

**FISH RESEARCH PROJECT OREGON  
INVESTIGATIONS INTO THE EARLY LIFE  
HISTORY OF NATURALLY PRODUCED  
SPRING CHINOOK SALMON  
IN THE GRANDE RONDE RIVER BASIN**

Project Period: 1 September 1997 to 31 August 1998

Annual Progress Report



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**INVESTIGATIONS INTO THE EARLY LIFE HISTORY OF  
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**ANNUAL PROGRESS REPORT**

Project Period: 1 September 1997 to 31 August 1998

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## ABSTRACT

We determined migration timing and abundance of juvenile spring chinook salmon from three populations in the Grande Ronde River basin. We estimated 6,716 juvenile chinook salmon left upper rearing areas of the Grande Ronde River from July 1997 to June 1998; approximately 6% of the migrants left in summer, 29% in fall, 2% in winter, and 63% in spring. We estimated 8,763 juvenile chinook salmon left upper rearing areas of Catherine Creek from July 1997 to June 1998; approximately 12% of the migrants left in summer, 37% in fall, 21% in winter, and 29% in spring. We estimated 8,859 juvenile chinook salmon left the Grande Ronde Valley, located below the upper rearing areas in Catherine Creek and the Grande Ronde River, from October 1997 to June 1998; approximately 99% of the migrants left in spring. We estimated 15,738 juvenile chinook salmon left upper rearing areas of the Lostine River from July 1997 to April 1998; approximately 3% of the migrants left in summer, 61% in fall, 2% in winter, and 34% in spring. We estimated 22,754 juvenile spring chinook salmon left the Willowa Valley, located below the mouth of the Lostine River, from September 1997 to April 1998; approximately 55% of the migrants left in fall, 5% in winter, and 40% in spring.

Juvenile chinook salmon PIT-tagged on the upper Grande Ronde River were detected at Lower Granite Dam from 4 April to 26 June 1998, with a median passage date of 1 May. PIT-tagged salmon from Catherine Creek were detected at Lower Granite Dam from 3 April to 26 June 1998, with a median passage date of 8 May. PIT-tagged salmon from the Lostine River were detected at Lower Granite Dam from 31 March through 26 May 1998, with a median passage date of 28 April. Juveniles tagged as they left the upper rearing areas of the Grande Ronde and Lostine rivers in fall and that overwintered in areas downstream were detected in the hydrosystem at a higher rate than fish tagged during winter in the upper rearing areas, indicating a higher overwinter survival in the downstream areas. Fish from Catherine Creek showed no difference in detection rates between the fall and winter tag groups, indicating similar overwinter survival in the upper and lower rearing areas.

Chinook salmon parr were generally associated with low velocity habitat types during winter in Catherine Creek, and both winter and summer in the Lostine River.

In summer 1997, we PIT-tagged parr on Catherine Creek and the Minam and Imnaha rivers in order to monitor their subsequent migration as smolts through the Snake and Columbia River hydrosystem. We found significant differences among populations in smolt migration timing at Lower Granite Dam in 1998. Fish from Catherine Creek and the Minam and Imnaha rivers were detected in the hydrosystem at rates of 16.4, 20.5, and 28.1%, respectively.

In 1998, we estimated parr abundance and the number of parr produced per redd in Catherine Creek and the Lostine River. We estimated that 429 mature, age 1+ male parr and 13,222 immature, age 0+ parr were present in Catherine Creek in August. An average of 29 mature, age 1+ male parr and 287 immature, age 0+ parr were produced from each redd constructed in 1996 and 1997, respectively. We estimated that 75 mature, age 1+ male parr and 40,748 immature, age 0+ parr were present in the Lostine River in August. An average of 3 mature, age 1+ male parr and 832 immature, age 0+ parr were produced from each redd constructed in 1996 and 1997, respectively. For every anadromous female spawner in Catherine Creek and the Lostine River in 1998, there were an estimated 13 and 3 mature male parr, respectively.

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## **EXECUTIVE SUMMARY**

### **Objectives**

1. Document the annual in-basin migration patterns, including abundance, timing, and duration, of juvenile spring chinook salmon in the upper Grande Ronde River, Catherine Creek and the Lostine River.
2. Estimate and compare survival indices from tagging to smolt detection at mainstem Snake and Columbia river dams for juveniles that leave upper river rearing areas at different times of the year.
3. Determine summer and winter habitat utilization and preference of juvenile spring chinook salmon in the upper Grande Ronde River, Catherine Creek, and the Lostine River.
4. Estimate and compare smolt detection rates at mainstem Columbia and Snake River dams for migrants from several local, natural populations in the Grande Ronde River and Imnaha River basins.
5. Document the annual migration patterns for spring chinook salmon juveniles from several local, natural populations in the Grande Ronde River and Imnaha River basins.
6. Determine survival to parr stage for spring chinook salmon in two local, natural populations in the Grande Ronde River Basin.
7. Investigate the significance of alternate life history strategies of spring chinook salmon in two local, natural populations in the Grande Ronde River Basin.

### **Accomplishments**

We accomplished all of our objectives in 1998 with the following exceptions. Due to a low abundance of spring chinook salmon in the upper Grande Ronde, we PIT-tagged fewer fish than planned during winter sampling. We could not generate egg-to-parr survival estimates for the Catherine Creek and the Lostine River populations because adequate data on female fecundity were not available.

### **Findings**

In the Grande Ronde River Basin, migration timing and abundance of juvenile spring chinook salmon was determined by operating rotary screw traps in both upper and lower river reaches of the Grande Ronde River and Wallowa River valleys. At the upper Grande Ronde River trap, 3,052 juvenile chinook salmon were captured from 1 July 1997 through 17 June 1998. The catch was expanded to an estimate of 6,716 migrants. Approximately 6% of the

migrant population left upper rearing areas in Grande Ronde River during summer, 29% in fall, 2% in winter, and 63% in spring. At the Catherine Creek trap, 3,189 juvenile chinook salmon were captured from 25 July through 9 June 1998 and the catch was expanded to an estimate of 8,763 migrants. Approximately 12% of the migrant population left upper rearing areas in Catherine Creek during summer, 37% in fall, 21% in winter, and 29% in spring. At the lower Grande Ronde River trap, 1,544 juvenile chinook salmon were captured as they left the Grande Ronde Valley from 23 October 1997 through 16 June 1998. The catch was expanded to an estimate of 8,859 migrants. Approximately 99% of the migrant population left the Grande Ronde Valley in spring. At the Lostine River trap, 5,422 juvenile chinook salmon were captured from 22 July 1997 through 30 April 1998. The catch was expanded to an estimate of 15,738 migrants. Approximately 3% of the migrant population left upper rearing areas in Lostine River during summer, 61% in fall, 2% in winter, and 34% in spring. At the Wallowa River trap, 4,650 juvenile spring chinook salmon were captured as they left the Wallowa Valley from 8 September 1997 through 30 April 1998. The catch was expanded to an estimate of 22,754 migrants. Approximately 55% of the migrant population left the Wallowa Valley in fall, 5% in winter, and 40% in spring.

Passive integrated transponders (PIT tags) were used to individually mark fish captured in traps and make subsequent observations without sacrificing the fish. Juvenile chinook salmon PIT-tagged on the upper Grande Ronde River were detected at Lower Granite Dam from 4 April to 26 June 1998, with a median passage date of 1 May. Cumulative mainstem dam detection rates for the different tag groups ranged from 10.5 to 46.8%. Fish tagged during spring were detected at the highest rate. The detection rate of fish that were tagged as they left the upper rearing area in fall and that overwintered in areas downstream (25.3%) was twice that of fish tagged during winter in upper rearing areas (10.5%). PIT-tagged salmon from Catherine Creek were detected at Lower Granite Dam from 3 April to 26 June 1998, with a median passage date of 8 May. Cumulative mainstem dam detection rates for the different tag groups ranged from 19.4 to 45.9%. Fish tagged during spring were detected at the highest rate. Juvenile salmon tagged as they left the upper rearing area in fall and overwintered in areas downstream were detected at 19.4%, a similar rate as fish tagged during winter in the upper rearing area at 23.1%. Lostine River fish were detected at Lower Granite Dam from 31 March through 26 May 1998, with a median passage date of 28 April. Cumulative mainstem dam detection rates for the different tag groups ranged from 38.6 to 70.4%, with fish tagged during spring detected at the highest rate. Fish tagged as they left the upper rearing area in fall and that overwintered in areas downstream were detected at a higher rate than fish tagged during winter in upper rearing areas, 38.6% and 30.9%, respectively.

Chinook salmon parr were generally associated with low velocity habitat types during both winter and summer habitat surveys. Parr were found in the greatest abundance in alcoves (25-27 rkm and 35-51 rkm) during winter habitat surveys in Catherine Creek and in backwater pools (0-23 rkm) in the Lostine River. During summer habitat surveys in the Lostine River, parr were most abundant in backwater and dammed pools and were observed rearing from Turkey Flat Campground to Williamson Campground (rkm 39-30) and from the Pole Bridge Picnic Area to the mouth (23-0 rkm).

In summer 1997, we PIT-tagged parr on Catherine Creek and the Minam and Imnaha rivers in order to monitor their subsequent migration as smolts through the Snake and Columbia River hydrosystem. We found significant differences among populations in smolt migration timing at Lower Granite Dam in 1998. Fish from Catherine Creek and the Minam and Imnaha rivers were detected in the hydrosystem at rates of 16.4, 20.5, and 28.1%, respectively. No parr PIT-tagged on Catherine Creek and the Imnaha, Lostine, Minam, and Wenaha rivers in 1996 (as part of the Fish Passage Center's Smolt Monitoring Program) were detected in the hydrosystem in 1998, as age 2+ smolts.

In 1998, we estimated parr abundance and the number of parr produced per redd in Catherine Creek and the Lostine River. We estimated that 429 mature, age 1+ male parr and 13,222 immature, age 0+ parr were present in Catherine Creek in August. An average of 29 mature, age 1+ male parr and 287 immature, age 0+ parr were produced from each redd constructed in 1996 and 1997, respectively. We estimated that 75 mature, age 1+ male parr and 40,748 immature, age 0+ parr were present in the Lostine River in August. An average of 3 mature, age 1+ male parr and 832 immature, age 0+ parr were produced from each redd constructed in 1996 and 1997, respectively. For every anadromous female spawner in Catherine Creek and the Lostine River in 1998, there were an estimated 13 and 3 mature male parr, respectively.

### **Management Implications and Recommendations**

The Grande Ronde River Valley provides more than a migration corridor for juvenile chinook salmon. Although the proportion varies annually, large numbers of juveniles leave upper rearing areas in Catherine Creek and the upper Grande Ronde River in fall and overwinter in the Grande Ronde River Valley. Rearing habitat in the Grande Ronde Valley is significantly altered and degraded. Three years of data for the upper Grande Ronde population indicate salmon that overwinter in the valley survive at a higher rate than salmon that overwinter in upper rearing areas. Enhancing habitat conditions to improve overwinter survival in the Grande Ronde River Valley should be given priority.

Juvenile chinook salmon that leave upper rearing areas in Catherine Creek and the upper Grande Ronde and Lostine rivers during fall overwinter in lower river reaches and arrive at Lower Granite Dam earlier in spring than juveniles that overwinter in upper rearing areas. As environmental conditions in the Snake and Columbia rivers vary throughout the smolt migration, survival may vary among fish exhibiting the different life histories. In general, fall-migrating salmon have been detected at mainstem dams at rates similar to or higher than those for salmon that overwinter in upper rearing areas. However, in some years detection rates for salmon that overwinter in upper areas have been greater for an individual population. These differences point out the need to maintain the diversity of life history strategies observed in the Grande Ronde River Basin. What may be a successful strategy one year may not be as successful in another year under different conditions.

Juvenile chinook salmon use the lower reaches of non-natal tributaries in addition to the spawning streams for rearing both in the upper Grande Ronde River and Catherine Creek. These

non-natal tributaries as well as spawning streams should be protected and enhanced. Juvenile chinook salmon are more abundant in pools than glides or riffles during both summer and winter. Maintenance of existing pool habitat and increasing habitat diversity should be a component of habitat management for chinook salmon populations in northeast Oregon streams.

The differences that exist between local populations and life history types in migration timing at Lower Granite Dam demonstrate the need to manage the hydrosystem so as to maximize survival throughout the entire migratory period of Snake River spring/summer chinook salmon smolts. Maintenance of the remaining populations in the Grande Ronde River and Imnaha River basins, their specific life histories, and any unique genetic resources they possess is critical to the continued persistence of chinook salmon in northeast Oregon and elsewhere in the Snake River Basin.

The mature male parr-to-anadromous female spawner ratios we observed in Catherine Creek and the Lostine River indicate mature male parr may have made significant gametic contributions to these populations, as has been demonstrated for Atlantic salmon. Given the continual low abundance of adult spawners, mature male parr may be an important means by which breeding population size is increased.

## INTRODUCTION

The Grande Ronde River originates in the Blue Mountains of northeast Oregon and flows 334 km to its confluence with the Snake River near Rogersburg, Washington. Historically, the Grande Ronde River Basin produced an abundance of salmonids including spring, summer and fall chinook salmon, sockeye salmon, coho salmon, and summer steelhead (ODFW 1990). During the past century, numerous factors have led to a reduction in salmonid stocks such that the only viable populations remaining are spring chinook salmon and summer steelhead. In addition, spring chinook salmon populations in the Grande Ronde River Basin have diminished in size and are substantially depressed from historic levels. It is estimated that prior to the construction of the Snake and Columbia river dams, more than 20,000 adult spring chinook salmon returned to spawn in the Grande Ronde River Basin annually (ODFW 1990). A spawning escapement of 12,200 adults was estimated for the basin in 1957 (USACE 1975). Recent population estimates vary from year to year, but remain at least an order of magnitude lower than historic estimates. In 1998, estimated escapement for the basin was 759 adults (253 redds x 3.0 adults/redd). The range of spring chinook salmon spawning in the Grande Ronde River Basin also has been constricted. Historically, spring chinook salmon were distributed among 21 streams, yet today most production is limited to only six tributaries, including the upper Grande Ronde River, Catherine Creek, Lookingglass Creek, the Minam River, the Lostine River and the Wenaha River (ODFW 1990).

Numerous factors are thought to have contributed to the decline of spring chinook salmon in the Snake River and its tributaries. These factors include juvenile and adult passage problems at mainstem Snake and Columbia river dams, cyclic changes in ocean productivity, overharvest, and habitat degradation associated with timber, agricultural, and land development practices. More than 80% of anadromous fish habitat in the upper Grande Ronde River is considered to be degraded (USFS 1992). Habitat problems throughout the Grande Ronde River Basin (reviewed by Bryson 1993) include poor water quality associated with high sedimentation and poor thermal buffering, moderately to severely degraded riparian zones and a decline in abundance of large pool habitat.

Precipitous declines in Snake River spring chinook salmon populations resulted in these stocks, including Grande Ronde River stocks, being listed as threatened under the Endangered Species Act (October 1992). Development of sound recovery strategies for these salmon stocks requires knowledge of stock-specific life history strategies and critical habitats for spawning, rearing, and downstream migration (Snake River Recovery Team 1993; NWPPC 1992; ODFW 1990). In addition, knowledge of juvenile migration patterns, smolt production and survival, and juvenile winter rearing habitat is needed within the basin. We currently are expanding our efforts to include life stage specific survival estimates (egg-to-parr, parr-to-smolt, and smolt-to-adult), and an evaluation of the importance and frequency at which alternative life history tactics are utilized by spring chinook salmon populations in northeast Oregon.

Both historic and recent estimates of juvenile production in the basin are lacking. However, given the dramatic decline in adult returns to the basin and the extent of habitat degradation, it is reasonable to assume that juvenile production is lower now than in the past. Recent parr-to-smolt survival estimates for populations in the Grande Ronde River Basin range

from 8.9% to 22.1% (Walters et al. 1993, 1994; Sankovich et al. 1995). These estimates are based on data from parr that were individually tagged with passive integrated transponder (PIT) tags in late summer and were detected at mainstem Snake and Columbia river dams. Before this study was initiated, it was not clear how much mortality occurred during the smolt migration and how much occurred during fall and winter rearing.

The chinook salmon smolt migration occurs in the spring. Data from Lookingglass Creek (Burck 1993), Catherine Creek (Keefe et al. 1995), the Grande Ronde River (Keefe et al. 1994, 1995), and the Lostine River (Jonasson et al. 1996, 1997) indicate an abundance of juveniles move out of upper rearing areas during the fall and overwinter downstream. Success of fall migrants varies from year to year and among streams. Over the past several years, we have estimated that 1 to 98% of the juvenile chinook salmon emigrating from upper rearing areas in streams in the Grande Ronde River Basin did so in the fall; at least 15 to 28% of the fall migrants have survived to Lower Granite Dam in the spring. We will continue to monitor the extent of the fall migrations and assess their importance to local populations.

Most juveniles that leave upper rearing areas in Catherine Creek and the upper Grande Ronde River in the fall overwinter in the Grande Ronde River Valley. Much of the habitat in these mid-reaches of the Grande Ronde River is degraded. Stream conditions in the Grande Ronde River below La Grande consist of both meandering and channeled sections of stream which run through agricultural land. Riparian vegetation in this area is sparse and provides little shade or instream cover. The river is heavily silted due to extensive erosion associated with agricultural and forest management practices and mining activities. It is reasonable to suggest that salmon overwintering in degraded habitat may be subject to increased mortality due to the limited ability of the habitat to buffer against environmental extremes. The fall migration from upper rearing areas in Catherine Creek constitutes a substantial portion of the juvenile production (Keefe et al. 1995, Jonasson et al. 1996, 1997). Therefore winter rearing habitat quantity and quality in the Grande Ronde valley may be important factors limiting chinook salmon smolt production in the Grande Ronde River.

Numerous enhancement activities have been undertaken in an effort to recover spring chinook salmon populations in the Grande Ronde River Basin. Supplementation programs have been initiated by the Oregon Department of Fish and Wildlife, the Confederated Tribes of the Umatilla Indian Reservation and the Nez Perce Tribe using endemic broodstock from the upper Grande Ronde River, Catherine Creek, and Lostine River. Information we collect will serve as the foundation for assessing the effectiveness of programs currently underway.

## **GOALS AND OBJECTIVES**

This study was designed to document and describe early life history strategies exhibited by spring chinook salmon in the Grande Ronde River Basin. In addition to our investigations into the in-basin migration timing and abundance of juvenile chinook salmon and their seasonal habitat preference, during the past year we initiated work on life-stage-specific survival estimates and the significance of alternative early life histories. The objectives of this study were to: 1) document the annual in-basin migration patterns, including abundance, timing, and duration, of

juvenile spring chinook salmon in the upper Grande Ronde River, Catherine Creek and the Lostine River, 2) estimate and compare survival indices from tagging to smolt detection at mainstem Snake and Columbia River dams for juveniles that leave upper river rearing areas at different times of the year, 3) determine summer and winter habitat utilization and preference of juvenile spring chinook salmon in the upper Grande Ronde River, Catherine Creek, and the Lostine River, 4) estimate and compare smolt detection rates at mainstem Columbia and Snake River dams for migrants from several local, natural populations in the Grande Ronde River and Imnaha River basins, 5) document the annual migration patterns for spring chinook salmon juveniles from several local, natural populations in the Grande Ronde River and Imnaha River basins, 6) determine survival to parr stage for spring chinook salmon in two local, natural populations in the Grande Ronde River Basin, and 7) investigate the significance of alternate life history strategies (precocious maturation in males and seaward migration at age 2+) of spring chinook salmon in two local, natural populations in the Grande Ronde River Basin.

## METHODS

In this report, we assume all juvenile chinook salmon captured in traps were downstream “migrants”. The term “migration year” (MY) refers to the earliest calendar year juveniles were expected to migrate to the ocean. The term “brood year” (BY) refers to the calendar year eggs were fertilized. All chinook salmon referred to in this report were naturally produced.

### **Egg-to-Parr Survival, Abundance, and Age Composition of Parr in Summer**

Our approach to spring chinook salmon parr investigations during the 1998 summer field season was, first, to conduct parr distribution surveys on Catherine Creek and the Lostine River in July. We then conducted mark-and-recapture experiments in August to estimate the abundance of mature and immature parr in those streams. During these experiments, we collected scale samples from parr to determine age composition of the juvenile population.

We surveyed Catherine Creek and the Lostine River before conducting mark-and-recapture experiments in order to determine the rearing distribution of parr and to estimate the proportion of parr present in different reaches of each stream. Mark-and-recapture methodology requires either that marked fish mix randomly with unmarked fish, or that fish are captured in proportion to their abundance during subsequent sampling (Ricker 1975). Using knowledge of parr distribution, we attempted to capture parr in proportion to their abundance during the recapture phase of the experiments.

Distribution surveys on Catherine Creek and the Lostine River were conducted by snorkeling a systematic sample of 25 m transects. Surveys began upstream from the upper-most chinook salmon redd observed in 1997 and ended at trap sites located near the bottom of chinook salmon rearing habitat. We snorkeled one transect for every 100 m of stream within the survey area in Catherine Creek. In the Lostine River, we snorkeled one transect for every 200 m of stream in the upper 3/4 of the survey area and one transect for every 300 m of stream in the lower 1/4 of the survey area. Transects were snorkeled in an upstream direction. Single pass

counts of mature and immature chinook salmon parr were made by two or three divers, depending on stream width and visibility. Mature parr were identified based on body morphology and coloration. Mature parr are typically longer, deeper bodied, and more yellowish in color than immature parr. Stream widths were measured at the beginning, middle, and end of each transect, after fish were counted. Each survey was conducted over an 11 d period in July.

Following the distribution surveys, we partitioned Catherine Creek into five sections ranging in length from 2.2 to 5.7 river kilometers (rkm) and the Lostine River into six sections ranging in length from 4.8 to 9.6 rkm. Sections were selected based on parr densities and the presence of recognizable boundaries. To estimate the abundance of parr in each section, we first determined the number of parr per square meter in each transect. Transect area was calculated as the product of the length of the transect and the average of the three width measurements taken within it. Once parr densities had been determined, we calculated the area of each section as the product of its length and the average of all stream widths measured within it. We multiplied the area of each section by the average density of parr in the transect to estimate the number of parr in each section. Abundance estimates for all sections were summed to obtain total abundance estimates within the two survey areas. We then calculated the proportion of parr observed in each section. These proportions were multiplied by our numeric goals for marking and subsequent sampling (see below) to determine the number of parr to be marked and sampled in each section. This procedure was followed for immature parr only. Results from the distribution surveys demonstrated that mature parr densities were low enough to require us to mark and sample as many mature parr as we could capture, regardless of their location. Although we were able to obtain abundance estimates from the distribution survey data, we assumed these estimates were negatively biased and less accurate than estimates obtained using mark-and-recapture techniques (Rodgers et al. 1992).

We began our mark-and-recapture experiments immediately following the distribution surveys. We captured, marked, and released parr during the first week in August on Catherine Creek and the second week in August on the Lostine River. We conducted subsequent sampling during the third week in August on Catherine Creek and the fourth week in August on the Lostine River. Our goal on each stream was to mark 1,000 immature parr and as many mature parr as we could capture in 5 d (not to exceed 1,000). During subsequent sampling, our goal was to capture 500 immature parr and as many mature parr as possible in 5 d (not to exceed 500).

Parr were located by snorkelers and captured by beach seining or herding fish into seines set perpendicular to the stream flow. Captured fish were held in aerated 19 L buckets or in 19 L carboys attached to pack frames. Fish were transferred periodically to live cages anchored in shaded areas of the stream. Daily collections continued until we captured a sufficient number of parr to mark or until stream temperatures reached 17°C.

Prior to being marked, fish were anesthetized in an aerated bath containing 40 to 50 mg/L of tricaine methanesulfonate (MS-222). We sorted fish in the bath to remove any that were injured or in poor condition. We marked all mature parr, and any immature parr less than 55 mm fork length, with Alcian Blue dye (applied with a tattoo machine above the anal fin). Immature parr greater than or equal to 55 mm fork length were either PIT-tagged or dye-marked. PIT tags were injected manually with modified hypodermic syringes as described by Prentice et al. (1986,



1990) and Mathews et al. (1990, 1992). Syringes were disinfected for 10 min in 70% isopropyl alcohol between each use. We used a portable tagging station that consisted of a computer, PIT tag reader, measuring board, and electronic balance to record the tag code, fork length (FL, 1 mm), and weight (0.1 g) of PIT-tagged fish. We recorded the length and weight of all but a small portion of the mature parr and the length of immature parr that were dye-marked. We collected scale samples from all mature parr captured and from a haphazard sample of 200 immature parr. We continued to process fish only as long as stream temperatures remained at or below 15° C. On some occasions, it was necessary to hold fish overnight and resume marking the following morning. All fish were released on the day they were processed, in the area of capture. We made releases in 22 different areas covering 22 km of stream on Catherine Creek, and 20 different areas covering 41 km of stream on the Lostine River. In order to facilitate the dispersal of fish, we scattered small groups over several riffles within each area.

During subsequent sampling, we captured fish throughout each stream section. We inspected each fish for marks and maturity status and recorded the number of mature and immature parr that were unmarked, dye-marked, PIT-tagged, or that had a tagging scar but lost their PIT tag. Scale samples were collected from unmarked, mature parr to augment the samples taken during marking.

The abundance of immature and mature parr in Catherine Creek and the Lostine River was determined using an adjusted Petersen estimate (Ricker 1975). Ninety-five percent confidence intervals were obtained using values in Appendix II and equation (3.7) in Ricker (1975). Age compositions of immature and mature parr were based on results from scale analysis. Scale impressions were made on acetate slides and inspected on a microfiche reader at 42x magnification. We counted annuli to determine whether parr were age 0+ (no annulus) or 1+ (one annulus). We calculated the proportion of immature and mature parr at each age and obtained 95% confidence intervals from Table P in Rohlf and Sokal (1995).

Using information gathered from the mark-and-recapture experiments, scale analyses, spawning surveys, and a previous year of this study, we determined the following: 1) the abundance of immature and mature parr, by age class, in Catherine Creek and the Lostine River in August 1998 and 2) the percentage of immature parr present in Catherine Creek in August 1997 that matured and were present in Catherine Creek in August 1998. To calculate the percentage of maturing parr, we first had to estimate the abundance of immature parr in August of 1997. We did so using the adjusted Peterson estimate (Ricker 1975) and trapping data for unmarked juveniles and juveniles PIT-tagged as parr in 1997 (Jonasson et al. 1997). We could not make a similar calculation for salmon in the Lostine River, because no parr were PIT-tagged there in 1997. An additional objective of our parr investigation was to estimate egg-to-parr survival rates for populations in Catherine Creek and the Lostine River. Because information on the fecundity of female chinook salmon in these streams is lacking, we were not able to make these estimates this year. Instead we developed an estimate of parr per redd as a means of tracking parr production. The numbers of age 0+ (1997 brood) and age 1+ (1996 brood) parr produced per redd were calculated using summer parr abundance, age composition, and 1996 and 1997 redd estimates for the Catherine Creek and Lostine River populations. We anticipate the ODFW's Endemic Brood Project will begin collecting fecundity data in the near future.

## **In-Basin Migration Timing and Abundance**

The seasonal migration timing and abundance of juvenile spring chinook salmon in the upper Grande Ronde River, Catherine Creek and the Lostine River were determined by operating rotary screw traps year round. In the Grande Ronde River subbasin, one rotary screw trap was located below spawning and upper rearing areas in the upper Grande Ronde River near the town of Starkey at rkm 299 (Figure 1). A second trap was located in Catherine Creek below spawning and upper rearing areas near the town of Union at rkm 32. Catherine Creek enters the Grande Ronde River at rkm 225 and is a major tributary for spring chinook salmon spawning and rearing. A third rotary screw trap was located in the Grande Ronde River at the lower end of the Grande Ronde Valley near the town of Elgin at rkm 164. At our upper Grande Ronde River trap site, a 1.5 m diameter trap was fished from 1 July 1997 through 30 June 1998. A 1.5 m diameter trap was fished at the Catherine Creek site from 23 July 1997 through 30 June 1998. At our lower Grande Ronde River trap site, a 1.5 m diameter trap was fished from 29 September 1997 through 18 February 1998. We fished a 2.4 m diameter trap at this site from 19 February 1998 through 30 June 1998.

In the Wallowa River subbasin, one rotary screw trap was located below the majority of spawning and rearing areas on the Lostine River near the town of Lostine at rkm 3 (Figure 1). A 1.5 m diameter trap was fished at this site from 1 September 1997 through 30 April 1998. A second rotary screw trap was located on the Wallowa River above the mouth of the Minam River near the town of Wallowa at rkm 27 (Figure 1). This trap was located below spawning and rearing areas of Hurricane, Prairie, Bear, and Parsnip creeks, the upper Wallowa River and the Lostine River. A 2.4 m diameter trap was fished at this site from 8 September 1997 through 30 April 1998.

The rotary screw traps were equipped with live boxes that safely held hundreds of juvenile spring chinook salmon trapped over 24 to 72 h periods. The traps were generally checked daily, but were checked as infrequently as every third day when only a few fish were captured per day and environmental conditions were not severe. All juvenile spring chinook salmon captured in traps were removed for enumeration and interrogated for PIT tags. We attempted to measure fork lengths (mm) and weights (g) of at least 100 juvenile spring chinook salmon each week. Prior to sampling, juvenile spring chinook salmon were anesthetized with MS-222 (40-60 mg/L). Fish were allowed to recover fully from anesthesia before release into the river. River height was recorded daily from permanent staff gauges. Water temperatures were recorded daily at each trap location using thermographs or hand held thermometers.

Migrant abundance was estimated by conducting trap efficiency tests throughout each trapping season at each trap site. Trap seasons were defined from catch distributions. Trap efficiency was determined by releasing a known number of paint-marked or PIT-tagged fish above each trap and enumerating recaptures. A Panjet marking instrument (Hart and Pitcher 1969) was used to paint-mark fish by injecting a small amount of non-toxic acrylic paint subcutaneously. Up to 100 juvenile spring chinook salmon were marked and released each week. On days when a trap stopped operating and no marked fish were recaptured, the number of marked fish released the previous day were subtracted from the seasonal total.

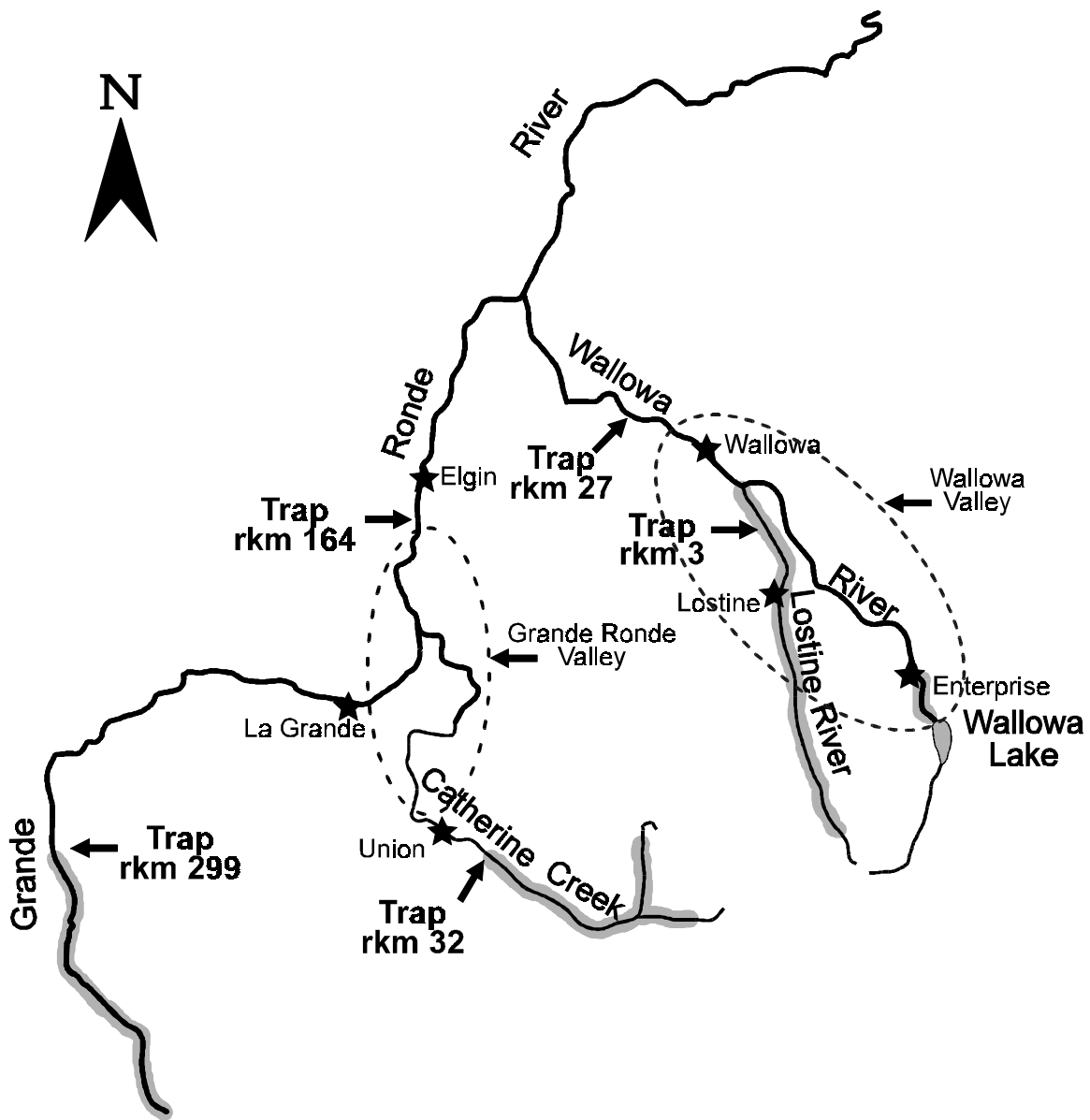


Figure 1. Locations of fish traps in the Grande Ronde River Basin during the study period. Shaded areas delineate spring chinook salmon spawning and upper rearing areas in each study stream. Dashed lines indicate the Grande Ronde River and Wallowa River valleys.

Trap efficiency was estimated by

$$\hat{E} = R / M ; \quad (1)$$

where  $\hat{E}$  is the estimated seasonal trap efficiency,  $M$  is the number of marked fish released upstream, and  $R$  is the number of marked fish recaptured.

The abundance of migrants that passed each trap site for each trapping season (summer, fall, winter, and spring) was estimated by

$$\hat{N} = U / \hat{E} ; \quad (2)$$

where  $\hat{N}$  is the estimated number of fish migrating past the trap,  $U$  is the total number of unmarked fish captured, and  $\hat{E}$  is the estimated seasonal trap efficiency.

Variance for each  $\hat{N}$  was estimated by the one-sample bootstrap method (Efron and Tibshirani 1986; Thedinga et al. 1994) with 1,000 iterations. Each bootstrap iteration calculated  $\hat{N}$  from equations (1 and 2) drawing  $R$  and  $U$  from the binomial distribution. Confidence intervals for  $\hat{N}$  were calculated by

$$95\% CI = 1.96\sqrt{V} ; \quad (3)$$

where  $V$  is the estimated variance of  $\hat{N}$  determined from the bootstrap. Abundance for the total migration past each trap was determined by adding the seasonal estimates. Seasonal variance estimates were summed to obtain estimated variance for the total migration. Migrant fry were able to escape from the trap without detection and, therefore, were not included in migrant abundance estimates. Sexually mature male parr were not included in migrant abundance estimates.

The lower Grande Ronde River trap and the Wallowa River trap were located below hatchery steelhead release sites. It was necessary to monitor these two traps continuously throughout the hatchery steelhead release periods to prevent overcrowding in trap live boxes. A portable fish sorter was designed to separate juvenile spring chinook salmon from larger steelhead migrants. Larger steelhead slid off the sorter directly back into the river. Juvenile spring chinook salmon migrants passed through the sorter into a live well. All fish were netted directly from the trap live box to a fish sorter to minimize handling during release periods.

Hatchery steelhead releases into the Wallowa River during the spring season necessitated modifications to our method of estimating migrant abundance at the Wallowa trap. During low catch periods, the trap was fished continuously throughout a 24 h period. During high catch periods, the trap was fished systematically (each night) for a 4 h interval from 20:00 to 24:00 using systematic two-stage sampling. Systematic sampling allowed us to reduce fish handling and overcrowding in the live box, and avoid labor intensive 24 h trap monitoring. Preliminary 24 h sampling indicated a strong diel pattern in chinook salmon catch rates. The interval from 20:00 to 24:00 was chosen because a relatively large proportion of the total daily catch was captured during this 4 h time block (Figure 2). Trap efficiency tests were conducted throughout the spring period whenever we were able to fish the trap continuously. Marked recaptures captured during the systematic sampling interval (20:00 to 24:00) were not included in seasonal totals.

Systematic sampling required us to estimate the proportion of the total daily catch captured during our sampling interval, i.e., during the systematic sampling interval from 20:00 to 24:00 or continuous sampling interval from 08:00 to 08:00 (24 h). We estimated the proportion of the total daily catch captured during the sampling interval by fishing the trap over six 24 h periods through the spring migration period and counting the number of fish trapped during the six successive 4 h intervals within each 24 h period. The proportion of the total daily catch captured during the sampling interval ( $i$ ) was estimated by

$$\hat{P}_i = S_i/C \quad (4)$$

where  $\hat{P}_i$  is the estimated proportion of the total daily catch for sampling interval  $i$ ,  $S_i$  is the total number of fish caught during sampling interval  $i$  throughout the six 24 h sampling periods, and  $C$  is the total number of fish caught throughout the six 24 h sampling periods.

Abundance during the spring period at the Wallowa trap was estimated for systematic and continuous sampling intervals by

$$\hat{N}_s = (U_i/\hat{P}_i)/\hat{E}; \quad (5)$$

where  $\hat{N}_s$  is the estimated number of fish migrating past the trap and  $U_i$  is the total number of unmarked fish captured during interval  $i$ . Abundance for the total spring migration at the Wallowa trap was determined by summing the continuous and systematic sampling estimates.

Variance for  $\hat{N}_s$  at the Wallowa trap during spring was estimated by the one-sample bootstrap method (Efron and Tibshirani 1986; Thedinga et al. 1994) with 1,000 iterations. Each bootstrap iteration calculated  $\hat{N}_s$  from equations (1, 4, and 5) drawing  $R$  and  $S_i$  from the binomial distribution and  $U_i$  from the Poisson distribution. Confidence intervals for the spring period were calculated using equation (3) where  $V$  is the estimated variance of  $\hat{N}$  (continuous + systematic) determined from the bootstrap.

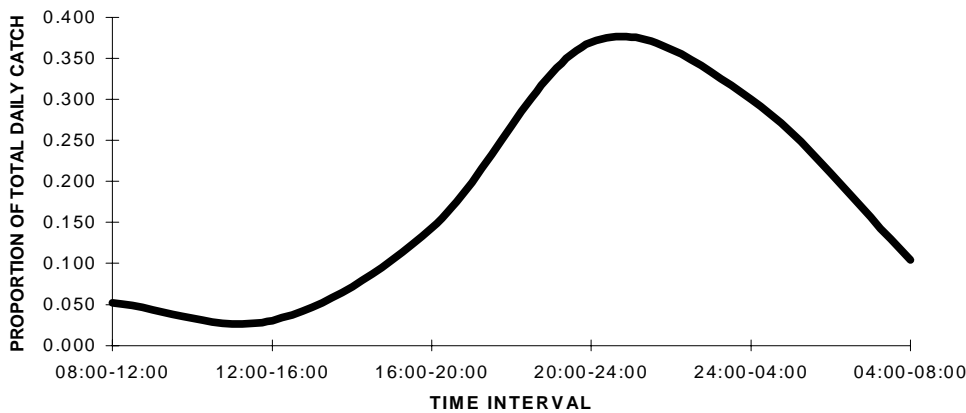


Figure 2. Diel pattern observed in capture of juvenile spring chinook salmon at the Wallowa trap during spring. Capture rates were determined from six 24 h sampling periods in which 230 fish were captured.

## **Migration Timing and Survival to Lower Granite Dam**

### **Juvenile Trapping Studies**

PIT tag technology allows fish to be individually marked and subsequently observed without being sacrificed. First-time detections of PIT-tagged fish at Snake and Columbia river dams were used to estimate migration timing and index survival among tag groups. During the 1998 migration year, PIT tag interrogation systems were used in juvenile bypass systems at six of eight Snake River and Columbia River dams to monitor fish passage.

Fish that emigrate from upper rearing areas at different times of the year and overwinter in different habitats are subject to different environmental conditions. Survival may vary among fish exhibiting the different life histories as a result. There is a distinct fall migration from summer rearing areas in the upper Grande Ronde River, Catherine Creek, and the Lostine River to areas downstream where fish overwinter. These fall migrants then migrate out of the basin to the sea the following spring. Other individuals remain in upper rearing areas through the fall and winter, and initiate their seaward migration in the spring. To determine if there were differences within populations with respect to the survival of juveniles that overwintered in different locations, we planned to tag 500 spring chinook salmon migrants captured in traps during the fall and spring and 500 spring chinook salmon that were residing above the traps in the winter. For tagging purposes and to be consistent with previous years of this study, we defined the fall migration as downstream movement past our upper trap sites between September and December and the spring migration as downstream movement past our upper trap sites between February and May. These times encompassed a majority of the fall and spring migrations. We also tagged 500 to 1,000 chinook salmon parr on Catherine Creek, and the Imnaha and Minam rivers in late summer 1997 as part of our investigation into parr strategies (Objectives 4-7).

Thus, there are four tag groups used to estimate migration timing and index survival to Lower Granite Dam: summer, fall, winter, and spring. Fish tagged in these groups do not necessarily represent unique life history strategies. For example, the summer tag group includes fish that migrate out of upper rearing areas in the fall, winter, or spring, and overwinter in either the upper or lower rearing areas. The summer tag group includes fish that exhibit all possible life histories and, as such, depicts timing and survival for the overall population. PIT-tagged fish were interrogated upon recapture in screw traps and in bypass systems at mainstem dams. All recaptured and interrogated fish were identified by their original tag group, thereby insuring the independence of tag groups for analysis. For example, dam detections of fish that were tagged in the summer and were recaptured at a river trap in the fall, were analyzed as summer tagged fish.

We estimated migration timing of individual tag groups at Lower Granite Dam by expanding daily numbers of PIT tag detections according to the proportion of river flow spilled each day. This procedure was necessary because some fish may pass undetected over the spillway and the amount of spill varies throughout the migration season. We assumed the proportion of fish that passed over the spillway (spill effectiveness) was directly related to the proportion of flow spilled. This assumption conforms fairly well to data obtained using non-species-specific hydroacoustic methods (Kuehl 1986). Kuehl (1986) estimated spill effectiveness at 11, 19, and 35% under 4, 20, and 40% spill conditions, respectively. We also

assumed there was no temporal variation either in the proportion of fish diverted from turbine intakes into the bypass system (fish guidance efficiency) or in the proportion of fish that passed through the surface bypass collector. We made these assumptions in light of evidence to the contrary (Giorgi et al. 1988, Swan et al. 1986, Johnson et al. 1997) because the data required to account for such variation were unavailable. The extent to which our results may be biased would depend on the overall rates of fish passage via the bypass system and surface bypass collector, and on the degree to which daily rates of fish passage by these routes may have varied throughout the migration seasons. The number of fish migrating past Lower Granite Dam by week was calculated by multiplying the number of fish detected each day by a daily expansion factor, which was calculated as:

$$\text{Expansion factor} = (\text{powerhouse flow} + \text{spillway flow}) / \text{powerhouse flow}. \quad (6)$$

Daily products were added and rounded to the nearest integer.

At the completion of the 1998 migration year, we obtained cumulative first-time detection information from PIT tag interrogation sites at Lower Granite, Little Goose, Lower Monumental, McNary, John Day, and Bonneville dams. We calculated survival indices for individual tag groups by dividing the cumulative number of first-time PIT tag detections at these sites by the number of fish released in each tag group and expressed this proportion as a percentage. We did not adjust our data to compensate for tagged fish that may have passed through the hydrosystem without being detected because we are unsure of the most appropriate methods to use at the time of this report. Therefore, the survival indices may only indicate the minimum rate of survival for each tag group. We evaluated relative success of fish that leave upper rearing areas at different times of the year by comparing the survival indices of fall and winter tag groups. Overwinter survival of fish that remained in upper rearing areas was assessed by dividing the survival indices of the winter tag groups by the corresponding index for the spring tag group. This proportion was then expressed as the percentage of fish in upper rearing areas that survived the winter. The survival indices for the summer tag groups provided information about the overall population survival from the time of tagging through the following smolt migration.

## **Parr Studies**

In 1997 and 1998, we PIT-tagged chinook salmon parr from several local populations in the Grande Ronde and Imnaha River basins in order to monitor their migration timing as smolts at Lower Granite Dam and their rates of detection in the hydrosystem. In 1997, we PIT-tagged parr on Catherine Creek and the Minam and the Imnaha rivers. We PIT-tagged parr on those streams and the Lostine River in 1998. We conducted tagging operations in late summer (Table 1) so that few fish would be too short to tag (<55 mm FL). Sampling occurred primarily in areas where spawning adults were concentrated the previous year. To collect and PIT tag the parr, we used the methods outlined previously for the mark-and-recapture experiments (see **Methods**, Parr-to-Smolt Survival, Abundance, and Age Composition of Parr in Summer). In summer 1997, we released from 495 to 1,010 PIT-tagged parr in Catherine Creek and the Imnaha and Minam rivers (Table 1). We released from 502 to 1,009 PIT-tagged parr in those streams and the

Lostine River in summer 1998 (Table 1). Information on the migration timing and detection rates of parr PIT-tagged in 1998 will be reported next year.

We estimated the timing with which fish from the different streams migrated through Lower Granite Dam in the same manner as described above for fish in the juvenile trapping studies. To determine if migration timing differed among populations, we performed a Kruskal-Wallis test on the dates of detection, expressed as day of year, of real and “expanded” fish. When significant differences were found, we used a multiple-comparison procedure (at  $\alpha=0.05$ ; Daniel 1990) to further analyze the data. First-time detection rates of fish from the different streams were calculated in the manner outlined above for fish in the juvenile trapping studies.

Table 1. Dates of tagging and number of chinook salmon parr PIT-tagged on various northeast Oregon streams in 1997 and 1998.

Year and stream	Dates of collection and tagging	Number of parr PIT-tagged and released	Kilometers upstream from Lower Granite Dam
1997			
Catherine Creek	18-22 August	495	352-369
Minam River	2-3 September	998	282-284
Imnaha River	8-9 September	1,010	237-241
1998			
Catherine Creek	3-7 August	502	354-375
Lostine River	10-13 August	506	274-302
Minam River	17-19 August	1,006	280-284
Imnaha River	24-26 August	1,009	237-243

### Habitat Utilization

We assessed habitat utilization for chinook salmon parr during the winter on the upper Grande Ronde River, Catherine Creek, and the Lostine River. Habitat utilization and rearing distribution were assessed for chinook salmon parr during the summer on the Lostine River. Fish were counted by visual observation with two or three persons snorkeling habitat units in an upstream direction. Three counts were made for each habitat unit sampled. Winter counts were made during the night with the use of dive lights, while summer observations were made during the day.

Sampling sites were selected based on redd and rearing distribution surveys from previous years, physical habitat surveys, and accessibility. We surveyed Catherine Creek during the winter from 3 km up both the North and South Forks down to rkm 27 and from rkm 18 to 19, above the town of Union. We surveyed the Lostine River during the winter from the Pole Bridge Picnic Area down to the mouth (rkm 23-0). During the summer, we surveyed the Lostine River



from Turkey Flat Campground to Williamson Campground (rkm 39-30) and from Pole Bridge Picnic Area to the mouth (rkm 23-0).

We identified habitat types using the habitat classification system described in Bisson et al. (1982) and modifications for backwater pools described by Nickelson et al. (1992). Fish of all species were enumerated and the following habitat variables were recorded: habitat type, surface area, depth, cover, substrate composition, water temperature, water velocity, slope, shade, and water visibility. The mean density of chinook salmon parr per habitat type was calculated as the maximum of three fish counts divided by the surface area of each habitat unit.

## RESULTS AND DISCUSSION

### Egg-to-Parr Survival, Abundance, and Age Composition of Parr in Summer

From the information obtained during our mark-and-recapture experiments, we estimated that 429 (95% CI: 237-858) mature male parr and 13,222 (95% CI: 10,047-17,189) immature parr were present in Catherine Creek in early-August 1998 (Table 2). All of the mature parr sampled for scales were age 1+ (BY 1996), whereas all of the immature parr were age 0+ (BY 1997)( Table 3). Based on our abundance and age composition estimates, and on redd counts from previous years, we determined that an average of 29 mature, age 1+ parr and 287 immature, age 0+ parr were produced from each redd constructed in 1996 and 1997, respectively. Our abundance estimate for mature parr indicated further that 1.6% of the 26,608 immature parr estimated to be present in Catherine Creek in August 1997 (P. Sankovich, unpublished data) matured and were present in Catherine Creek in August 1998.

Table 2. Results from mark-and-recapture experiments conducted in Catherine Creek and the Lostine River in August 1998.

Stream and group	Number marked (M)	Number sampled (C)	Number Recaptured (R)	Population estimate ( $\hat{N}$ ) (95% CI)
Catherine Creek				
Immature	1,050	628	49	13,222 (10,047-17,819)
Mature	73	57	9	429 (237-858)
Lostine River				
Immature	1,010	926	22	40,748 (27,403-63,324)
Mature	14	9	1	75 (23-136)

Abundance estimates for mature and immature parr in the Lostine River in mid-August 1998 were 75 (95% CI: 23-136) and 40,748 (95% CI: 27,403-63,324), respectively (Table 2). The abundance estimate for mature parr may have been biased because we recaptured only one marked, mature parr (Ricker 1975) (Table 2). As in Catherine Creek, all of the mature and immature parr sampled for scales were ages 1+ and 0+, respectively (Table 3). We estimated that an average of 3 mature, age 1+ parr were produced from each redd constructed in 1996. An average of 832 immature, age 0+ parr were produced from each redd in 1997.

An interesting note regarding chinook salmon populations in Catherine Creek and the Lostine River is that there were an estimated 13 and 3 mature male parr for every anadromous female spawner (i.e., redd) in the respective streams in 1998. To our knowledge, it has not been shown whether mature chinook salmon parr are capable of fertilizing eggs and producing viable offspring, as has been demonstrated in Atlantic salmon (Thorpe and Morgan 1980; Hutchings and Myers 1985, 1988). Therefore, we can conclude only that the potential existed for mature parr to have made significant gametic contributions to their respective populations. Given the continual low abundance of anadromous spawners in northeast Oregon streams, mature male parr may be an important means by which breeding population size is increased.

Table 3. Age composition of immature and mature chinook salmon parr sampled in Catherine Creek and the Lostine River in 1998. Age was determined by analysis of scales.

Stream and group	Number of samples	Percent age 0+ (95% CI)	Percent age 1+ (95% CI)
Catherine Creek			
Immature	208	100.0 (98.2-100.0)	0.0 (0.0-1.8)
Mature	113	0.0 (0.0-3.3)	100.0 (96.7-100.0)
Lostine River			
Immature	231	100.0 (98.4-100.0)	0.0 (0.0-1.6)
Mature	20	0.0 (0.0-16.7)	100.0 (83.3-100.0)

### In-Basin Migration Timing and Abundance

The upper Grande Ronde River trap fished for 225 d from 11 July through ice up on 2 December 1997, and from 6 February 1998 through 30 June 1998. Distinct fall and spring migrations were evident (Figure 3), while smaller numbers of salmon were captured during summer and winter (Table 4). The date that the median fall migrant passed the trap was 31 October and was similar to timing observed in MY 94, 95, and 96. Timing in MY 97 was somewhat later with the median fall migrant moving past our upper trap on 13 November. The date that the median spring migrant moved past the trap was 25 March and was consistent with past observations that ranged from 15 to 31 March.

We estimated a minimum of  $6,716 \pm 618$  juvenile spring chinook salmon migrants moved out of the upper Grande Ronde rearing areas during MY 1998. This estimate is considerably greater than our estimate of 66 fish in MY 97 and is more consistent with estimates from MY 94 through 96 that ranged from 1,151 to 30,926. Seasonal trap efficiencies were 5.3, 70.2, 27.3, and 38.4% for summer, fall, winter, and spring, respectively. Based on these efficiencies, we estimated that approximately 29% ( $1,953 \pm 132$ ) of the migrants moved in fall and 63% ( $4,221 \pm 446$ ) migrated in spring. In addition, approximately 6% ( $399 \pm 359$ ) moved in summer and 2% ( $142 \pm 191$ ) moved during winter. At 29%, the proportion of fall migrants leaving the upper Grande Ronde rearing areas was greater than the proportion observed in MY 94 (10%) and MY 95 (11%). The pattern of a dominant spring migration in the upper Grande Ronde is consistent for all migration years studied to date with the exception of MY 97, when 98% of the migrants moved in fall. It is worth mentioning, however, that MY 97 was exceptional in that only 29 fish were trapped.

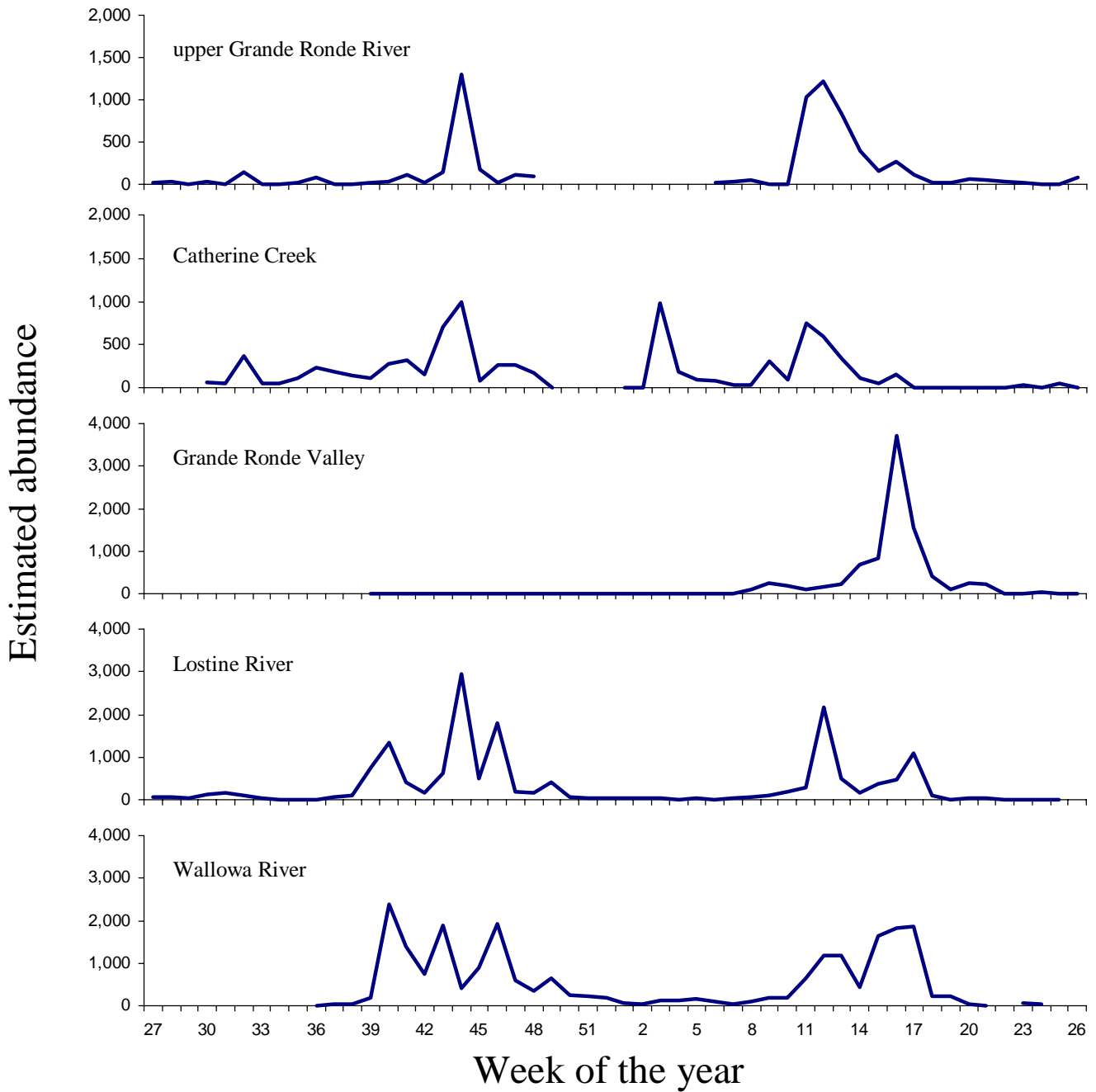


Figure 3. Estimated migration timing and abundance of juvenile spring chinook salmon migrants captured by rotary screw traps. During the 1998 migration year, traps were located at rkm 299 and 164 of the Grande Ronde River, rkm 32 of Catherine Creek, rkm 3 of the Lostine River, and rkm 27 of the Wallowa River.

Table 4. Seasonal catch of juvenile chinook salmon at five trap locations in the Grande Ronde River Basin.

Trap site	Season	Migration period	Days fished	Trap catch
Upper Grande Ronde	Summer	1 Jul 97 – 16 Sep 97	74	21
	Fall	17 Sep 97 – 2 Dec 97	67	1,372
	Winter	3 Dec 97 – 25 Feb 98	5	39
	Spring	26 Feb 98 – 30 Jun 98	109	1,620
Catherine Creek	Summer	23 Jul 97 – 16 Sep 97	77	212
	Fall	17 Sep 97 – 2 Dec 97	77	1,535
	Winter	3 Dec 97 – 11 Feb 98	32	587
	Spring	12 Feb 98 – 30 Jun 98	118	855
Grande Ronde Valley	Fall	29 Sep 97 – 18 Feb 98	140	4
	Spring	19 Feb 98 – 30 Jun 98	113	1,540
Lostine River	Summer	22 Jul 97 - 30 Aug 97	65	88
	Fall	1 Sep 97 - 31 Dec 97	107	3,328
	Winter	1 Jan 98 - 28 Feb 98	49	137
	Spring	1 Mar 98 - 30 Apr 98	60	1,869
Wallowa River Valley	Fall	8 Sep 97 - 31 Dec 97	104	2,335
	Winter	1 Jan 98 - 11 Mar 98	62	274
	Spring	12 Mar 98 – 30 Apr 98	45	2,041

The Catherine Creek trap fished for 304 d from 28 July through ice up on 5 December 1997, and from 5 January through 30 June 1998. Substantial numbers of migrants were captured continually from the time we deployed the trap in summer through spring (Figure 3). The date that the median migrant passed the trap by season was 22 August, 30 October, 21 January, and 19 March for summer, fall, winter and spring, respectively (Table 4). The pattern of continual movement out of Catherine Creek has been emerging over the past few years. With higher summer flows and warmer winter weather, we have been able to extend our trapping earlier into summer and later into winter. We do not know whether this pattern simply reflects an increase in trapping effort or is a response to interannual changes in environmental conditions in Catherine Creek. We will attempt to address this issue over the next few years.

We estimated that a minimum of  $8,763 \pm 759$  juvenile spring chinook salmon migrants moved out of the upper Catherine Creek rearing areas during MY 98. This estimate is greater than, yet on the same order of magnitude as, estimates from MY 97 (3,951) and MY 96 (6,341) and is considerably lower than our migrant estimate from MY 95 (18,680). Seasonal trap efficiencies at Catherine Creek were 19.3, 46.6, 31.7 and 33.9% for summer, fall, winter, and spring, respectively. Based on these efficiencies, we estimated that approximately 12% ( $1,096 \pm 375$ ) of the migrants moved in summer, 37% ( $3,292 \pm 271$ ) moved in fall, 21% ( $1,852 \pm 492$ ) moved in winter and 29% ( $2,523 \pm 346$ ) migrated in spring. The Catherine Creek population appears to be different from the upper Grande Ronde population with respect to the proportion of fish migrating in spring and fall. The proportion of spring migrants has ranged from 11 to 50% of the total migrant population while the proportion of fall migrants has ranged from 37 to 76%. In contrast, the largest outmigration from the upper Grande Ronde River has consistently been observed in spring.

The lower Grande Ronde River trap fished for 253 d between 23 October 1997 and 16 June 1998. A distinct spring migration was evident; few fish passed the trap in fall and winter (Figure 3). The date that the median migrant passed the trap was 20 April and was similar to timing observed in MY 95 and 96. Timing in MY 97 was somewhat later with the median migrant moving past this trap on 8 May.

We estimated that a minimum of  $8,859 \pm 1,490$  juvenile spring chinook salmon migrants left the Grande Ronde Valley during MY 98. The magnitude of this estimate is consistent with estimates from MY 96 and 97 that were 2,475 and 9,001 migrants respectively, and is one order of magnitude lower than our estimates in MY 94 and 95. Seasonal trap efficiency was 17.4% for our 2.4 m trap. Only four fish were captured in fall with our 1.5 m trap and thus we were not able to determine trap efficiency. As in the past four years, more than 99% of the chinook salmon migrants passed our trap during spring. This data indicates that most juvenile spring chinook salmon that left the upper rearing areas during fall overwintered in the valley reaches of the Grande Ronde River. Protection and enhancement of habitat in the Grande Ronde Valley should be given high priority to maintain or enhance overwinter survival of juvenile spring chinook salmon that reside in the valley during winter.

The Lostine River trap fished for 281 d between 22 July 1997 and 30 June 1998. Distinct fall and spring migrations were evident (Figure 3), while smaller numbers of salmon were captured during summer and winter (Table 4). The date that the median fall migrant passed the trap was 1 November. The date that the median spring migrant moved past the trap was 25 March and was similar to last year's median of 3 April.

We estimated that a minimum of  $15,738 \pm 1,231$  juvenile spring chinook salmon migrants moved out of the Lostine River during MY 98. Seasonal trap efficiencies were 22.8, 34.9, 52.3 and 35.1% for summer, fall, winter, and spring, respectively. Based on these efficiencies, we estimated that approximately 61% ( $9,459 \pm 1,010$ ) of the migrants moved in fall and 34% ( $5,388 \pm 641$ ) migrated in spring. In addition, approximately 3% ( $540 \pm 283$ ) moved prior to the start of fall and 2% ( $262 \pm 56$ ) moved during winter. In MY 98, the majority of the migrants left the Lostine River in fall. In MY 97, we did not begin operating the Lostine River

trap until 24 October 1996 (week 43). It is not appropriate, therefore, to compare annual abundance or seasonal distribution of migrants in MY 97 with other years.

The Wallowa River trap fished for 221 d between 8 September 1997 and 11 June 1998. Distinct fall and spring migrations were evident at this trap (Figure 3). The dates that the median fall and spring migrants passed the trap were 26 October and 14 April, respectively.

We estimated that a minimum of  $22,754 \pm 2,484$  juvenile spring chinook salmon migrants moved past our trap during MY 98. Seasonal trap efficiency was 19.3, 24.4 and 21.7% in fall, winter, and spring, respectively. Based on these trap efficiencies, 55% ( $12,100 \pm 1,759$ ) of the migrant population moved out of upper rearing areas in fall, 5% ( $1,122 \pm 296$ ) in winter, and 40% ( $9,533 \pm 1,728$ ) in spring.

The pattern of movement at this trap was very similar to that seen upriver at the Lostine trap. Trap-to-trap travel times suggest Lostine River spring chinook salmon use the valley portion of the Wallowa River primarily as a migration corridor and that fall migrants move below the Wallowa River trap site for overwintering. Travel times between the Lostine trap and the Wallowa trap in fall ranged from 1 to 36 d with a mean of 4.0 d ( $N = 72$ ).

Mean lengths and weights of juvenile spring chinook salmon captured in the upper Grande Ronde River and PIT-tagged are given in Tables 5 and 6. Mean lengths and weights of juvenile spring chinook salmon captured from Catherine Creek and PIT-tagged are given in Tables 7 and 8. Mean lengths and weights of juvenile spring chinook salmon captured from the Lostine River and PIT-tagged are given in Tables 9 and 10. Length frequency distributions of juvenile spring chinook salmon caught in all traps by migration period are shown in Figures 4 through 8.

No trends for increasing size of migrants over time were evident from weekly mean lengths and weights of salmon at any of the traps (Tables 11 – 15). This is in contrast to what we have observed in previous years. Migrants captured at the lower Grande Ronde River trap generally were larger than fish captured at the upper Grande Ronde and Catherine Creek traps in MY 98. The mean weekly size of the spring migrating cohort at the lower Grande Ronde trap has been consistently greater than the mean size at the upper traps, suggesting salmon grow substantially during their downstream migration. This idea is supported by size data collected from individuals that were PIT-tagged at the upper traps during spring and recaptured on average one month later at the lower Grande Ronde trap (Table 16). Spring PIT-tagged fish from Catherine Creek grew an average of 16.7 mm ( $SE = 2.99$ ) while fish from the upper Grande Ronde grew 7.2 mm ( $SE = 0.90$ ).

It does not appear that we can detect spring growth from the Wallowa subbasin trap data. Although the mean weekly length is consistently more than 5 mm larger at the Wallowa trap than at the Lostine trap, the travel time between traps averages only four days. In addition, no change in size was evident for PIT-tagged fish from the Lostine River (Table 16). Thus, we believe the discrepancy in mean size between the Lostine and Wallowa traps reflects that the Wallowa trap collects larger salmon from other tributary populations in addition to the Lostine River population rather than growth of fish between the Lostine trap and the Wallowa trap.

Table 5. Fork lengths (mm) of juvenile chinook salmon collected from the upper Grande Ronde River. Winter fish were captured with seines or dipnets in the upper Grande Ronde River from rkm 299 to 323. Fall and spring fish were captured with a rotary screw trap at rkm 299. Min. = minimum, Max. = maximum.

Group	Collected				
	<i>N</i>	Mean	SE	Min.	Max.
Fall	646	82.0	0.44	59	115
Winter	160	75.0	0.80	57	106
Spring	865	86.6	0.37	64	118
Release group	Tagged and released				
	<i>N</i>	Mean	SE	Min.	Max.
Fall	591	82.3	0.45	59	115
Winter	124	71.0	0.52	57	82
Spring	513	89.1	0.48	65	118

Table 6. Weights (g) of juvenile chinook salmon collected from the upper Grande Ronde River. Winter fish were captured with seines or dipnets in the upper Grande Ronde River from rkm 299 to 323. Fall and spring fish were captured with a rotary screw trap at rkm 299. Min. = minimum, Max. = maximum.

Group	Collected				
	<i>N</i>	Mean	SE	Min.	Max.
Fall	642	6.18	0.097	2.1	15.7
Winter	160	4.55	0.157	2.0	12.2
Spring	862	6.78	0.088	2.0	16.3
Release group	Tagged and released				
	<i>N</i>	Mean	SE	Min.	Max.
Fall	589	6.22	0.101	2.1	15.7
Winter	124	3.78	0.090	2.0	6.1
Spring	513	7.29	0.116	2.0	16.2



Table 7. Fork lengths (mm) of juvenile chinook salmon collected from Catherine Creek. Winter fish were captured with seines or dipnets in Catherine Creek from rkm 42 to 50. Fall and spring fish were captured with a rotary screw trap at rkm 32. Min. = minimum, Max. = maximum.

Group	Collected				
	<i>N</i>	Mean	SE	Min.	Max.
Fall	978	87.9	0.22	52	109
Winter	579	89.7	0.28	69	108
Spring	539	93.2	0.32	67	120
Release group	Tagged and released				
	<i>N</i>	Mean	SE	Min.	Max.
Fall	597	88.1	0.28	65	108
Winter	437	89.6	0.32	70	107
Spring	453	93.2	0.34	70	118

Table 8. Weights (g) of juvenile chinook salmon collected from Catherine Creek. Winter fish were captured with seines or dipnets in Catherine Creek from rkm 42 to 50. Fall and spring fish were captured with a rotary screw trap at rkm 32. Min. = minimum, Max. = maximum.

Group	Collected				
	<i>N</i>	Mean	SE	Min.	Max.
Fall	977	7.63	0.060	1.6	14.5
Winter	578	7.65	0.075	3.5	13.6
Spring	525	8.54	0.089	2.6	17.2
Release group	Tagged and released				
	<i>N</i>	Mean	SE	Min.	Max.
Fall	596	7.74	0.078	2.4	14.1
Winter	436	7.68	0.085	3.5	13.6
Spring	450	8.55	0.096	3.1	17.2

Table 9. Fork lengths (mm) of juvenile chinook salmon collected from the Lostine River. Winter fish were captured with dipnets in the Lostine River from rkm 5 to 21. Fall and spring fish were captured with a rotary screw trap at rkm 3. Min. = minimum, Max. = maximum.

Group	Collected				
	<i>N</i>	Mean	SE	Min.	Max.
Fall	1348	96.9	0.22	61	123
Winter	132	97.6	0.86	70	128
Spring	857	107.4	0.46	71	147
Release group	Tagged and released				
	<i>N</i>	Mean	SE	Min.	Max.
Fall	498	97.9	0.35	66	122
Winter	505	94.6	0.36	76	123
Spring	470	109.1	0.63	77	147

Table 10. Weights (g) of juvenile chinook salmon collected from the Lostine River. Winter fish were captured with dipnets in the Lostine River from rkm 5 to 21. Fall and spring fish were captured with a rotary screw trap at rkm 3. Min. = minimum, Max. = maximum.

Group	Collected				
	<i>N</i>	Mean	SE	Min.	Max.
Fall	1217	10.71	0.08	3.4	22.8
Winter	132	10.24	0.28	3.6	22.7
Spring	857	14.51	0.20	3.6	38.4
Release group	Tagged and released				
	<i>N</i>	Mean	SE	Min.	Max.
Fall	426	11.20	0.21	3.4	81.8
Winter	505	9.39	0.12	4.8	22.2
Spring	470	15.35	0.28	6.0	38.4

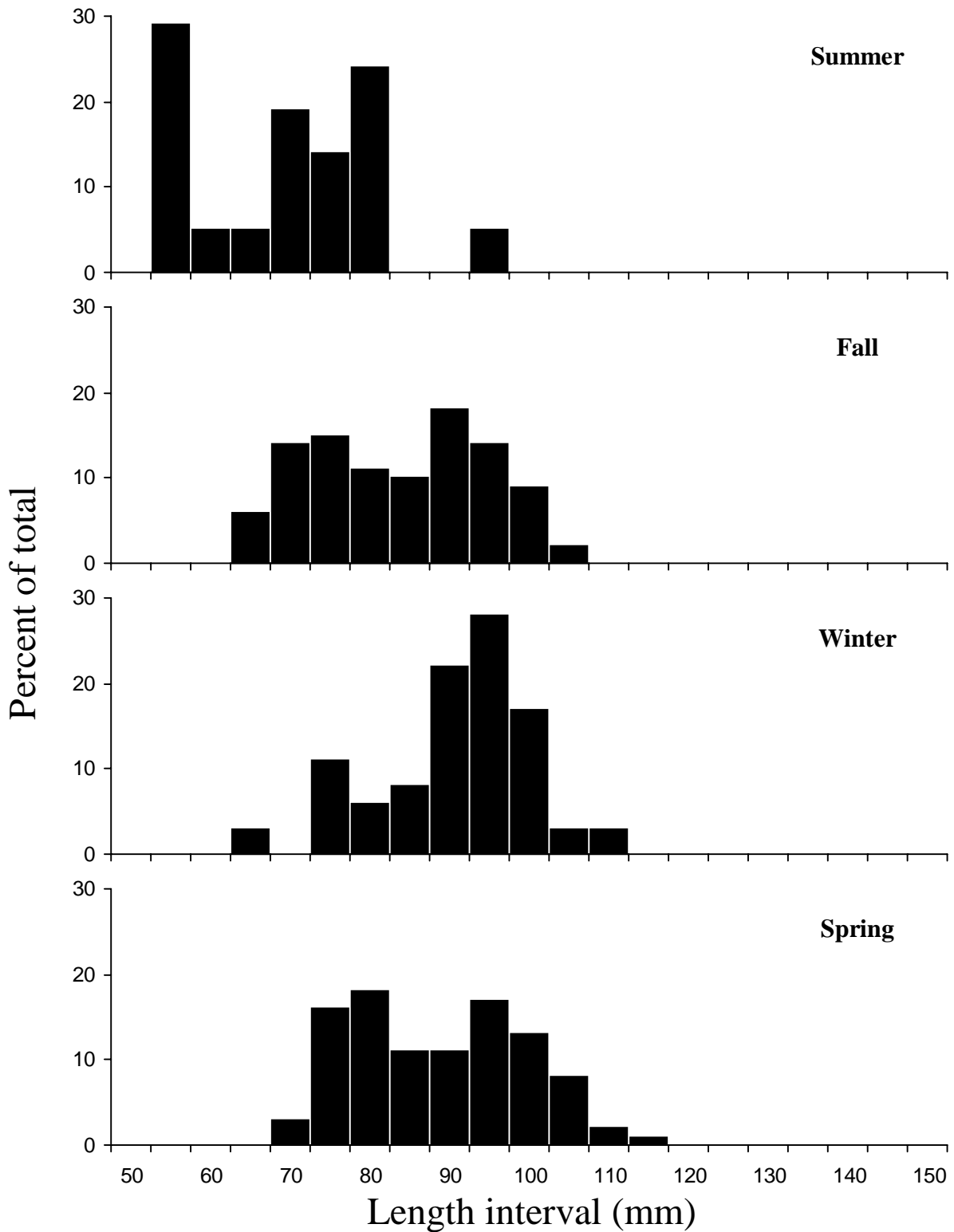


Figure 4. Length frequency distribution (fork length) of juvenile spring chinook salmon migrants captured at the upper Grande Ronde River trap (rkm 164) by seasonal migration period, during the 1998 migration year.

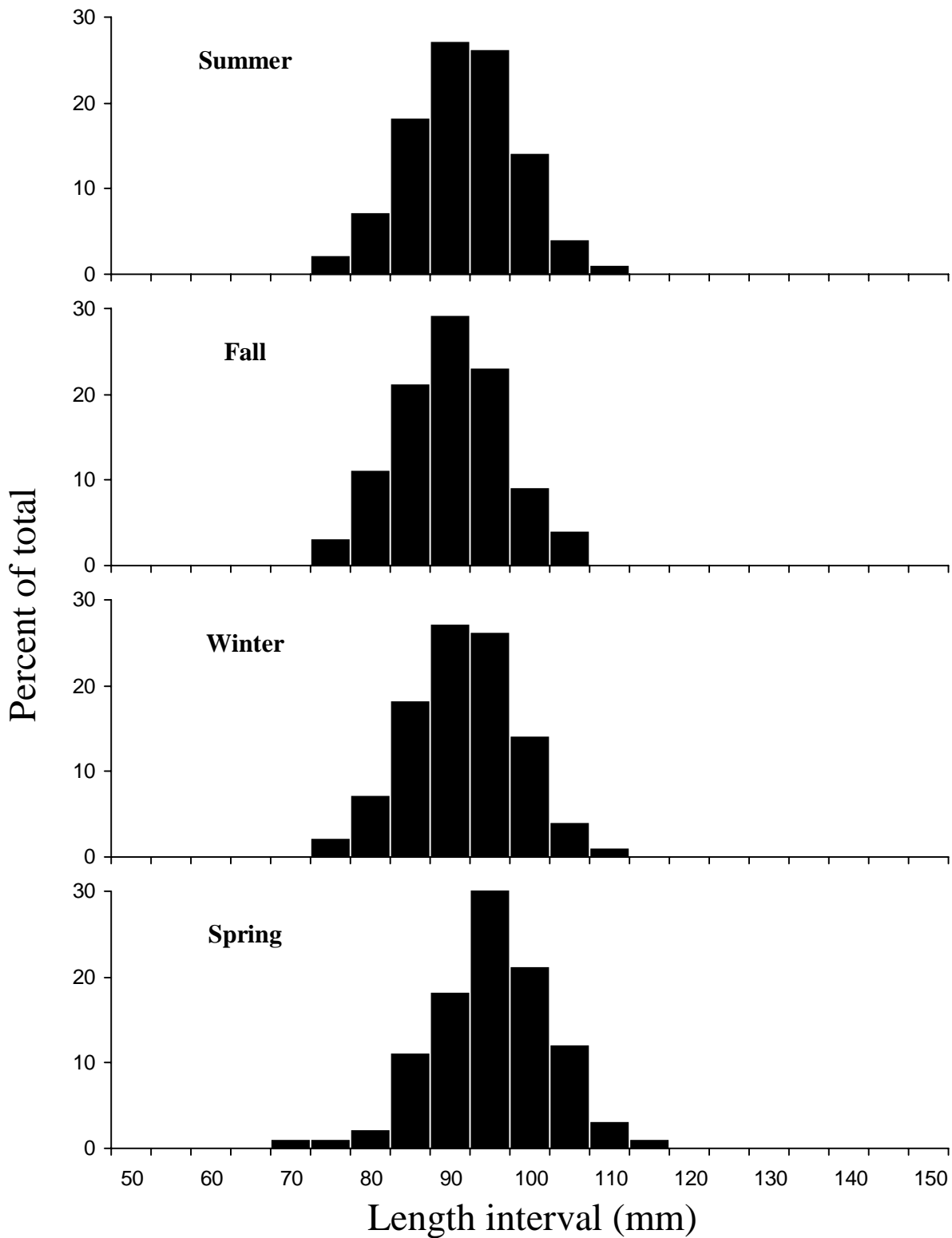


Figure 5. Length frequency distribution (fork length) of juvenile spring chinook salmon migrants captured at the Catherine Creek trap (rkm 32) by seasonal migration period, during the 1998 migration year.

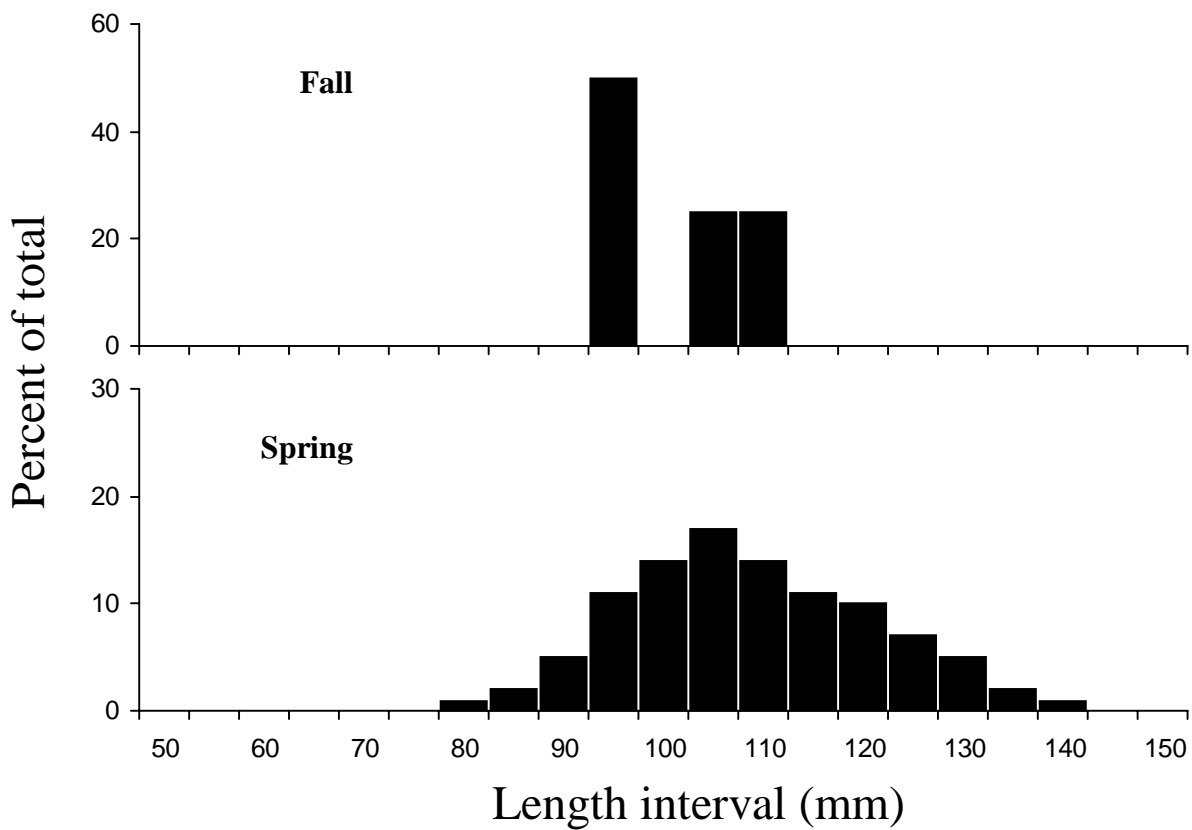


Figure 6. Length frequency distribution (fork length) of juvenile spring chinook salmon migrants captured at the Grande Ronde Valley trap (rkm 299) by seasonal migration period, during the 1998 migration year.

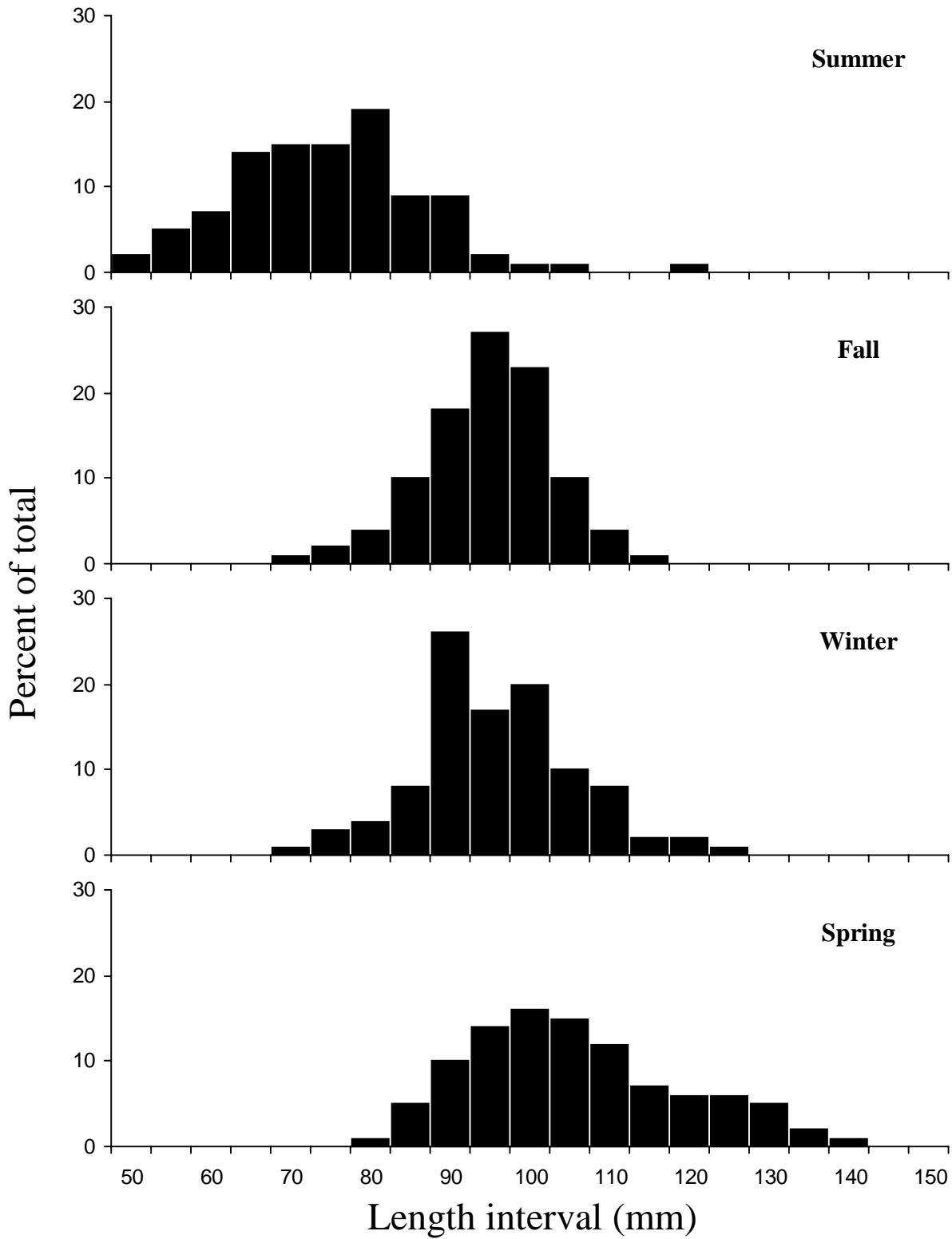


Figure 7. Length frequency distribution (fork length) of juvenile spring chinook salmon migrants captured at the Lostine River trap (rkm 3) by seasonal migration period, during the 1998 migration year.

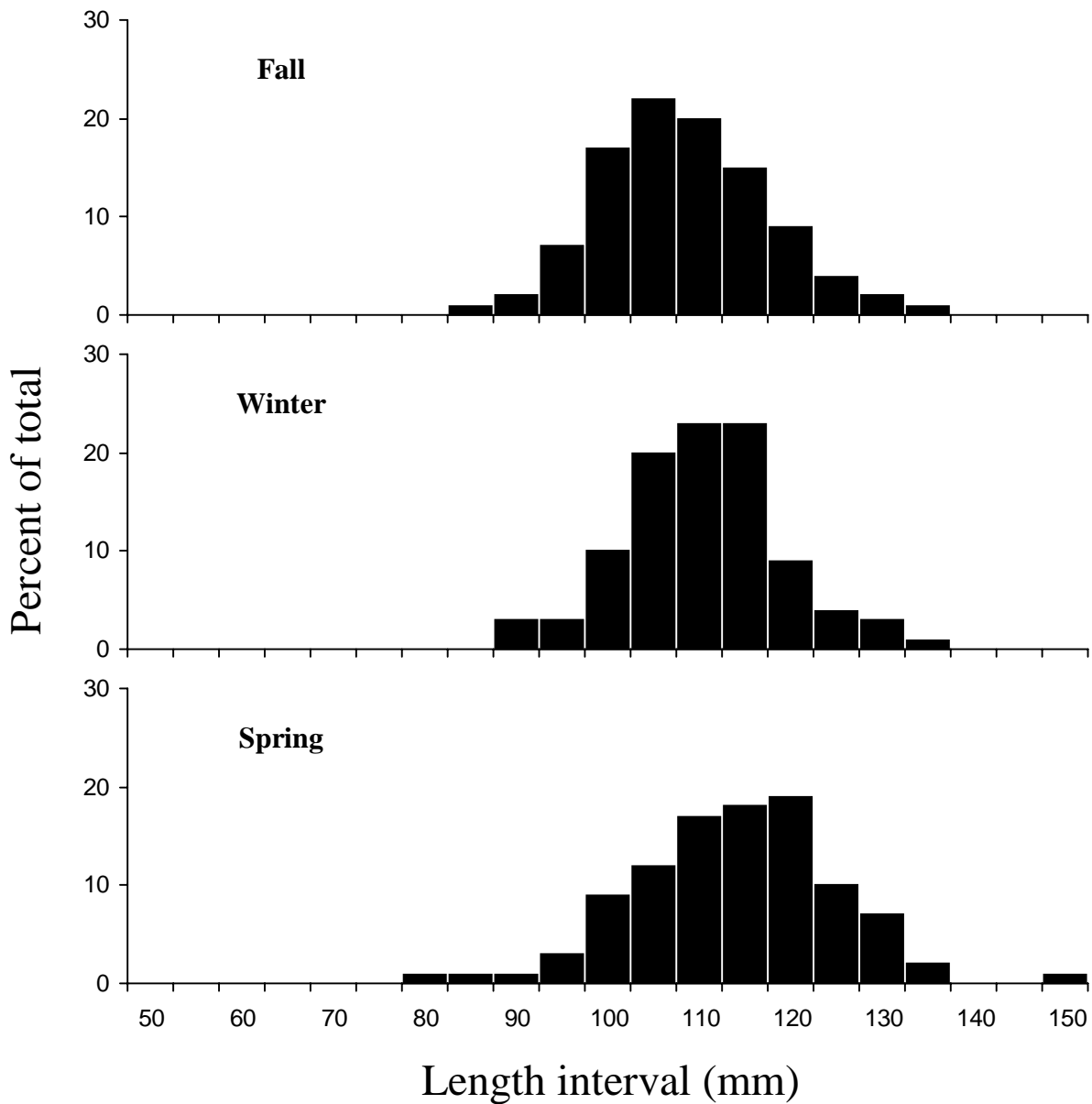


Figure 8. Length frequency distribution (fork length) of juvenile spring chinook salmon migrants captured at the Wallowa Valley trap (rkm 27) by seasonal migration period, during the 1998 migration year.

Table 11. Fork lengths (mm) and weights (g) of juvenile chinook salmon captured by a rotary screw trap at rkm 299 of the Grande Ronde River, weeks 26 to 48, 1997 and weeks 5 to 22, 1998. Min. = minimum, Max. = maximum.

Year, week	Length					Weight				
	<i>N</i>	Mean	SE	Min.	Max.	<i>N</i>	Mean	SE	Min.	Max.
1997:										
26	4	52.0	0.50	51	53	0				
27	1			53	53	0				
28	2	56.0	0.71	55	57	2	2.35	0.177	2.1	2.6
30	2	65.5	1.06	64	67	0				
32	7	74.7	1.79	67	79	7	5.16	0.410	3.3	6.5
35	1			74	74	1			5.1	5.1
36	4	78.0	4.60	70	93	4	5.73	1.092	3.5	9.2
38	5	81.4	4.13	72	97	5	6.95	1.041	4.1	11.2
39	11	85.4	2.65	69	98	11	6.87	1.955	3.4	10.2
40	18	81.6	2.08	64	95	18	6.21	1.767	3.0	9.2
41	75	81.9	1.12	64	100	75	6.12	0.245	2.2	11.3
42	16	83.4	2.42	68	98	16	6.47	0.582	3.2	10.4
43	101	83.6	1.03	61	106	101	6.45	0.230	2.5	13.1
44	241	80.0	0.68	59	106	237	5.77	0.151	2.1	14.7
45	78	76.6	1.15	60	101	78	4.97	0.248	2.4	11.7
46	7	83.7	3.62	69	94	7	6.66	0.848	3.3	8.9
47	72	91.0	1.29	61	115	72	8.10	0.309	2.4	15.7
48	22	82.7	2.66	62	112	22	6.46	0.631	2.5	15.4
1998:										
5	4	86.3	4.60	71	94	4	6.33	0.877	3.6	8.1
7	14	87.2	2.45	71	99	14	6.71	0.530	3.9	9.4
8	18	90.6	2.32	63	106	18	7.78	0.536	2.4	12.2
10	2	94.5	3.18	90	99	2	8.25	1.096	6.7	9.8
11	213	93.2	0.65	71	118	213	8.31	0.167	3.5	16.2
12	206	86.8	0.74	65	115	206	6.72	0.175	2.0	15.2
13	106	83.5	1.02	65	111	106	5.95	0.233	2.9	13.7
14	106	81.6	0.97	64	108	105	5.51	0.215	2.2	12.7
15	56	84.8	1.61	65	118	55	6.22	0.353	2.7	12.4



Table 11. Continued.

Year, week	Length					Weight				
	<i>N</i>	Mean	SE	Min.	Max.	<i>N</i>	Mean	SE	Min.	Max.
1998:										
16	72	83.4	1.21	69	102	71	5.95	0.253	2.4	10.9
17	41	80.2	1.20	66	98	41	5.69	0.276	3.0	10.3
19	7	88.9	2.76	81	105	7	8.73	0.951	6.0	14.2
20	27	83.3	0.91	75	95	27	6.56	0.236	4.4	9.3
21	17	85.2	2.32	71	111	17	7.36	0.705	4.1	16.3
22	12	90.2	1.98	80	102	12	8.47	0.594	5.1	11.9

Table 12. Fork lengths (mm) and weights (g) of juvenile chinook salmon captured by a rotary screw trap at rkm 32 of Catherine Creek, weeks 30 to 48, 1997 and weeks 1 to 18, 1998. Min. = minimum, Max. = maximum.

Year, week	Length					Weight				
	<i>N</i>	Mean	SE	Min.	Max.	<i>N</i>	Mean	SE	Min.	Max.
1997:										
30	3	72.0	3.21	67	78	3	4.17	0.626	3.4	5.7
31	9	81.3	2.55	72	92	9	6.33	0.593	4.0	9.6
32	57	83.6	0.79	67	99	57	6.79	0.199	3.3	10.9
33	10	82.3	1.86	71	92	10	6.60	0.470	4.2	10.1
34	9	84.7	1.81	75	92	9	7.71	0.620	4.5	10.6
35	16	85.1	1.68	70	96	16	7.14	0.393	4.3	10.5
36	46	85.4	0.66	72	93	46	7.52	0.174	5.5	10.1
37	34	85.9	1.10	70	99	31	7.35	0.332	3.4	10.9
38	55	84.3	0.91	65	96	55	6.95	0.223	3.0	9.6
39	49	89.1	0.80	75	99	49	8.21	0.234	4.8	11.4
40	124	88.6	0.64	73	108	124	8.03	0.189	4.1	14.1
41	139	85.8	0.59	52	101	139	7.01	0.141	1.6	11.6
42	64	89.4	0.90	76	104	64	8.20	0.272	4.8	13.6
43	244	88.8	0.41	75	104	244	7.91	0.114	4.2	13.3
44	75	87.8	0.75	74	109	75	7.63	0.199	4.2	14.5

Table 12. Continued.

Year, week	Length					Weight				
	<i>N</i>	Mean	SE	Min.	Max.	<i>N</i>	Mean	SE	Min.	Max.
1997:										
45	20	86.7	1.58	75	96	20	7.20	0.397	4.4	10.3
46	62	88.8	0.94	67	104	62	7.62	0.242	2.4	12.1
47	117	87.4	0.63	70	107	116	7.13	0.170	3.4	14.0
48	29	90.4	1.34	74	102	29	7.84	0.346	4.4	10.9
1998:										
1	2	82.0	8.00	74	90	2	5.75	1.237	4.0	7.5
3	40	91.9	1.12	77	108	40	8.31	0.304	4.0	13.4
4	35	87.1	1.02	73	96	35	6.81	0.252	3.9	10.0
5	37	90.0	1.24	74	107	37	7.42	0.310	4.0	13.3
6	28	90.7	1.33	69	103	28	7.59	0.328	3.8	12.2
7	7	90.0	1.46	84	96	7	7.40	0.417	5.8	8.9
8	7	94.4	2.46	83	103	7	8.69	0.666	5.6	11.6
9	89	94.3	0.78	67	113	89	8.64	0.227	2.6	16.0
10	32	95.1	1.12	78	107	32	9.00	0.324	4.5	12.6
11	124	92.4	0.60	74	118	124	8.21	0.153	3.8	13.3
12	104	93.4	0.64	70	108	104	8.49	0.174	3.3	14.1
13	86	90.7	0.86	70	105	86	8.07	0.226	3.1	13.2
14	23	94.9	1.82	82	113	20	8.68	0.471	5.8	13.0
15	16	92.9	1.76	77	104	16	8.69	0.464	4.6	10.9
16	48	95.5	1.44	73	120	39	10.08	0.441	5.3	17.2
17	1			100	100	1			11.7	11.7
18	2	96.0	9.00	87	105	0				

Table 13. Fork lengths (mm) and weights (g) of juvenile chinook salmon captured by a rotary screw trap at rkm 164 of the Grande Ronde River, weeks 43 to 49, 1997 and weeks 8 to 21, 1998. Min. = minimum, Max. = maximum.

Year, week	Length					Weight				
	<i>N</i>	Mean	SE	Min.	Max.	<i>N</i>	Mean	SE	Min.	Max.
1997:										
43	1			95	95	1			8.9	8.9
46	1			95	95	1			9.1	9.1
47	1			107	107	1			14.5	14.5
49	1			105	105	1			11.5	11.5
1998:										
8	16	107.4	3.53	84	136	16	13.51	1.350	5.6	24.5
9	42	110.1	1.49	84	135	42	14.42	0.612	6.3	26.9
10	32	109.2	2.30	76	126	32	14.57	0.844	4.9	21.1
11	16	107.0	3.18	88	130	16	13.55	1.277	6.6	23.3
12	21	106.6	2.35	87	127	21	13.03	0.994	6.7	22.3
13	28	106.4	2.21	87	131	28	13.27	0.847	7.7	24.4
14	92	104.6	1.13	90	142	92	12.18	0.471	6.8	31.4
15	141	107.0	1.15	80	149	141	14.04	0.484	6.0	36.3
16	218	109.8	0.84	80	141	199	14.81	0.351	5.8	29.1
17	123	105.3	1.20	79	153	123	13.04	0.460	4.8	39.7
18	40	102.8	2.18	76	126	40	12.75	0.808	4.8	25.3
19	9	103.7	3.65	91	130	9	13.59	1.686	9.3	27.1
20	38	106.8	2.04	84	130	38	14.48	0.819	6.4	23.0
21	32	104.8	2.08	86	126	32	13.00	0.786	7.5	22.3

Table 14. Fork lengths (mm) and weights (g) of juvenile chinook salmon captured by a rotary screw trap at rkm 3 of the Lostine River, weeks 25 to 52, 1997 and weeks 1 to 18, 1998. Min. = minimum, Max. = maximum.

Year, week	Length					Weight				
	<i>N</i>	Mean	SE	Min.	Max.	<i>N</i>	Mean	SE	Min.	Max.
1997:										
25	6	59.2	3.64	46	71	6	2.78	0.477	1.1	4.4
26	8	52.3	3.68	32	64	8	1.93	0.328	0.3	3.4
27	11	65.7	2.13	56	82	11	3.56	0.372	2.4	6.3
28	16	65.5	2.08	51	83	16	3.64	0.343	1.8	7.2
29	8	70.5	4.21	58	95	8	4.23	0.941	2.1	10.4
30	30	74.4	2.35	50	104	30	5.49	0.522	1.8	14.4
31	32	76.1	1.64	54	93	32	5.85	0.362	2.0	10.5
32	20	75.5	1.93	60	103	20	5.93	0.537	2.6	14.4
33	7	80.3	3.12	69	89	7	6.56	0.722	4.2	8.6
34	2	95.5	20.50	75	116	2	12.40	7.600	4.8	20.0
36	5	94.6	4.06	87	110	5	10.80	1.718	8.5	17.6
37	26	91.4	2.20	69	123	26	9.74	0.746	3.6	22.5
38	36	93.5	1.22	78	110	36	10.11	0.407	5.8	17.0
39	94	98.5	0.84	71	122	94	11.77	0.284	4.4	22.8
40	191	99.3	0.55	66	117	191	11.93	0.193	3.4	20.8
41	62	98.3	0.90	83	116	62	11.53	0.351	6.2	19.2
42	47	97.3	1.19	77	118	47	10.72	0.374	5.6	17.0
43	113	97.6	0.70	76	122	113	11.26	0.663	4.3	16.6
44	199	96.9	0.54	71	117	199	10.41	0.179	4.0	19.9
45	88	94.7	0.92	72	115	88	10.84	0.255	5.0	16.4
46	85	97.9	0.76	80	110	85	10.57	0.253	5.2	17.5
47	217	95.7	0.55	61	115	217	9.79	0.196	3.5	20.3
48	51	98.3	1.33	81	121	51	9.60	0.330	5.3	15.0
49	87	95.7	0.97	76	118	87	9.88	0.303	3.6	17.8
50	23	96.2	1.62	79	109	23	10.70	0.876	5.8	22.7
51	11	92.5	2.37	81	107	11	9.48	0.822	5.9	15.9
52	13	92.5	2.28	79	106	13	11.22	0.970	6.8	20.0

Table 14. Continued.

Year, week	Length					Weight				
	<i>N</i>	Mean	SE	Min.	Max.	<i>N</i>	Mean	SE	Min.	Max.
1998:										
1	20	95.4	2.37	75	108	20	12.04	0.664	7.9	16.8
2	17	94.1	1.97	79	111	17	12.31	0.870	8.1	22.2
3	11	99.1	3.03	88	116	11	10.55	0.800	8.0	15.6
4	8	96.6	3.21	80	110	8	10.36	0.501	7.1	11.5
5	10	101.2	2.19	91	111	10	10.80	0.654	7.9	14.2
6	5	96.6	3.23	89	106	5	9.38	1.029	7.2	12.2
7	15	95.3	2.99	70	114	15	9.35	0.789	3.6	15.0
8	33	98.5	1.80	83	128	33	10.48	0.653	5.8	22.7
9	31	102.3	1.55	85	120	31	11.90	0.567	6.8	20.0
10	58	103.8	1.26	89	127	58	12.37	0.482	7.1	22.2
11	95	102.8	0.91	85	124	95	12.01	0.320	6.3	20.9
12	184	102.4	0.71	77	132	184	12.11	0.257	5.2	25.0
13	86	101.0	1.12	80	130	86	11.66	0.414	5.8	25.7
14	52	114.0	2.21	79	141	52	17.85	0.988	6.4	32.2
15	126	120.6	1.19	77	147	126	20.76	0.566	6.1	38.4
16	126	110.0	1.17	83	142	126	15.69	0.518	6.3	30.8
17	98	106.6	1.34	71	147	98	14.58	0.548	3.6	34.0
18	14	101.6	2.93	90	119	14	13.10	1.178	8.1	19.2

Table 15. Fork lengths (mm) and weights (g) of juvenile chinook salmon captured by a rotary screw trap at rkm 27 of the Wallowa River, weeks 37 to 52, 1997 and weeks 1 to 21, 1998. Min. = minimum, Max. = maximum.

Year, week	Length					Weight				
	<i>N</i>	Mean	SE	Min.	Max.	<i>N</i>	Mean	SE	Min.	Max.
1997:										
37	3	99.3	5.70	88	106	3	12.23	2.218	7.8	14.6
38	3	103.3	2.33	97	107	3	13.77	1.074	11.8	15.5
39	35	105.0	1.35	92	136	35	14.46	0.605	9.4	29.6
40	177	103.3	0.63	72	134	177	13.58	0.272	4.5	31.0
41	104	106.2	0.77	83	128	104	14.62	0.333	6.4	25.1
42	96	105.2	0.90	86	127	96	13.82	0.366	7.5	23.9
43	111	105.0	0.98	83	132	64	13.10	0.481	6.4	29.6
44	38	102.9	1.24	90	123	38	12.91	0.497	8.3	21.7
45	89	104.5	1.03	86	131	89	13.30	0.419	6.7	28.1
46	130	107.8	0.89	83	142	130	14.60	0.396	6.8	36.1
47	100	106.1	0.96	83	129	100	13.71	0.420	6.3	34.2
48	54	106.3	1.55	79	129	54	13.78	0.599	6.1	23.5
49	93	104.6	0.98	78	127	93	12.95	0.360	5.1	21.5
50	44	109.5	1.40	94	128	44	14.56	0.577	8.8	22.8
51	38	105.9	1.39	82	123	38	13.17	0.525	6.1	19.7
52	34	107.4	1.51	93	137	34	13.69	0.630	8.8	27.6
1998:										
1	13	107.8	3.09	94	130	13	13.71	1.277	8.7	24.4
2	8	102.9	2.00	97	114	8	11.55	0.666	10.0	15.6
3	32	105.7	1.32	87	117	32	12.95	0.464	7.9	17.5
4	27	106.0	1.39	93	122	27	12.86	0.515	8.4	19.4
5	36	106.3	1.08	89	118	36	12.75	0.380	7.0	17.1
6	17	107.5	2.07	92	120	17	13.37	0.770	8.1	18.8
7	11	115.0	2.88	100	131	11	16.35	1.165	9.9	22.8
8	19	105.9	2.69	87	128	19	13.22	1.059	6.6	22.2
9	37	107.8	1.62	86	129	37	13.75	0.625	7.2	23.1
10	40	110.4	1.60	92	142	40	14.80	0.750	8.3	34.4

Table 15. Continued.

Year, week	Length					Weight				
	<i>N</i>	Mean	SE	Min.	Max.	<i>N</i>	Mean	SE	Min.	Max.
1998:										
11	92	111.8	0.98	83	145	91	15.95	0.443	7.0	34.8
12	89	111.3	1.04	88	134	89	15.83	0.440	8.6	27.8
13	91	109.3	1.21	77	129	91	15.00	0.453	5.2	23.3
14	63	113.0	1.35	85	147	63	16.39	0.682	6.5	34.9
15	174	117.8	0.81	88	147	174	18.65	0.398	7.1	34.6
16	114	115.1	0.93	89	143	114	17.89	0.444	7.7	32.8
17	60	111.4	1.47	88	133	60	16.47	0.617	7.4	29.6
18	18	106.4	2.96	84	126	18	14.36	1.107	6.7	21.4
19	10	103.9	4.29	83	119	10	14.37	1.832	6.6	21.6
20	4	102.3	7.83	85	123	4	13.18	2.753	7.3	20.6
21	3	91.7	4.81	85	101	3	9.27	1.386	7.2	11.9

Table 16. Mean fork lengths (mm) by tag group of juvenile spring chinook salmon PIT-tagged on the upper Grande Ronde River, Catherine Creek, and Lostine River and recaptured at the Grande Ronde Valley or Wallowa Valley traps during spring. Standard errors are in parentheses.

Trap site of tagging, tag group	<i>N</i>	Mean fork length	
		Tagging	Recapture
Upper Grande Ronde			
Fall	30	83.4 (2.30)	101.7 (1.70)
Winter	2	76.0 (0.71)	98.0 (4.95)
Spring	52	92.0 (1.29)	99.2 (1.19)
Catherine Creek			
Summer	6	84.5 (3.42)	116.2 (2.53)
Fall	13	90.7 (0.96)	116.7 (1.96)
Winter	4	92.3 (0.65)	106.0 (1.70)
Spring	13	98.8 (2.09)	115.5 (2.05)
Lostine River			
Fall	11	96.3 (1.53)	110.2 (2.89)
Winter	23	97.1 (2.11)	108.4 (2.14)
Spring	72	112.0 (1.56)	112.9 (1.52)

## Migration Timing and Survival to Lower Granite Dam

### Juvenile Trapping Studies

At the upper Grande Ronde River trap, we PIT-tagged 592 fall- and 513 spring-migrating chinook salmon juveniles that were not previously tagged. At the Catherine Creek trap, we PIT-tagged 598 fall- and 453 spring-migrating spring chinook salmon juveniles that were not previously tagged. During winter, we captured and PIT-tagged an additional 124 and 438 juveniles from rearing areas upstream for the upper Grande Ronde River and Catherine Creek traps, respectively. At the Lostine River trap, we PIT-tagged 500 fall- and 466 spring-migrating juvenile chinook salmon that were not previously tagged. During winter, we captured and PIT-tagged an additional 504 juveniles from rearing areas above the trap.

PIT-tagged fish from the upper Grande Ronde River ( $N = 203$ ) were detected at Lower Granite Dam from 4 April to 26 June 1998, with 50% of the fish passing the dam by 1 May 1998 (Figure 9). PIT-tagged fish from Catherine Creek ( $N = 283$ ) were detected at Lower Granite Dam from 3 April to 26 June 1998, with 50% of the fish passing the dam by 8 May 1998 (Figure 10). These dates are within the migration windows observed for fish from the upper Grande Ronde and Catherine Creek in past years. PIT-tagged fish from the Lostine River ( $N = 265$ ) were detected at Lower Granite Dam from 31 March through 26 May 1998, with 50% of the fish passing the dam by 27 April 1998 (Figure 11). The timing of the Lostine River fish in MY 98 was similar to that observed in MY 98 with respect to the first, last, and median fish passing the dam.

Travel times to Lower Granite Dam for fish tagged during the spring migration at the upper Grande Ronde River trap ranged from 25 to 71 d with a mean of 49 d ( $N = 116$ ). Travel times for fish tagged at the Catherine Creek trap ranged from 12 to 87 d with a mean of 57 d ( $N = 109$ ). Travel times for fish tagged at the Lostine River trap ranged from 6 to 59 d with a mean of 21 d ( $N = 183$ ). Data from the past three years indicate travel times have remained relatively constant for fish from these three populations. Fish from the Grande Ronde River population have exhibited the most variation, with means ranging from 49 to 57 d.

Median arrival dates at Lower Granite Dam for fish PIT-tagged at the upper Grande Ronde River trap during fall, winter, and spring were 27 April, 5 June, and 5 May 1998, respectively (Figure 9). Medians for fish PIT-tagged at the Catherine Creek trap were 1 May (fall), 11 May (winter), and 21 May (spring) (Figure 10). Medians for fish PIT-tagged at the Lostine River trap were 21 April (fall), 29 April (winter), and 28 April (spring) (Figure 11). As in past years, the earliest of the upper Grande Ronde River, Catherine Creek, and Lostine River fish to be detected were those that were tagged during fall and overwintered in lower rearing areas.



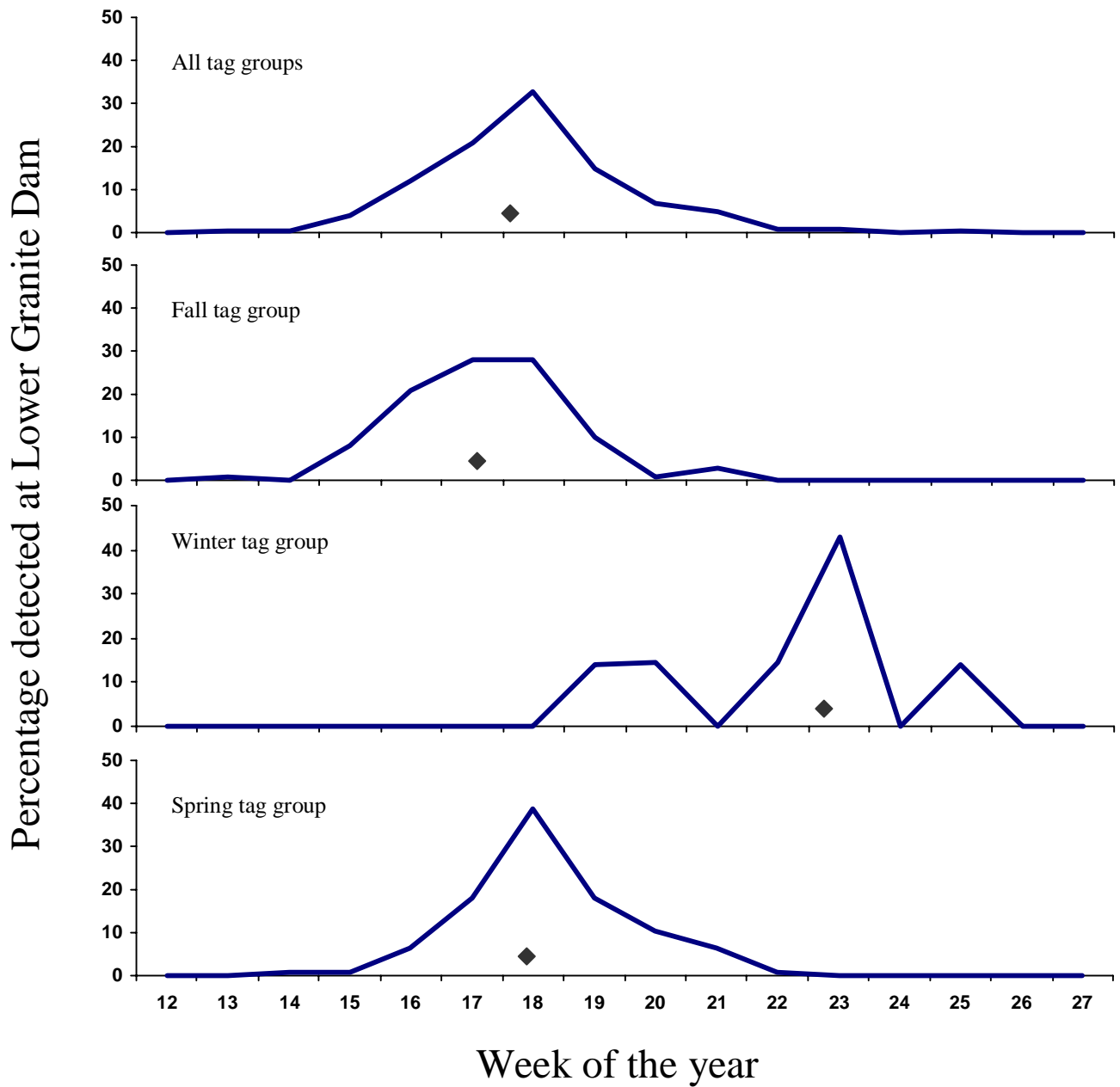


Figure 9. Migration timing at Lower Granite Dam for juvenile spring chinook salmon PIT-tagged on the upper Grande Ronde River by tag group, during the 1998 migration year. ♦ = median arrival date. Data were expanded for spillway flow.

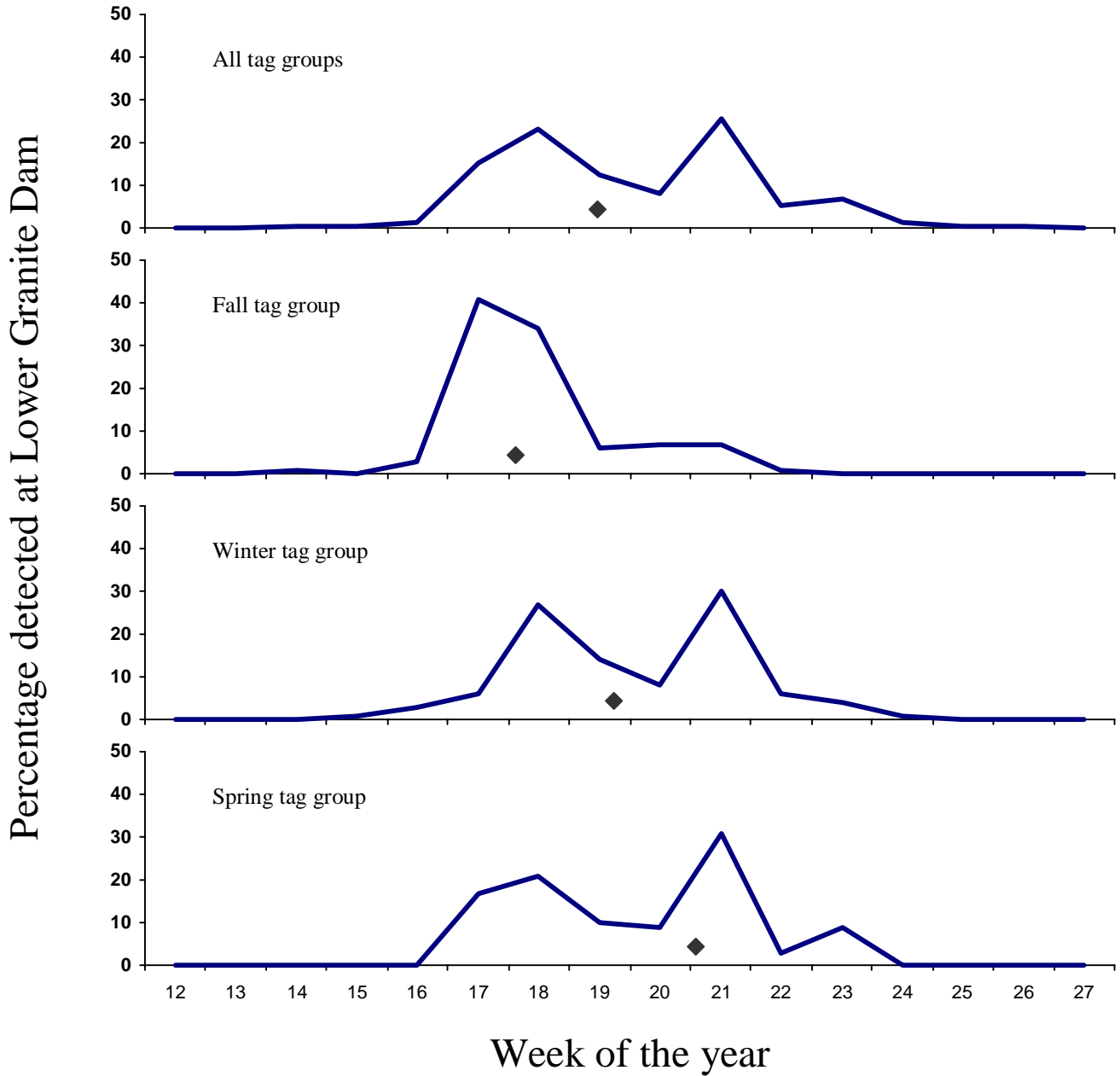


Figure 10. Migration timing at Lower Granite Dam for juvenile spring chinook salmon PIT-tagged on Catherine Creek by tag group, during the 1998 migration year. ♦ = median arrival date. Data were expanded for spillway flow.

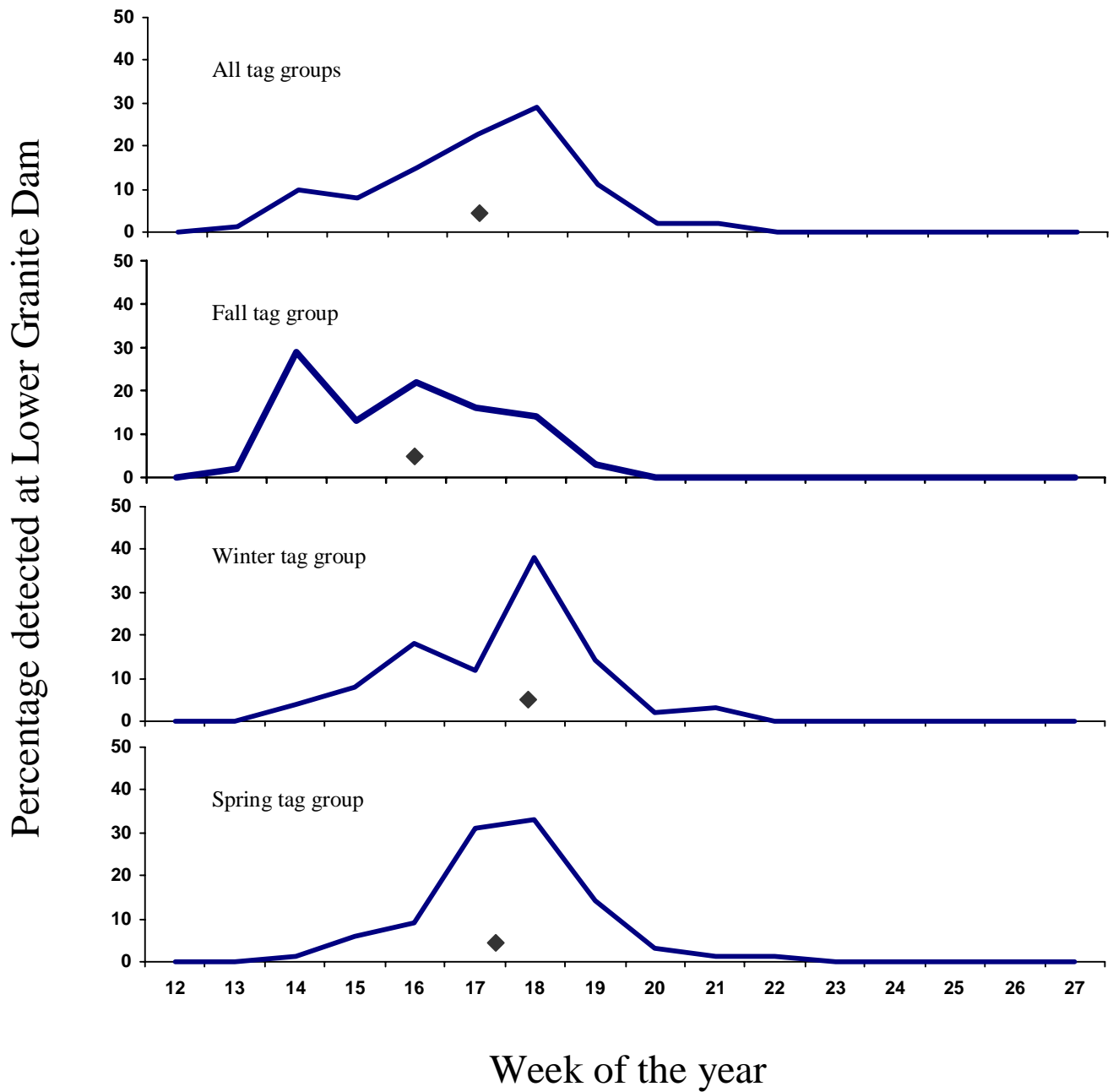


Figure 11. Migration timing at Lower Granite Dam for juvenile spring chinook salmon PIT-tagged on the Lostine River by tag group, during the 1998 migration year. ♦ = median arrival date. Data were expanded for spillway flow.

Detection rates by tag group for upper Grande Ronde River fish ranged from 11% for fish tagged during the winter to 47% for fish tagged during the spring migration (Table 17). We anticipated that spring-tagged fish would have the highest detection rate since this group is the only tag group not subject to overwinter mortality after tagging. Fall-tagged fish from the upper Grande Ronde were detected at a higher rate than winter-tagged fish, suggesting better overwinter survival for fish that moved out of the upper rearing areas and overwintered in the Grande Ronde Valley habitat. This finding is consistent with past years when we have been able to compare fall- and winter-tagged fish. A comparison of the detection rates of winter- and spring-tagged fish from the upper Grande Ronde indicated that overwinter survival of fish remaining in upper rearing areas was approximately 22% for the 1996 brood year. This rate is comparable to past estimates that have ranged from 25 to 33%.

Detection rates by tag group for Catherine Creek fish ranged from 19% for fish tagged during the fall to 46% for fish tagged during the spring migration (Table 17). Fall-tagged fish were detected at a slightly lower rate than winter-tagged fish, suggesting similar overwinter survival for fish that remained in upper rearing areas and those that overwintered in the Grande Ronde Valley habitat. There appears to be no distinct pattern for survival advantage among Catherine Creek fish. In some years it appears to be a better strategy to overwinter in upper rearing areas, in other years the opposite is true, and in still others, there appears to be no difference in the survival of fish overwintering in upper versus lower rearing areas. Comparing detection rates of winter- and spring-tagged fish from Catherine Creek indicates that overwinter

Table 17. Detection rates of juvenile chinook salmon PIT-tagged on the upper Grande Ronde River, Catherine Creek, and the Lostine River by group and dam site during the 1998 migration year. Detection rates are presented as a percentage of the total fish released.

Stream and group	Number released	Lower Granite	Little Goose	Lower Mon.	McNary	John Day	Bonn.	Total
Grande Ronde River								
Fall	592	13.7	6.4	3.6	0.3	1.0	0.3	25.3
Winter	124	4.9	3.2	1.6	0.8	0.0	0.0	10.5
Spring	513	22.6	16.4	5.1	1.6	1.2	0.0	46.8
Catherine Creek								
Fall	598	10.0	5.0	2.2	0.7	1.2	0.3	19.4
Winter	438	13.1	5.7	3.2	0.9	0.2	0.0	23.1
Spring	453	24.0	12.4	6.2	2.2	0.7	0.4	45.9
Lostine River								
Fall	500	22.0	7.6	2.4	5.6	0.4	0.6	38.6
Winter	504	19.0	6.2	3.0	1.8	0.4	0.6	30.9
Spring	466	39.3	21.2	6.0	2.6	1.1	0.2	70.4

survival of fish remaining in the upper rearing areas was approximately 50% for BY 96. This rate is comparable with the BY 93 estimate of 53% and is considerably greater than the BY 94 and BY 95 estimates of 32 and 19%, respectively.

Detection rates by tag group for Lostine River fish ranged from 31% for fish tagged during the winter to 70% for fish tagged during the spring migration (Table 17). Fall-tagged fish from the Lostine River were detected at a higher rate than winter-tagged fish, suggesting better survival for fish that moved out of the upper rearing areas and overwintered downstream, perhaps in the Wallowa canyon or the lower Grande Ronde River. Comparing detection rates of winter- and spring-tagged fish from the upper Lostine River indicates that overwinter survival of fish remaining in the upper rearing areas was approximately 44% in BY 96. This rate is comparable to the BY 95 estimate of 53%.

A preliminary look at interannual patterns of migration and dam detections for fish from Catherine Creek and the Lostine River indicates fish that exhibit the predominant migration strategy in any given year are detected at the dams at a higher rate than fish that exhibit the alternative migration strategies. In years when a majority of the population migrated out of upper rearing areas in the fall, higher survival indices were observed for the fall group than for the group of fish that remained in upper rearing areas for winter. In contrast, in years when the proportions of fish outmigrating in fall and overwintering in upper rearing areas for the winter were similar, survival indices for the two groups have been similar. This pattern is not evident for the upper Grande Ronde population. In that population, a majority of fish consistently remain in upper rearing areas for the winter, even in years when survival indices were greater for fish that outmigrated in the fall. These patterns warrant further consideration and analyses that we will conduct after MY 99.

In all populations, fish that leave upper rearing areas in the fall arrive at Lower Granite Dam earlier than fish that leave in the spring. As environmental conditions in the Snake and Columbia rivers vary from year to year, the survival rates of fish utilizing the different early life history strategies may vary as fish arrive at the dams during different periods of the migration season. These differences point out the need to maintain the diversity of life history strategies observed in the spring chinook salmon of the Grande Ronde River Basin.

## **Parr Studies**

Juvenile chinook salmon captured with seines and PIT-tagged on Catherine Creek and the Imnaha and Minam rivers in summer 1997 were detected at Lower Granite Dam over a 63 d period beginning on 3 April 1998 and ending on 4 June 1998 (Figure 12). The migratory period of individual populations ranged from 42 d (Catherine Creek ) to 58 d (Minam River) in length. Median dates of migration ranged from 29 April (Imnaha and Minam River populations) to 17 May (Catherine Creek population). Migration timing differed significantly among populations ( $P=0.0001$ ). Fish from the Imnaha and Minam rivers passed the dam significantly earlier than fish from Catherine Creek. There was no significant difference between fish from the Imnaha and Minam rivers.

Our findings in 1998 were consistent with past observations (Sankovich et al. 1996, in press; Walters et al. 1997). For each population, the median date of migration in 1998 fell within the range of medians observed from 1993 to 1997. Furthermore, comparisons of timing between populations yielded results that had been obtained in at least some past years. Fish from the Minam and Imnaha rivers migrated through the dam with similar timing (no significant difference) in 1998 and in one of five previous years of study (Minam River fish were earlier in the remaining years). Fish from Catherine Creek migrated through the dam later than fish from the Imnaha and Minam rivers in 1998 and in three of five and all of five previous years of study, respectively. The differences we have observed among populations demonstrate the need to manage the hydrosystem so as to maximize survival throughout the entire migratory period of Snake River spring/summer salmon smolts. Maintenance of the remaining populations, their specific life histories, and unique genetic characteristics is critical to the continued persistence of chinook salmon in northeast Oregon and elsewhere in the Snake River Basin.

Of the parr PIT-tagged on Catherine Creek and the Minam and Imnaha rivers in 1997, 16.4, 20.5, and 28.1% were detected in the hydrosystem as smolts in 1998 (Table 18). These detection rates were among the highest observed thus far for each population, despite relatively high levels of spill at the dams and a theoretical reduction in the probability of detection of PIT-tagged fish.

During the 1998 migration, there were no detections of any age 2+ smolts that had been PIT-tagged as parr on Catherine Creek, and the Imnaha, Lostine, Minam, and Wenaha rivers in summer 1996. A total of 2,780 parr were PIT-tagged and released in those streams in 1996 (Sankovich et al. 1996). To date, the information we have gathered regarding age 2+ smolts indicates this life history is rare among northeast Oregon chinook salmon. Of 24,727 parr PIT-tagged on Catherine Creek and the Grande Ronde, Imnaha, Lostine, Minam, and Wenaha rivers from 1992 to 1996 (Walters et al. 1992, 1997; Sankovich et al. 1996, in press), only 11 (0.04%) were detected in the hydrosystem as age 2+ smolts. Eight of the fish originated in the upper Grande Ronde River and all but one were detected in 1995. This may indicate that the age 2+ smolt life history is expressed at varying levels among populations and is dependent upon conditions which occur infrequently. Further investigation will be required to address these issues.

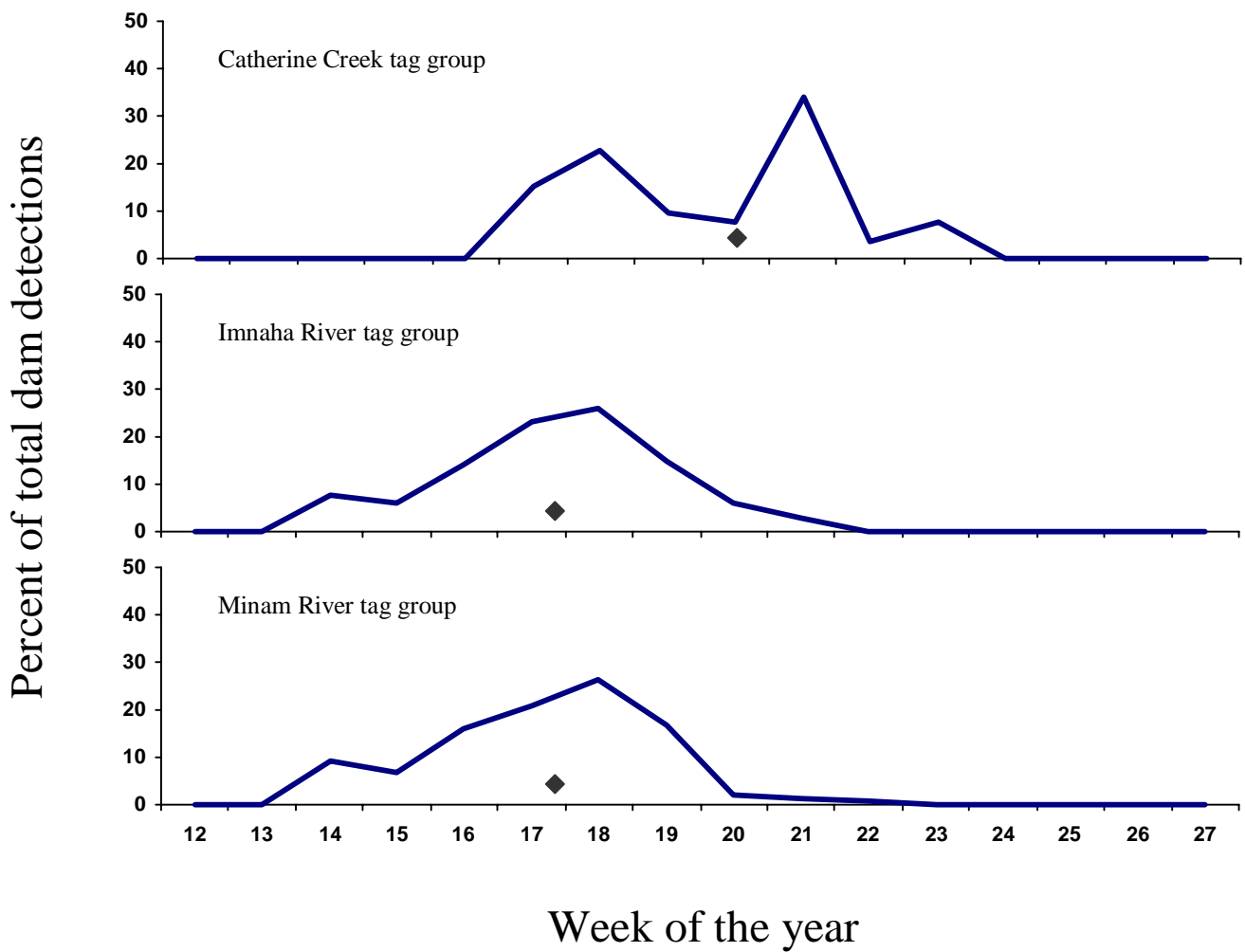


Figure 12. Migration timing at Lower Granite Dam for juvenile spring chinook salmon PIT-tagged as parr during summer 1997. ♦ = median arrival date. Data were expanded for spillway flow.

One question that needs to be resolved regarding age 2+ smolts is whether they arise from immature or mature age 1+ parr, or both. We assumed they arise from immature age 1+ parr and, therefore, assessed the frequency of the age 2+ smolt life history in part by determining the abundance of immature, age 1+ parr in Catherine Creek and the Lostine River in 1998. Our research indicated that no such fish were present in those streams in 1998 (see **Results and Discussion**, Egg-to-Parr Survival, Abundance, and Age Composition of Parr in Summer). This result is not surprising given the apparent rarity of the age 2+ smolt life history. However, the question that arises is this: Can we conclude from our findings that no age 1+ parr were on a course to become age 2+ smolts, or to do so, would information on the fate of mature, age 1+ parr also be required? Ricker (1972), who cited two studies (Gebhards 1960 and Burck 1967), suggested that maturation of age 1+ parr is always followed by death. It is conceivable, however, that some mature age 1+ parr recondition and migrate seaward the following spring. This has been shown to occur for mature, age 0+ parr (Ricker 1972). Furthermore, at our upriver traps on Catherine Creek and the Lostine and upper Grande Ronde rivers, we regularly capture mature, age 1+ parr that appear outwardly to be in excellent condition, weeks after the spawning season. In the future, it may be prudent to attempt to determine the fate of these fish.

Table 18. Detection rates in 1998 of chinook salmon PIT-tagged as parr on Catherine Creek and the Imnaha and Minam rivers in 1997.

Stream	Number released	Lower Granite	Little Goose	Lower Mon.	McNary	John Day	Bonn.	Total
Catherine Cr.	495	8.7	4.9	2.6	0.2	0.0	0.0	16.4
Imnaha R.	998	15.9	6.8	3.7	1.2	0.4	0.0	28.1
Minam R.	1,010	12.2	5.2	2.2	0.5	0.5	0.0	20.5

### Habitat Utilization

We surveyed 79 habitat units in 29 rkm of Catherine Creek during the winter and observed 401 chinook salmon parr. Chinook salmon were observed in all habitat types except rapids with boulders, and were most abundant in alcoves (Table 19). Juvenile chinook salmon were generally found in low velocity habitat types during winter surveys. We surveyed 91 habitat units in 23 rkm during winter surveys on the Lostine River and observed 243 spring chinook salmon parr. Parr were most abundant in backwater pools and were generally found in low velocity habitat types (Table 20). We surveyed 100 habitat units in 32 rkm of the Lostine River during summer surveys and observed 1,283 spring chinook salmon parr rearing from Turkey Flat Campground to Williamson Campground (rkm 39-30) and from Pole Bridge Picnic Area to the mouth (rkm 23-0). Parr were observed in all habitat types and were most abundant in backwater and dammed pools (Table 21). Parr were generally found in low velocity habitat types. Only one class (1995 BY) of chinook salmon parr were identified during winter counts conducted in January and February of 1997. Summer counts were conducted on the Lostine River from mid-July through early August 1998. Very few mature chinook salmon parr were observed and they were, therefore, not included in density tables.



Chinook salmon parr were more abundant in pools than glides or riffles during both summer and winter surveys. Maintenance and/or enhancement of existing pool habitat should be given priority in habitat restoration programs. In addition, increasing habitat diversity should be an important component of habitat management for threatened chinook salmon populations in northeast Oregon streams.

Table 19. Density (fish/100 m<sup>2</sup>) of chinook salmon parr in Catherine Creek (rkm 18-19 and rkm 27-46) and mean water velocity (m/s) by habitat type during winter 1998.

Habitat type	<i>N</i>	Density	Water velocity
Pools:			
Alcove	1	126.87	0.00
Backwater	2	13.89	0.00
Dammed	2	5.19	0.31
Lateral scour	22	15.12	0.26
Plunge	2	2.86	0.31
Straight scour	21	10.24	0.27
Glide	1	1.60	0.36
Riffle	17	0.51	0.56
Riffle with pockets	8	0.60	0.38
Rapid with boulders	3	0.00	0.89

Table 20. Density (fish/100 m<sup>2</sup>) of chinook salmon parr in the Lostine River (rkm 0-23) and mean water velocity (m/s) by habitat type during winter 1998.

Habitat type	<i>N</i>	Density	Water velocity
Pools:			
Backwater	12	32.40	0.425
Isolated	9	25.38	0.004
Lateral scour	13	21.15	2.363
Plunge	4	4.85	1.486
Straight scour	10	15.68	2.396
Glide	14	10.10	2.701
Riffle	11	8.28	4.781
Riffle with pockets	8	1.88	3.664
Rapid with boulders	10	0.00	7.761

Table 21. Density (fish/100 m<sup>2</sup>) of chinook salmon parr in the Lostine River (rkm 0-23 and rkm 30-39) and mean water velocity (m/s) by habitat type during summer 1998.

Habitat type	<i>N</i>	Density	Water velocity
Pools:			
Backwater	17	15.66	-0.033
Beaver dam	3	6.38	0.044
Dammed	1	18.16	0.160
Lateral scour	23	13.86	0.334
Plunge	2	10.38	0.378
Straight scour	8	7.86	0.378
Glide	12	7.05	0.408
Riffle	16	3.47	0.571
Riffle with pockets	13	1.31	0.588
Rapid with boulders	5	1.44	0.838

### Future Directions

We will continue this early life history study of spring chinook salmon in Catherine Creek and the upper Grande Ronde, Lostine, and Wallowa rivers. In MY 2000, we will begin to piece together the components to build a life history model for spring chinook salmon in our study streams. In addition, we will begin to investigate the life history of summer steelhead in the Grande Ronde River Basin.

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