NOAA Contract Report NMFS-NWFSC-CR-2024-01

https://doi.org/10.25923/0034-k407

# Monitoring the Migrations of Wild Snake River Spring/Summer Chinook Salmon Juveniles:

## Survival and Timing, 2023

Project **1991-028-00**, Contract **83639 REL 33**
covering the period from **January 2022 to December 2023**

**January 2024**

**U.S. DEPARTMENT OF COMMERCE**

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northwest Fisheries Science Center

## NOAA Contract Report Series NMFS-NWFSC-CR



## Recommended citation:

(Lamb et al. 2024)[1]

[1] Lamb, J. J., B. P. Sandford, G. A. Axel, S. G. Smith, and M. G. Nesbit. 2024. Monitoring the Migrations of Wild Snake River Spring/Summer Chinook Salmon Juveniles: Survival and Timing, 2023. U.S. Department of Commerce, NOAA Contract Report NMFS-NWFSC-CR-2024-01.

https://doi.org/10.25923/0034-k407

# Monitoring the Migrations of Wild Snake River Spring/Summer Chinook Salmon Juveniles:
## Survival and Timing, 2023

Jesse J. Lamb, Benjamin P. Sandford, Gordon A. Axel, Steven G. Smith, and Matthew G. Nesbit

https://doi.org/10.25923/0034-k407

**January 2024**

Fish Ecology Division
Northwest Fisheries Science Center
2725 Montlake Boulevard East
Seattle, Washington 98112

**U.S. DEPARTMENT OF COMMERCE**

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northwest Fisheries Science Center

# Executive Summary

From late summer 2022 to mid-2023, we continued a multiyear research project to monitor the migration behavior and survival of wild juvenile spring/summer Chinook salmon *Oncorhynchus tshawytscha* in the Snake River Basin of Idaho. Wild parr were collected in natal tributaries, implanted with passive integrated transponder (PIT) tags, and released near their respective collection sites. In this report, we present data and analyses from detections of fish tagged in summer 2022 and monitored through spring 2023. Comprehensive detail on fish collection and tagging is described in our report of January 2023, *Monitoring the migrations of wild Snake River spring/summer Chinook salmon juveniles: Fish collection and tagging, 2022*.

Our analyses included estimates of survival from release to instream monitoring systems and from monitoring systems to Lower Granite Dam. These estimates are summarized in Table 1 for populations from three Idaho streams with PIT-tag monitoring systems. For the remaining two populations and for all five stream populations combined, we estimated detection and survival estimates from release to Lower Granite Dam as well as median date of arrival at the dam. We also recorded growth rate and fish condition factor for recaptured subsamples of these fish. Results from all work in 2022-2023 are summarized below:

- During July 2022, we PIT-tagged 4,051 wild Chinook salmon parr and released them back into the five sample streams from which they were collected.

- For tagged parr from all five streams combined, the average estimated rate of parr-to-smolt survival to Lower Granite Dam was 17.0% (range 12.4-22.5%).

- For tagged parr from all five stream populations combined, peak detections at Lower Granite Dam occurred during 3-5 May 2023. Respective dates of the 10th, 50th, and 90th passage percentiles at the dam were 27 April, 6 May, and 24 May 2023.

- During 2023, we recaptured 170 study fish using the separation-by-code system at Lower Granite Dam. Recaptures included fish from all five Idaho populations sampled in 2022.

- For the 170 recaptured fish, average growth was 44 mm in length and 9.3 g in weight over an average period of 291 d. Mean condition factor declined from 1.24 at release (parr) to 1.01 at recapture (smolt). Among fish tagged and released as parr in 2022, we found no significant difference relating to size (length at tagging) between fish detected during spring and summer 2023 and those that were never detected ($P = 0.9621$).

Table 1. Numbers and proportions of PIT-tagged wild spring/summer Chinook salmon released during 2022 and detected during 2022-2023 with associated estimates of survival to monitoring systems and to Lower Granite Dam. Results shown are for three tagging cohorts which migrated past instream PIT-tag monitoring systems.

| | | Instream monitoring systems | | | | | | Estimated survival (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Detected | | Detection period (%) | | | | | To Lower Granite Dam | |
| Collection site | Released (n) | (n) | (%) | Late summer/ fall | Winter | Spring | Detection efficiency (%) | To instream monitor | From instream monitor | From release site |
| S Fork Salmon R | 1,182 | 150 | 12.7 | 71.3 | 10.6 | 18.0 | 41.6 | 30.7 | 37.2 | 12.4 |
| Marsh Cr | 999 | 579 | 58.0 | 81.9 | 14.3 | 3.8 | 86.9 | 66.7 | 31.4 | 20.8 |
| Cape Horn Cr | 248 | 148 | 59.7 | 87.8 | 9.5 | 2.7 | 85.3 | 70.9 | 32.0 | 22.5 |

# Contents

# Introduction

Snake River spring/summer-run Chinook salmon *Oncorhynchus tshawytscha* was listed as threatened under the U.S. Endangered Species Act (ESA) in 1992. Since that time, this evolutionarily significant unit (ESU) has been the focus of a recovery plan to restore its populations to self-sustaining levels. The plan serves as base of coordination for recovery efforts from federal, state, tribal, and municipal entities, as well as from private groups and individuals. Recovery efforts focus on both salmon populations and their habitats.

In its 2016 status review, the National Marine Fisheries Service (NMFS) concluded that the Snake River spring/summer Chinook salmon ESU remains at high overall risk, and that all but one population (Chamberlain Creek) remain at high risk (NMFS 2016). In this status review, NMFS (2016) reported that natural-origin abundance for most populations in the Snake River spring/summer Chinook salmon ESU have increased over levels reported in the previous status review. However, these increases were inconsistent across populations and not substantial enough to change viability ratings.

In an analysis of potential recovery strategies, Kareiva et al. (2000) found that "modest reductions in first-year mortality or estuarine mortality would reverse current population declines" for Snake River spring/summer-run Chinook salmon. Their finding supports prioritization of the juvenile stage as an efficient approach toward allocation of resources for recovery goals.

For Pacific salmon Oncorhynchus spp., tagging and recapture studies have been a central component of research to improve survival of juvenile downstream migrants. When tagging studies began in the mid-1950s, researchers relied on data from methods that could only provide limited information on fish passage (i.e., freeze branding, index counts, etc.). In the late 1980s, the passive integrated transponder (PIT) tag was introduced to the fisheries community. The PIT tag allows researchers to track and record the movements of individual fish. Because it is small and biologically inert, a PIT tag can be retained throughout the fish's life cycle. The “passive” capability means that the tag does not require a battery so that a single tag can potentially produce multiple detections of an individual fish throughout the life-span of that fish.

Since its introduction, use of the PIT tag has expanded from about 50,000 to more than 2 million fish tagged annually within the Federal Columbia River Power System. These tagging efforts, along with automated data-collection methods, have provided large data sets for a broad mixture of wild/natural and hatchery stocks, ages, and year classes. The Columbia Basin PIT Tag Information System (PTAGIS) was established as a shared repository for these data (PSMFC 1996).

Construction and installation of the spillway detection system at Lower Granite Dam was completed in January 2020 allowing for PIT-tagged fish (including fish from this study) to be detected as they pass through spill bay 1 ( PITAGIS interrogation site GRS). During 2022, the new site detected 195,666 fish, increasing total project detection by nearly 172%. Prior to installation of the spillway detection system, a large number of PIT tagged fish passed Lower Granite without detection. Greater detection numbers with the new system have allowed for more precise estimates of survival and timing for the wild Snake River spring/summer Chinook tagged as part of this project.

Data from PIT tag detections continues to provide insight for decisions on programs to enhance juvenile passage at dams, such as spill and transportation. However, there is an ongoing need for recent data upon which to base decisions for these and other restoration and recovery efforts. Gaps remain in understanding life history patterns and survival at different points in the life cycle of Columbia Basin stocks. Our research directly addresses data gaps for wild Snake River spring/summer Chinook salmon at the parr-to-smolt stage.

The 2020 NMFS biological opinion (NMFS 2020) calls for investigations to understand the factors contributing to expressions of life-history diversity for spring/summer Chinook, such as yearling vs. subyearling life-history strategies. We need to examine factors influencing the adoption of alternative life-history strategies and how such strategies might contribute to the abundance and productivity of affected populations.

Such investigations require examinations of how and where potential density-dependence limitations affect spring/summer Chinook productivity in freshwater habitats, including the potential impact of freshwater overwintering strategies. Also needed are investigations of factors that contribute to the subyearling life-history pattern and the limiting factors that determine adult returns of spring/summer Chinook salmon.

Section 1.3.2.5.5 of the 2020 NMFS biological opinion states:

> The Action Agencies will continue to: monitor habitat status and trends (including stream temperature and flow); conduct compliance and implementation monitoring (to ensure that habitat improvement actions are implemented as planned); monitor effectiveness of their habitat mitigation efforts at a range of scales; fund fish and habitat monitoring; and, support research projects with regional partners as funding and priorities allow.

Clearly, the migratory performance of wild fish (e.g., run-timing/survival) is important and should continue to be monitored. To this end, marking wild/natural parr with PIT tags in their natal streams during the summer of their first year of life provides the opportunity to precisely track these stocks during their parr/smolt migrations through natal rearing streams, unimpounded sections of the Salmon and Snake River, and the hydroelectric complex.

This report provides information on wild Chinook salmon monitored from fall 2022 to spring and early summer 2023 as they moved downstream and began migration towards the Pacific Ocean. Estimates of survival and timing to Lower Granite Dam are reported, as well as interrogation data at several other sites throughout the Snake and Columbia River hydropower system (Appendix Table 18). Results from previous study years were reported by Achord et al. (1994; 1995a,b; 1996; 1997-1998; 2000; 2001a,b; 2002; 2003-2006; 2007a,b; 2008-2012) and Lamb et al. (2013-2017; 2018a,b,c; 2019a,b; 2021; 2023). Ongoing goals of this study are to:

1. Characterize migration timing and growth and estimate parr-to-smolt survival to Lower Granite Dam for individual stream populations of wild Snake River spring/summer Chinook salmon

2. Determine whether consistent patterns in migration timing and survival are apparent

3. Determine which environmental factors may influence patterns in migration/survival

4. Characterize the migrational behavior and estimated survival of different wild juvenile Chinook populations as they migrate from natal rearing areas.

This study provides critical information for recovery planning and restoration efforts for these wild Chinook salmon populations, all of which remain listed as threatened under the U.S. Endangered Species Act of 1973 (NMFS 2008).

During 2022-2023, we recorded water temperature and depth measured at 14 locations in the Salmon River Basin, Idaho, for the *Baseline Environmental Monitoring Program*. These environmental data can be compared with parr/smolt migration, survival, and timing data to discern patterns or characteristic relationships that may exist. Understanding these relationships will provide additional insight for recovery planning of threatened salmon populations.

# Fish Collection, Tagging, and Release

This section provides a brief summary of tagging and collection effort in summer 2022. Complete details of this work were reported by Lamb et al. (2023). Briefly, National Marine Fisheries Service (NMFS) personnel tagged fish in 5 Idaho streams (Figure 1; Table 2). Fish collection followed the safe handling methods developed for this study by Matthews et al. (1990, 1997). Anesthetized fish were randomly selected for tagging, provided they met the minimum fork length (FL) requirement of 55-mm.

In 2022, fish were tagged using 12-mm advanced performance PIT tags (ATP12, Biomark, Inc. Boise, Idaho).[1] All fish were implanted with tags using pre-loaded, individual single-use hypodermic needles. This method ensured that each fish was tagged with a sterile, sharp needle, thus minimizing stress, injury, and disease transmission during the tagging process. After recovery from the anesthetic, fish were released back to the streams from which they had been originally captured.

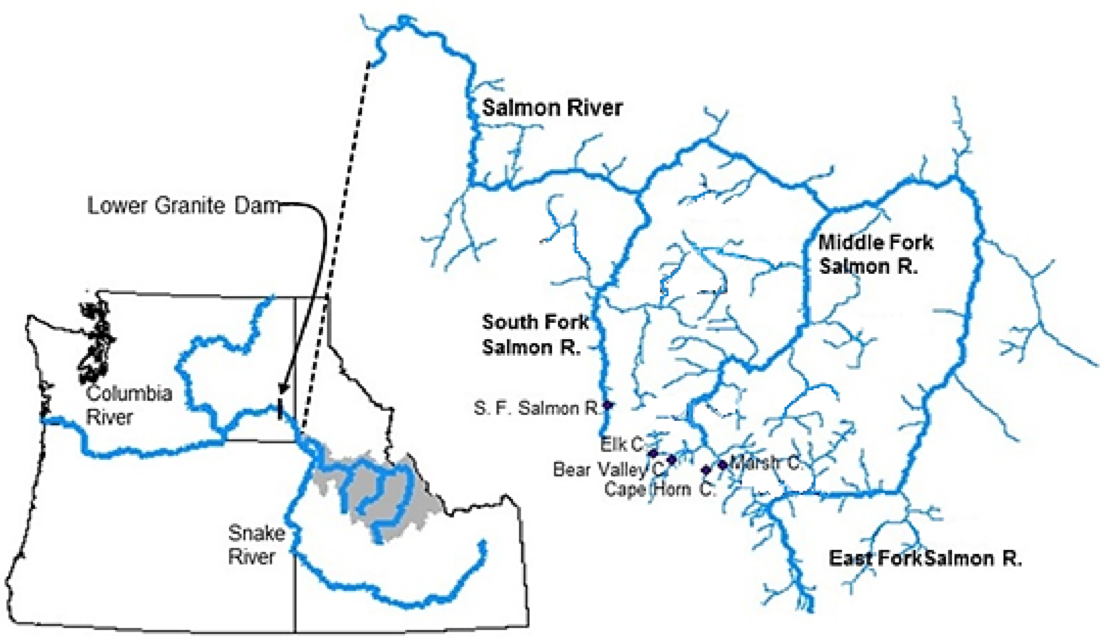


Figure 1. Map showing the streams and sample reaches where wild spring/summer Chinook salmon parr were PIT tagged during 2022.

[1] Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Table 2. Summary of collection, PIT tagging, and release of wild Chinook salmon parr with average fork lengths and weights (collection totals include recaptured tagged fish), approximate distances, and estimated areas sampled in Idaho streams during July 2022.

| | Number of fish | | Average length (mm) | | Average weight (g) | | Collection area to stream mouth (km) | Estimated stream area sampled ($m^2$) |
|---|---|---|---|---|---|---|---|---|
| Tagging location | Collected | Tagged & released | Collected | Tagged | Collected | Tagged | | |
| Marsh Creek | 1,774 | 999 | 57.8 | 61.0 | 2.7 | 2.7 | 11-13.5 | 25,788 |
| Cape Horn Creek | 1,271 | 248 | 55.0 | 61.0 | 4.0 | 2.7 | 0.5-2.5 | 18,235 |
| Bear Valley Creek | 1109 | 1,063 | 66.0 | 66.0 | 2.7 | 3.7 | 8-9.75 & 12.3-13.5 | 29,231 |
| Elk Creek | 569 | 559 | 65.0 | 65.0 | 3.5 | 3.4 | 0.2-1.0 & 3.0-4.0 | 17,170 |
| S Fork Salmon River | 2,044 | 1,182 | 58.0 | 61.0 | 2.8 | 2.7 | 115-117 &119-120 | 29,153 |
| Totals/averages | 6,767 | 4,051 | 60.4 | 62.8 | 3.1 | 3.0 | 13.25 | 119,577 |

# Downstream Detection and Recapture

## Detection of Tagged Fish

### *Instream monitoring systems*

In 2002, the first instream PIT-tag monitoring systems were installed by NOAA at two sites in Valley Creek. These systems were designed to detect fish closer to their natal rearing sites. Expansion and improvement of these systems since 2002 has been detailed in previous annual reports (Achord et al. 2004-2005, 2009-2012; Lamb et al. 2013-2021).

Instream monitoring systems automatically interrogate, store, and transmit data from passing tagged fish that are detected. From late July 2022 through June 2023, we collected detection data from wild PIT-tagged Chinook salmon juveniles passing instream monitoring sites (Table 3). Detection data are uploaded to the Columbia River PIT-Tag Information System (PTAGIS), a regional shared database operated by the Pacific States Marine Fisheries Commission (PSMFC 1996).

Table 3. Details of collection, tagging, and release areas and instream monitoring sites used in studies of wild spring/summer Chinook salmon parr implanted with 12-mm passive integrated transponder (PIT) tags, 2022-2023.

| Fish collection, tagging, and release areas | Instream monitoring site | | |
|---|---|---|---|
| | Description | River or creek (rkm) | Site code* |
| S Fork Salmon River | Krassel Creek | S Fork Salmon R (rkm 65) | KRS |
| S Fork Salmon River | Guard Station Rd Bridge | S Fork Salmon R (rkm 30) | SFG |
| Marsh Creek | Lola Cr Campground | Marsh Cr (rkm 8) | MAR |
| Cape Horn Creek | Lola Cr Campground | Marsh Cr (rkm 8) | MAR |

* Site code is an abbreviation designated for monitoring systems listed in the Columbia Basin PIT Tag Information System (PTAGIS) regional database.

### *Monitoring systems at dams and in the estuary*

During spring and summer 2023, wild Chinook smolts that had been PIT-tagged as parr in 2022 began a directed migration downstream. Of the eight dams encountered by these smolts on the lower Snake and Columbia Rivers, seven have PIT-tag interrogation systems in their juvenile bypass systems. These were Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dam on the Snake River and McNary, John Day, and Bonneville Dam on the Columbia River.

At these seven dams, smolts guided into juvenile bypass systems were monitored for PIT tags by interrogation systems similar to those described by Prentice et al. (1990a,b,c). At Lower Granite Dam, the spillway ogee detection system began operation in 2020 (Axel et al. 2023). For the first year since spillway detection operations began, the majority of wild fish from our study were detected at the Lower Granite bypass system (180; 59.4%).

Tagged fish had several possibilities for detection in the lower Columbia River estuary during 2023. A pair-trawl fitted with a PIT-tag detection antenna was operated ~150 km downstream from Bonneville Dam, deploying from Columbia River rkm 66 to 84 (Ledgerwood et al. 2004; Magie et al. 2010; Morris et al. 2015).

In addition to the trawl, a detection system located downstream of Bonneville Dam was operated from April to June on a pile dike at rkm 68 (PTAGIS site code PD6). The PD6 site was intended to supplement detections on an existing pile dike site (PD7), which has been in operation since 2012 with minimal success. During the initial year of the project, seven fish associated with our project were detected at PD6. That pilot project was expanded during 2023 to include two additional pile dike sites (PD5 and PD8), located at rkm 62, and 82, respectively. The pile dike detections systems detected 10 fish from our study.

For all of these monitoring systems, date and time to the nearest second were automatically recorded for each detected fish. Detection data were then transferred to the PTAGIS database at designated intervals, depending on the respective communications procedure of each monitoring system.

# Recapture of Tagged Fish

## *Juvenile migrant traps*

Some fish PIT tagged as parr in natal rearing areas were subsequently collected at migrant traps. During summer/fall 2022 and spring 2023, juvenile migrant traps were operated at the following locations:

- South Fork Salmon River at Krassel Creek
- Marsh Creek below its confluence with Cape Horn Creek, near Lola Campground
- Bear Valley Creek downstream of the confluence with Elk Creek, near Fir Creek Campground
- Salmon River at rkm 103 near Whitebird
- Snake River at Lewiston, Idaho

Traps were operated by the Idaho Fish and Game and the Shoshone-Bannock Tribe. Generally, study fish recaptured at these traps were anesthetized, scanned for PIT tags, measured, and weighed. Upon recovery from the anesthetic, fish were released back to the stream or river.

## *Separation-by-code at Lower Granite Dam*

At Lower Granite Dam, sampling was conducted from April through June 2023 in an effort to recapture subsamples of our study fish tagged as parr in summer 2022. Recaptures were obtained by programming the Lower Granite PIT-tag separation-by-code (SbyC) system, which can divert specific, predesignated tagged study fish from the population passing the dam (Downing et al. 2001). The SbyC system was programmed to divert a maximum of 100 fish from each stream at a maximum collection rate of 15 fish/d per stream.

All recaptured fish were handled using water-to-water transfers and other best handling practices. After measuring weight and length, we returned all tagged and non-tagged fish to the river via the bypass system.

In addition to recording fork length (mm) and weight (g) for these wild smolts at Lower Granite Dam, we calculated a Fulton-type condition factor (CF) as:

$$CF = \frac{weight\ (g)}{length\ (mm)^3} \times 10^5$$

Condition factor was calculated both at release and recapture using release data associated with the PIT tag code.

# Results and Discussion

A total of 141 wild spring/summer Chinook salmon tagged in summer 2022 were recaptured at traps above Lower Granite Dam from summer/fall 2022 to spring 2023 (Table 4). Average time to recapture was 50 days for all populations, with the largest number of recaptured fish from Marsh Creek (80; Table 4). Only a single fish was recaptured in the Salmon River trap l near Whitebird, ID.

We recaptured 170 fish in the SbyC system at Lower Granite Dam for examination of length, weight, and condition factor (Table 4). During 2022-2023, the largest numbers of fish recaptured at the dam were from Marsh and Bear Valley Creeks, with 51 and 50 fish respectively. For recaptured study fish, overall mean growth was 0.15 mm/d during 2022-2023. This was comparable to overall growth rates measured in previous years (Achord et al. 1994; 1995a,b; 1996; 1997-1998; 2000; 2001a,b; 2002; 2003-2006;, 2007a,b; 2008-2012; Lamb et al. 2013-2017; 2018a,b,c; 2019a,b; 2021; 2023).. Overall mean weight gain of these fish was 0.032 g/d and was also comparable to that measured in previous years.

Table 4. Fork length, weight, and condition factor of wild spring/summer Chinook salmon PIT-tagged in Idaho during summer 2022 and recaptured either in the separation-by-code system at Lower Granite Dam or at traps during summer/fall 2022 and spring/summer 2023. Precocious males were not included in the analysis.

| | Recaptured fish | | | | | | Weight and condition factor (CF) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Days to recapture | | | Length gain (mm) | | | | Weight gain (g) | | Mean CF | |
| Origin | n | Range | Mean | n | Range | Mean | n | Range | Mean | Release | Recapture |
| **Wild spring/summer Chinook salmon recaptured in SbyC at Lower Granite Dam** | | | | | | | | | | | |
| Marsh Creek | 51 | 275-311 | 294 | 51 | 28-62 | 45 | 44 | 4.5-15.5 | 9.5 | 1.39 | 1.05 |
| Cape Horn Creek | 16 | 269-307 | 290 | 16 | 33-57 | 45 | 14 | 2.0-14.4 | 9.8 | 1.23 | 1.01 |
| Bear Valley Creek | 50 | 264-310 | 289 | 50 | 27-63 | 44 | 23 | 4.0-15.0 | 9.5 | 1.26 | 0.98 |
| Elk Creek | 17 | 281-309 | 290 | 17 | 31-59 | 43 | 14 | 4.8-13.5 | 8.9 | 1.2 | 1.01 |
| S Fork Salmon R | 36 | 266-309 | 291 | 35 | 25-59 | 43 | 31 | 4.3-17.3 | 8.6 | 1.13 | 1.02 |
| Total or average | 170 | 264-311 | 291 | 169 | 25-63 | 44 | 126 | 2.0-17.3 | 9.3 | 1.24 | 1.01 |

Table 4. Continued.

| Origin | Recaptured fish: Days to recapture n | Range | Mean | Length gain (mm) n | Range | Mean | Weight and condition factor (CF) n | Weight gain (g) Range | Mean | Mean CF Release | Recapture |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Wild spring/summer Chinook salmon recaptured at traps** | | | | | | | | | | | |
| **South Fork Salmon River (Krassel Cr)** | | | | | | | | | | | |
| S Fork Salmon R | 21 | 83-98 | 91 | 21 | 5-32 | 20 | 19 | -0.2-6.1 | 2.8 | 1.12 | 1.01 |
| **Bear Valley Creek** | | | | | | | | | | | |
| Bear Valley Cr | 23 | 1-77 | 10 | 23 | -5-16 | 5 | 9 | -2.9-0.9 | -0.5 | 1.28 | 1.08 |
| Elk Creek | 2 | 1-79 | -- | 2 | 0-20 | -- | 2 | -0.4-2.1 | -- | --- | --- |
| **Marsh Creek** | | | | | | | | | | | |
| Cape Horn Cr fall | 13 | 1-82 | 32 | 13 | -4-20 | 6 | 1 | 0.6 | -- | 1.19 | --- |
| Cape Horn Cr spring | 1 | 241 | -- | 1 | 21 | -- | 0 | --- | -- | 1.22 | --- |
| Marsh Cr fall | 78 | 1-99 | 44 | 78 | -3-27 | 10 | 3 | -0.2-2.5 | 1.2 | 1.14 | 1.16 |
| Marsh Cr spring | 2 | 276-280 | 278 | 2 | 25-31 | 28 | 0 | --- | -- | 1.32 | --- |
| Salmon R spring | 1 | --- | 268 | 1 | --- | 33 | 0 | --- | --- | --- | --- |
| **Total or average** | 141 | 1-280 | 50 | 141 | -5-32 | 12 | 34 | -2.9-6.1 | 1.6 | 1.15 | 1.04 |

# Detection and Survival in Monitored Streams

## Methods

For each release group from each stream population, we estimated detection probability at Lower Granite Dam. Estimates of survival from release as parr to arrival at the dam as smolts were based on these detection probability estimates. However, for fish from monitored streams, the reach was divided into two smaller segments: 1) a stream segment, which spanned from the point of release to the lower instream monitor, and 2) a river segment, which spanned from the lower instream monitor to the dam.

For estimates of parr-to-smolt survival in stream segments, we constructed a detection history for each fish that specified detection or non-detection at 1) the instream monitor and 2) any downstream dam. This produced four possible detection histories for fish in each release group: detection or non-detection at a stream monitor and detection or non-detection at a dam. Counts of fish with each detection history were fitted to a multinomial model, with cell probabilities parameterized as functions of detection and survival probability.

To estimate survival, we used the Cormack-Jolly-Seber (CJS) single-release model with multiple recapture (Cormack 1964; Jolly 1965; Seber 1965). This model is used extensively to estimate survival for PIT-tagged fish in the Columbia River Basin.

In the past we explored a method to estimate detection and survival in reaches with two instream detection sites based only on detection data from the instream monitors (Connolly et al. 2008). However, detection data from monitoring systems with two antenna arrays have shown that detection probability at an upstream antenna array was not independent of detection probability at a downstream array.

This pattern of detection violated a critical assumption required by the CJS model—that probabilities of detection (recapture) at each location are independent of one another. Assuming a survival rate of 100% between upper and lower instream monitors, we could have modeled dependency between these detection probabilities. However, it was not possible to test the assumption of 100% survival, and sample size in many cases was not sufficient to obtain useful estimates of dependency. Therefore, we used the CJS model for two separate estimates of survival: from release to the instream monitors and from the instream monitors to Lower Granite Dam.

# Results

## *Marsh and Cape Horn Creek*

We collected and tagged 999 wild Chinook salmon parr from Marsh Creek on 19-20 July 2022. We then collected and tagged 248 fish from Cape Horn Creek on 20-21 July. Release sites for these fish were 2-3 km upstream from the instream monitoring array near Lola Creek Campground on Marsh Creek.

From July 2022 to May 2023, 579 Marsh and 150 Cape Horn Creek fish were detected on the Marsh Creek instream array (Figure 2). Of the 579 detections from Marsh Creek, 474 (81.9%) occurred in late summer/fall, 83 (14.3%) in winter, and 22 (3.8%) in spring. Of the 148 detections of fish from Cape Horn Creek, 132 (87.8%) occurred in late summer/fall, 14 (9.5%) in winter, and 4 (2.7%) in spring (Table 1).

Based on detections at downstream dams, overall detection efficiency of the instream monitoring system at Marsh Creek was 86.9% for parr from Marsh Creek (n = 579) and 85.3% for those from Cape Horn Creek (n = 150; Table 1). Based on these detection efficiencies, we estimated survival to the Marsh Creek instream monitoring system at 66.7% for parr from Marsh Creek and 70.9% for those from Cape Horn Creek (Table 1).

Data from the Marsh Creek monitoring system showed that Cape Horn Creek fish that had been larger at the time of tagging were detected significantly later than their smaller cohorts ($R^2$ = 8.74%, $P \leq 0.001$). For Marsh Creek fish, detection data indicated no significant relationship between fork length at tagging and date of detection ($R^2$ = 0.98%, $P$ = 0.017; Figure 3).

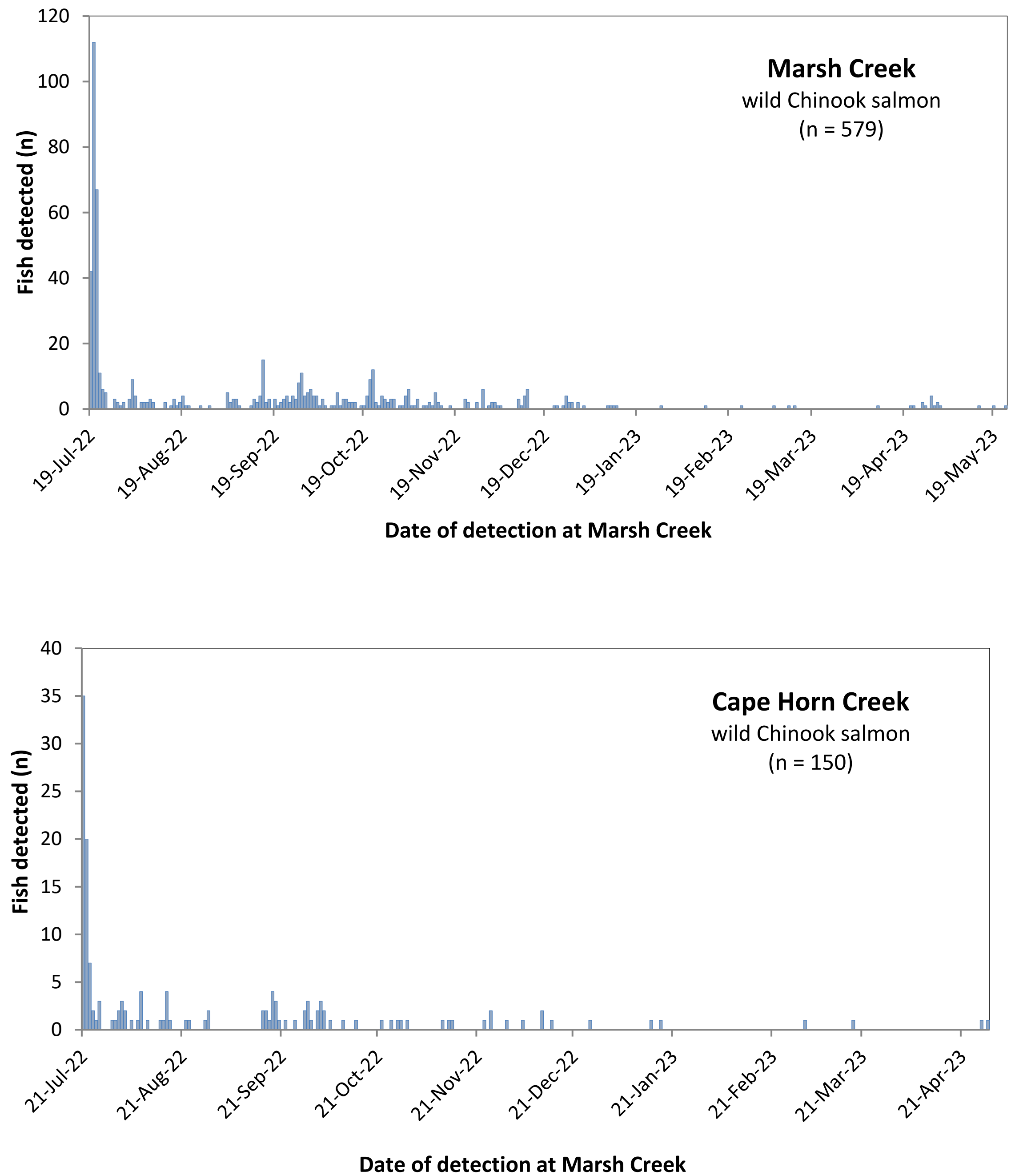


Figure 2. Detections on instream monitors at Marsh Creek from wild spring/summer Chinook salmon from Marsh (upper panel) and Cape Horn Creek (lower panel). We tagged and released 999 fish from Marsh and 248 fish from Cape Horn Creek. All fish were released in areas 2-3 km above the Marsh Creek monitors.

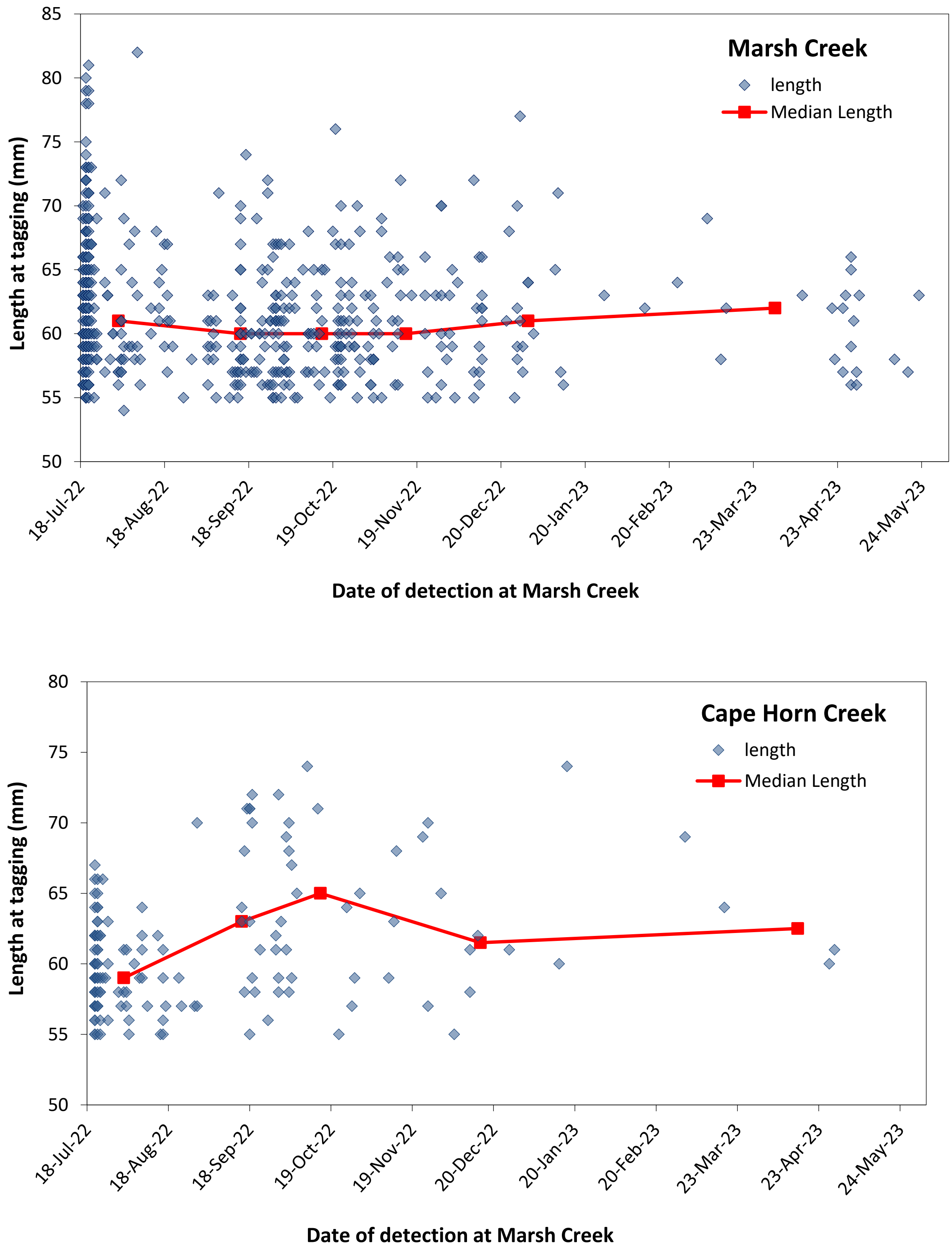


Figure 3. Length at tagging vs. date of detection for fish collected and tagged at Marsh (upper panel) and Cape Horn Creek (lower panel). A total of 579 fish from Marsh and 148 from Cape Horn Creek were detected at the instream monitoring site in Marsh Creek.

## *South Fork Salmon River*

We released 1,182 tagged wild Chinook salmon parr to the South Fork Salmon River during 26-27 July 2022 (Table 2). All fish were released to natal rearing areas 52-53 km upstream from the monitoring system near Krassel Creek at rkm 65. Of fish tagged and released to the South Fork Salmon River, 150 were detected near Krassel Creek from July 2022 through May 2023. Of these 150 detections, 107 (71.3%) occurred during late summer/fall, 16 (10.6%) during winter, and 27 (18.0%) during the following spring (Table 1; Figure 4).

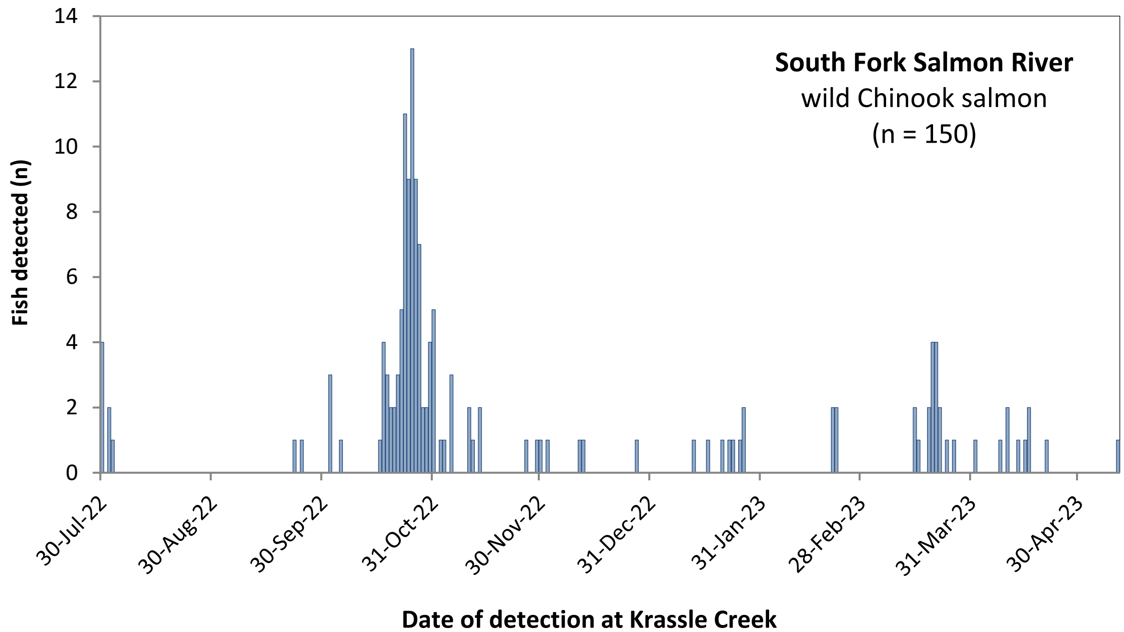


Figure 4. Detections by date of 150 wild spring/summer Chinook salmon parr, pre-smolts, and smolts at instream monitors in the South Fork Salmon River near Krassel Creek. A total of 1,182 Chinook parr were PIT tagged and released approximately 52-53 km upstream from the Krassel Creek monitors.

Based on detections at downstream dams, overall detection efficiency of the instream monitoring system at Krassel Creek was 41.6%. Using this detection efficiency rate, we estimated survival to the Krassel Creek monitoring system at 30.7% for all tagged parr from the South Fork Salmon River. We found a small, but significant relationship between fork length at tagging and timing of detection for these fish ($R^2 = 2.31\%$, $P = 0.035$; Figure 5).

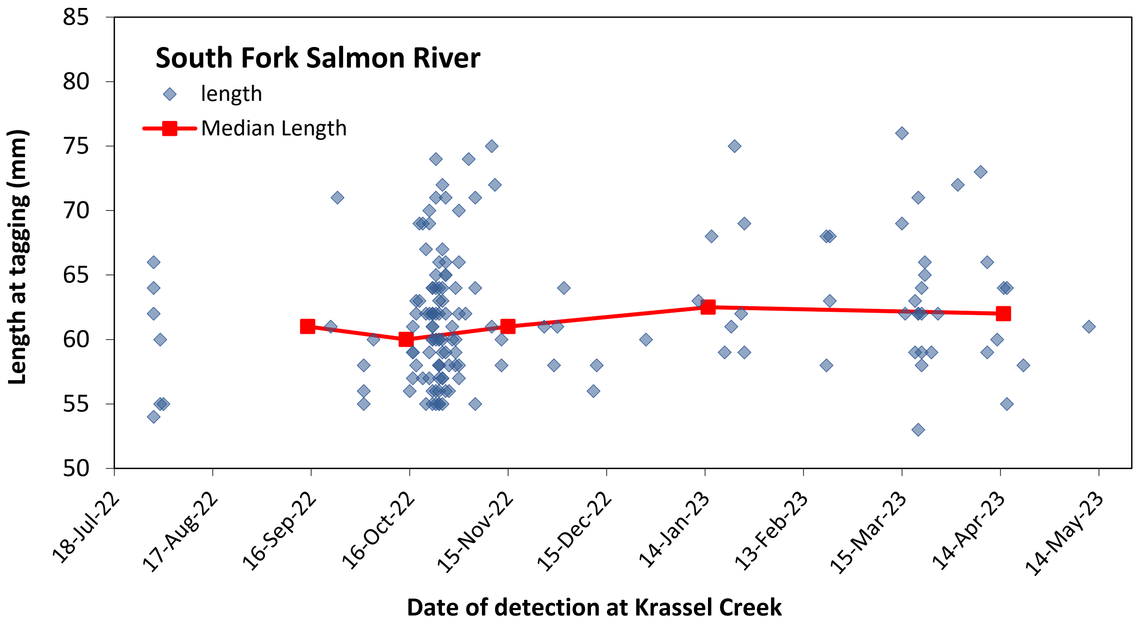


Figure 5. Fork length at tagging vs. date of detection for 150 wild spring/summer Chinook salmon tagged in the South Fork Salmon River and detected at the instream PIT-tag monitoring site at Krassel Creek in the South Fork Salmon River.

# Discussion

During 2022-2023, the instream PIT-tag monitoring system on Marsh Creek again had a high detection efficiency. Based on numbers of fish from Marsh and Cape Horn Creek that were detected at Marsh Creek and subsequently detected at downstream dams, we estimated detection efficiency of the new system at 86.5%. We are confident that the system will continue to perform well due to its location and the advanced technology that was used in the installation of the site. Environmental factors will continue to play a role in the detection efficiency, and we expect to see variation from year to year.

For fish from the South Fork River, detection efficiencies continue to be satisfactory. At Krassel Creek (rkm 65), detection efficiency was 41.6% for South Fork Salmon River fish. These detection efficiencies are most likely attributable to technological updates made during 2020 (during 2016-2020 detection efficiencies were in the 10-26.3% range). Favorable environmental conditions and continued advances in technology should help to enhance this site in the future.

# Survival to Lower Granite Dam and Overall Parr-to-Smolt Survival

## Methods

In this section, we present methods for estimating detection probability and parr-to-smolt survival at Lower Granite Dam. For fish from the five streams with monitoring systems, we also estimated survival from instream monitors to Lower Granite Dam. For fish from streams without monitoring systems, we estimated detection and survival probability from respective release points to the dam.

### *Estimated survival from streams to Lower Granite Dam*

We estimated separate probabilities of survival to Lower Granite Dam for fish from each stream overall and for each of three detection periods: late summer/fall (August-October), winter (November-February), and spring (March-June). For fish from monitored streams with two arrays, we estimated survival from the lowermost array to the dam.

For these estimates, we first grouped detected fish by seasonal period of detection on instream monitors. For each seasonal group, we then compiled a temporal distribution of daily detections at Lower Granite Dam by stream cohort.

For fish from each stream, each daily count at the dam was divided by the estimate of detection probability for Lower Granite Dam on that day to obtain an expanded daily passage estimate. Methods for expanded estimates are explained below in *Estimates of parr-to-smolt survival*. Daily passage estimates were then summed to estimate the total number of fish from each stream that survived to Lower Granite Dam. This total was divided by the total number of fish released from that stream to derive the estimate of survival to Lower Granite Dam.

For the three sampling sites with monitoring systems, we used the above process for the number of fish that survived to Lower Granite Dam and had previously been detected on an instream monitoring system during each seasonal period. To derive estimates of survival to the dam by season, the pertinent totals of expanded daily passage numbers at the dam were divided by the total number of fish detected on instream monitors during each seasonal period, regardless of whether they had been detected at Lower Granite Dam. For fish from these monitored streams, we estimated overall parr-to-smolt survival by calculating the weighted mean of the three seasonal survival estimates calculated above. Means for each season were weighted according to the proportion of total detections from that season.

## *Estimates of parr-to-smolt survival*

To estimate parr-to-smolt survival, we used daily detection probabilities at Lower Granite Dam to expand daily observed detections. Detection probability estimates for this expansion were based on detections of our tagged study fish pooled with detections of fish tagged for other studies, or "auxiliary" detection data. These auxiliary data included any wild Snake River Chinook salmon PIT-tagged and released upstream from the dam, regardless of source. Pooled detections of study and auxiliary fish at Lower Granite Dam were used for all estimates of parr-to-smolt survival and travel time.

To estimate expanded detection probabilities from pooled detections, we followed the methods of Schaefer (1951) as modified by Sandford and Smith (2002). For each day of the migration season, we estimated numbers of tagged fish detected at Lower Granite Dam, as well as numbers of tagged fish not detected that day but known to have passed because they were subsequently detected downstream. We developed a series of daily detection probabilities as follows:

1. Fish detected on day ***i*** at Little Goose Dam and previously been detected at Lower Granite were tabulated according to day of passage at Lower Granite Dam.
2. Fish detected on day ***i*** at Little Goose but not previously detected at Lower Granite were assigned an estimated day of passage at Lower Granite, assuming that passage distribution for these fish was proportionate to passage distribution of fish detected at Lower Granite.
3. This process was repeated for all days with detections at Little Goose Dam.
4. Detected and non-detected fish known to have passed Lower Granite Dam on day ***i*** were summed.
5. Detection probability on day ***i*** was estimated by dividing the number of fish detected at Lower Granite on day ***i*** by the sum of both detected and non-detected fish (with the latter known to have passed Lower Granite because of detection at Little Goose and estimated to have passed on day ***i***).

We slightly modified the method of Sandford and Smith (2002) for parr-to-smolt survival estimates of fish that passed Lower Granite during the early and late periods of each season, or "tails" of the passage distribution curve. This modification was necessary because for fish passing during these periods, there were often no detections at Little Goose Dam; thus, no passage date at Lower Granite could be inferred. For this modification, bootstrap methods were used to derive standard errors for the estimated probability of survival to Lower Granite Dam.

Auxiliary data were used to derive bootstrap distributions of estimated daily detection probability at the dam. Standard errors were derived for estimates of survival to the dam from both release sites and instream monitors (Achord et al. 2007b). For fish from each stream release or instream monitor detection group, we used detections at Lower Granite for bootstrap distributions of dam passage.

# Results

## *Survival of fish from all Idaho streams*

For fish from all Idaho streams combined, we estimated average parr-to-smolt survival probability at 17.0% (SE 1.0%; Table 5). This estimate was based on expanded detections at Lower Granite Dam from 12 April to 5 July 2023 (n = 687). An additional 180 first-time detections were recorded at Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, Bonneville Dam, the PIT Trawl, and lower Columbia pile dike sites (Appendix Tables 3-7).

Table 5. Summary of observed vs. expanded detections of wild spring/summer Chinook smolts at Lower Granite Dam in 2022-2023. Proportions of detected fish from the expanded numbers were used for parr-to-smolt survival estimates and are shown with the SE of each estimate.

| | | Lower Granite Dam detections, 2022-2023 | | | | |
|---|---|---|---|---|---|---|
| | Tagged and | Observed | | Expanded (parr-to-smolt survival) | | |
| Stream | released (n) | (n) | (%) | (n)* | (%) | SE (%) |
| Marsh Creek | 999 | 94 | 9.4 | 208 | 20.8 | 2.2 |
| Cape Horn Creek | 248 | 24 | 9.7 | 56 | 22.5 | 4.7 |
| Bear Valley Creek | 1,063 | 86 | 8.1 | 197 | 18.5 | 2.1 |
| Elk Creek | 559 | 34 | 6.1 | 79 | 14.1 | 2.4 |
| S Fork Salmon River | 1,182 | 65 | 5.5 | 147 | 12.4 | 1.6 |
| Totals or averages | 4,051 | 303 | 7.5 | 687 | 17.0 | 1.0 |

* Due to rounding, expanded detection numbers may vary slightly from those in Appendix Tables 3-7.

## *Survival of Fish from Monitored Streams*

**Marsh and Cape Horn Creek—**For wild juvenile Chinook from Marsh Creek detected on Marsh Creek monitors, we estimated overall survival to Lower Granite Dam at 31.4% and overall parr-to-smolt survival at 20.8% (Table 6).

For wild juvenile Chinook from Cape Horn Creek detected on Marsh Creek monitors, we estimated overall survival to Lower Granite Dam at 32.0% and overall parr-to-smolt survival at 22.5% (Table 6).

**South Fork Salmon River—**For wild juvenile Chinook from the South Fork Salmon River detected on the instream array near Krassel Creek, overall survival to Lower Granite Dam was estimated at 37.2% and overall parr-to-smolt survival at 12.4% (Table 6).

Table 6. Estimated survival to Lower Granite Dam for fish detected on instream monitors with overall estimated parr-to-smolt survival for study populations passing instream PIT-tag monitoring arrays, 2022-2023.

| | | Estimated survival to Lower Granite Dam (%) | | | Estimated parr-to-smolt survival (%) | | |
|---|---|---|---|---|---|---|---|
| Stream population | Instream monitor | Overall mean | SE | 95% CI | Overall mean | SE | 95% CI |
| Marsh Creek | Marsh Cr | 31.4 | 3.3 | 25.1-38.0 | 20.8 | 2.2 | 17.1-25.5 |
| Cape Horn Cr | Marsh Cr | 32.0 | 7.3 | 19.4-47.8 | 22.5 | 4.7 | 14.0-32.8 |
| S Fork Salmon R | Krassel Cr | 37.2 | 6.8 | 25.4-51.8 | 12.4 | 1.6 | 9.5-15.8 |

## *Relationship between Length at Tagging and Detection at Dams*

For tagged fish from all streams combined, average fork length at release was 62.8 mm (Table 2; Appendix Table 1). Among these fish, average fork length at release was not significantly different for fish that were detected vs. those not detected the following spring at Lower Granite Dam (63.0 vs. 63.1 mm; Z = 0.05; *P* = 0.9621; Figure 6).

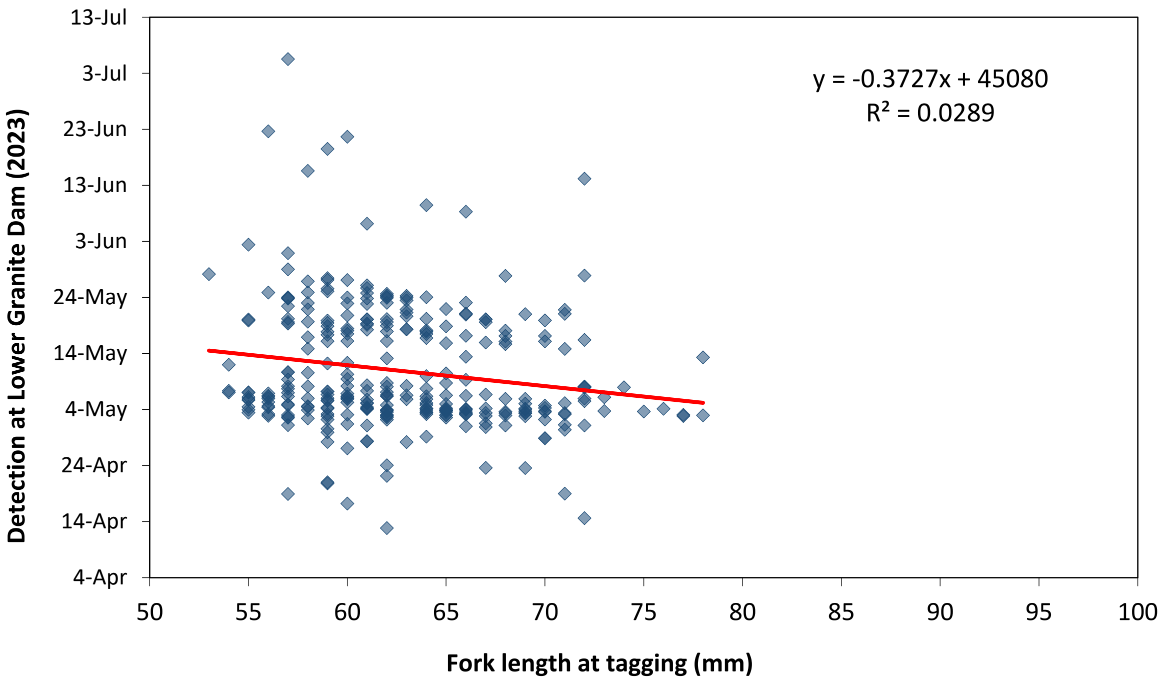


Figure 6. Relationship between fork length of wild Chinook salmon parr at tagging (2022) and detection date at Lower Granite Dam in 2023 (n = 482).

To examine this relationship further, we grouped all released fish into 5-mm length bins and compared length distributions at release vs. detection using a series of *Z*- tests. Length distribution of non-detected fish was compared to that of fish detected at dams in spring by comparing the two percentages in each bin. Percentages were relative to the total released for each bin (detected or not). We saw no significant difference among length bins between detected vs. non-detected fish (Figure 7), with the exception of the >79-mm group, which was a single detected fish compared to 17 fish that were not detected ($P < 0.05$).

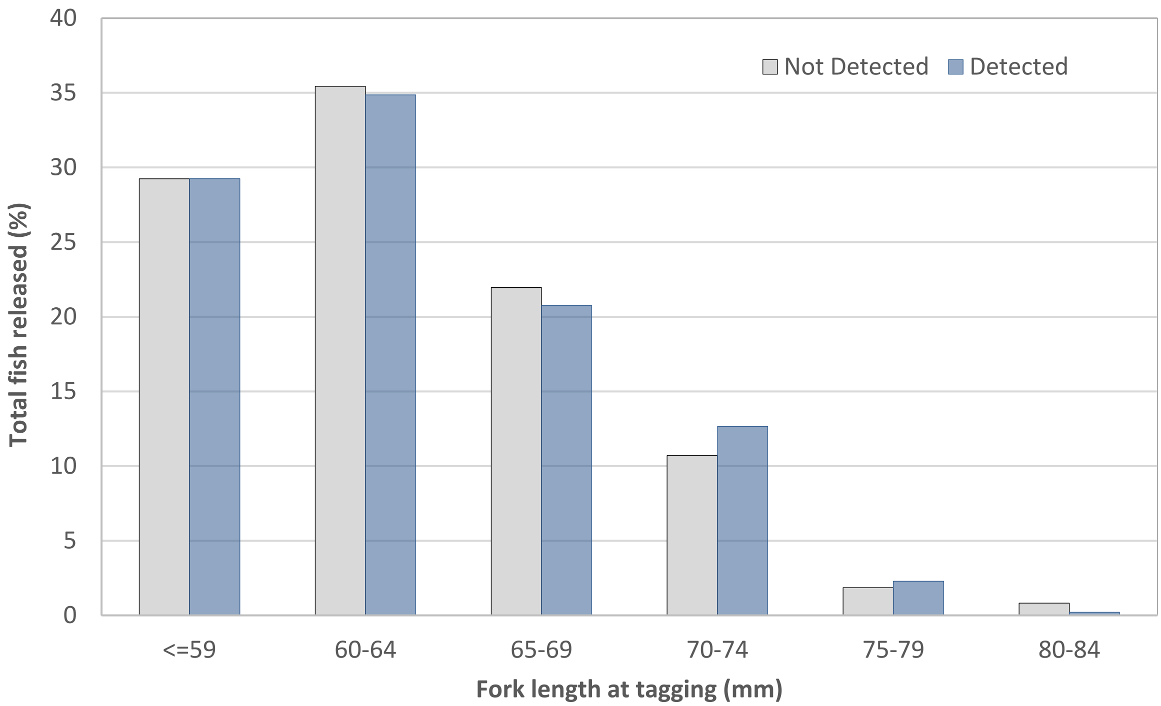


Figure 7. Distributions of fork length by 5-mm length bin for wild spring/summer Chinook salmon parr PIT-tagged and released in Idaho streams, 2022. Gray bars represent percentages not detected (n = 3,543) and blue bars represent percentages detected at Lower Granite Dam in spring/summer 2023 (n = 551).

# Discussion

Annual parr-to-smolt survival estimates have ranged 7.9-25.4% for Idaho stream populations studied over the past 30 years. Similar to past years, survival to Lower Granite Dam for fish that were detected on instream monitors was considerably higher than that of fish never seen on the instream monitors (Table 6). Fish from all streams combined had an overall parr-to-smolt survival rate of 15.2% averaged over all years (Figure 8). During 2023, we estimated an overall survival of 17.0%, which was above the median survival rate across all years of the study. However, this survival rate represents fish from only five sampling locations (compared to potentially 16 locations in certain years).

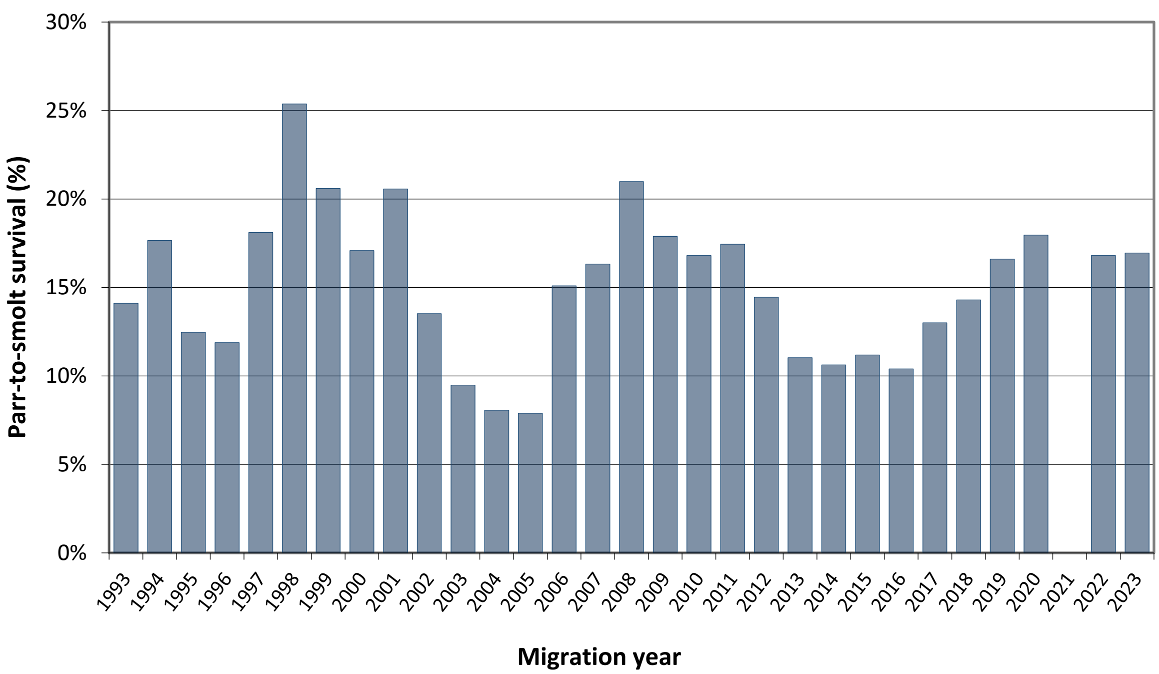


Figure 8. Overall estimated rates of parr-to-smolt survival for wild spring/summer Chinook salmon from all streams combined, 1993-2023. Standard errors ranged 0.3-2.5% over all years and averaged 0.8%.

Annual average data continues to indicate a potential inverse relationship between parr-to-smolt survival and parr density (Figure 15). Achord et. al. (2003b) hypothesized that observed density dependence may stem from a shortage of marine-derived nutrients, which is directly related to the number of returning adults to each stream. In years with low numbers of returning adults, the carrying capacity for juvenile rearing is limited, effecting the parr-to-smolt survival.

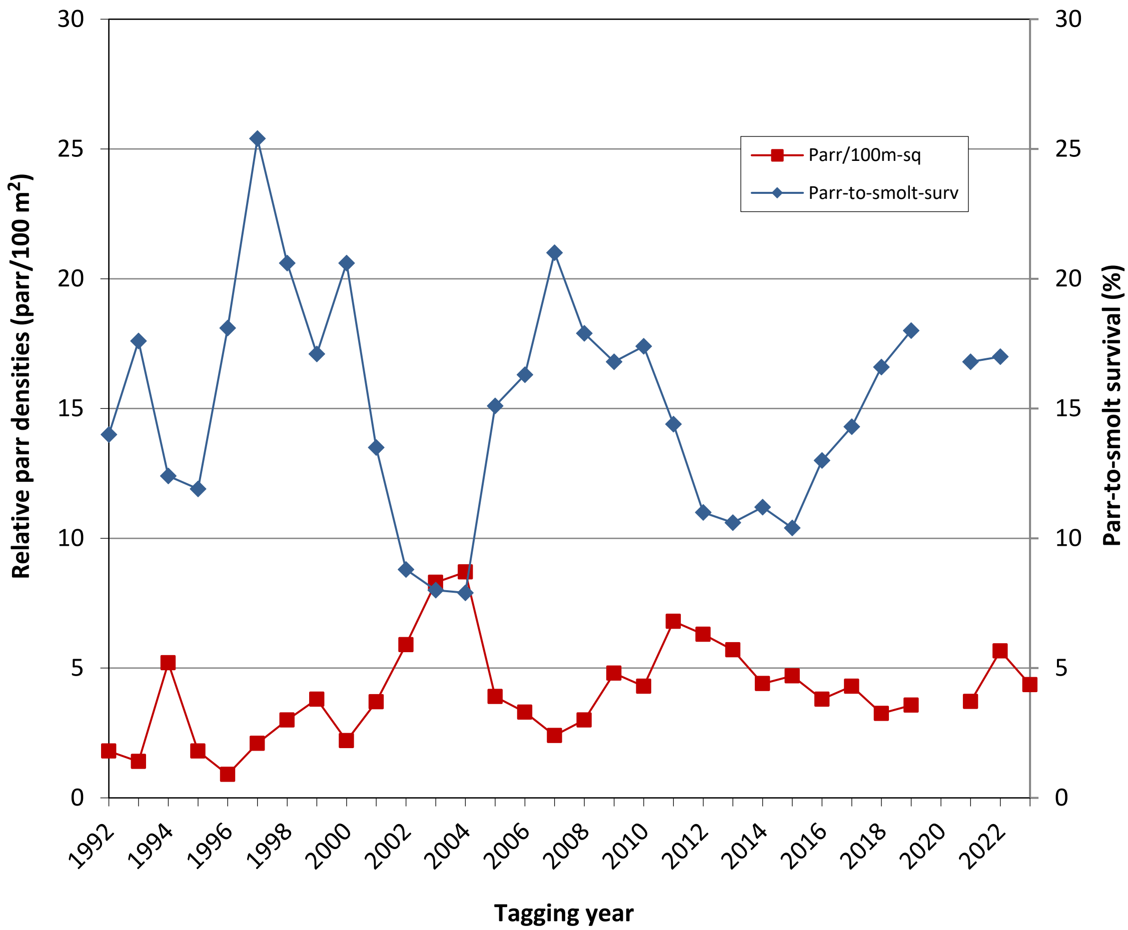


Figure 9. Annual average density of Chinook salmon parr (parr/100 $m^2$) in Idaho streams vs. annual estimated survival of smolts from these streams to Lower Granite Dam the following year, 1992 to 2023 (excluding 2020, when no fish were collected).

# Arrival Timing at Lower Granite Dam

## Methods

For each stream population, we estimated arrival timing at Lower Granite Dam based on detections of tagged study fish at the dam. Variation in arrival timing was expected because stream populations vary in size and streams vary in temperature, elevation, and mean flow.

To estimate arrival time, we used expanded detection data as described in the methods section, *Estimates of parr-to-smolt survival*. We pooled daily detections at Lower Granite Dam and divided each daily detection total by its corresponding daily detection probability estimate. Arrival timing at the dam was then calculated based on dates from the expanded detections, with passage dates of the 10th, median, and 90th percentile calculated for each stream population.

We compared arrival timing at Lower Granite Dam among individual populations and among years to determine trends and similarities or differences between years and populations. Comparisons of the 10th, 50th, and 90th percentile passage dates were made among streams using a two-factor analysis of variance (ANOVA), where year was considered a random factor and stream a fixed factor. Residuals were visually examined to assess normality. Treatment means were compared using Fisher's least significant difference procedure (Peterson 1985) with $\alpha = 0.05$.

## Results

### *Dates of arrival at Lower Granite Dam*

In 2023, arrival timing of tagged fish at Lower Granite Dam varied among Idaho stream populations (Figure 10). Fish from the Cape Horn Creek were the first to arrive, while fish from Elk Creek arrived later than fish from all other streams. For populations from all streams combined, the median passage date at Lower Granite was very similar to timing in 2020 and 2022, occurring from late April to late May (Figure 10; Tables 7-8).

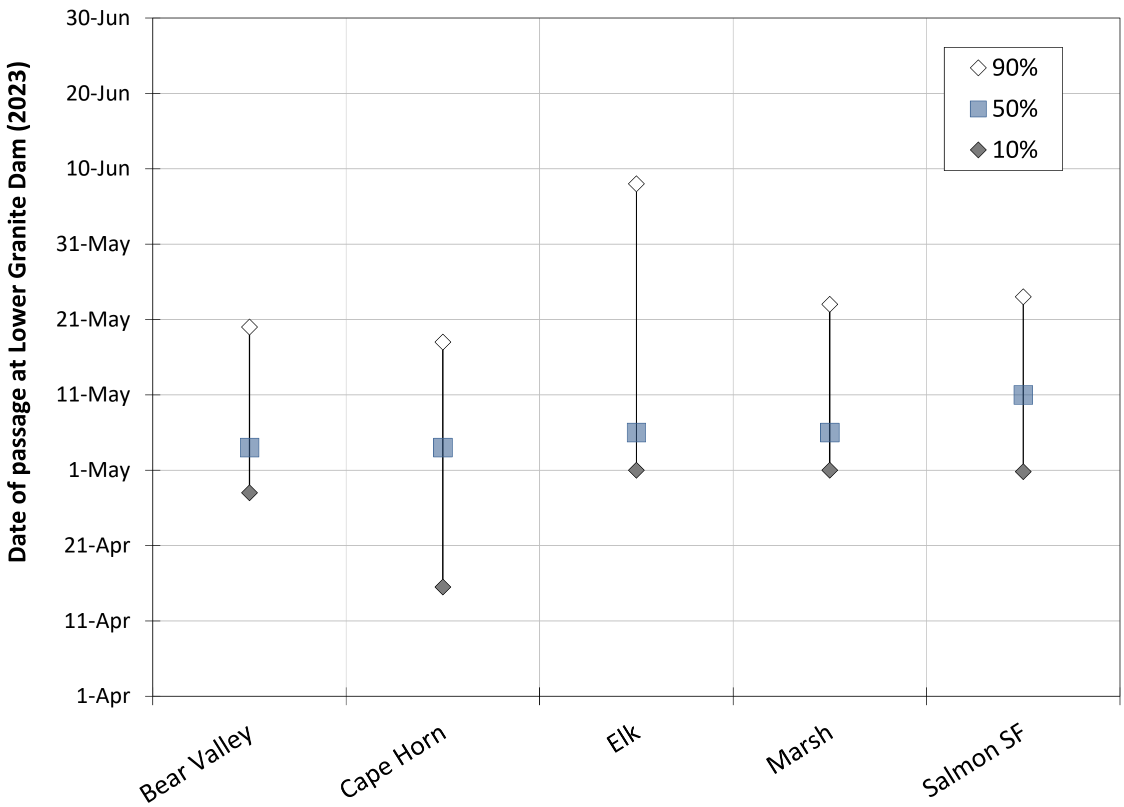


Figure 10. Estimated passage distribution dates at Lower Granite Dam from earliest to latest in 2023 for wild spring/summer Chinook salmon smolts tagged in Idaho streams. See Appendix Tables 3-7 for daily estimated passage numbers.

For fish from the 16 sample sites studied for 15 years or more, detection data at Lower Granite Dam has shown clear patterns among stream populations in timing of the 10th, 50th, and 90th passage percentiles (Table 7). Timing of the 10th passage percentile at Lower Granite Dam was significantly earlier for fish from the Secesh River than for fish from all other streams, with the exception of Lake Creek.

Dates of the 50th passage percentile at Lower Granite Dam have been significantly later for fish from Upper Big Creek than for fish from all other streams. Over all study years, the Upper Big Creek population has also been one of the latest arriving groups in comparisons of the 90th passage percentile; only the Valley Creek and South Fork Salmon River populations have been comparable.

Table 7. Percentile passage dates at Lower Granite Dam by stream population of wild spring/summer Chinook salmon smolts tagged as parr in Idaho streams the previous summer. Statistics for each stream are constructed using only migration years that stream was sampled from 1989 to 2023 (streams sampled during 2023 are highlighted in gray). For each stream population, 95% confidence intervals (CIs) for each passage percentile are included with standard errors (SEs). Streams in **boldface font** indicate those sampled in 2022-23 and discussed in this report.

| | Dates of passage at Lower Granite Dam by population percentile | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 10th percentile | | | 50th percentile | | | 90th percentile | | | |
| Stream | Mean date | 95% CI | SE (d) | Mean date | 95% CI | SE (d) | Mean date | 95% CI | SE (d) | Total study years (n) |
| Secesh River | 14 Apr | 11-16 Apr | 1 | 25 Apr | 23-28 Apr | 1 | 24 May | 18-30 May | 3 | 32 |
| **S Fork Salmon R** | **18 Apr** | **16-21 Apr** | **1** | **6 May** | **3-9 May** | **1** | **29 May** | **24 May-2 Jun** | **2** | **31** |
| **Bear Valley Cr** | **21 Apr** | **18-23 Apr** | **1** | **6 May** | **3-8 May** | **1** | **28 May** | **24 May-31 May** | **2** | **31** |
| Valley Creek | 23 Apr | 19-26 Apr | 2 | 9 May | 6-12 May | 2 | 31 May | 27 May-4 Jun | 2 | 30 |
| **Elk Creek** | **19 Apr** | **17-22 Apr** | **1** | **3 May** | **1 May-6 May** | **1** | **26 May** | **22-29 May** | **2** | **30** |
| Lake Creek | 15 Apr | 13-18 Apr | 1 | 28 Apr | 25 Apr-1 May | 1 | 26 May | 21 May-1 Jun | 3 | 28 |
| Big Cr (upper) | 28 Apr | 25 Apr-1 May | 1 | 16 May | 12-19 May | 2 | 2 Jun | 27 May-7 Jun | 3 | 27 |
| **Marsh Creek** | **20 Apr** | **17-22 Apr** | **1** | **3 May** | **30 Apr-6 May** | **1** | **21 May** | **18-24 May** | **1** | **26** |
| Loon Creek | 25 Apr | 22-28 Apr | 2 | 6 May | 2-9 May | 2 | 18 May | 14-21 May | 2 | 22 |
| **Cape Horn Cr** | **22 Apr** | **19-26 Apr** | **2** | **8 May** | **4-12 May** | **2** | **25 May** | **20-30 May** | **2** | **22** |
| Chamberlain Cr | 20 Apr | 17-24 Apr | 2 | 30 Apr | 26 Apr-3 May | 2 | 21 May | 14-27 May | 3 | 16 |

Table 8. Mean annual passage dates at Lower Granite Dam for the past 10 years (2014-2023) for combined stream populations of wild spring/summer Chinook salmon smolts PIT tagged the previous summers as parr. For all study years (1989-2023), average dates for the 10th, 50th, and 90th passage percentiles were 20 April, 4 May, and 25 May, respectively.

| | Timing of passage percentiles at Lower Granite Dam | | | |
|---|---|---|---|---|
| Year | 10th | 50th | 90th | Range |
| 2014 | 17 Apr | 28 Apr | 19 May | 25 Mar-15 Jun |
| 2015 | 20 Apr | 30 Apr | 14 May | 25 Mar-12 Jun |
| 2016 | 13 Apr | 24 Apr | 12 May | 24 Mar-9 Jun |
| 2017 | 12 Apr | 23 Apr | 15 May | 23 Mar-6 Jun |
| 2018 | 14 Apr | 29 Apr | 14 May | 1 Apr-8 Jun |
| 2019 | 13 Apr | 29 Apr | 17 May | 28 Mar-24 Jun |
| 2020 | 25 Apr | 5 May | 26 May | 4 Apr-5 Jul |
| 2021 | --- | --- | --- | --- |
| 2022 | 29 Apr | 10 May | 28 May | 7 Apr-5 Jul |
| 2023 | 27 Apr | 6 May | 24 May | 12 Apr-5 Jul |
| 10-year average | 19 Apr | 30 Apr | 19 May | 23 Mar-5 Jul |
| All-year average | 20 April | 4 May | 25 May | 23 Mar-22 Sept |

## *Flow Volume vs. Arrival Timing at Lower Granite Dam*

To examine potential relationships between flow levels and arrival timing at Lower Granite Dam, we used first-time detections at Lower Granite Dam for tagged fish from all streams combined. First detections at Lower Granite were expanded using the same methods described previously in *Estimates of parr-to-smolt survival*.

We then visually compared the temporal distribution of expanded detections with river flows during the same period (Figure 11; Appendix Table 8). Overall, the passage distribution of first detections ranged from mid-April to early July 2023, with the middle 80th percentile occurring during the 28-d period from 27 April to 24 May (Table 7). Peak passage dates were also estimated using expanded detections, and these occurred from 3 to 5 May during a period of elevated flow at the dam (Figure 11; Appendix Table 8).

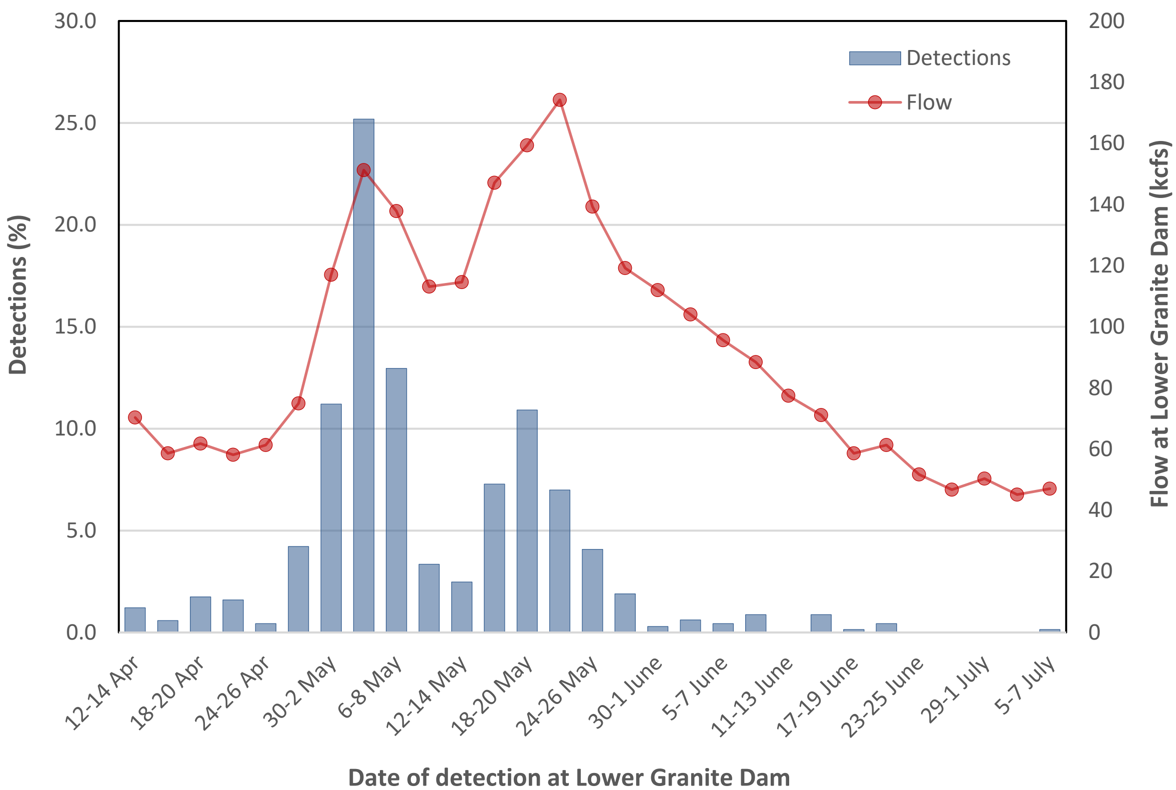


Figure 11. Overall migration timing of PIT-tagged wild spring/summer Chinook salmon smolts with associated river flows at Lower Granite Dam, 2023. Daily detections from all streams were expanded based on daily detection probability and pooled in 3-d intervals. Daily river flows at the dam were averaged over the same intervals.

# Discussion

For fish detected on instream monitoring systems, the relationship between length at tagging and movement downstream has varied widely (Achord et al. 1994; 1995a,b; 1996; 1997-1998; 2000; 2001a,b; 2002; 2003-2006;, 2007a,b; 2008-2012; Lamb et al. 2013-2017; 2018a,b,c; 2019a,b; 2021; 2023). Results over all study years have shown that initiation of movement from natal rearing streams to larger rivers by parr, pre-smolts, and smolts is probably not related to parr size at tagging. However, larger tagged fish probably transition to the smolt stage earlier in spring than their smaller tagged cohorts; thus, they begin moving downstream sooner and arrive at Lower Granite Dam earlier.

Arrival timing of wild juvenile Chinook at Lower Granite Dam has continued to vary among populations from streams with and without monitoring systems, but shows some indication of a geographical component (distance from Lower Granite) linked to early arriving populations. In all study years, fish from Lake Creek and the Secesh River have arrived significantly earlier at the dam than fish from all other streams. Dates encompassing the middle 80th percentile passage period have varied from year to year and between all streams.

# Environmental Information

In 2007, Northwest Fisheries Science Center personnel published the Water Quality Baseline Environmental Monitoring website for storage and dissemination of water quality data collected during this study since 1993 (NWFSC 2007). This website was updated in January 2020 and converted to a web application.

During 2023, we were able to collect hourly water quality measurements from 8 of our 14 environmental sampling sites: Camas, Loon, Herd, Valley, Bear Valley, Lake, SF Salmon River (Knox Bridge) and upper Big Creek. Mapped over time, this information, along with weather and climate data, can provide tools to predict movement of individual wild fish populations. Such tools and information are vital to recovery planning for threatened and endangered populations of Pacific salmon.

# Acknowledgments

We thank the Bonneville Power Administration for funding this project.  Thanks also to Scott Hecht, Morgan Bond, Ron Marr, Steve Corbett, Leah Davis, Jayvoni Francis, and Ross Gleason of the National Marine Fisheries Service for their excellent assistance in collecting and PIT tagging fish for this study.

Special thanks to personnel from Nez Perce Tribe, Biomark-Merck Animal Health, and Gabriel Brooks of NOAA for troubleshooting and maintaining PIT tag arrays associated with the project.

# References


Achord, S., G. A. Axel, E. E. Hockersmith, B. P. Sandford, M. B. Eppard, and G. M. Matthews. 2001a. Monitoring the migrations of wild Snake River spring/summer Chinook salmon smolts, 1999. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.[2]

Achord, S., G. A. Axel, E. E. Hockersmith, B. P. Sandford, M. B. Eppard, and G. M. Matthews. 2001b. Monitoring the migrations of wild Snake River spring/summer Chinook salmon smolts, 2000. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.

Achord, S., G. A. Axel, E. E. Hockersmith, B. P. Sandford, M. B. Eppard, and G. M. Matthews. 2002. Monitoring the migrations of wild Snake River spring/summer Chinook salmon smolts, 2001. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.

Achord, S., M. B. Eppard, E. E. Hockersmith, B. P. Sandford, G. A. Axel, and G. M. Matthews. 2000. Monitoring the migrations of wild Snake River spring/summer Chinook salmon smolts, 1998. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.

Achord, S., M. B. Eppard, E. E. Hockersmith, B. P. Sandford, and G. M. Matthews. 1997. Monitoring the migrations of wild Snake River spring/summer Chinook salmon smolts, 1996. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.

Achord, S., M. B. Eppard, E. E. Hockersmith, B. P. Sandford, and G. M. Matthews. 1998. Monitoring the migrations of wild Snake River spring/summer Chinook salmon smolts, 1997. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.

Achord, S., M. B. Eppard, B. P. Sandford, and G. M. Matthews. 1996. Monitoring the migrations of wild Snake River spring/summer Chinook salmon smolts, 1995. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.


[2] Reports from the National Marine Fisheries Service Northwest Fisheries Science Center are available from our publications database (webapps.nwfsc.noaa.gov/apex/nwfsc/r/nwfsc_web_apex/scipubs/search) or from the NOAA Institutional Repository (https://repository.library.noaa.gov/).

Achord, S., E. E. Hockersmith, B. P. Sandford, R. A. McNatt, B. E. Feist, and G. M. Matthews. 2003a. Monitoring the migrations of wild Snake River spring/summer Chinook salmon smolts, 2002. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.

Achord, S., P. S. Levin, R. W. Zabel. 2003b. Density-dependent mortality in Pacific salmon: the ghost of impacts past? Ecology Letters, 6(4):335-342.

Achord, S., J. M. Hodge, B. P. Sandford, E. E. Hockersmith, K. W. McIntyre, N. N. Paasch, and J. G. Williams. 2005. Monitoring the migrations of wild Snake River spring/summer Chinook salmon smolts, 2004. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.

Achord, S., D. J. Kamikawa, B. P. Sandford, and G. M. Matthews. 1995a. Monitoring the migrations of wild Snake River spring/summer Chinook salmon smolts, 1993. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.

Achord, S., D. J. Kamikawa, B. P. Sandford, and G. M. Matthews. 1995b. Monitoring the migrations of wild Snake River spring/summer Chinook salmon smolts, 1994. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.

Achord, S., G. M. Matthews, D. M. Marsh, B. P. Sandford, and D. J. Kamikawa. 1994. Monitoring the migrations of wild Snake River spring and summer Chinook salmon smolts, 1992. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.

Achord, S., R. A. McNatt, E. E. Hockersmith, B. P. Sandford, K. W. McIntyre, N. N. Paasch, J. G. Williams, and G. M. Matthews. 2004. Monitoring the migrations of wild Snake River spring/summer Chinook salmon smolts, 2003. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.

Achord, S., B. P. Sandford, E. E. Hockersmith, J. M. Hodge, K. W. McIntyre, N. N. Paasch, L. G. Crozier, and J. G. Williams. 2006. Monitoring the migrations of wild Snake River spring/summer Chinook salmon juveniles, 2004-2005. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.

Achord, S., B. P. Sandford, E. E. Hockersmith, J. J. Lamb, K. W. McIntyre, N. N. Paasch, and R. W. Zabel. 2012. Monitoring the migrations of wild Snake River spring/summer Chinook salmon juveniles, 2010-2011. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.

Achord, S., B. P. Sandford, E. E. Hockersmith, K. W. McIntyre, N. N. Paasch, and J. G. Williams. 2007a. Monitoring the migrations of wild Snake River spring/summer Chinook salmon juveniles, 2005-2006. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.

Achord, S., B. P. Sandford, E. E. Hockersmith, M. G. Nesbit, N. D. Dumdei, J. J. Lamb, K. W. McIntyre, N. N. Paasch, and J. G. Williams. 2008. Monitoring the migrations of wild Snake River spring/summer Chinook salmon juveniles, 2006-2007. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.

Achord, S., B. P. Sandford, E. E. Hockersmith, M. G. Nesbit, N. D. Dumdei, J. J. Lamb, K. W. McIntyre, N. N. Paasch, and J. G. Williams. 2009. Monitoring the migrations of wild Snake River spring/summer Chinook salmon juveniles, 2007-2008. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.

Achord, S., B. P. Sandford, E. E. Hockersmith, M. G. Nesbit, N. D. Dumdei, J. J. Lamb, K. W. McIntyre, N. N. Paasch, and J. G. Williams. 2010. Monitoring the migrations of wild Snake River spring/summer Chinook salmon juveniles, 2008-2009. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.

Achord, S., B. P. Sandford, E. E. Hockersmith, M. G. Nesbit, N. D. Dumdei, J. J. Lamb, K. W. McIntyre, N. N. Paasch, S. G. Smith, and R. W. Zabel. 2011. Monitoring the migrations of wild Snake River spring/summer Chinook salmon juveniles, 2009-2010. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.

Achord, S., R. W. Zabel, and B. P. Sandford. 2007b. Migration timing, growth, and estimated parr-to-smolt survival rates of wild Snake River spring/summer Chinook salmon from the Salmon River basin, Idaho, to the lower Snake River. Transactions of the American Fisheries Society 136:142-154.

Axel, G. A., D. Widener, S.G. Smith, M.G. Nesbit, and B.P. Sandford. 2023. Post-construction assessment of passive integrated transponder detection efficiencies in Spillbay 1 at Lower Granite Dam, 2022. Report of the National Marine Fisheries Service to the U.S. Army Corps of Engineers, Walla Walla Washington.

Connolly, P. J., I. G. Jezorek, and K. D. Martens. 2008. Measuring the performance of two stationary interrogation systems for detecting downstream and upstream movement of PIT-tagged salmonids. North American Journal of Fisheries Management 28:402-417.

Cormack, R. M. 1964. Estimates of survival from the sightings of marked animals. Biometrika 51:429-438.

Downing, S. L., E. F. Prentice, B. W. Peterson, E. P. Nunnallee, and B. F. Jonasson. 2001. Development and evaluation of passive integrated transponder tag technology, annual report: 1999 to 2000. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.

Jolly, G. M. 1965. Explicit estimates from capture-recapture data with both death and immigration—stochastic model. Biometrika 52:225-247.

Kareiva, P., M. Marvier, and M. McClure. 2000. Recovery and management options for spring/summer Chinook salmon in the Columbia River Basin. Science 290:290:977-979.

Lamb, J. J., S. Achord, B. P. Sandford, G. A. Axel, M. G. Nesbit, K. W. McIntyre, and B. L. Sanderson. 2013. Monitoring the migrations of wild Snake River spring/summer Chinook salmon juveniles, 2011-2012. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.

Lamb, J. J., B. P. Sandford, G. A. Axel, M. G. Nesbit, and B. L. Sanderson. 2018a. Monitoring the migrations of wild Snake River spring/summer Chinook salmon juveniles: fish collection and tagging, 2017. Report of the National Marine Fisheries Service to Bonneville Power Administration, Portland, OR.

Lamb, J. J., B. P. Sandford, G. A. Axel, M. G. Nesbit, and B. L. Sanderson. 2018c. Monitoring the migrations of wild Snake River spring/summer Chinook salmon juveniles: fish collection and tagging, 2018. Report of the National Marine Fisheries Service to Bonneville Power Administration, Portland, OR.

Lamb, J. J., B. P. Sandford, G. A. Axel, M. G. Nesbit, and B. L. Sanderson. 2019b. 9Monitoring the migrations of wild Snake River spring/summer Chinook salmon juveniles: fish collection and tagging, 2019. Report of the National Marine Fisheries Service to Bonneville Power Administration, Portland, OR.

Lamb, J. J., B. P. Sandford, G. A. Axel, M. G. Nesbit, and B. L. Sanderson. 2023a. Monitoring the migrations of wild Snake River spring/summer Chinook salmon juveniles: fish collection and tagging, 2021. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.

Lamb, J. J., B. P. Sandford, G. A. Axel, S.G. Smith, M. G. Nesbit, and B. L. Sanderson. 2014. Monitoring the migrations of wild Snake River spring/summer Chinook salmon juveniles, 2012 2013. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.

Lamb, J. J., B. P. Sandford, G. A. Axel, S.G. Smith, M. G. Nesbit, and B. L. Sanderson. 2015. Monitoring the migrations of wild Snake River spring/summer Chinook salmon juveniles, 2013-2014. Report of the National Marine Fisheries Service to the Bonneville Power Administration, Portland, OR.

Lamb, J. J., B. P. Sandford, G. A. Axel, S. G. Smith, M. G. Nesbit, and B. L. Sanderson. 2016. Monitoring the migrations of wild Snake River spring/summer Chinook salmon juveniles, 2014-2015. Report of the National Marine Fisheries Service to Bonneville Power Administration, Portland, OR.

Lamb, J. J., B. P. Sandford, G. A. Axel, S. G. Smith, M. G. Nesbit, and B. L. Sanderson. 2017. Monitoring the migrations of wild Snake River spring/summer Chinook salmon juveniles, 2015-2016. Report of the National Marine Fisheries Service to Bonneville Power Administration, Portland, OR.

Lamb, J. J., B. P. Sandford, G. A. Axel, S. G. Smith, M. G. Nesbit, and B. L. Sanderson. 2018b. Monitoring the migrations of wild Snake River spring/summer Chinook salmon juveniles: survival and timing, 2017. Report of the National Marine Fisheries Service to Bonneville Power Administration, Portland, OR.

Lamb, J. J., B. P. Sandford, G. A. Axel, S. G. Smith, M. G. Nesbit, and B. L. Sanderson. 2019a. Monitoring the migrations of wild Snake River spring/summer Chinook salmon juveniles: survival and timing, 2018. Report of the National Marine Fisheries Service to Bonneville Power Administration, Portland, OR.

Lamb, J. J., B. P. Sandford, G. A. Axel, S. G. Smith, M. G. Nesbit, and B. L. Sanderson. 2021. Monitoring the migrations of wild Snake River spring/summer Chinook salmon juveniles: survival and timing, 2020. Report of the National Marine Fisheries Service to Bonneville Power Administration, Portland, OR.

Lamb, J. J., B. P. Sandford, G. A. Axel, S. G. Smith, M. G. Nesbit, and B. L. Sanderson. 2023. Monitoring the migrations of wild Snake River spring/summer Chinook salmon juveniles: survival and timing, 2022. Report of the National Marine Fisheries Service to Bonneville Power Administration, Portland, OR.

Ledgerwood, R. D., B. A. Ryan, E. M. Dawley, E. P. Nunnallee, and J. W. Ferguson. 2004. A surface trawl to detect migrating juvenile salmonids tagged with passive integrated transponder tags. North American Journal of Fisheries Management 24:440-451.

Prentice, E. F., T. A. Flagg, C. S. McCutcheon. 1990a. Feasibility of using implantable passive integrated transponder (PIT) tags in salmonids. Pages 317-322 *in* Parker, N. C., A. E. Giorgi, R. C. Heidinger, D. B. Jester, E. D. Prince, G. A. Winans (Eds). Fish-Marking Techniques. American Fisheries Society Symposium 7. Bethesda, Maryland.

Prentice, E. F., T. A. Flagg, C. S. McCutcheon. 1990b. PIT tag monitoring systems for hydroelectric dams and fish hatcheries. Pages 323-334 *in* Parker, N. C., A. E. Giorgi, R. C. Heidinger, D. B. Jester, E. D. Prince, G. A. Winans (Eds). Fish marking techniques. American Fisheries Society Symposium 7. Bethesda, Maryland.

Prentice, E. F., T. A. Flagg, C. S. McCutcheon, D. F. Brastow, D. C. Cross. 1990c. Equipment, methods, and an automated data-entry station for PIT tagging. Pages 335-340 *in* Parker, N. C., A. E. Giorgi, R. C. Heidinger, D. B. Jester, E. D. Prince, G. A. Winans (Eds). Fish-Marking Techniques. American Fisheries Society Symposium 7. Bethesda, Maryland.

PSMFC (Pacific States Marine Fisheries Commission). 1996. The Columbia Basin PIT Tag Information System. Interactive database available at www.ptagis.org.

Magie, R. J., M. S. Morris, R. D. Ledgerwood, A. Cook, B. P. Sandford, and G. M. Matthews. 2010. Detection of PIT-tagged juvenile salmonids in the Columbia River estuary using pair-trawls, 2008. Report of the National Marine Fisheries Service to the U.S. Army Corps of Engineers. Walla Walla, Washington.

Matthews, G. M., N. N. Paasch, S. Achord, K. W. McIntyre, and J. R. Harmon. 1997. A technique to minimize the adverse effects associated with handling and marking salmonid smolts. The Progressive Fish-Culturist 59:307-309.

Matthews, G. M., J. R. Harmon, S. Achord, O. W. Johnson, and L. A. Kubin. 1990. Evaluation of transportation of juvenile salmonids and related research on the Snake and Columbia Rivers, 1989. Report to the U.S. Army Corp of Engineers.

Morris, M. S., L. N. Webb, P. J. Bentley, A. J. Borsky, B. P. Sandford, and R. D. Ledgerwood. 2015. Detection of PIT-tagged juvenile salmonids in the Columbia River estuary using pair-trawls, 2015. Report of the National Marine Fisheries Service to the U.S. Army Corps of Engineers. Walla Walla, Washington.

NMFS (National Marine Fisheries Service). 2008. Endangered Species Act Section 7(a)(2) Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation: NOAA Log number F/NWR/2005/05883. 333

NMFS (National Marine Fisheries Service). 2016. 5-Year review: Summary & evaluation of Snake River sockeye, Snake River spring/summer Chinook, Snake River fall-run Chinook, Snake River Basin steelhead. National Marine Fisheries Service, West Coast Region.

NMFS (National Marine Fisheries Service). 2020. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response: Continued Operation and Maintenance of the Columbia River System. NMFS Consultation: WCRO 2020-00113

NWFSC (Northwest Fisheries Science Center). 2007. The baseline water quality environmental monitoring program. Online database available at *www.webapps.nwfsc.noaa.gov/WaterQuality/.*

Sandford, B. P., and S. G. Smith. 2002. Estimation of smolt-to-adult return percentages for Snake River Basin anadromous salmonids, 1990-1997. Journal of Agricultural, Biological, and Environmental Statistics 7(2):243-263.

Schaefer, M. B. 1951. Estimation of the size of animal populations by marking experiments. U.S. Fish and Wildlife Service Fishery Bulletin 52:191-203.

Seber, G. A. F. 1965. A note on the multiple recapture census. Biometrika 52:249-259.

# Appendix

Appendix Table 1. Summary of numbers collected, tagged, released (with tags), and minimum, maximum, and mean lengths and weights of wild Chinook salmon parr, collected and PIT tagged in various Idaho streams, 2022. Some length-weight data includes recaptured tagged fish and precocious Chinook.

| | Fish (n) | | | Collection | | | | Tagging and release | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Length (mm) | | Weight (g) | | Length (mm) | | Weight (g) | |
| | Collected | Tagged | Released | Range | Mean | Range | Mean | Range | Mean | Range | Mean |
| Marsh Creek | 1,774 | 999 | 999 | 38-136 | 57.8 | 0.5-36.2 | 2.7 | 54-82 | 61.0 | 0.8-7.2 | 2.7 |
| Cape Horn Creek | 1,271 | 248 | 248 | 30-121 | 55.0 | 0.8-26.4 | 4.0 | 55-75 | 61.0 | 1.3-5.6 | 2.7 |
| Bear Valley Creek | 1,109 | 1,063 | 1,063 | 43-125 | 66.0 | 1.3-5.6 | 2.7 | 54-85 | 66.0 | 1.7-8.4 | 3.7 |
| Elk Creek | 569 | 559 | 559 | 53-153 | 65.0 | 1.2-30.5 | 3.5 | 54-81 | 65.0 | 1.2-6.7 | 3.4 |
| S Fork Salmon River | 2,044 | 1,190 | 1,182 | 39-134 | 58.0 | 0.8-36 | 2.8 | 53-95 | 61.0 | 1.2-6.5 | 2.7 |
| **Total or mean** | **6,767** | **4,059** | **4,051** | **30-153** | **60.4** | **0.5-36.2** | **3.1** | **53-95** | **62.8** | **0.8-8.4** | **3.0** |

Appendix Table 2. Cumulative passage dates at Lower Granite Dam by stream of origin for tagged wild spring/summer Chinook salmon smolts over the past 10 years.

| | Percentile passage dates at Lower Granite Dam | | | |
|---|---|---|---|---|
| Year | 10th | 50th | 90th | Range |
| **Bear Valley Creek** | | | | |
| 2014 | 17 April | 11 May | 12 June | 13 April-15 June |
| 2015 | 20 April | 27 April | 2 June | 13 April-2 June |
| 2016 | 13 April | 26 April | 12 May | 12 April-31 May |
| 2017 | 13 April | 25 April | 24 May | 9 April-5 June |
| 2018 | 17 April | 30 April | 12 May | 12 April-30 May |
| 2019 | 14 April | 30 April | 17 May | 1 April-6 June |
| 2020 | 24 April | 5 May | 3 June | 16 April-26 June |
| 2021[a] | --- | --- | --- | --- |
| 2022 | 30 April | 15 May | 7 June | 28 April-22 June |
| **2023** | **28 April** | **4 May** | **20 May** | **12 April-27 May** |
| **Elk Creek** | | | | |
| 2014 | 17 April | 25 April | 22 May | 14 April-9 June |
| 2015 | 18 April | 27 April | 11 May | 2 April-19 May |
| 2016 | 14 April | 27 April | 13 May | 27 March-25 May |
| 2017 | 6 April | 19 April | 13 May | 31 March-4 June |
| 2018 | 11 April | 27 April | 18 May | 8 April-3 June |
| 2019 | 17 April | 13 May | 4 June | 12 April-4 June |
| 2020 | 23 April | 5 May | 27 May | 10 April-25 June |
| 2021[a] | --- | --- | --- | --- |
| 2022 | 22 April | 6 May | 28 May | 20 April-20 June |
| **2023** | **1 May** | **6 May** | **8 June** | **30 April-15 June** |
| **Marsh Creek** | | | | |
| 2014 | 19 April | 28 April | 22 May | 15 April-31 May |
| 2015 | 19 April | 25 April | 19 May | 19 April-19 May |
| 2016 | 14 April | 27 April | 9 May | 10 April-18 May |
| 2017 | 10 April | 22 April | 10 May | 3 April-28 May |
| 2018 | 14 April | 29 April | 11 May | 10 April-21 May |
| 2019[a] | --- | --- | --- | --- |
| 2020 | 23 April | 30 April | 15 May | 7 April-15 May |
| 2021[a] | --- | --- | --- | --- |
| 2022 | 5 May | 12 May | 26 May | 27 April-13 June |
| **2023** | **1 May** | **6 May** | **23 May** | **20 April-July 5** |
| **Cape Horn Creek** | | | | |
| 2014 | 20 April | 2 May | 21 May | 15 April-9 June |
| 2015 | 25 April | 2 May | 11 May | 12 April-17 May |
| 2016 | 13 April | 21 April | 9 May | 8 April-14 May |
| 2017 | 15 April | 27 April | 14 May | 9 April-27 May |
| 2018 | 19 April | 3 May | 18 May | 16 April-6 June |
| 2019[a] | --- | --- | --- | --- |
| 2020 | 4 May | 19 May | 3 June | 2 May-1 June |
| 2021[a] | --- | --- | --- | --- |
| 2022 | 2 May | 15 May | 27 May | 13 April-27 June |
| **2023** | **15 April** | **4 May** | **18 May** | **14 April-24 May** |

Appendix Table 2. Continued.

| Year | Percentile passage dates at Lower Granite Dam | | | |
|---|---|---|---|---|
| | 10th | 50th | 90th | Range |
| **South Fork Salmon River** | | | | |
| 2014 | 12 April | 26 April | 23 May | 1 April-4 June |
| 2015 | 4 April | 23 April | 11 May | 4 April-11 May |
| 2016 | 11 April | 15 April | 26 April | 5 April-25 May |
| 2017 | 11 April | 21 April | 9 May | 1 April-26 May |
| 2018 | 14 April | 4 May | 13 May | 4 April-24 May |
| 2019 | 15 April | 5 May | 1 June | 2 April-6 June |
| 2020 | 24 April | 3 May | 23 May | 19 April-1 June |
| 2021[a] | --- | --- | --- | --- |
| 2022 | 29 April | 9 May | 27 May | 14 April-1 June |
| **2023** | **1 May** | **11 May** | **24 May** | **18 April-22 June** |

[a] No parr were tagged the summer prior to this migration year.

[b] Insufficient numbers detected to estimate timing.

Appendix Table 3. Detections during 2023 of PIT-tagged smolts by date at Snake and Columbia River dams for 1,063 wild Chinook salmon from Bear Valley Creek released 22-23 July 2022. Release sites were 629-635 km above Lower Granite Dam. One fish was also detected on the lower Columbia River PIT Trawl (TWX) 30 May 2023.

| | **Bear Valley Creek** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Detection | Lower Granite | | | First detection | | | | | |
| date (2023) | Spill | Bypass | Expanded | Little Goose | Lower Monumental | Ice Harbor | McNary | John Day | Bonneville |
| 12 Apr | | 1 | 3 | | | | | | |
| 18 Apr | 1 | | 4 | | | | | | |
| 22 Apr | | 1 | 3 | 2 | | | | | |
| 23 Apr | | 2 | 5 | | | | | | |
| 27 Apr | | 1 | 3 | | | | | | |
| 28 Apr | 2 | 1 | 10 | | | | | | |
| 29 Apr | | 1 | 3 | | | | | | |
| 30 Apr | | 1 | 3 | | | | | | |
| 1 May | 1 | | 3 | 1 | 2 | | | | |
| 2 May | 4 | 5 | 20 | 2 | | 1 | | | |
| 3 May | 8 | 8 | 33 | 2 | | | | | |
| 4 May | 1 | 6 | 13 | 4 | 1 | | | | |
| 5 May | 4 | 2 | 12 | 3 | 4 | | | | |
| 6 May | 2 | 2 | 8 | 2 | 2 | | | | |
| 7 May | 1 | 2 | 6 | 2 | 1 | | | | |
| 8 May | 1 | 2 | 7 | 1 | 1 | | | | |
| 9 May | | 1 | 2 | | 1 | | | | |
| 10 May | | | | 2 | 2 | 1 | | 1 | |
| 11 May | | | | 2 | 1 | | | | |
| 13 May | 1 | | 2 | 1 | | | | | |
| 14 May | | 1 | 3 | | | | 1 | | |
| 15 May | 1 | 1 | 5 | | 1 | | | | 1 |
| 16 May | 1 | 1 | 5 | | 2 | | | | |
| 17 May | 1 | 2 | 8 | 1 | | | | | |
| 18 May | 2 | 2 | 9 | | | | | 1 | |
| 19 May | 2 | 1 | 7 | | | | | | |
| 20 May | | 1 | 2 | | | | | | |
| 21 May | | 1 | 5 | | | | | 1 | |
| 22 May | | | | 1 | | | | | |
| 23 May | 1 | 1 | 5 | | | | | | |
| 24 May | | | | | | | | | 1 |
| 25 May | 1 | | 2 | 1 | | | | | |
| 26 May | 1 | | 2 | | | | | | 1 |
| 27 May | | 2 | 4 | 1 | | | | | |
| 28 May | | | | | | | | 1 | |
| 29 May | | | | | | | | | |
| 30 May | | | | | | | | | 1 |
| **Total** | **36** | **50** | **197** | **28** | **18** | **2** | **1** | **4** | **4** |

Appendix Table 4. Detections during 2023 of PIT-tagged smolts by date at four Snake River dams and three Columbia River dams for 559 wild Chinook salmon from Elk Creek released 23-24 July 2022. Release sites were 634-638 km above Lower Granite Dam. One fish was also detected on a lower Columbia River Pile Dike (PD6) 30 May 2023.

| | **Elk Creek** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Detection | Lower Granite | | | First detection | | | | | |
| date (2023) | Spill | Bypass | Expanded | Little Goose | Lower Monumental | Ice Harbor | McNary | John Day | Bonneville |
| 20 Apr | | | | 1 | | | | | |
| 25 Apr | | | | 1 | | | | | |
| 27 Apr | | | | 1 | | | | | |
| 29 Apr | | | | 1 | | | | | |
| 30 Apr | 1 | | 3 | | | | | | |
| 1 May | 1 | 2 | 8 | 1 | | | | | |
| 2 May | 1 | 1 | 4 | 1 | 1 | | | | |
| 3 May | 2 | 4 | 12 | | 2 | | | | |
| 4 May | | 2 | 4 | 2 | | | | | |
| 5 May | 1 | 1 | 4 | 1 | 1 | | | | |
| 6 May | | 2 | 4 | 1 | | | | | |
| 7 May | | | | 3 | 2 | | | | |
| 8 May | | 1 | 2 | | 2 | | | | |
| 10 May | | | | 1 | 1 | | | | |
| 11 May | | | | | | | | | |
| 13 May | | 1 | 2 | | | | | | |
| 14 May | | 1 | 3 | | | | | | |
| 15 May | | | | | | | | | |
| 16 May | 1 | | 2 | | | | | | |
| 18 May | 1 | | 2 | | | | | | |
| 19 May | 1 | 1 | 5 | | | | | | |
| 20 May | | | | | | | | | |
| 21 May | 1 | | 2 | | | | | | |
| 22 May | | | | 1 | | | 1 | | |
| 23 May | | | | | | | | 1 | |
| 24 May | | 2 | 4 | 2 | | | | | |
| 25 May | 1 | | 2 | | | | | | |
| 26 May | | | | 2 | | | | | |
| 27 May | | 1 | 2 | | | | | | |
| 28 May | | | | | | | | | |
| 30 May | | | | | | | | | |
| 6 June | 1 | | 3 | | | | | | 1 |
| 8 June | 1 | | 3 | | | | | | |
| 14 June | 1 | | 3 | | | | | | |
| 15 June | 1 | | 3 | | | | | | |
| **Total** | **15** | **19** | **79** | **20** | **9** | **0** | **1** | **1** | **1** |

Appendix Table 5. Detections during 2023 of PIT-tagged smolts by date at four Snake River dams and three Columbia River dams for 1,182 wild Chinook salmon from South Fork Salmon River released 26-27 July 2022. Release sites were 467-469 km above Lower Granite Dam.

| | **South Fork Salmon River** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Detection | Lower Granite | | | First detection | | | | | |
| date (2023) | Spill | Bypass | Expanded | Little Goose | Lower Monumental | Ice Harbor | McNary | John Day | Bonneville |
| 18 Apr | | 1 | 4 | | | | | | |
| 20 Apr | | | | | | | | | |
| 23 Apr | | | | 1 | | | | | |
| 27 Apr | | | | | | | | | |
| 28 Apr | 1 | 1 | 7 | | | | | | |
| 29 Apr | 1 | | 3 | | | | | | |
| 30 Apr | | | | | | | | | |
| 1 May | | | | 2 | | | | | |
| 2 May | | 2 | 4 | | 1 | | | | |
| 3 May | 4 | 1 | 10 | | 2 | | | | |
| 4 May | 2 | 2 | 8 | 3 | | | | | |
| 5 May | 2 | 2 | 8 | 2 | 2 | | | | |
| 6 May | 1 | 3 | 8 | 1 | 2 | | | | |
| 7 May | 2 | 2 | 9 | 2 | | | | | |
| 8 May | | 2 | 4 | 2 | | | | | |
| 9 May | | 1 | 2 | | | | | | |
| 10 May | 1 | 1 | 5 | | 2 | | | | |
| 11 May | | 1 | 2 | | | | | | |
| 14 May | | | | | 1 | | | | |
| 15 May | | | | 1 | 2 | | | | |
| 16 May | | 2 | 5 | 1 | 1 | | | | |
| 17 May | 2 | | 5 | | | | | | |
| 18 May | | 1 | 2 | | | | | | |
| 19 May | 1 | 2 | 7 | | | | | | |
| 20 May | 3 | 3 | 13 | | | | | | |
| 21 May | | 3 | 7 | | | | | | |
| 22 May | | 2 | 4 | | 1 | | | | |
| 23 May | 2 | 1 | 7 | | 1 | | | | |
| 24 May | 2 | 2 | 8 | | | | | | |
| 25 May | | | | | | | | | |
| 26 May | | | | 1 | | | | | |
| 27 May | | | | | | | | | |
| 28 May | | 1 | 2 | | | | | | |
| 29 May | | 1 | 1 | | | | | | 1 |
| 30 May | | | | | | | | | |
| 31 May | | 1 | 2 | | | | | | |
| 2 June | 1 | | 4 | | | | | | |
| 5 June | | | | 1 | | | | | |
| 8 June | | | | | | | 1 | | |
| 9 June | 1 | | 3 | | | | | | |
| 16 June | | | | | | | | 1 | |
| 22 June | 1 | | 1 | | | | | | |
| **Total** | **27** | **38** | **147** | **17** | **16** | **0** | **1** | **1** | **1** |

Appendix Table 6. Detections during 2023 of PIT-tagged smolts by date at four Snake River dams and three Columbia River dams for 248 wild Chinook salmon from Cape Horn Creek released 20-21 July 2022. The release site was 631 km above Lower Granite Dam.

| Detection date (2023) | Cape Horn Creek | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Lower Granite | | | First detection | | | | | |
| | Spill | Bypass | Expanded | Little Goose | Lower Monumental | Ice Harbor | McNary | John Day | Bonneville |
| 14 Apr | | 1 | 5 | | | | | | |
| 17 Apr | 1 | | 4 | | | | | | |
| 1 May | | | | 1 | | | | | |
| 2 May | 1 | 2 | 7 | | | | | | |
| 3 May | 1 | 2 | 6 | | | | | | |
| 4 May | | 4 | 8 | 1 | | | | | |
| 5 May | | 1 | 2 | | 1 | | | | |
| 6 May | 1 | 2 | 6 | 1 | | | | | |
| 7 May | | | | | | | | | |
| 8 May | 1 | | 2 | | | | | | |
| 9 May | | 1 | 2 | | | | | | |
| 10 May | | | | | 1 | | | | |
| 11 May | | | | 1 | | | | | |
| 12 May | | 1 | 2 | | | | | | |
| 13 May | | | | | | | | | |
| 14 May | | | | | | | | | 1 |
| 15 May | 1 | | 2 | | | | | | 1 |
| 16 May | 1 | | 2 | | | | | | |
| 17 May | | | | | | | | | |
| 18 May | | 1 | 2 | | | | | | |
| 19 May | | 1 | 2 | | | | | | |
| 24 May | | 1 | 2 | | 1 | | | | |
| 30 May | | | | | | | | | 1 |
| **Total** | **7** | **17** | **56** | **4** | **3** | **0** | **0** | **0** | **3** |

Appendix Table 7. Detections during 2023 of PIT-tagged smolts by date at four Snake River dams and three Columbia River dams for 999 wild Chinook salmon released from Marsh Creek, 19-20 July 2022. The release site was 631 km above Lower Granite Dam.

| | Marsh Creek | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Detection | Lower Granite | | | First detection | | | | | |
| date (2023) | Spill | Bypass | Expanded | Little Goose | Lower Monumental | Ice Harbor | McNary | John Day | Bonneville |
| 20 April | | 1 | 5 | | | | | | |
| 21 April | | 1 | 3 | | | | | | |
| 24 April | | 1 | 3 | | | | | | |
| 28 April | | 1 | 3 | | | | | | |
| 29 April | | | | 1 | | | | | |
| 30 April | | 1 | 3 | | | | | | |
| 1 May | 2 | 2 | 11 | | | | | | |
| 2 May | 1 | 3 | 9 | | 1 | | | | |
| 3 May | 2 | 6 | 17 | | | | | | |
| 4 May | 3 | 7 | 19 | 2 | 1 | | | | |
| 5 May | 3 | 6 | 17 | 2 | 3 | | | | |
| 6 May | 4 | 3 | 14 | 1 | | | | | |
| 7 May | 1 | 4 | 11 | 2 | 1 | | | 1 | |
| 8 May | 2 | 1 | 7 | 1 | | | | | |
| 9 May | | 1 | 2 | | | 1 | | | |
| 10 May | 1 | 2 | 7 | 1 | 1 | | | | |
| 11 May | | | | | 2 | | | | |
| 12 May | 1 | | 2 | | | 1 | | | |
| 13 May | 1 | | 2 | | | | | | |
| 14 May | | | | 1 | | | | | 1 |
| 15 May | | | | | | | | | |
| 16 May | 2 | | 5 | | | | | | |
| 17 May | 2 | 2 | 10 | 1 | | | | 1 | |
| 18 May | 1 | 3 | 9 | | | | | | |
| 19 May | 1 | 1 | 5 | 1 | | | | | |
| 20 May | 3 | 1 | 9 | 1 | | | | | |
| 21 May | | 2 | 5 | | | | | 1 | 1 |
| 22 May | | 1 | 2 | 1 | | | | | |
| 23 May | 1 | 4 | 11 | | | | | | 1 |
| 24 May | 2 | | 4 | | 1 | | | | |
| 25 May | | 1 | 2 | 1 | | | | 1 | 1 |
| 26 May | | 1 | 2 | | 1 | | | | |
| 27 May | 2 | | 4 | | 1 | | | | |
| 29 May | | | | | | | | | 1 |
| 4 June | | | | | 1 | | | | |
| 9 June | | | | | | | | | 1 |
| 19 June | 1 | | 1 | | | | | | |
| 21 June | 1 | | 2 | | | | | | |
| 22 June | | | | | | | 1 | | |
| 27 June | | | | | | 1 | | | |
| 5 July | 1 | | 1 | | | | | | |
| **Total** | **38** | **56** | **208** | **16** | **13** | **3** | **1** | **4** | **6** |

Appendix Table 8. Daily detections and expanded detection numbers (i.e., estimated detection efficiency) of PIT-tagged wild spring/summer Chinook salmon smolts at Lower Granite Dam during 2023 with associated river conditions at the dam.

| | Lower Granite Dam | | | | | | |
|---|---|---|---|---|---|---|---|
| Date (2023) | Average flow (kcfs) | Average spill (kcfs) | Water temperature (°C) | Spill Detections (n) | Bypass Detections (n) | Detections (n) | Expanded detections (n) |
| 12 Apr | 76.3 | 63.7 | 8.1 | | 1 | 1 | 3 |
| 13 Apr | 69.2 | 56.7 | 8.9 | | | 0 | 0 |
| 14 Apr | 65.4 | 53.0 | 8.9 | | 1 | 1 | 5 |
| 15 Apr | 59.2 | 46.9 | 8.0 | | | 0 | 0 |
| 16 Apr | 55.9 | 43.6 | 7.6 | | | 0 | 0 |
| 17 Apr | 60.7 | 48.3 | 7.6 | 1 | | 1 | 4 |
| 18 Apr | 63.1 | 50.8 | 7.9 | 1 | 1 | 2 | 7 |
| 19 Apr | 62.2 | 49.7 | 8.3 | | | 0 | 0 |
| 20 Apr | 60.2 | 47.8 | 8.6 | | 1 | 1 | 5 |
| 21 Apr | 59.9 | 47.5 | 8.4 | | 1 | 1 | 3 |
| 22 Apr | 57.5 | 45.2 | 8.3 | | 1 | 1 | 3 |
| 23 Apr | 56.8 | 44.0 | 8.4 | | 2 | 2 | 5 |
| 24 Apr | 56.8 | 36.5 | 8.5 | | 1 | 1 | 3 |
| 25 Apr | 62.1 | 40.5 | 8.8 | | | 0 | 0 |
| 26 Apr | 65.0 | 41.4 | 9.3 | | | 0 | 0 |
| 27 Apr | 68.6 | 42.9 | 9.5 | | 1 | 1 | 3 |
| 28 Apr | 73.8 | 47.1 | 10.0 | 3 | 3 | 6 | 20 |
| 29 Apr | 82.4 | 51.9 | 10.4 | 1 | 1 | 2 | 6 |
| 30 Apr | 97.4 | 56.8 | 10.8 | 1 | 2 | 3 | 10 |
| 1 May | 118.0 | 57.6 | 11.1 | 4 | 4 | 8 | 22 |
| 2 May | 135.6 | 57.6 | 11.4 | 7 | 13 | 20 | 44 |
| 3 May | 147.6 | 57.0 | 11.2 | 17 | 21 | 38 | 79 |
| 4 May | 153.9 | 59.3 | 10.8 | 6 | 21 | 27 | 52 |
| 5 May | 151.9 | 62.4 | 10.5 | 10 | 12 | 22 | 42 |
| 6 May | 150.7 | 62.1 | 10.2 | 8 | 12 | 20 | 41 |
| 7 May | 136.1 | 59.0 | 10.1 | 4 | 8 | 12 | 26 |
| 8 May | 126.5 | 55.9 | 10.0 | 4 | 6 | 10 | 22 |
| 9 May | 118.2 | 56.0 | 9.9 | | 4 | 4 | 9 |
| 10 May | 116.5 | 45.0 | 10.1 | 2 | 3 | 5 | 12 |
| 11 May | 104.8 | 47.1 | 10.2 | | 1 | 1 | 2 |
| 12 May | 110.6 | 56.8 | 10.8 | 2 | 1 | 2 | 5 |
| 13 May | 112.2 | 57.1 | 11.7 | 2 | 1 | 3 | 7 |
| 14 May | 121.0 | 53.0 | 12.2 | | 2 | 2 | 5 |
| 15 May | 138.1 | 53.4 | 12.7 | 2 | 1 | 3 | 7 |
| 16 May | 150.6 | 62.3 | 12.7 | 5 | 3 | 8 | 19 |
| 17 May | 152.7 | 61.5 | 12.3 | 5 | 4 | 9 | 23 |
| 18 May | 156.6 | 65.1 | 11.8 | 4 | 7 | 11 | 26 |
| 19 May | 157.9 | 66.5 | 11.9 | 5 | 6 | 11 | 25 |
| 20 May | 163.5 | 71.1 | 12.2 | 6 | 5 | 11 | 24 |
| 21 May | 170.1 | 76.7 | 12.7 | 1 | 7 | 8 | 19 |
| 22 May | 175.8 | 78.7 | 12.9 | | 3 | 3 | 7 |
| 23 May | 176.7 | 74.5 | 12.9 | 4 | 6 | 10 | 23 |
| 24 May | 156.0 | 71.4 | 12.6 | 4 | 5 | 9 | 18 |
| 25 May | 136.3 | 57.0 | 12.7 | 2 | 1 | 3 | 6 |

Appendix Table 8. Continued.

| | Lower Granite Dam | | | | | | |
|---|---|---|---|---|---|---|---|
| Date (2023) | Average flow (kcfs) | Average spill (kcfs) | Water temperature (°C) | Spill Detections (n) | Bypass Detections (n) | Detections (n) | Expanded detections (n) |
| 26 May | 125.6 | 56.4 | 13.1 | 1 | 1 | 2 | 4 |
| 27 May | 121.1 | 57.6 | 13.5 | 2 | 3 | 5 | 10 |
| 28 May | 120.4 | 57.4 | 13.7 | | 1 | 1 | 2 |
| 29 May | 116.2 | 58.1 | 13.5 | | 1 | 1 | 1 |
| 30 May | 114.5 | 59.7 | 13.7 | | | 0 | 0 |
| 31 May | 111.6 | 58.9 | 14.6 | | 1 | 1 | 2 |
| 1 Jun | 109.8 | 59.4 | 14.7 | | | 0 | 0 |
| 2 Jun | 110.1 | 58.9 | 14.8 | 1 | | 1 | 4 |
| 3 Jun | 100.7 | 59.0 | 14.8 | | | 0 | 0 |
| 4 Jun | 101.2 | 59.0 | 15.2 | | | 0 | 0 |
| 5 Jun | 95.7 | 58.8 | 15.6 | | | 0 | 0 |
| 6 Jun | 97.5 | 59.0 | 15.9 | 1 | | 1 | 3 |
| 7 Jun | 93.7 | 56.2 | 15.8 | | | 0 | 0 |
| 8 Jun | 90.9 | 54.8 | 16.0 | 1 | | 1 | 3 |
| 9 Jun | 91.8 | 56.4 | 16.5 | 1 | | 1 | 3 |
| 10 Jun | 82.5 | 50.2 | 16.9 | | | 0 | 0 |
| 11 Jun | 80.5 | 49.8 | 16.8 | | | 0 | 0 |
| 12 Jun | 74.1 | 46.8 | 16.92 | | | 0 | 0 |
| 13 Jun | 77.5 | 47.9 | 17.34 | | | 0 | 0 |
| 14 Jun | 74.5 | 45.4 | 17.52 | 1 | | 1 | 3 |
| 15 Jun | 71.4 | 44.5 | 17.62 | 1 | | 1 | 3 |
| 16 Jun | 67.4 | 40.6 | 17.65 | | | 0 | 0 |
| 17 Jun | 59.9 | 37.8 | 17.67 | | | 0 | 0 |
| 18 Jun | 55.3 | 35.2 | 17.74 | | | 0 | 0 |
| 19 Jun | 60.5 | 40.0 | 17.6 | 1 | | 1 | 1 |
| 20 Jun | 63.4 | 50.9 | 17.47 | | | 0 | 0 |
| 21 Jun | 61.8 | 18.9 | 17.09 | 1 | | 1 | 2 |
| 22 Jun | 58.7 | 18.4 | 16.59 | 1 | | 1 | 1 |
| 23 Jun | 55.8 | 18.3 | 15.95 | | | 0 | 0 |
| 24 Jun | 52.5 | 17.9 | 16.04 | | | 0 | 0 |
| 25 Jun | 46.7 | 18.1 | 16.68 | | | 0 | 0 |
| 26 Jun | 48.2 | 18.2 | 17.04 | | | 0 | 0 |
| 27 Jun | 46.2 | 18.1 | 17.23 | | | 0 | 0 |
| 28 Jun | 45.8 | 18.3 | 17.66 | | | 0 | 0 |
| 29 Jun | 49.6 | 18.6 | 18.1 | | | 0 | 0 |
| 30 Jun | 52.6 | 18.4 | 18.41 | | | 0 | 0 |
| 1 Jul | 48.7 | 18.1 | 18.74 | | | 0 | 0 |
| 2 Jul | 44.2 | 18.4 | 19.03 | | | 0 | 0 |
| 3 Jul | 44.1 | 18.5 | 19.66 | | | 0 | 0 |
| 4 Jul | 47.0 | 18.6 | 20.07 | | | 0 | 0 |
| 5 Jul | 46.3 | 18.5 | 20.22 | 1 | | 1 | 1 |
| 6 Jul | 45.1 | 18.4 | 19.72 | | | 0 | 0 |
| 7 Jul | 49.8 | 18.6 | 19.22 | | | 0 | 0 |
| **Avg/Total** | **92.0** | **47.2** | **13.5** | **124** | **180** | **303** | **687** |

Appendix Table 9. Daily detections at Little Goose Dam for wild spring/summer Chinook salmon smolts with river conditions at the dam, 2023. Fish were PIT-tagged and released in streams during summer 2022.

| | **Little Goose Dam** | | | |
|---|---|---|---|---|
| Date (2023) | Average flow (kcfs) | Average spill (kcfs) | Water temperature (°C) | Numbers detected (n) |
| 20 Apr | 55.4 | 30.9 | 8.11 | 1 |
| 22 Apr | 54.5 | 30.4 | 8.47 | 2 |
| 23 Apr | 51.6 | 30.6 | 8.91 | 1 |
| 25 Apr | 59.7 | 36.8 | 8.99 | 1 |
| 27 Apr | 65.3 | 39.8 | 9.12 | 1 |
| 29 Apr | 79.0 | 49.9 | 9.97 | 2 |
| 1 May | 117.4 | 61.0 | 10.75 | 5 |
| 2 May | 131.0 | 63.3 | 11.24 | 3 |
| 3 May | 144.3 | 63.3 | 11.64 | 2 |
| 4 May | 148.2 | 63.8 | 11.89 | 12 |
| 5 May | 148.0 | 62.7 | 11.47 | 8 |
| 6 May | 147.3 | 61.8 | 10.91 | 7 |
| 7 May | 129.9 | 63.1 | 10.72 | 9 |
| 8 May | 121.5 | 62.8 | 10.53 | 4 |
| 10 May | 113.2 | 45.3 | 10.55 | 4 |
| 11 May | 97.6 | 36.1 | 10.56 | 3 |
| 13 May | 105.6 | 34.3 | 11.08 | 1 |
| 14 May | 112.1 | 36.6 | 11.4 | 1 |
| 15 May | 133.8 | 41.0 | 12.29 | 1 |
| 16 May | 142.1 | 47.5 | 12.91 | 1 |
| 17 May | 147.3 | 50.6 | 13.23 | 2 |
| 19 May | 153.9 | 101.2 | 12.65 | 1 |
| 20 May | 158.6 | 106.3 | 12.46 | 1 |
| 22 May | 168.3 | 98.5 | 12.92 | 3 |
| 24 May | 152.8 | 82.7 | 13.19 | 2 |
| 25 May | 129.4 | 57.6 | 13.16 | 2 |
| 26 May | 121.3 | 60.0 | 12.93 | 3 |
| 27 May | 116.0 | 58.8 | 13.1 | 1 |
| 5 Jun | 90.2 | 28.2 | 15.33 | 1 |
| **Avg/Total** | **117.1** | **55.3** | **11.4** | **85** |

Appendix Table 10. Daily detections at Lower Monumental Dam in 2023 of wild spring/summer Chinook salmon smolts with river conditions at the dam. Fish were PIT-tagged and released in streams during summer 2022.

| | Lower Monumental Dam | | | |
|---|---|---|---|---|
| Date (2023) | Average flow (kcfs) | Average spill (kcfs) | Water temperature (°C) | Numbers detected (n) |
| 6 May | 60.0 | 41.7 | 10.9 | 1 |
| 1 May | 119.1 | 76.9 | 10.7 | 2 |
| 2 May | 126.9 | 69.7 | 11.0 | 3 |
| 3 May | 147.3 | 81.1 | 11.5 | 4 |
| 4 May | 147.4 | 79.2 | 12.0 | 2 |
| 5 May | 147.2 | 79.3 | 12.2 | 12 |
| 6 May | 148.4 | 76.4 | 11.7 | 4 |
| 7 May | 128.1 | 74.1 | 11.3 | 4 |
| 8 May | 120.0 | 65.4 | 11.1 | 3 |
| 9 May | 116.7 | 73.5 | 11.0 | 1 |
| 10 May | 114.3 | 50.7 | 11.0 | 7 |
| 11 May | 98.5 | 42.3 | 11.0 | 3 |
| 14 May | 110.3 | 42.3 | 11.5 | 1 |
| 15 May | 134.6 | 44.3 | 11.8 | 3 |
| 16 May | 139.6 | 45.2 | 12.5 | 3 |
| 22 May | 159.7 | 71.4 | 13.0 | 1 |
| 23 May | 174.2 | 79.3 | 13.2 | 1 |
| 24 May | 148.6 | 71.1 | 13.6 | 2 |
| 26 May | 119.2 | 66.4 | 13.8 | 1 |
| 27 May | 116.7 | 71.3 | 13.7 | 1 |
| 4 Jun | 99.5 | 35.3 | 15.3 | 1 |
| **Avg/Total** | **103.2** | **64.8** | **11.3** | **37** |

Appendix Table 11. Daily detections at Ice Harbor Dam in 2023 of wild spring/summer Chinook salmon smolts with river conditions at the dam. Fish were PIT-tagged and released in streams during summer 2022.

| | Ice Harbor Dam | | | |
|---|---|---|---|---|
| Date (2023) | Average flow (kcfs) | Average spill (kcfs) | Water temperature (°C) | Numbers detected (n) |
| 2 May | 126.5 | 107.4 | 11.0 | 1 |
| 9 May | 118.6 | 107.1 | 11.6 | 1 |
| 11 May | 102.4 | 89.7 | 11.5 | 1 |
| 12 May | 110.1 | 89.9 | 11.6 | 1 |
| 27 Jun | 47.2 | 14.4 | 18.9 | 1 |

Appendix Table 12. Daily detections at McNary Dam in 2023 of wild spring/summer Chinook salmon smolts with river conditions at the dam. Fish were PIT-tagged and released in streams during summer 2022.

| | McNary Dam | | | |
|---|---|---|---|---|
| Date (2023) | Average flow (kcfs) | Average spill (kcfs) | Water temperature (°C) | Numbers detected (n) |
| 14 May | 333.5 | 265.0 | 11.8 | 1 |
| 22 May | 406.8 | 306.7 | 13.9 | 1 |
| 8 Jun | 214.7 | 159.9 | 16.9 | 1 |
| 22 Jun | 168.1 | 92.0 | 17.2 | 1 |

Appendix Table 13. Daily detections at John Day Dam in 2023 of wild spring/summer Chinook salmon smolts with river conditions at the dam. Fish were PIT-tagged and released in streams during summer 2022.

| | John Day Dam | | | |
|---|---|---|---|---|
| Date (2023) | Average flow (kcfs) | Average spill (kcfs) | Water temperature (°C) | Numbers detected (n) |
| 7 May | 346.7 | 192.2 | 12.3 | 1 |
| 10 May | 340.4 | 203.0 | 12.4 | 1 |
| 17 May | 413.8 | 212.8 | 13.2 | 1 |
| 18 May | 417.2 | 204.8 | 13.4 | 1 |
| 21 May | 417.1 | 202.8 | 14.0 | 2 |
| 23 May | 416.3 | 212.7 | 14.4 | 1 |
| 25 May | 356.4 | 180.9 | 14.7 | 1 |
| 28 May | 278.0 | 155.1 | 14.8 | 1 |
| 16 Jun | 189.2 | 65.9 | 18.0 | 1 |

Appendix Table 14. Daily detections at Bonneville Dam in 2023 of wild spring/summer Chinook salmon smolts with river conditions at the dam. Fish were PIT-tagged and released in streams during summer 2022.

| | Bonneville Dam | | | |
|---|---|---|---|---|
| Date (2023) | Average flow (kcfs) | Average spill (kcfs) | Water temperature (°C) | Numbers detected (n) |
| 14 May | 341.4 | 148.1 | 13.4 | 2 |
| 15 May | 365.1 | 149.1 | 13.5 | 2 |
| 21 May | 422.9 | 200.0 | 14.3 | 1 |
| 23 May | 420.0 | 189.7 | 14.1 | 1 |
| 24 May | 393.5 | 163.7 | 14.4 | 1 |
| 25 May | 369.4 | 151.1 | 14.8 | 1 |
| 26 May | 349.2 | 149.4 | 15.0 | 1 |
| 29 May | 294.7 | 148.7 | 15.1 | 2 |
| 30 May | 281.5 | 149.4 | 15.2 | 2 |
| 6 Jun | 232.9 | 149.9 | 16.5 | 1 |
| 9 Jun | 206.3 | 150.0 | 16.9 | 1 |
| Avg/Total | 334.3 | 159.0 | 14.8 | 15 |

U.S. Secretary of Commerce
Gina M. Raimondo

Under Secretary of Commerce for
Oceans and Atmosphere
Dr. Richard W. Spinrad

Assistant Administrator for Fisheries
Janet Coit

**January 2024**

fisheries.noaa.gov

OFFICIAL BUSINESS

National Marine
Fisheries Service
Northwest Fisheries Science Center
2725 Montlake Boulevard East
Seattle, Washington 98112