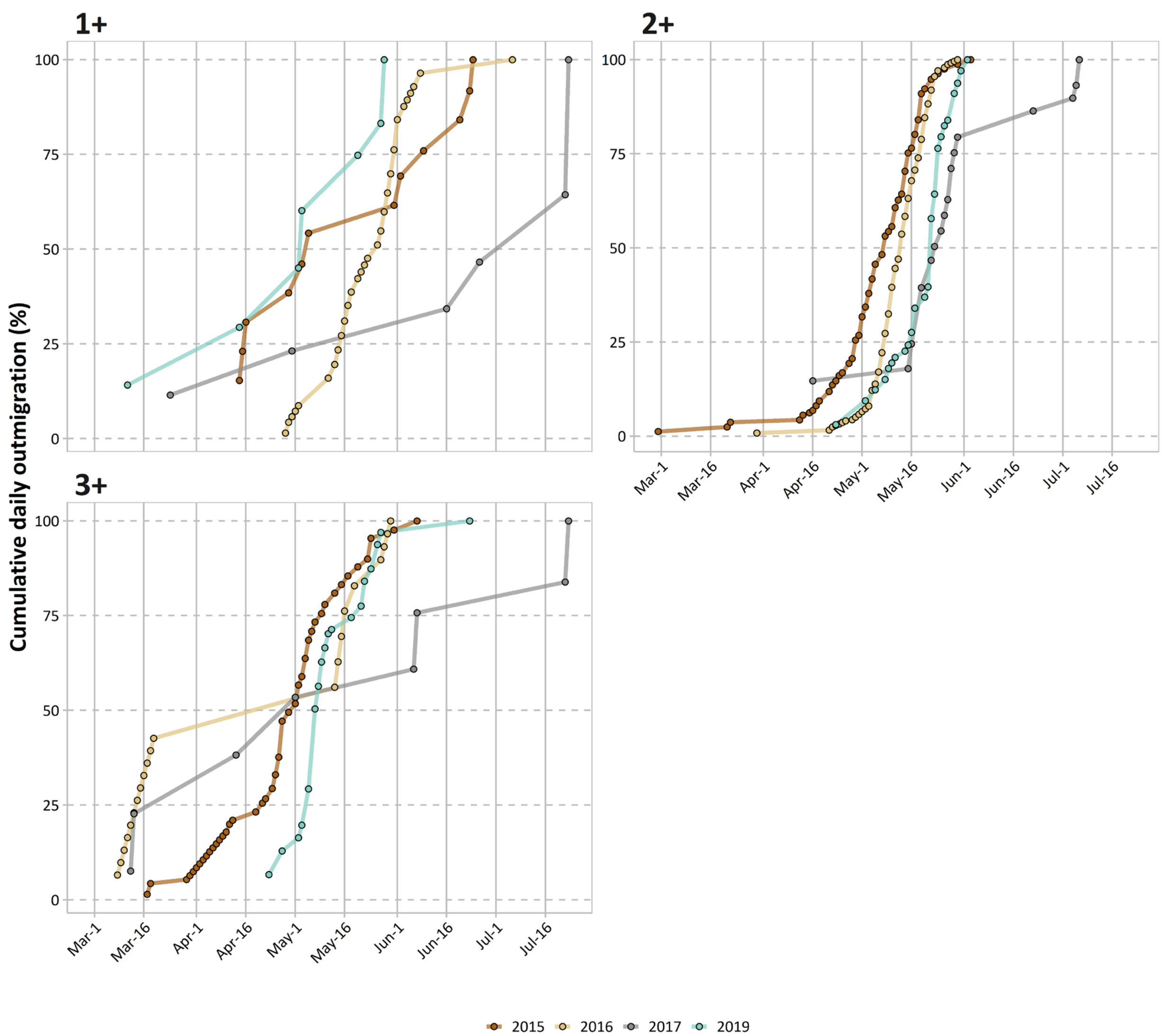


Figure 21. Continued (2 of 2).

b)

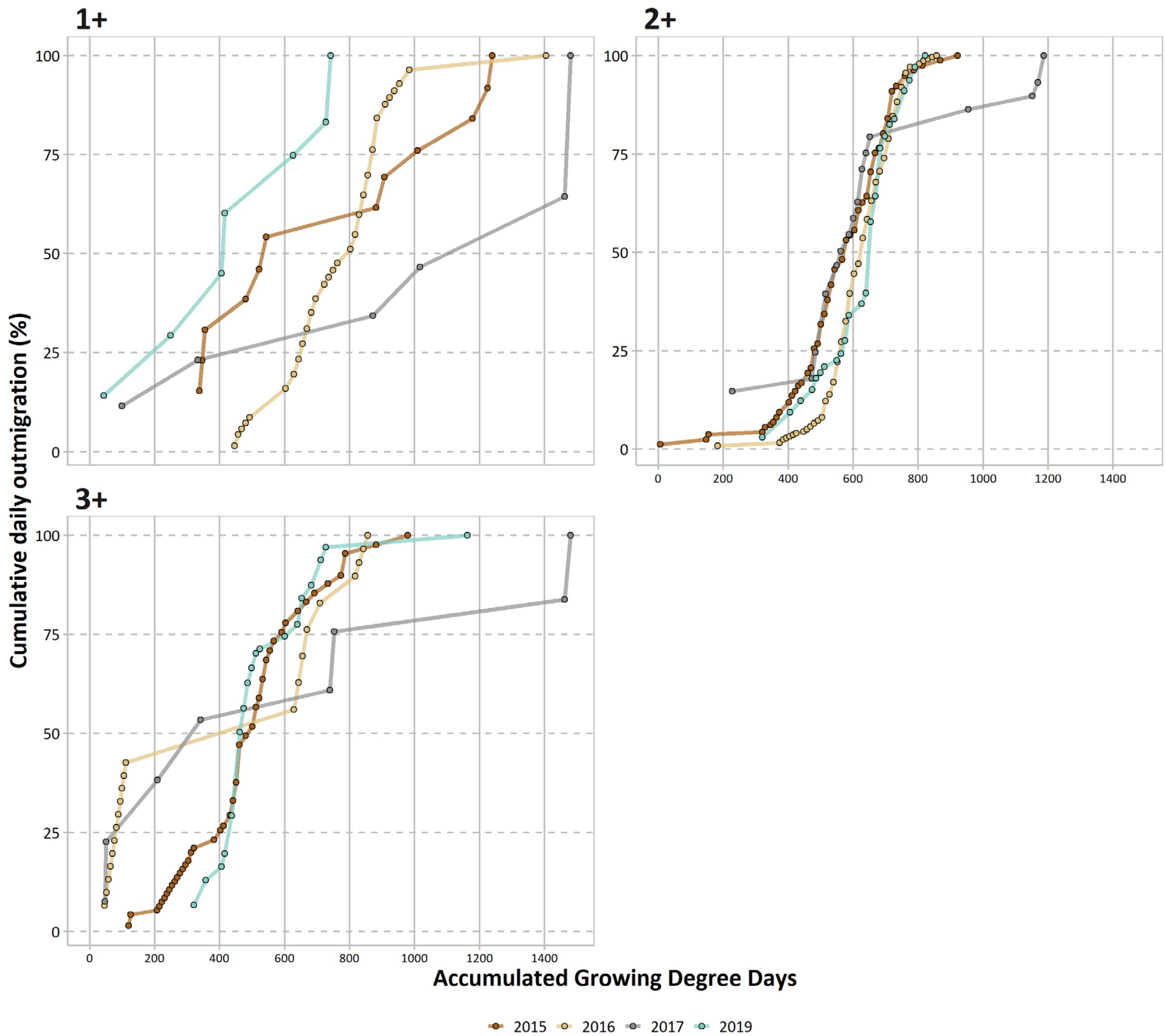
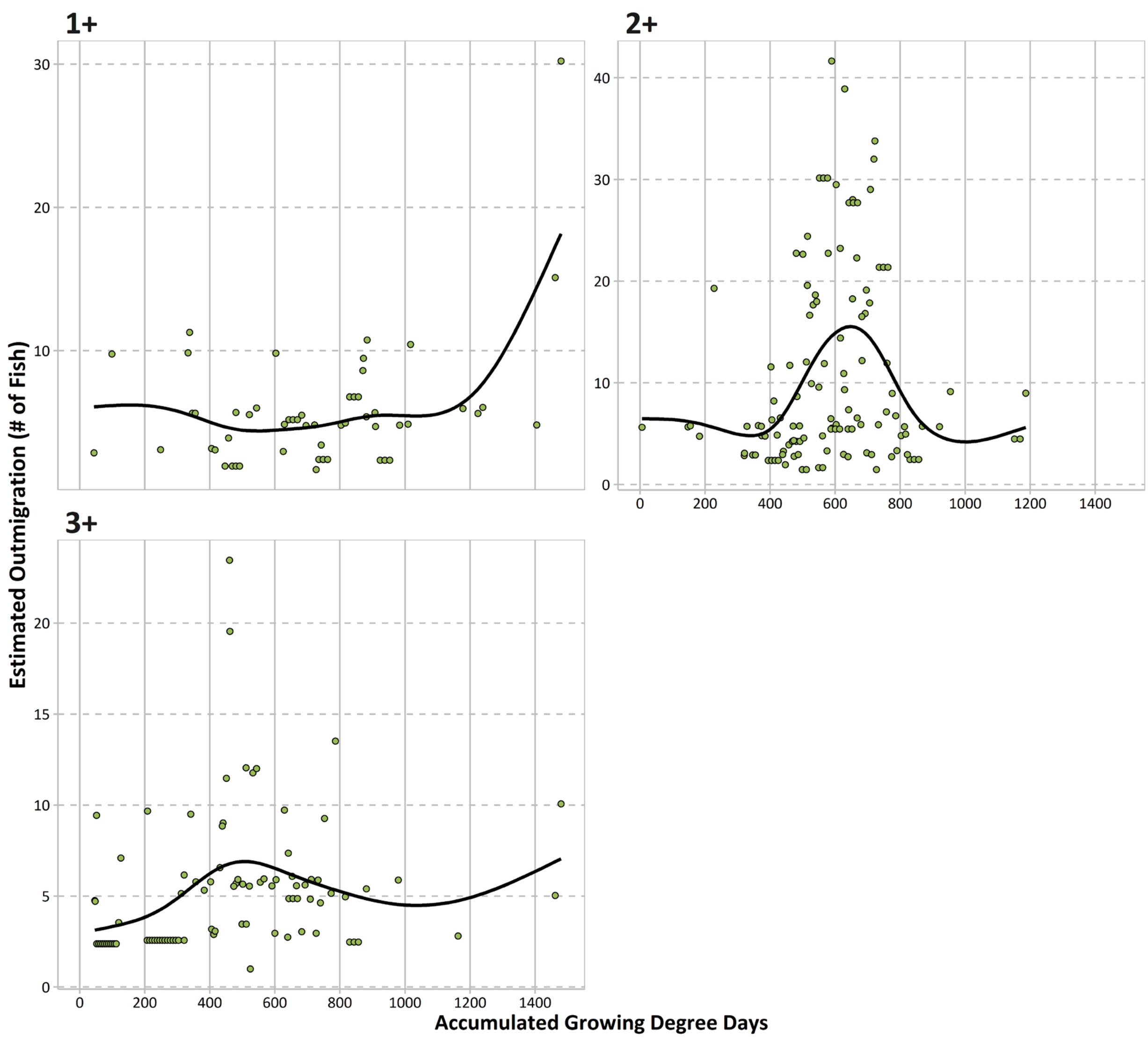


Figure 22. **Daily estimates of outmigration and accumulated growing degree days for Rainbow Trout age 1+ or older. No accumulated growing degree day was calculated for Year 6 (2020) due to lack of water temperature information. Note fish age 0+ and older start to accumulate growing degree days from March 1 onwards. Adult fish were capture in only one occasion in 2017. Lines are fitted using a generalized additive model to provide visual aid on the relationship between AGDD and outmigration.**



3.2. Fall and Spring Spawner Enumeration

3.2.1. Fall Spawners

Chinook and Coho Salmon adult spawner abundance in fall 2019 were estimated to be 214 and 663 individuals respectively using the area under the curve method (Table 9). Pink Salmon had the highest estimated abundance of spawners of 1,960 individuals. A population of 424 Chum Salmon and 21 Sockeye Salmon were also estimated in 2019 (Table 9). Few Steelhead were observed in fall with a peak observed abundance of only four individuals.

Chinook counts in 2019 were higher than 2014, 2017, and 2018 but lower than 2015 and 2016 (Figure 23). Chinook observations peaked in mid to late-October over an approximate three-week period, similar to spawning periodicity in previous years.

Coho counts in 2019 were the third highest observed to date with higher counts occurring in 2017 and 2018 (Figure 24). Coho Salmon in 2019 had the earliest peak spawn to date occurring in mid-October compared to early to mid-November in in previous years. Spawning periodicity was similar to previous years occurring over an approximate 6-week period.

Peak Chum counts in 2019 were lower than all previous years with the exception of 2014 where snorkel surveys were not conducted around typical peak chum spawn timing therefore, they were likely missed (Figure 25). Chum spawn timing was similar among all years with peak counts occurring in late October and early November.

Pink Salmon counts in 2019 were similar to those observed in 2017 and 2018, but much lower than peak counts observed in 2014 and 2015 (Figure 26). Pink Salmon had the earliest peak compared to the other fall spawning salmonid species present in the Elk Canyon, similar to previous years, with observed spawner counts peaking in late September.

Sockeye observations in 2019 were notably lower than all previous years with a peak count of only ten individuals (Figure 27). Sockeye observations peaked mid-September, where other years peaks typically occurred late September early October.

A maximum of four Steelhead were observed in mid-October similar to previous years with observations scattered throughout the fall surveys (Figure 28).

The maximum number of redds observed are summarized in Table 10. Pink, followed by Coho Salmon and Chum had the highest numbers of redds at 78, 65, and 46 redds, respectively, while a maximum of 45 Chinook Salmon redds, and two Sockeye Salmon redds were observed during fall snorkels. Similar to spawner counts, redd counts peaked for Pink, Sockeye and Chinook Salmon in September and October, with Pink and Sockeye Salmon redd counts peaking the earliest, followed by counts of Chinook. Chum and Coho Salmon redd counts peaked in mid November.

3.2.1.1. Productivity of Fall Salmon Spawners

Salmon fry and smolt production from Elk Canyon was estimated based on the fall 2019 redd counts and fecundity, egg-to-fry and egg-to-smolt survival values from the literature (Bradford 1995, Quinn 2005). These estimates were compared to the 2020 outmigration predicted from RST catch (Section 3.1.4) (Table 11).

Chinook Salmon predictions for fry production based on redd counts were similar to outmigration estimates from the RST, 54,687 versus 73,530. In contrast Chinook smolts were notably different with 2,257 estimated from RST catch compared to 19,544 predicted from the redds observed. The production estimates based on redd counts versus estimates from the RST for the remaining species were highly variable.

In contrast, 207,373 Chum Salmon fry were estimated from the RST catch, although only 18,989 individuals were predicted from the Chum redds observed.

For Coho Salmon 49,335 fry were estimated from the RST catch, although only 8,472 individuals were predicted from the Coho redds observed. Coho smolts showed an even larger deviation with only 276 smolts estimated from the RST catch, although only 32,175 individuals were predicted from the Coho redds observed.

For Sockeye Salmon, only 276 Sockeye fry were estimated from the RST compared to 889 individuals predicted from the Sockeye redds observed.

For Pink Salmon, 16,146 fry were estimated from the RST compared to 6,963 individuals predicted from the Pink redds observed.

These differences in production estimates derived from redd surveys and RST catches could be attributed to multiple factors, including our coarse estimates of fecundity and survival by species from the literature, and redd superimposition, where redds constructed from early spawners such as Pink and Sockeye Salmon are superimposed by later spawners. For Chum Salmon however, the results suggest that redd counts may have been underestimated, or, alternatively, that egg-to-fry survival was high. As Chum and Coho salmon have a similar spawn timing and similar size redds it seems plausible that some redds identified as Coho were likely Chum redds based on results. It can be difficult to distinguish redds from different species when multiple species are in the system at a given time.

Fall spawner abundance was examined in relation to estimated outmigration. Fall spawner abundance estimates were weakly positively correlated to 0+ fry and 0+ smolt outmigration estimates for most species with some exceptions (Figure 29). Chum Salmon saw the strongest positive correlation except for fall spawners from 2016. All species saw a decrease in estimated outmigration relative to fall spawner abundance from 2016. This was likely due to the large spill event that occurred in November 2016. The remaining salmonid species did not have a clear relationship between fall spawners and estimated outmigration. Additional data points collected in subsequent years (2021 through 2024) will allow us to examine this relationship in further detail.

Table 9. Fall salmon spawner counts by species and estimates of abundance.

Date	Count of Adult Fish Observed[1]					
	ST	CH	CM	CO	PK	SK
6/Sep/19	1	8	0	7	416	1
16/Sep/19	1	25	2	52	503	10
24/Sep/19	0	24	2	49	1,350	8
4/Oct/19	0	42	4	103	1,063	7
15/Oct/19	4	112	18	201	36	3
25/Oct/19	0	32	202	116	0	0
4/Nov/19	1	16	233	118	0	0
12/Nov/19	0	0	66	126	0	0
20/Nov/19	0	0	13	11	0	0
29/Nov/19	1	0	2	9	0	0
Abundance Estimate[2]	**4**	**214**	**424**	**663**	**1,960**	**21**

[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 23. Adult Chinook Salmon counts in Elk Canyon by date and year.

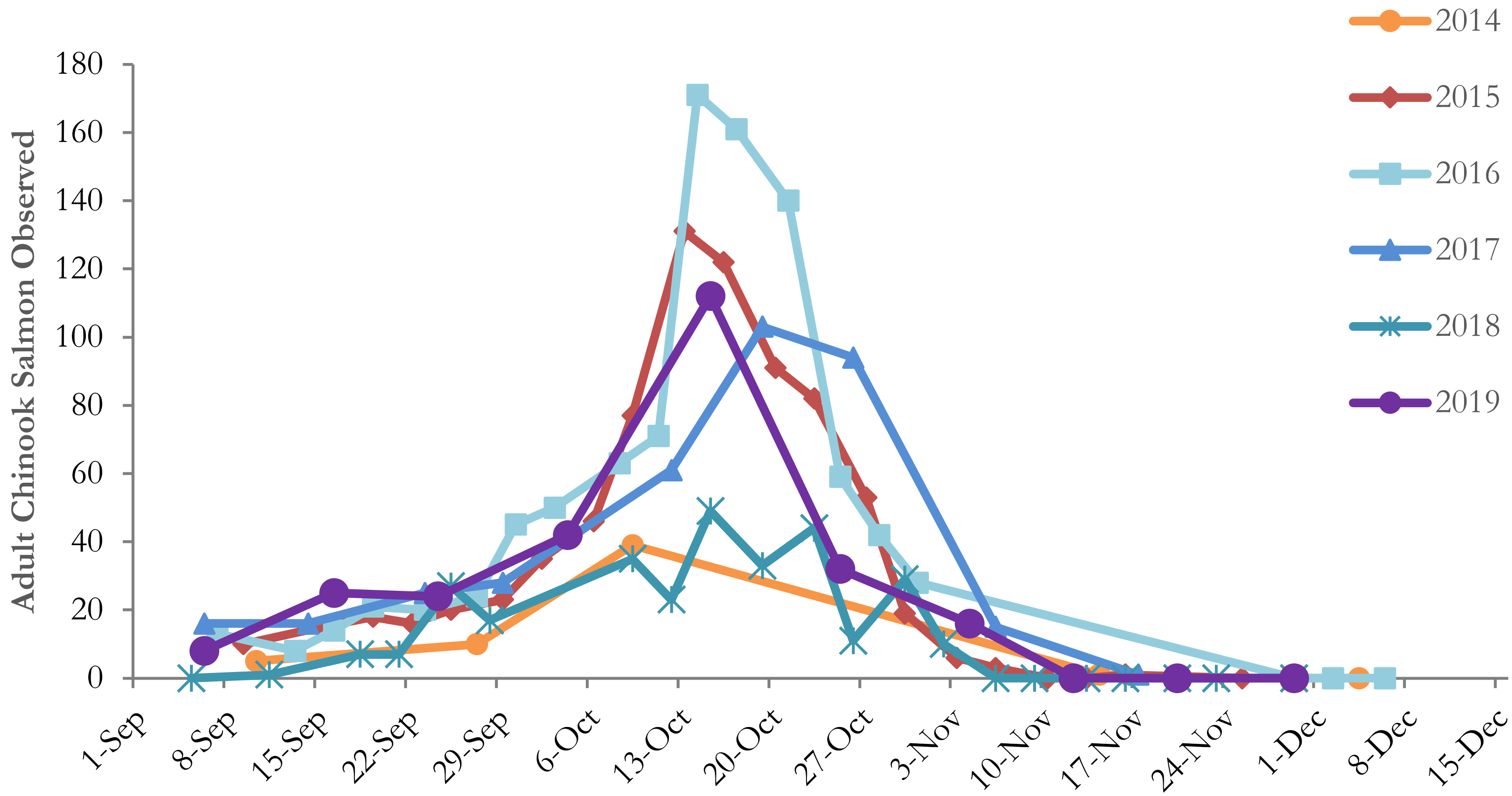


Figure 24. Adult Coho Salmon counts in Elk Canyon by date and year.

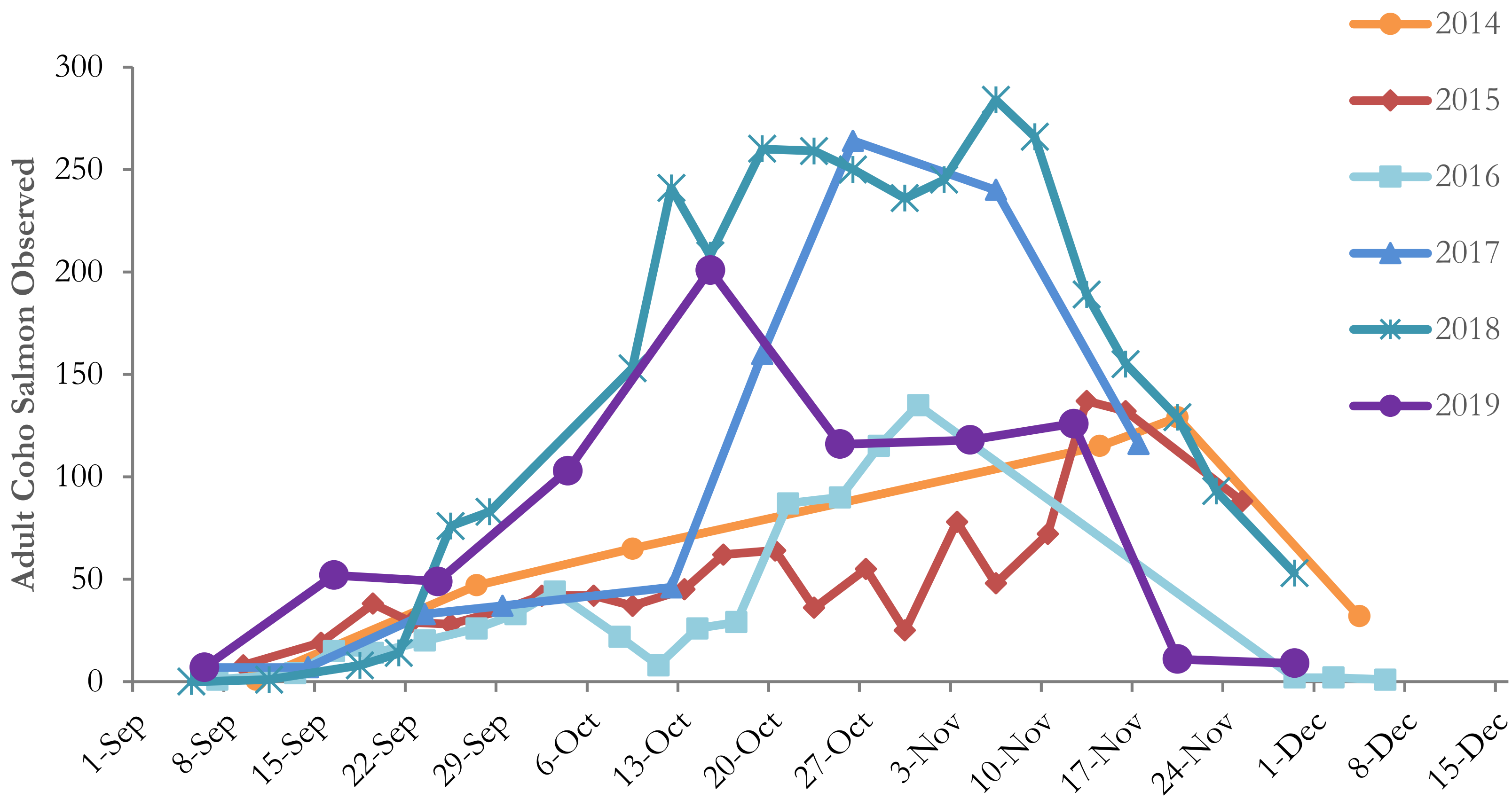


Figure 25. Adult Chum Salmon counts in Elk Canyon by date and year.

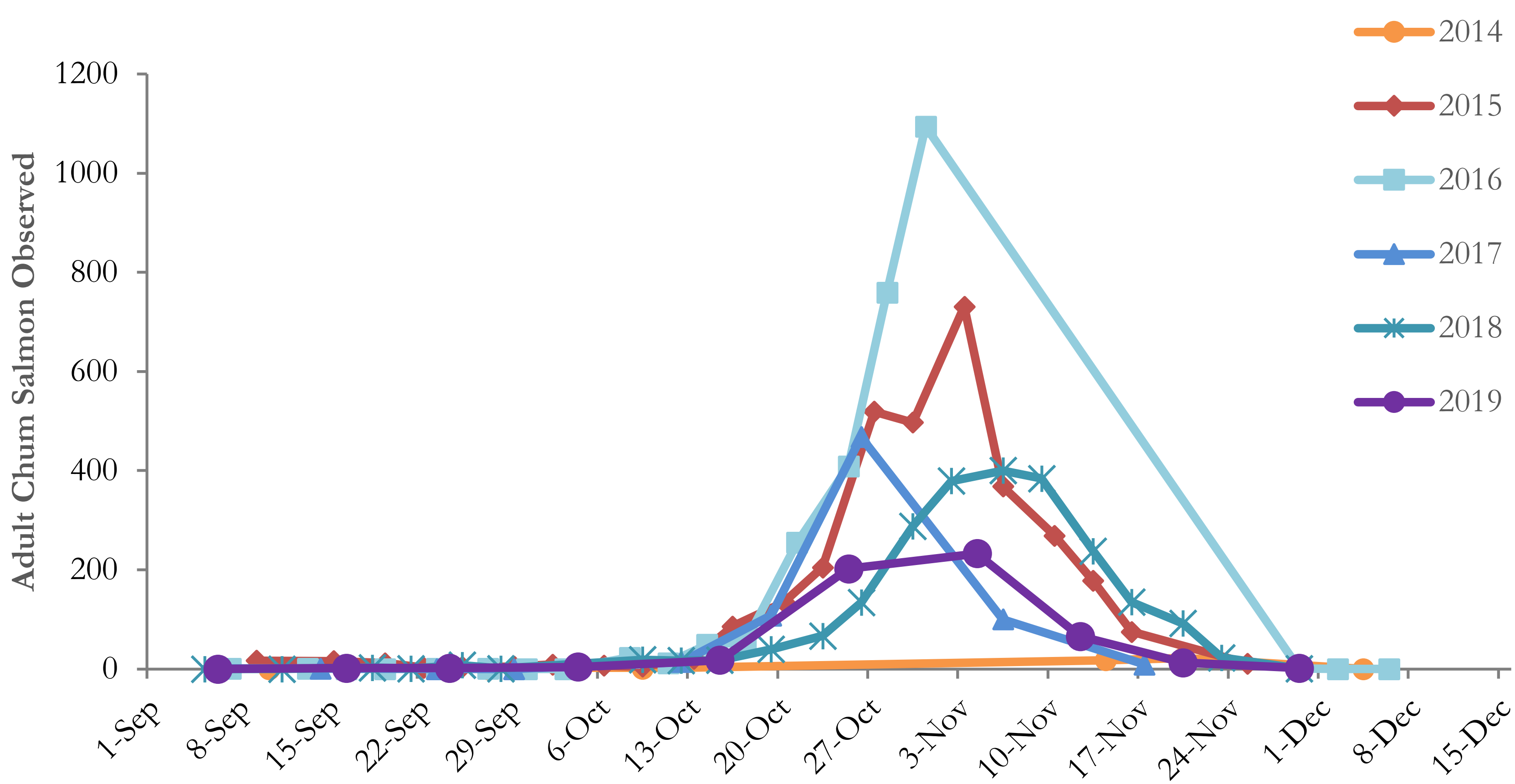


Figure 26. Adult Pink Salmon counts in Elk Canyon by date and year.

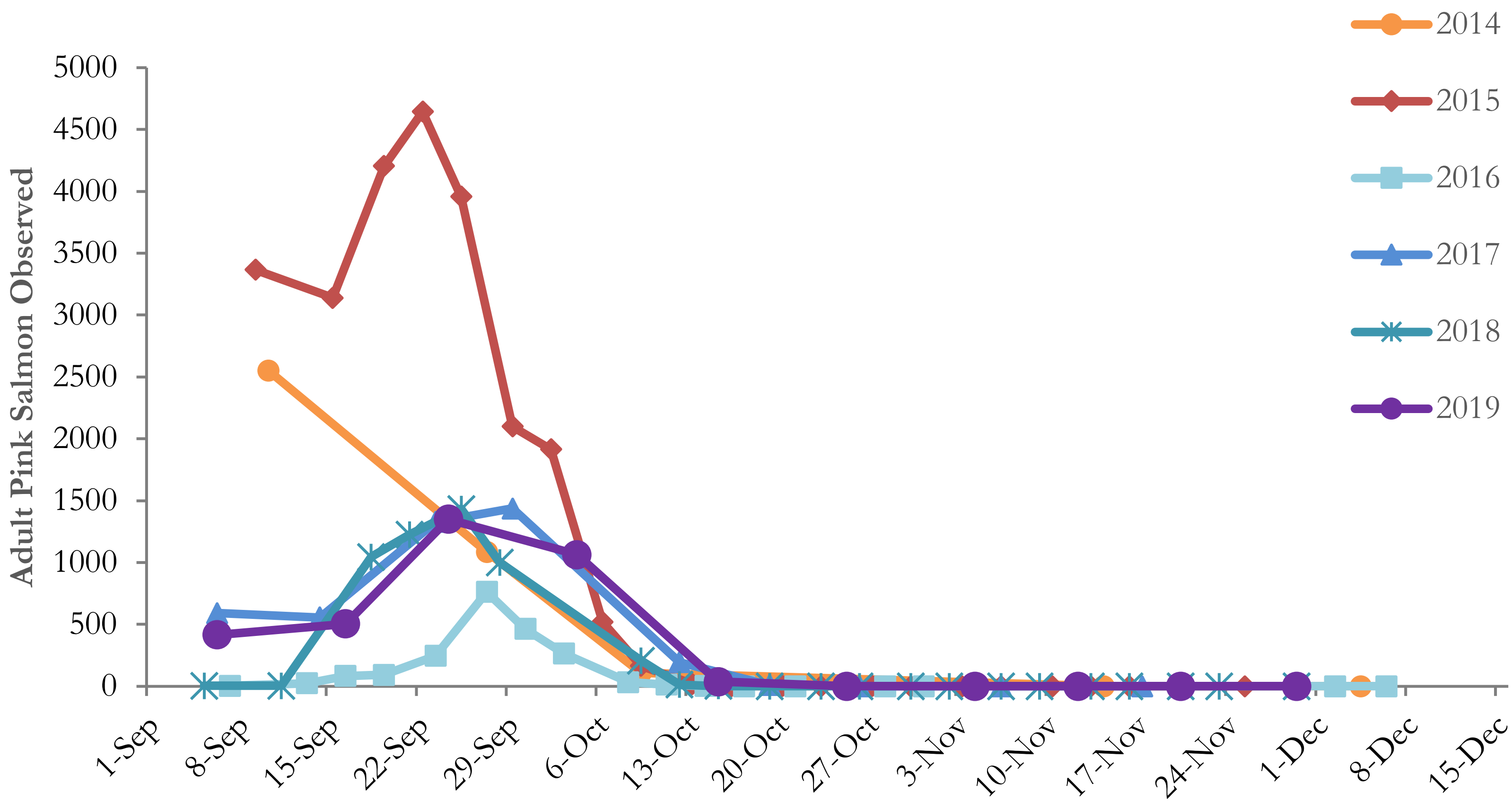


Figure 27. Adult Sockeye Salmon counts in Elk Canyon by date and year.

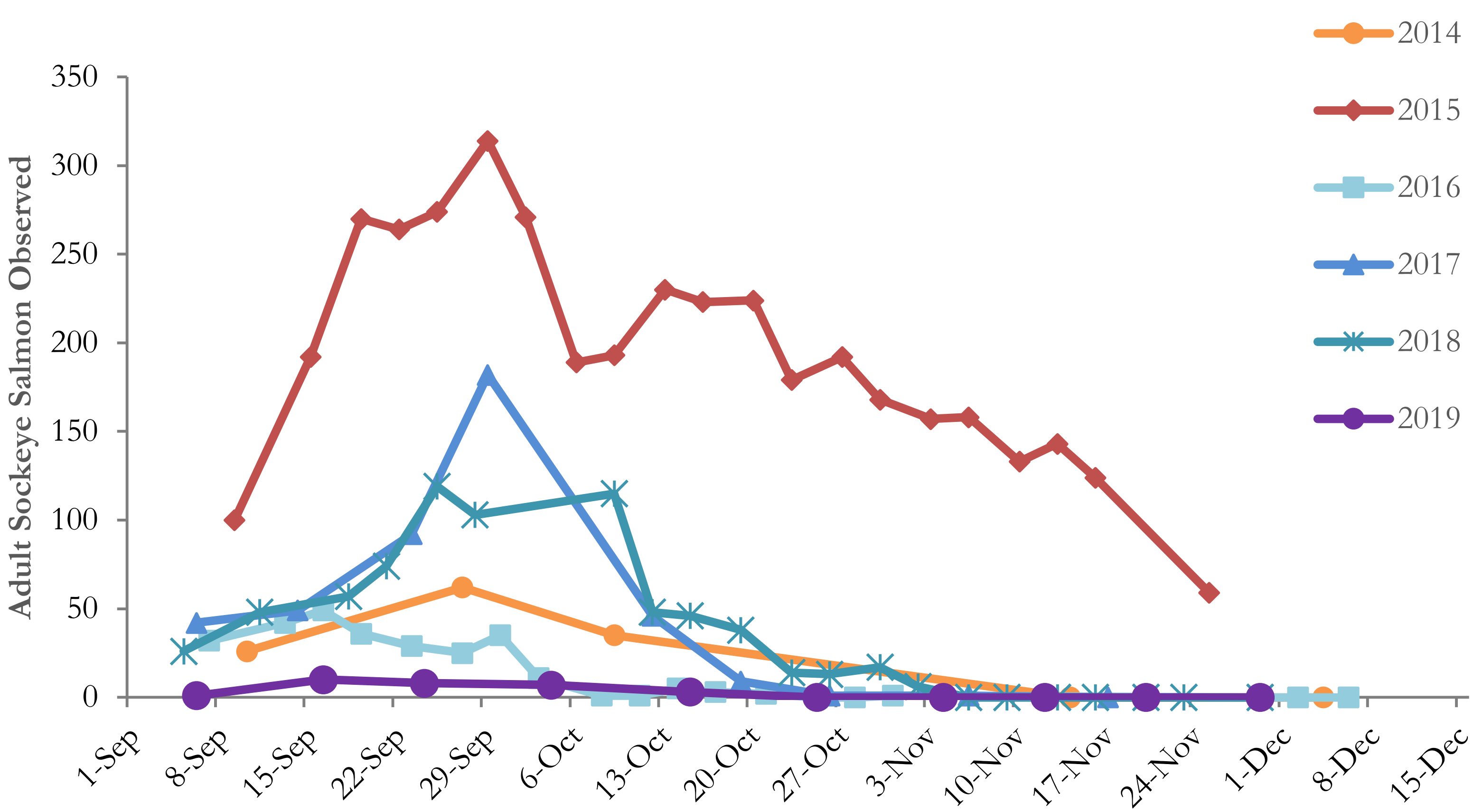


Figure 28. Adult Steelhead counts in Elk Canyon by date and year.

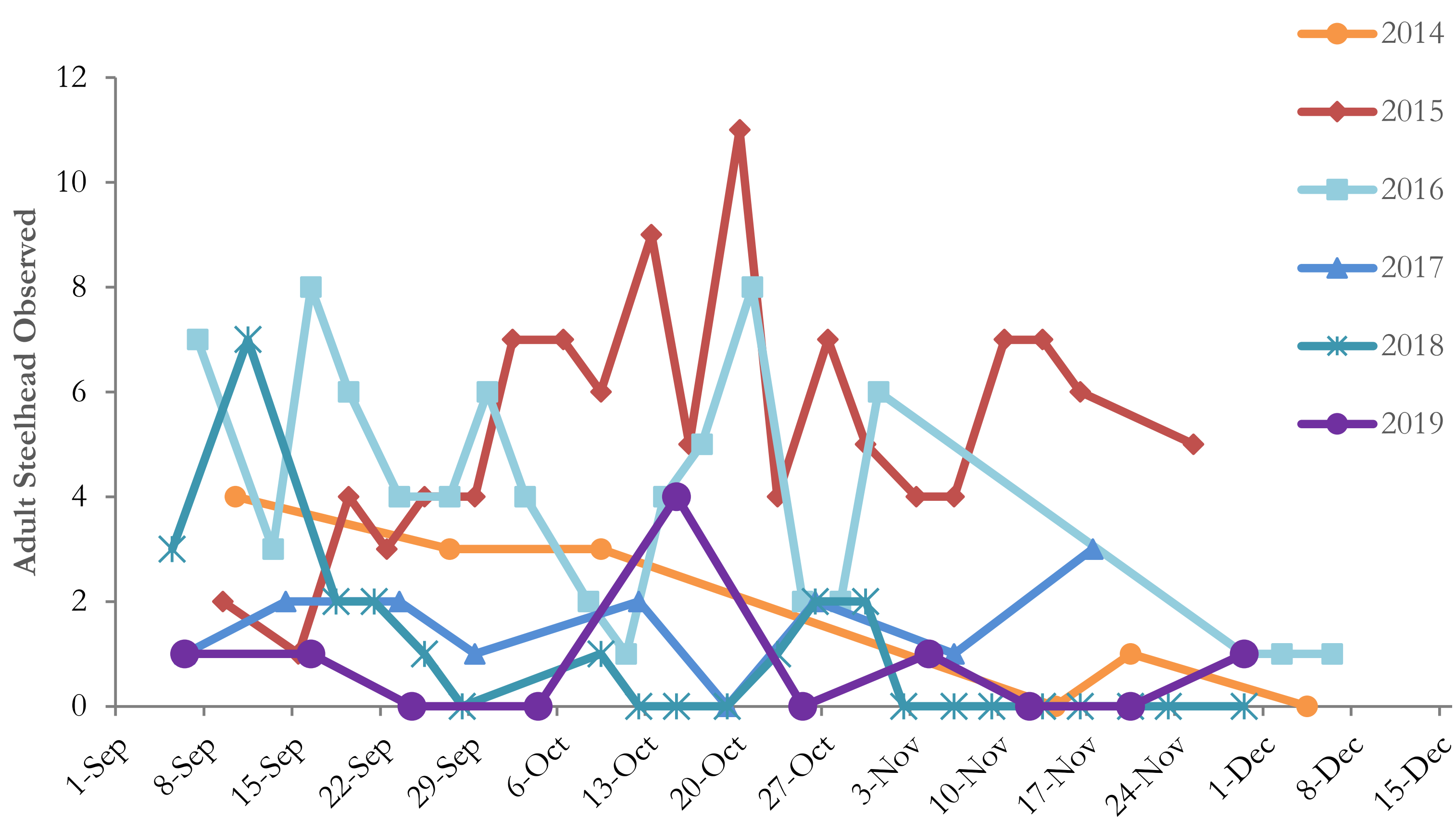


Table 10. Fall counts of salmon redds by species.

Date	Count of Trout/Salmon Redds[1]					
	ST	CH	CM	CO	PK	SK
6/Sep/19	0	0	0	0	0	0
16/Sep/19	0	0	0	0	7	0
24/Sep/19	0	0	0	0	78	0
4/Oct/19	0	0	0	0	58	2
15/Oct/19	0	45	0	6	5	0
25/Oct/19	0	0	0	0	0	0
4/Nov/19	0	0	46	6	0	0
12/Nov/19	0	0	24	65	0	0
20/Nov/19	0	0	0	0	0	0
29/Nov/19	0	2	15	5	0	0
Max Observed	**0**	**45**	**46**	**65**	**78**	**2**

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

Table 11. Comparisons of estimated juvenile production by salmon species from Elk Canyon derived from redd counts and RST catch.

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	78	140,400	0.115	n/a	16,146	n/a	6,963	n/a
Chum	3,200	46	147,200	0.129	n/a	18,989	n/a	207,373	n/a
Sockeye	3,500	2	7,000	0.127	n/a	889	n/a	131	n/a
Coho	3,000	65	195,000	0.253	0.17	49,335	32,175	8,472	276
Chinook	4,300	45	193,500	0.38	0.10	73,530	19,544	54,687	2,257

[1] Information from Bradford (1995).

[2] Information from Quinn (2005).

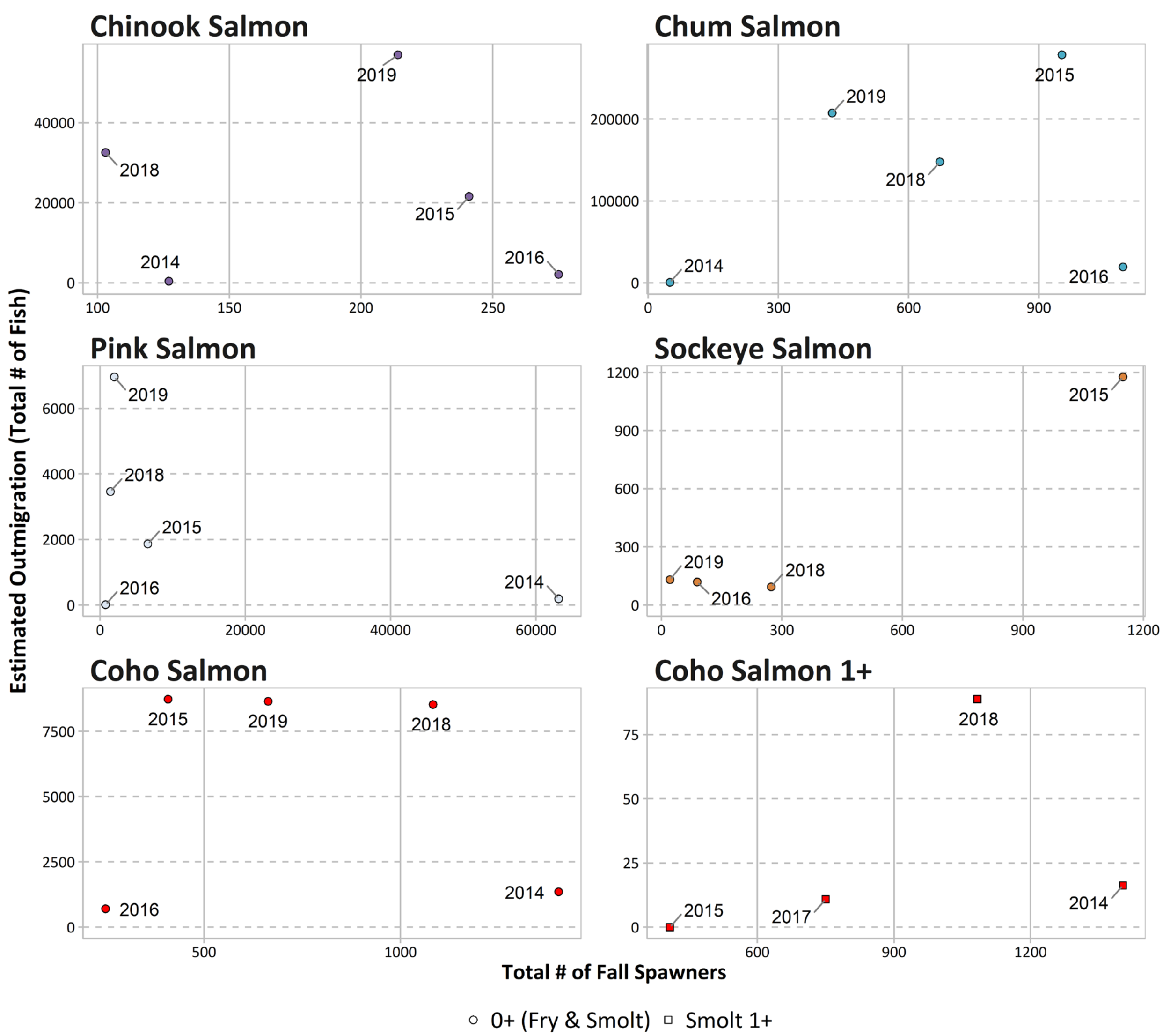
[3] Estimated redd production based on the total estimated eggs and literature survival rates.

[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.

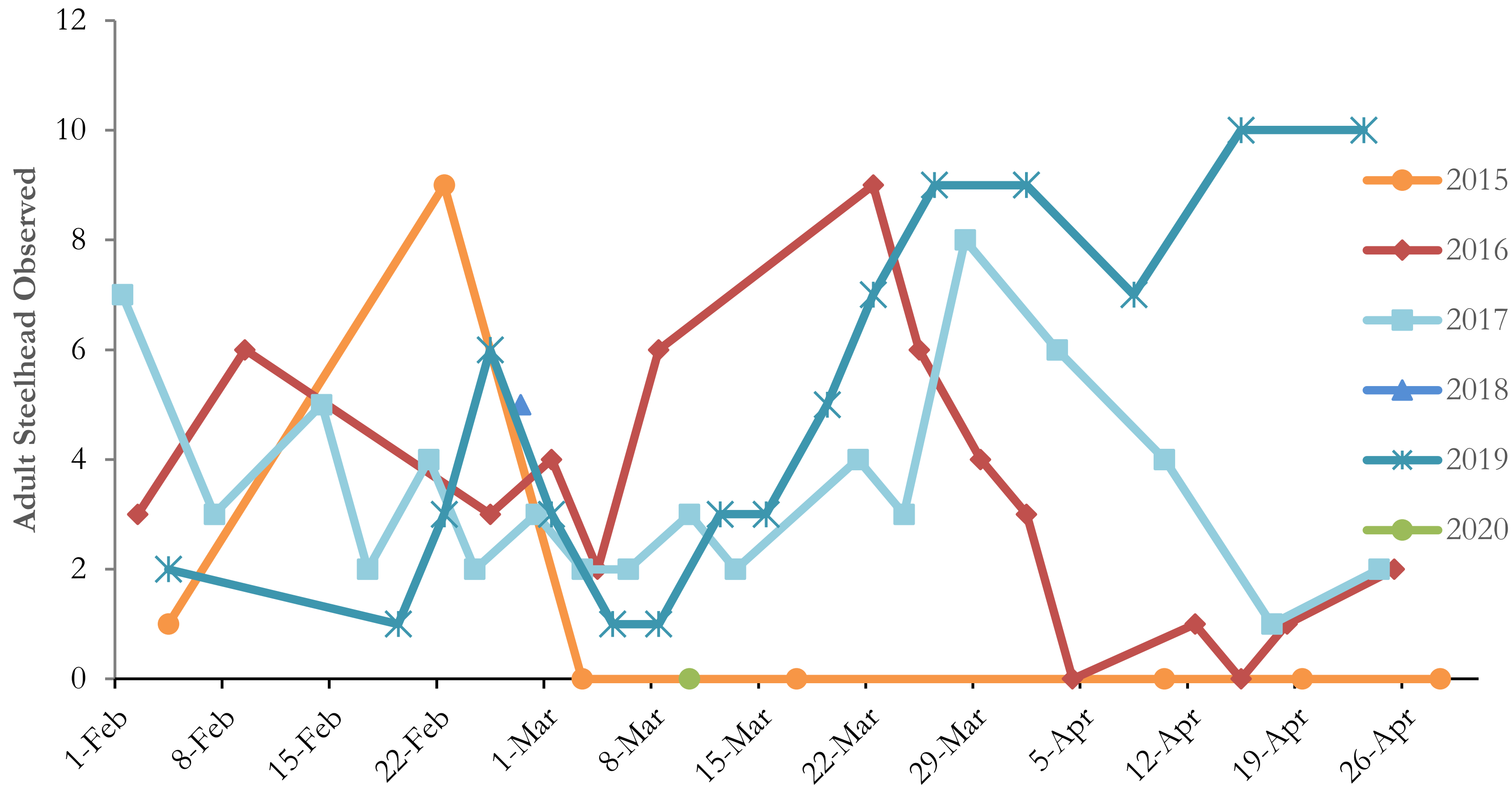
Figure 29. Estimated annual outmigration by salmon species as a function of the abundance of adult fish spawners. Labels indicate adult spawning year in the Elk Canyon.



3.2.2. Spring Spawners

A single spring snorkel survey was conducted on March 10, 2020, where no Steelhead or redds were observed. Additional surveys were not possible due to COVID19 restrictions. Steelhead counts in previous years ranged from 1 to 10 fish (Figure 30).

Figure 30. Steelhead counts during the spring spawner surveys by Year.



4. DISCUSSION

4.1. Overview

All BC coast salmonid species were observed using Elk Canyon for spawning and/or rearing during the Year 6 of sampling of the JHTMON-15 program. 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. The following sections highlight the main conclusions for each component of the study conducted in Year 6.

4.2. Smolt Enumeration

4.2.1. Year 6 Salmonid Outmigration

In Year 6, the RST operated for a total effort of approximately 89 days or 2,145 between March 3,to July 23, 2020. In total, 11,576 fish were captured in the RST in 2020. Similar to previous RST sampling years, the catches in 2020 were primarily composed of Chum Salmon (69.0%), Chinook Salmon (22.9%), and Coho Salmon (3.3%). Steelhead/Rainbow Trout and Sockeye Salmon accounted for 0.15% and 0.04% of the catch, respectively. The combined catch of all salmonids (11,335 fish) accounted for 97.9% of the total catch, whereas the catch of the key target species of Chinook Salmon, Coho Salmon, and Steelhead/Rainbow Trout (3,053 fish) accounted for 26.4% of the total catch.

Total salmonid outmigration by species in Year 6 was estimated by standardizing the RST catch by the capture efficiency of the RST, which was determined from mark recapture experiments. As in Year 2 and 3, and 5, Chum Salmon outmigration was the highest of all salmonid species.

Overall, outmigration estimates in 2020 were similar to or higher than estimates since 2015.

Outmigration timing information by life stage was evident within and across species from the RST data. Two peaks in Chinook outmigration were observed, one in early to mid March to early April (Chinook fry that may rear downstream in the Campbell River system) and a second one in late May and early June consisting of larger individuals that have reared for a few months in Elk Canyon.

Two primary Coho Salmon life stages were observed including an early migration of Coho fry in mid-March and early-April. Moreover, larger 0+ Coho smolts tended to leave the canyon by early June. Four age classes of Steelhead/Rainbow Trout were identified in the RST catches: 0+, 1+, 2+, and 3+. The peak in Steelhead/Rainbow Trout outmigration occurred between early May and mid-June.

4.2.2. Five-Year Salmonid Outmigration Assessment

Over all five years of monitoring (2015, 2016, 2017, 2019, and 2020), the RST captured a total of 58,650 fish in the Elk Canyon and salmonids represented 92.8% of the total catch (54,432 fish). With the exception of Year 1, the most abundant fish species caught in the RST have been consistently Chum and Chinook Salmon. In Year 3 (2017), we observed a substantial decrease in all salmonids caught by the RST, likely the result of the large spill event between November 4 and 24, 2016, which likely scoured redds within Elk Canyon.

A total of 82 Mark-Recapture trials were conducted in five years of the RST monitoring program of which 71 trials were used to estimate overall capture efficiencies per salmonid life stage. These capture efficiencies were used to estimate total smolt outmigration by species, life stage and year.

Estimates of daily outmigration showed 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 Rainbow Trout differed by age class. 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+ 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+ Rainbow Trout occurred consistently between years with most outmigration occurring between mid-April and late-May. Daily outmigration timing of 3+ Rainbow Trout was similar to 2+ Rainbow Trout although it was typically spread out over a wider time period.

The outmigration timing of 0+ salmonid fry was examined in relation to the accumulated growing degree days (AGDD) between the fall peak spawning date to the date each individual fish was caught in the RST. Examining outmigration timing versus AGDD provides important information related to factors other than flow that can affect fish productivity and migration behaviour in Elk Canyon. Looking at this relationship helped determine whether water temperature can be used to predict outmigration timing. Overall, better understanding the factors that affect fish productivity allows for informed discussions of the benefits of the WUP operations and will establish a productivity reference point for these discussions. For Chum, Coho, Chinook, and Sockeye Salmon, we observed that the majority of 0+ fry tended to migrate at similar levels of AGDD every year. This suggests that Chum, Coho, Chinook, and Sockeye salmon 0+ fry require a specific accumulation of thermal units during egg to fry development and to migrate out of the Elk Canyon.

For Rainbow Trout and Pink Salmon, we observed that cumulative daily 0+ fry migration was associated differently with AGDD every year. Rainbow Trout 0+ fry outmigration occurred between approximately 1,400 and 2,900 AGDD. The annual differences were even higher for Pink Salmon suggesting that Pink Salmon have a lower dependency on AGDD to migrate out of the Elk Canyon and rather are out-migrating on a consistent date each year.

Accumulated growing degree days to outmigration were also examined for Chinook, Coho, and Rainbow Trout smolts (0+, 1+, 2+ and 3+) which spent a month or more rearing in Elk Canyon prior to outmigration. The relationship observed between the annual cumulative daily outmigration and AGDD for smolts differed between salmonid species but was less apparent than trends observed for

0+ fry. For Coho smolts 0+ and older, the relationship between AGDD and outmigration had two clear peaks. For Rainbow Trout aged 1+, we observed no clear pattern between AGDD and estimated daily outmigration; however, for fish aged 2+ and 3+ we observed a clear peak of individuals leaving the canyon between 400 and 800 AGDD.

4.3. Fall and Spring Spawner Enumeration

Chinook and Coho Salmon adult abundance were estimated to be 214 and 663 individuals, respectively. Pink Salmon had the highest estimated abundance of 1,960 individuals. Populations of 44 Chum Salmon and 21 Sockeye Salmon were also estimated. Few Steelhead were observed in fall with a peak observed abundance of only four individuals.

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 four Steelhead were observed in mid-October.

Chinook, Chum, Coho, Pink and Sockeye Salmon redds were counted during fall spawning surveys. Pink, followed by Coho and Chum Salmon had the highest numbers of redds at 78, 65, and 46 redds, respectively; a maximum of 45 Chinook Salmon redds, and two Sockeye Salmon redds were observed. Chinook Salmon predictions for juvenile production based on redd counts were similar to outmigration estimates from the RST, whereas the other species' estimates diverged. The differences in production estimates derived from redd surveys and RST catch could be attributed to multiple factors, including our use of coarse estimates of fecundity and survival by species from the literature, and redd superimposition. For Chum Salmon, however, the results suggest that redd counts may have been underestimated, or, alternatively, that egg-to-fry survival was high. Chum and Coho salmon have a similar spawn timing and similarly sized redds, so it seems plausible that some redds identified as Coho were likely Chum redds.

Fall spawner abundance was examined in relation to estimated outmigration. Fall spawner abundance estimates were weakly positively correlated to 0+ fry and 0+ smolt outmigration estimates for most species with some exceptions. Chum Salmon saw the strongest positive correlation except for fall spawners from 2016. All species saw a decrease in estimated outmigration relative to fall spawner abundance from 2016. This was likely due to the large spill event in November 2016. The remaining salmonid species did not have a clear relationship between fall spawners and estimated outmigration. Additional data points collected in subsequent years (2021 through 2024) will allow us to examine this relationship in further detail.

A single spring snorkel survey was conducted on March 10, 2020, when no Steelhead or redds were observed. Additional surveys were not possible due to COVID19 restrictions. Steelhead counts in previous years ranged from 1 to 10 fish.

5. CONSIDERATIONS FOR YEAR 7

The following is a summary of considerations for Year 7.

Smolt enumeration component:

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. Year 6 represents the final year of the mark-recapture experiments. In subsequent years, outmigration estimates will be calculated using the same mark recapture efficiencies applied in Year.
2. Based on the catch results of the target fish species, the RST sampling period should remain open until the end of July to ensure that the Coho and Chinook Salmon outmigration periods are measured sufficiently.
3. The assessment of accumulated growing degree days with outmigration timing provided a useful addition to the analysis and increases our understanding of the factors that influence salmonid productivity in Elk Canyon. A similar synthesis analysis will be completed after Year 10 to summarize the smolt enumeration component.

Spawner enumeration component:

1. Adult Steelhead, Chinook, Chum, Coho, Pink and Sockeye Salmon were all observed in Elk Canyon; Chinook, Chum, Coho, Pink and Sockeye redds were also counted. Year 6 was the fourth year when estimates of production derived from RST catches were compared to estimates of production predicted from redd counts by species. This was a useful component of the analysis, which showed that egg-to-fry survival for Chum Salmon was high in 2019-2020. However, this component also highlighted that identification of species specific redds is challenging, especially for species that construct similar size redds during the same time period. This is likely to remain a challenge for the program.
2. Steelhead counts during the spring snorkel surveys in Years 1 through 6 have been very low (≤10). Such low Steelhead counts will not allow us to address Hypothesis $H_0 9$ for Steelhead from the ToR, which states: *$H_0 9$: Annual abundance of 'resident' smolts is not correlated with an index of Steelhead spawner abundance.*

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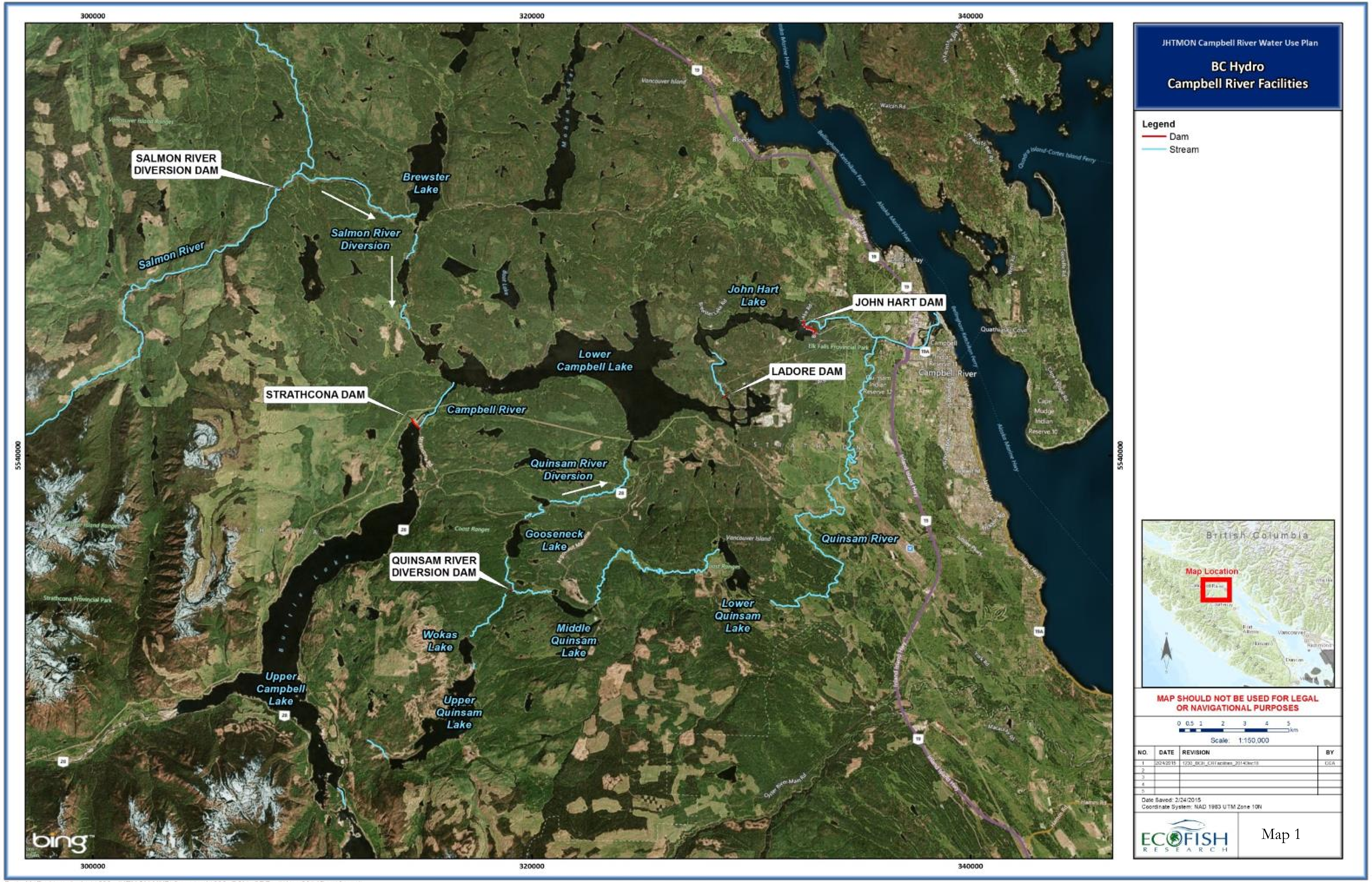
PROJECT MAPS



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APPENDICES

Appendix A. Results Tables and Figures - 2020

LIST OF TABLES

LIST OF FIGURES

Table 1. Daily average RST catch per operational day by half month periods for key salmonid species in Year 6.

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+
March 1-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
March 16-31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
April 1-15	74.3	0.0	15.1	0.0	0.0	0.0	0.2	0.0	0.0	544.3	6.0	0.0
April 16-30	9.9	0.0	3.1	0.0	0.4	0.0	0.1	0.0	0.0	78.2	0.2	0.1
May 1-15	0.8	0.2	0.8	0.0	0.4	0.0	0.3	0.2	0.1	0.4	0.0	0.0
May 16-31	1.3	2.9	0.0	0.3	0.0	0.0	0.1	0.4	0.0	0.1	0.0	0.0
June 1-15	4.0	7.3	0.1	0.4	0.0	0.3	0.0	0.1	0.0	0.0	0.0	0.0
June 16-30	3.8	9.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
July 1-15	0.0	3.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
July 16-31	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 1. Total RST catch by species from March 3 to July 23, 2020, excluding Chum and Chinook Salmon. ST/RB = Steelhead/Rainbow Trout, CO = Coho Salmon, PK = Pink Salmon, SK = Sockeye Salmon, CT = Cutthroat Trout, TR = unknown trout spp., CC = sculpin (*Cottus* spp.), TSB = Threespine Stickleback, UNK = unknown fish species (fry mortalities that were too damaged to identify to species in the field).

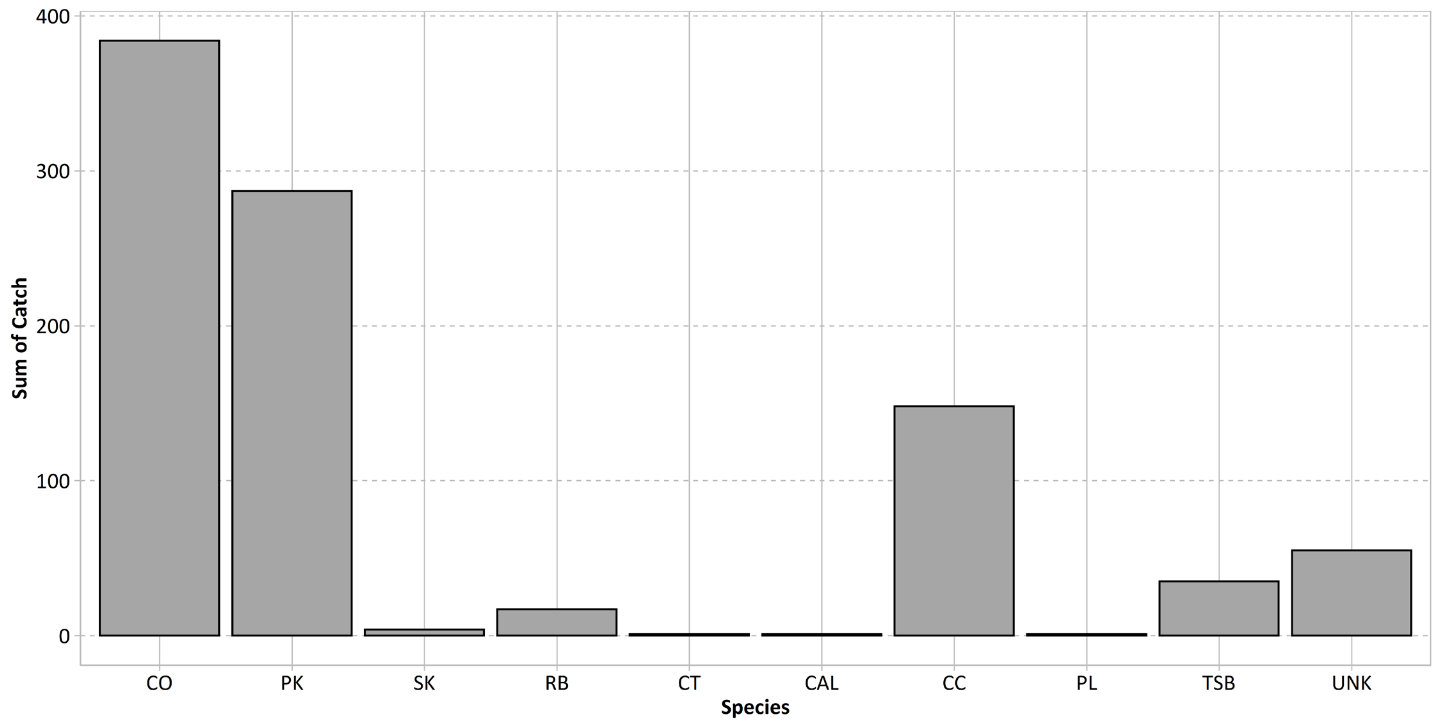

Figure 2. Daily average RST catch of key salmonid species from March 3 to July 23, 2020.

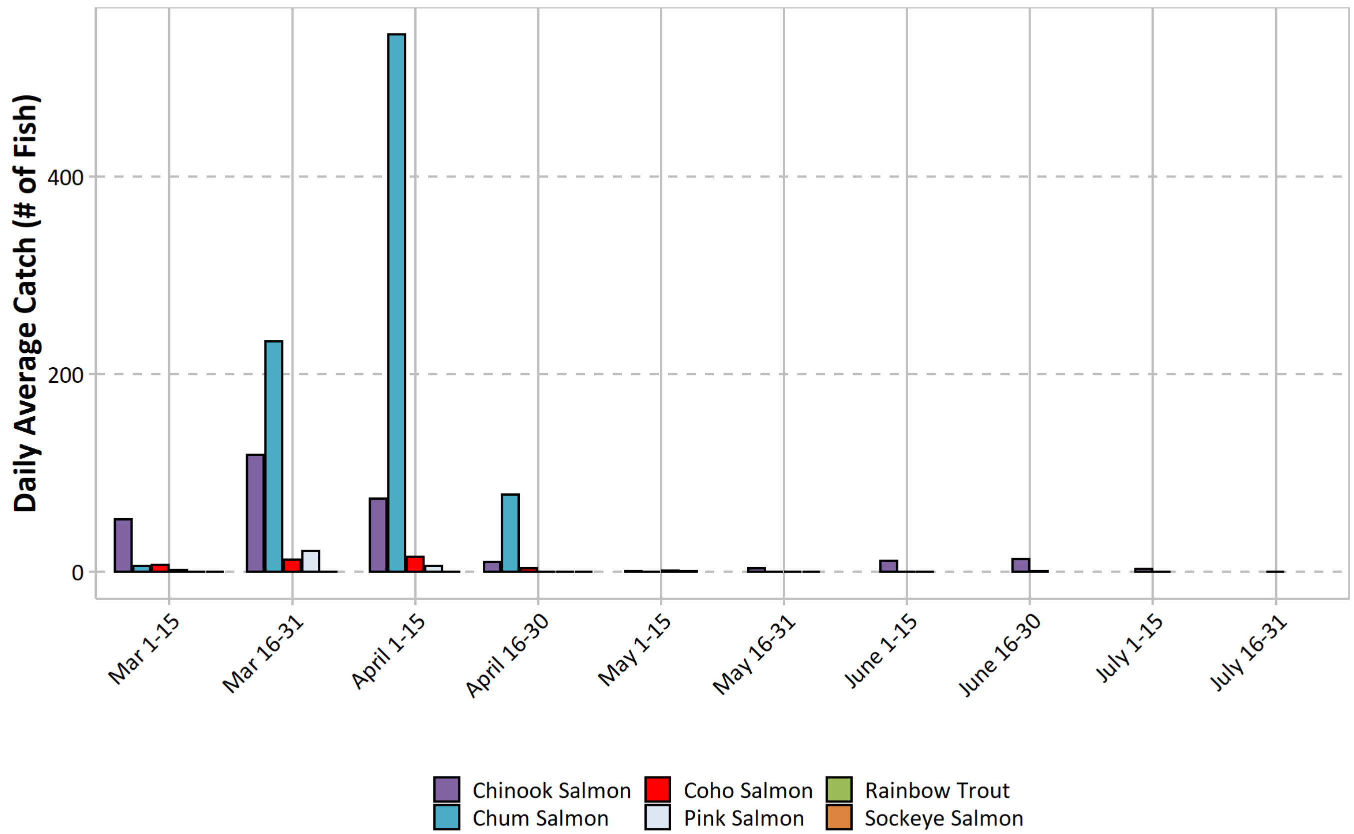

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Figure 3. Daily average RST catch of key salmonid species (excluding Chum Salmon) from March 3 to July 23, 2020.

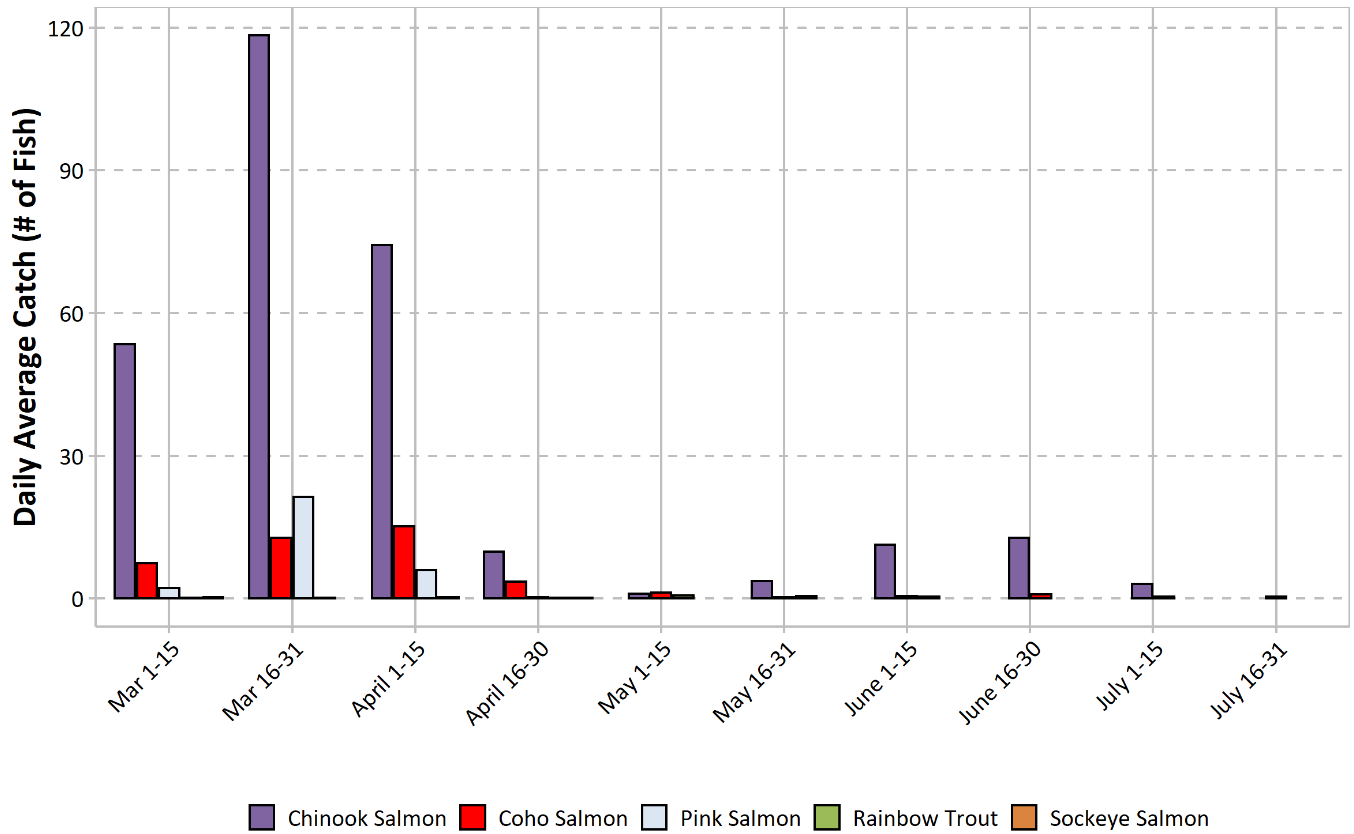

Figure 4. Length frequency histogram of Chum Salmon captured in the RST by month.

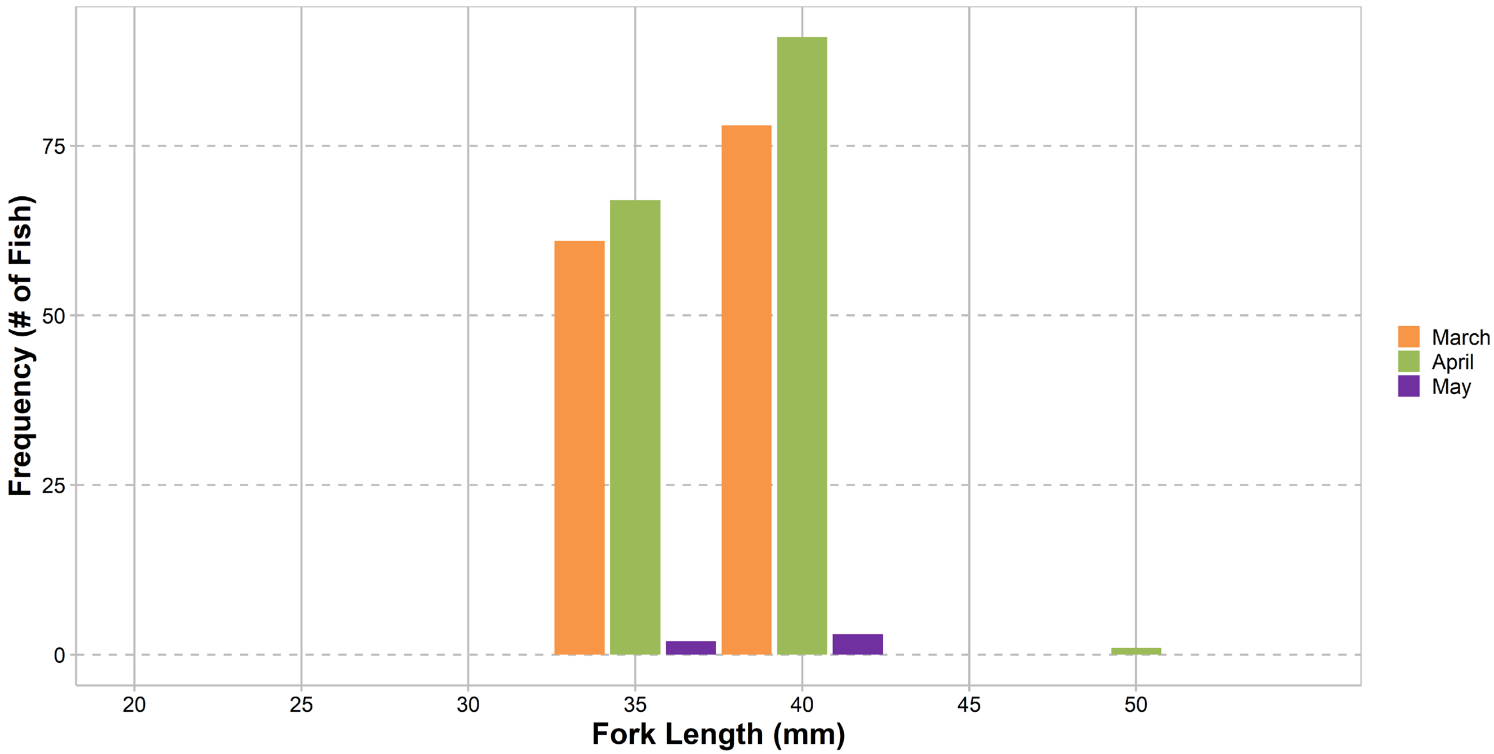

Figure 5. Length frequency histogram of Chinook Salmon captured in the RST by month.

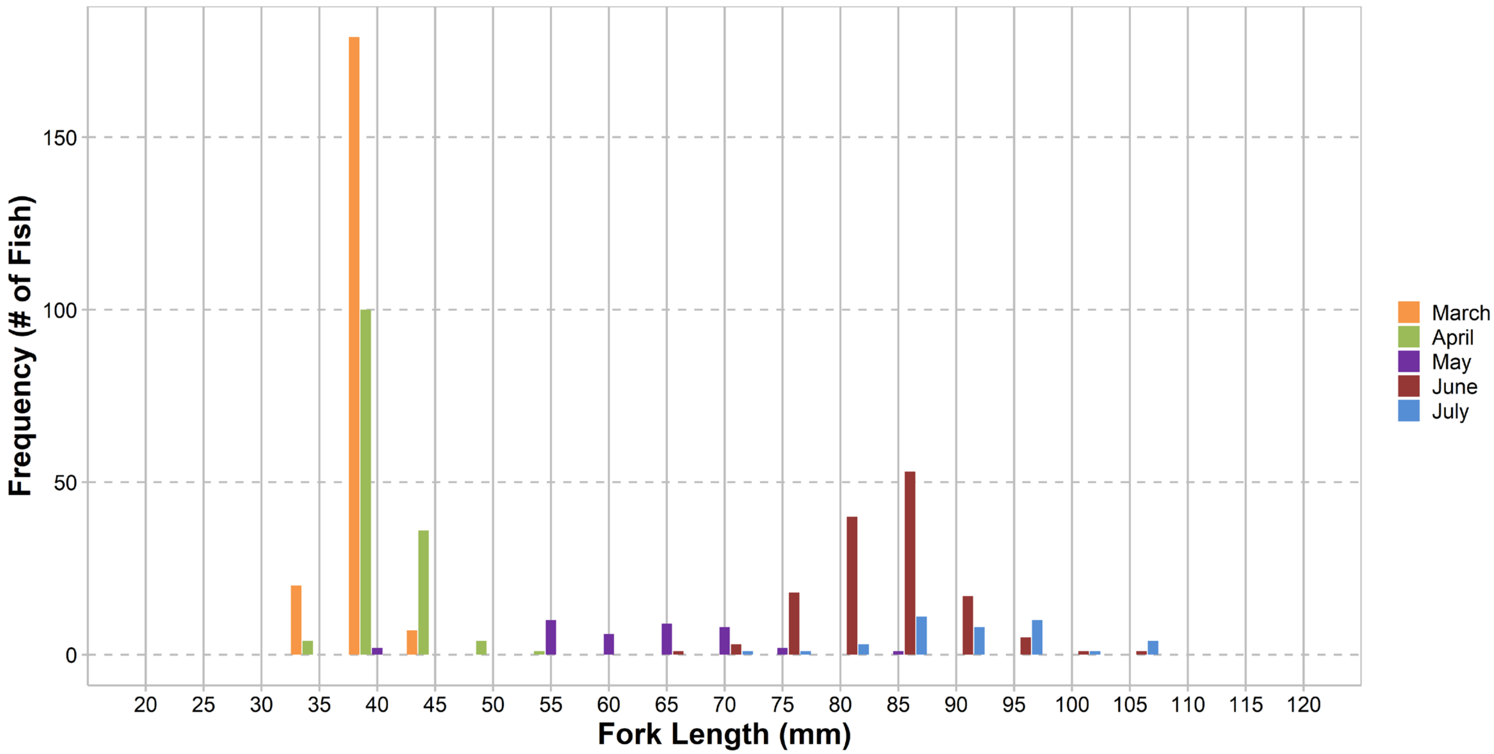

Figure 6. Length frequency histogram of Coho Salmon captured in the RST by month.

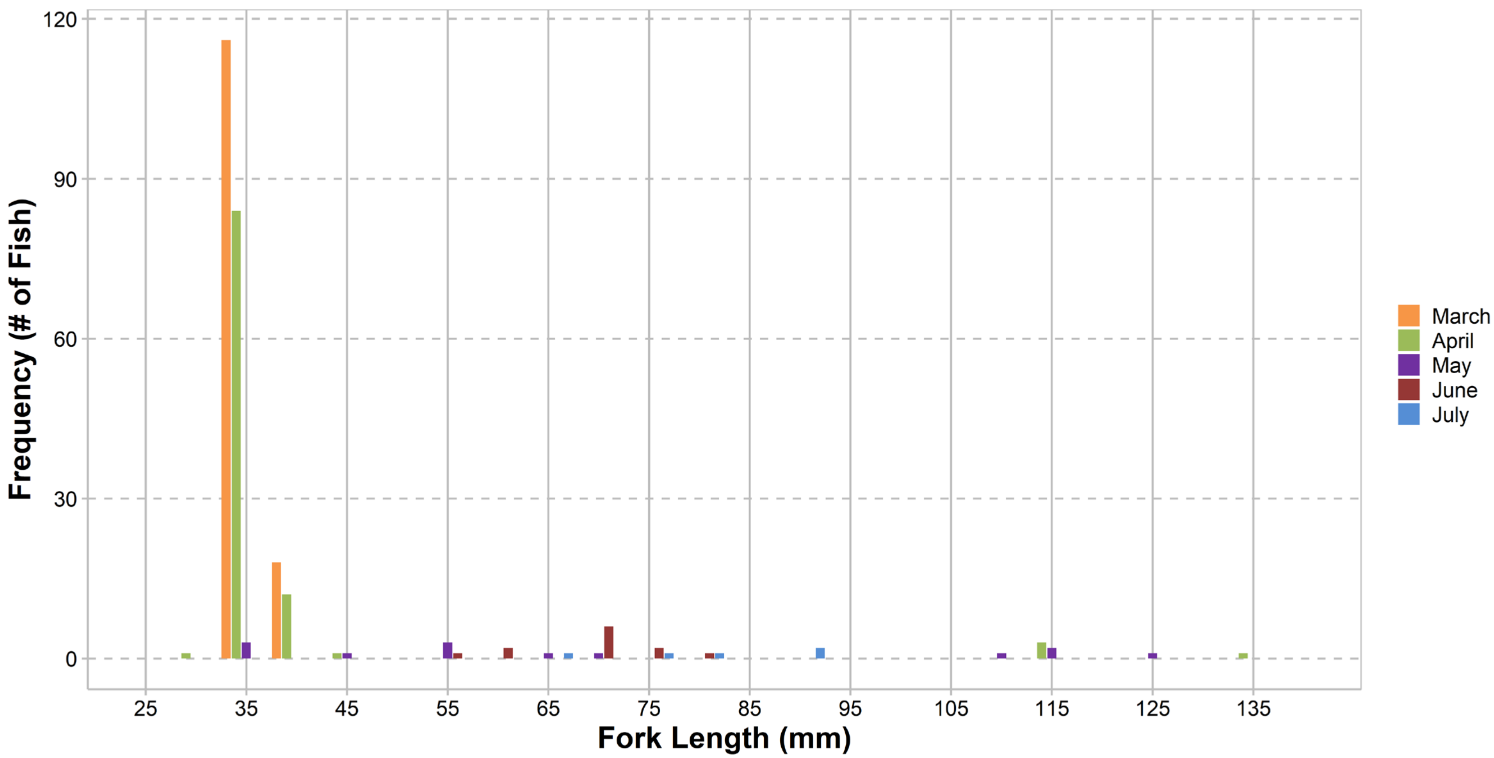

Figure 7. Length frequency histogram of Steelhead/Rainbow Trout captured in the RST by month.