Investigations into the Early Life-history of Naturally Produced Spring Chinook Salmon and Summer Steelhead in the Grande Ronde River Basin

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INVESTIGATIONS INTO THE EARLY LIFE HISTORY OF NATURALLY PRODUCED SPRING CHINOOK SALMON AND SUMMER STEELHEAD IN THE GRANDE RONDE RIVER BASIN

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ABSTRACT

We determined migration timing and abundance of juvenile spring chinook salmon *Oncorhynchus tshawytscha* and juvenile steelhead/rainbow trout *O. mykiss* from three populations in the Grande Ronde River basin. Based on migration timing and abundance, two distinct life-history strategies of juvenile spring chinook and *O. mykiss* could be distinguished. An 'early' migrant group left upper rearing areas from July through January with a peak in the fall. A 'late' migrant group descended from upper rearing areas from February through June with a peak in the spring. We estimated 14,780 juvenile chinook salmon left upper rearing areas of the Grande Ronde River from July 1999 to June 2000 with approximately 26% descending as early migrants. An estimated 17,845 juvenile *O. mykiss* emigrated from the upper Grande Ronde River during the same period with early migrants accounting for only 6% of the total migrating population. We estimated 23,991 juvenile chinook salmon left upper rearing areas of Catherine Creek from July 1999 to June 2000 with approximately 82% leaving as early migrants. During the same period, an estimated 35,699 juvenile *O. mykiss* migrated out of Catherine Creek. Approximately 39% of the *O. mykiss* left upper rearing areas as early migrants. We estimated 23,016 juvenile chinook salmon left the Grande Ronde Valley, located below the upper rearing areas in Catherine Creek and the Grande Ronde River, from July 1999 to June 2000 with approximately 97% of the migrants leaving as late migrants. We also estimated 60,266 juvenile *O. mykiss* migrated out of the Grande Ronde Valley with 95% leaving as late migrants. These data indicate that the majority of early migrating spring chinook salmon and summer steelhead from the Grande Ronde River basin overwinter in the valley above Grande Ronde River rkm 164. An estimated 12,250 juvenile chinook salmon left upper rearing areas of the Lostine River from July 1999 to June 2000; approximately 68% of the juvenile chinook left as early migrants and 31% as late migrants. We also estimated 11,981 *O. mykiss* emigrated from the Lostine River during the same period with approximately 56% leaving as early migrants. We estimated 22,650 juvenile spring chinook salmon and 18,967 *O. mykiss* left the Wallowa Valley, located below the mouth of the Lostine River, from July 1999 to March 2000.

Juvenile chinook salmon PIT-tagged on the upper Grande Ronde River were detected at Lower Granite Dam from 12 April to 20 July 2000, with a median passage date of 12 May. PIT-tagged salmon from Catherine Creek were detected at Lower Granite Dam from 12 April to 2 July 2000, with a median passage date of 6 May. PIT-tagged salmon from the Lostine River were detected at Lower Granite Dam from 3 April through 2 July 2000, with a median passage date of 6 May. Juveniles tagged as early migrants in the Grande Ronde River and Catherine Creek and subsequently overwintered in the Grande Ronde Valley were detected in the hydrosystem at higher rates than fish tagged during winter in the upper rearing areas, indicating a higher overwinter survival in the downstream areas. Fish from Lostine River showed no significant difference in detection rates, indicating similar overwinter survival in upper and lower rearing areas.

In summer 1999, we PIT-tagged parr on Catherine Creek and the Imnaha, Lostine, and Minam rivers in order to monitor their subsequent migration as smolts through the Snake and Columbia River hydrosystem. Median passage dates at Lower Granite Dam ranged from 2 May to 7 May. We found significant differences among populations in smolt migration timing at Lower Granite Dam in 2000. Catherine Creek fish arrived at the dam significantly later than the Minam and Imnaha River fish. Similarly, Lostine River fish arrived significantly later than the Minam River fish. Fish from Catherine Creek and the Imnaha, Lostine, and Minam rivers were detected in the hydrosystem at rates of 10.9, 11.6, 14.9, and 17.5%, respectively. Survival

probabilities to Lower Granite Dam for these populations were 0.150 (Catherine Creek), 0.141 (Imnaha River), 0.212 (Lostine River), 0.239 (Minam River).

In August 2000, we estimated chinook parr abundance and the number of parr produced per redd in Catherine Creek and the Lostine River. We estimated that 703 mature, age-1 male parr; 299 immature age-1 parr; and 25,698 immature, age-0 parr were present in Catherine Creek. An average of 21 mature and 8 immature, age-1 male parr were produced from each redd constructed in 1998. An average of 676 immature, age-0 parr were produced per redd constructed in 1999. In the Lostine River, we estimated that 297 mature age-1 parr and 12,372 immature, age-0 parr were present in August. An average of 11 mature, age-1 parr were produced per redd in 1998. An average of 275 immature age-0 parr were produced per redd in 1999. We estimated 27 mature male parr present for every redd in Catherine Creek in 2000. Additionally, an estimated 5.6 mature male parr were present per redd in the Lostine River.

The *O. mykiss* PIT-tagged at the upper Grande Ronde River trap were detected at Lower Granite Dam from 31 March to 28 June 2000, with a median passage date of 7 May 2000. PIT-tagged fish from Catherine Creek were detected at Lower Granite Dam from 2 April to 29 June 2000, with median passage date of 3 May 2000. PIT-tagged fish from the Lostine River were detected at Lower Granite Dam from 26 March through 16 June 2000, with 50% of the fish passing the dam by 8 May 2000. Lostine River *O. mykiss* had a median passage date that was significantly later than the Catherine Creek fish.

In July 2000, we conducted a population estimate of *O. mykiss* in the mainstem Catherine Creek and South Fork Catherine Creek. We estimated 22,393 *O. mykiss* in the mainstem Catherine Creek and 9,971 *O. mykiss* in the South Fork. Scale analysis revealed that *O. mykiss* ranged from age-0 to age-3 in both streams. Age-1 was the most abundant age class, accounting for 59.7% in mainstem Catherine Creek and 71.4% in the South Fork.

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EXECUTIVE SUMMARY

Objectives

1. Document the annual in-basin migration patterns, including abundance, timing, duration, and egg-to-migrant survival of juvenile spring chinook salmon in the upper Grande Ronde River, Catherine Creek and the Lostine River.

2. Estimate and compare dam detection rates and survival probabilities 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. Estimate and compare detection rates and survival probabilities from tagging to detection at mainstem Columbia and Snake River dams for migrants from four local, natural populations in the Grande Ronde River and Imnaha River basins.

4. Document the annual migration patterns for spring chinook salmon juveniles from four local, natural populations in the Grande Ronde River and Imnaha River basins.

5. Determine survival to parr stage for spring chinook salmon in two local, natural populations in the Grande Ronde River Basin.

6. Investigate the significance of alternate life history strategies of spring chinook salmon in two local, natural populations in the Grande Ronde River Basin.

7. Document patterns of movement for juvenile *O. mykiss* from populations in Catherine Creek, the upper Grande Ronde River and the Lostine River, including data on migration timing, duration, and smolt abundance.

8. Estimate and compare smolt detection rates and survival probabilities to mainstem Columbia and Snake River dams for summer steelhead from Catherine Creek and the upper Grande Ronde and Lostine rivers.

9. Describe the population characteristics of the juvenile *O. mykiss* population in Catherine Creek including abundance, and age structure.

Accomplishments

We accomplished all of our objectives in 2000.

Findings

In the Grande Ronde River Basin, migration timing and abundance of juvenile spring chinook salmon and summer steelhead were determined by operating rotary screw traps in both upper and lower river reaches of the Grande Ronde River and Wallowa River valleys. Distinct early and late migration patterns were observed for both species at most trap sites with peaks occurring in the fall and spring, respectively. At the upper Grande Ronde River trap, 6,329 juvenile chinook salmon were captured from 1 July 1999 through 30 June 2000. The catch was expanded to an estimate of 14,780 juvenile migrants. Approximately 26% of the migrant population left upper rearing areas in Grande Ronde River early (between 1 July 1999 and 29 January 2000) to overwinter downstream. During the same period, 2,463 juvenile *O. mykiss* were captured with the catch expanded to an abundance estimate of 17,845 migrants. Approximately 6% of these fish descended the upper Grande Ronde as early migrants. At the Catherine Creek trap, 9,292 juvenile chinook salmon were captured from 1 July 1999 through 28 June 2000 and the catch was expanded to an estimate of 23,991 migrants. Approximately 82% of the Catherine Creek migrant chinook population left upper rearing areas early and overwintered downstream. We also captured 4,483 juvenile *O. mykiss* at this trap with an abundance estimate of 35,699 migrants. Approximately 39% left upper rearing areas early to overwinter downstream. At the lower Grande Ronde River trap, 1,973 juvenile chinook salmon were captured as they left the Grande Ronde Valley from 1 July 1999 through 25 June 2000. The catch was expanded to an estimate of 23,016 chinook migrants. Approximately 97% of the chinook migrant population left the Grande Ronde Valley in spring as late migrants (between 30 January and 30 June 2000). We also captured 3,947 juvenile *O. mykiss* with a resultant abundance estimate of 60,266 migrants. Approximately 95% of the juveniles left the Grande Ronde Valley in spring as late migrants. At the Lostine River trap, 5,316 juvenile chinook salmon were captured from 6 July 1999 through 30 June 2000. The catch was expanded to an estimate of 12,250 migrants. Approximately 68% of the chinook migrant population left upper rearing areas in Lostine River early to overwinter downstream. We captured 2,186 juvenile *O. mykiss* during this same period. The catch was expanded to an estimate of 11,981 migrants of which approximately 56% descended the Lostine River as early migrants to overwinter downstream. At the Wallowa River trap, 5,331 juvenile spring chinook salmon and 2,002 juvenile *O. mykiss* were captured as they left the Wallowa Valley from 6 July 1999 through 23 March 2000. We discontinued trap operations on 23 March because catch patterns closely resembled those of the Lostine River trap, thus indicating that spring chinook and summer steelhead from the Lostine River overwintered below the Wallowa River trap.

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 12 April to 20 July 2000, with a median passage date of 12 May. Fish tagged during spring as late migrants were detected at the highest rate. The detection rate of early migrants that subsequently overwintered in areas downstream (21.7%) was higher than the rate for fish tagged during winter in upper rearing areas and subsequently left rearing areas as late migrants the following spring (11.2%) suggesting better survival for early migrants. PIT-tagged salmon from Catherine Creek were detected at Lower Granite Dam from 12 April to 2 July 2000, with a median passage date of 6 May. Fish tagged during spring were detected at the highest rate. The detection rate of juvenile salmon tagged as they left upper rearing areas in fall (early migrants) and overwintered downstream (16.0%) was higher than the rate for fish tagged during winter in the upper rearing area (11.2%). Lostine River fish were detected at Lower Granite Dam from 3 April through 26 July 2000, with a median passage date of 6 May. As in the other streams, fish tagged during spring were detected at the highest rate. The detection rate of fish tagged as they left the upper rearing area in fall and overwintered in areas downstream (26.7%) was not significantly different from that of fish tagged during winter in upper rearing areas (22.1%). Survival probabilities estimated for the same stream/tag-group showed similar results as dam detection rates. Survival rates of early migrants from upper Grande Ronde (S = 0.341) and Catherine Creek (S = 0.212) were significantly higher than survival rates of fish tagged during winter in upper rearing areas of these streams (S = 0.133, 0.138 respectively). In the Lostine River, there was no significant difference between early migrants (S = 0.317) and those tagged in winter in upper rearing areas (S = 0.392).

Chinook salmon parr that were collected by seining and PIT-tagged on Catherine Creek and the Imnaha, Lostine, and Minam rivers in summer 1999 were detected at Lower Granite Dam over a 68 d period from 10 April to 16 June 2000. The migratory period of individual populations ranged from 50 d (Minam River) to 66 d (Imnaha River) in length. Median dates of migration ranged from 2 May (Imnaha River) to 7 May (Catherine Creek and Lostine River). We found significant differences in migration timing among populations (Kruskal-Wallis $P < 0.001$). Catherine Creek smolts arrived at the dam significantly later than the Minam and Imnaha River smolts. Similarly, Lostine River smolts arrived significantly later than the Minam River smolts. Cumulative detection rates (i.e., first-time detections at all dams outfitted with PIT tag monitoring facilities) varied among populations, ranging from 10.9 (Catherine Creek) to 17.5% (Minam River). Likewise, survival probabilities based on CJS estimates for these populations were significantly different (ANOVA $P = 0.002$). The Minam River population had a significantly higher survival rate than both the Catherine Creek and Imnaha River populations.

During the 2000 migration, there were no detections of any age-2 smolts that had been PIT-tagged as parr on Catherine Creek and the Imnaha, Lostine, and Minam rivers in 1998. We estimated previously that there were no immature, age-1 parr (i.e., fish that would presumably become age-2 smolts) in Catherine Creek or the Lostine River in summer 1998 (Jonasson et al. 1999).

Using mark-and-recapture and scale-aging techniques, we determined population size and age-structure of spring chinook parr in Catherine Creek and the Lostine River. In Catherine Creek, we estimated 703 mature, age-1 parr; 299 immature, age-1 parr; and 25,698 immature, age-0 parr were present during August 2000. An average of 21 mature and 8 immature, age-1 parr were produced from each redd constructed in 1998. An average of 676 immature age-0 parr were produced from each redd constructed in 1999. We estimated that 3.1% of the immature, age-0 parr inhabiting Catherine Creek in August 1999 matured and were present in Catherine Creek in August 2000. There were an estimated 27 mature male parr for every redd in Catherine Creek in 2000.

An estimated 297 mature, age-1 parr and 12,372 immature, age-0 parr inhabited the Lostine River in August 2000. We estimated an average of 11 mature, age-1 parr were produced from each redd constructed in 1998. An average of 275 immature parr were produced from each redd constructed in 1999. We estimated that 1% of the immature, age-0 parr present in the Lostine River in 1999 matured and were present in the Lostine River in August 2000. There was an average of 5.6 mature male parr for every redd in the Lostine River in 2000.

The *O. mykiss* PIT-tagged at the upper Grande Ronde River trap were detected at Lower Granite Dam from 31 March to 28 June 2000, with a median passage date of 7 May 2000. PIT-tagged fish from Catherine Creek were detected at Lower Granite Dam from 2 April to 29 June 2000, with median passage date of 3 May 2000. PIT-tagged fish from the Lostine River were detected at Lower Granite Dam from 26 March through 16 June 2000, with 50% of the fish passing the dam by 8 May 2000. Lostine River *O. mykiss* had a median passage date that was significantly later than the Catherine Creek fish.

Median arrival dates at Lower Granite Dam for *O. mykiss* PIT-tagged at the upper Grande Ronde River as early-migrants and late-migrants were 2 May, and 7 May 2000, respectively. Median arrival date for fish PIT-tagged at the Catherine Creek trap as early migrants and late migrants were 3 May, and 6 May 2000, respectively. Medians for fish PIT-tagged at the Lostine River trap were 10 May for early migrants, and 6 May for late migrants. Only the Catherine Creek population demonstrated a significant difference between early and late migrants.

We used mark-and-recapture and scale-aging techniques to determine population size and age-structure of *O. mykiss* in the mainstem Catherine Creek and its tributary South Fork Catherine Creek. We estimated 22,393 *O. mykiss* inhabited the mainstem Catherine Creek and 9,971 *O. mykiss* inhabited the South Fork. Scale analysis showed that *O. mykiss* ranged from age-0 to age-3 in both streams. Age-1 fish were the most abundant, accounting for 59.7% in mainstem Catherine Creek and 71.4% in the South Fork.

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. Four 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, early-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.

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 information we have gathered thus far on the occurrence of age-2 smolts indicates this life history is rare among northeast Oregon chinook salmon and, in terms of life cycle modeling at least, can probably be discounted. The mature male parr life history is more prevalent and deserves consideration from both life cycle modeling and biological perspectives. Based on the mature male parr to redd ratios we have observed, it is evident mature male parr hold the potential to make significant gametic contributions to northeast Oregon chinook salmon populations. Given the continual low abundance of adult spawners, mature male parr may be an important means by which the 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 1999, estimated escapement for the basin was 540 adults (180 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 from the Grande Ronde basin occurs in spring. Data from Lookingglass Creek (Burck 1993) and Catherine Creek, the Grande Ronde River and the Lostine River (Keefe et al. 1994, 1995; Jonasson et al. 1996, 1997, 1999; and Tranquilli et al. 1998) indicate a substantial number of juveniles move out of upper rearing areas during fall and overwinter downstream within the Grande Ronde basin. The proportion of the total migrant population these early migrants represent, and their survival to Snake and Columbia river dams, varies among years and streams.

Juveniles that leave upper rearing areas in Catherine Creek and the upper Grande Ronde River in 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, 1999). 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 continued 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, duration, and egg-to-migrant survival of juvenile spring chinook salmon in the upper Grande Ronde River, Catherine Creek and the Lostine River, 2) estimate and compare survival indices and survival probabilities from tagging to smolt detection at mainstem Snake and Columbia River dams for juveniles spring chinook that leave upper river rearing areas at different times of the year, 3) estimate and compare smolt detection rates and survival probabilities from tagging to detection at mainstem Columbia and Snake River dams for spring chinook migrants from several local, natural populations in the Grande Ronde River and Imnaha River basins, 4) document the annual migration patterns for spring chinook salmon juveniles from several local, natural populations in the Grande Ronde River and Imnaha River basins, 5) determine survival to parr stage for spring chinook salmon in two local, natural populations in the Grande Ronde River Basin, 6) 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, 7) document patterns of movement for juvenile *O. mykiss* from populations in Catherine Creek, the upper Grande Ronde River, and the Lostine River, including data on migration timing, duration, and smolt abundance, 8) estimate and compare smolt detection rates and survival probabilities to mainstem Columbia and Snake River dams for summer steelhead from Catherine Creek and the upper Grande Ronde and Lostine rivers, and 9) describe the population characteristics of the juvenile *O. mykiss* population in Catherine Creek including abundance and age structure.

SPRING CHINOOK SALMON INVESTIGATIONS

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, Parr Abundance, and Age Composition in Summer

We used mark-and-recapture and scale-aging techniques to estimate the abundance of immature and mature (male) parr, by age class, in Catherine Creek and the Lostine River in August 2000. 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 for each stream was to mark 1,000 immature parr and as many mature parr as we could capture in 5 d. During subsequent sampling, our goal was to capture at least 500 immature parr and as many mature parr as possible in 5 d. We collected scales from a haphazard sample of approximately 200 immature parr and all but a small portion of the mature parr captured in each stream. We identified mature parr based on body morphology and coloration. Mature parr tend to be longer, deeper-bodied, and more yellowish in color (laterally) than immature parr.

We collected parr for marking either by herding them (while snorkeling) into a seine set perpendicular to the stream flow or by beach seining. Captured fish were held in aerated, 19 L buckets or in aerated, 19 L carboys attached to pack frames and transferred periodically to live cages anchored in shaded areas of the stream. The live cages were located near designated marking stations. On both Catherine Creek and the Lostine River, parr were collected (and marked and released) within a reach of stream beginning upstream from the upper-most redd observed in 1998 and ending at a rotary screw trap (see Figure 1 for rotary screw trap locations). These reaches were 22 km (Catherine Creek) and 41 km (Lostine River) in length.

Prior to being marked, fish were anesthetized in an aerated bath containing 40 to 50 mg/L of tricaine methanesulfonate (MS-222). We marked all mature parr, and any immature parr less than 55 mm fork length (FL), with Alcian Blue dye. The dye was applied with a tattoo machine, slightly anterior of the pelvic fin of each fish. Immature parr that were 55 mm FL or greater were either dye-marked or PIT-tagged. PIT tags were injected manually with a modified hypodermic syringe as described by Prentice et al. (1986, 1990) and Matthews et al. (1990, 1992). Syringes were disinfected for 10 minutes in 70% isopropyl alcohol and allowed to dry for 10 minutes 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 (1 mm), and weight (0.1 g) of PIT-tagged fish. We also recorded the fork length and weight of mature parr, and the fork length of dye-marked, immature parr. All fish were handled and marked at stream temperatures of 15°C or less and released in the area of capture on the day they were processed.

During subsequent sampling, we collected parr from at least seven randomly selected reaches of approximately 1.6 km each on Catherine Creek and the Lostine River. We used the seining methods outlined above to capture parr. Each fish was inspected for marks and maturity status, and the numbers of mature and immature parr that were unmarked, dye-marked, PIT-tagged, or that had lost their PIT tag (i.e., no tag could be detected, but a PIT-tagging scar was evident) were recorded.

We used the adjusted Petersen estimate (Ricker 1975) to determine the abundance of immature and mature parr in Catherine Creek and the Lostine River. Ninety-five percent confidence intervals were obtained using equation (3.7) and values from Appendix II in Ricker (1975). Estimates of the age composition of groups of immature and mature parr were based on results from scale analyses. 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 abundance and age composition estimates from August 1999 (Jonasson et al. 1999) and 2000, and redd count data from 1998 and 1999, we determined the following regarding chinook salmon populations in Catherine Creek and the Lostine River: 1) the abundance of immature and mature parr, by age class, in August 2000, 2) the percentage of immature, age-0 parr present in each stream in August 1999 that either matured or did not mature and were present in August 2000, 3) the average number of mature and immature, age-0 parr (in 2000) produced from each redd constructed in 1999, and 4) the average number of mature and immature age-1 parr (in 2000) produced from each redd constructed in 1998. We estimated rates of egg-to-parr survival, based on an estimated fecundity of 4,348 eggs/female (mean fecundity of 12 female spring chinook salmon captured at the Lostine River weir and spawned at Lookingglass Hatchery in 1997 [4 fish] and 2000 [8 fish]; ODFW files) and the number of redds counted above the trap sites on Catherine Creek and the Lostine River.

In-Basin Migration Timing and Abundance

The 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. Although we attempted to fish the traps year round, there were times when a trap could not be operated due to low flow or freezing conditions. At our upper Grande Ronde River trap site, a 1.5 m diameter trap was fished from 1 July through 4 December 1999, and 23 February through 30 June 2000. A 1.5 m diameter trap was fished at the Catherine Creek site from 1 July through 23 December 1999, and 14 January through 30 June 2000. At our lower Grande Ronde River trap site, a 2.4 m diameter trap was fished for the first week of July 1999, and 1.5 m diameter trap was fished from 30 September 1999 through 7 February 2000. We then fished a 2.4 m diameter trap at this site from 8 February through 25 June 2000.

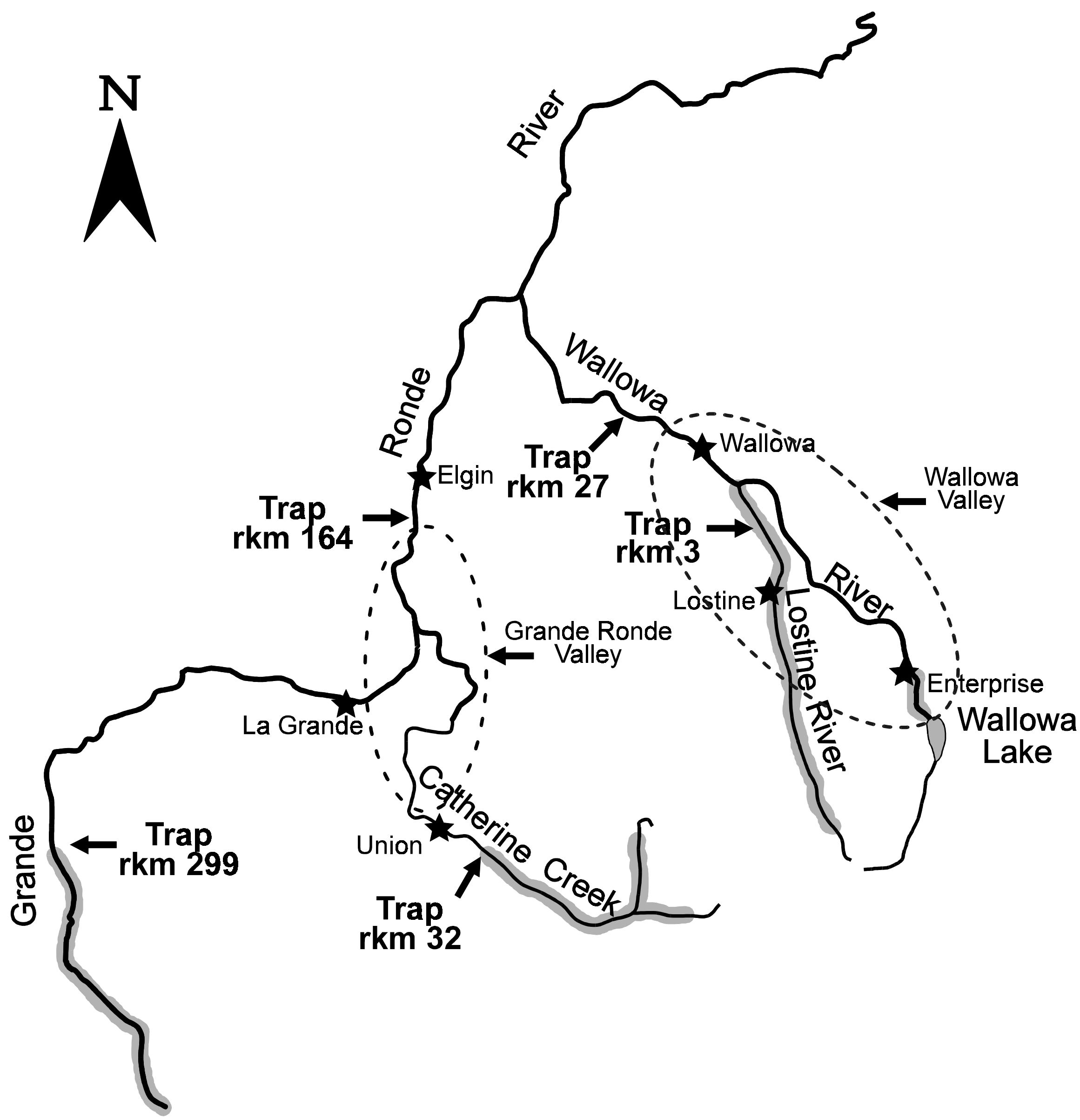

Figure 1. Locations of fish traps in the Grande Ronde River Basin during the study period. Shaded areas delineate spring chinook salmon spawning and upper rearing areas in each study stream. Dashed lines indicate the Grande Ronde River and Wallowa River valleys.

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 6 July 1999 through 22 May 2000 and from 5 June through 30 June 2000. A second rotary screw trap was located on the Wallowa River above the confluence 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 6 July 1999 through 23 March 2000.

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 weekly trap efficiency tests throughout the migratory year at each trap site. 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 weekly totals.

Trap efficiency was estimated by

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

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

The weekly abundance of migrants that passed each trap site was estimated by

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

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 weekly trap efficiency.

Variance of each weekly $\hat{N}$ was estimated by the one-sample bootstrap method (Efron and Tibshirani 1986; Thedinga et al. 1994) with 1,000 iterations. Preliminary analysis indicated that when there were less than 10 recaptured fish in a week, bootstrap variance estimates were greatly expanded. For this reason, we combined consecutive weeks when there were fewer than 10 recaptures until total recaptures were greater or equal to 10 fish. This combined trap efficiency estimate was used in the bootstrap procedure to estimate weekly population estimates and variance. Each bootstrap iteration calculated weekly $\hat{N}$ from equations (1 and 2) drawing *R* and *U* from the binomial distribution. Abundance for the total migration past each trap for the migratory year was determined by adding the weekly estimates. Similarly, weekly variance estimates were summed to obtain an estimated variance for the total migrant abundance. Confidence intervals for total migrant abundance were calculated by

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

where *V* is the estimated total variance determined from the bootstrap. Migrant fry were able to escape from the trap without detection and, therefore, were not included in migrant abundance estimates. Also, sexually mature male parr were not included in migrant abundance estimates.

The Catherine Creek trap and the Lostine River trap were located below hatchery chinook release sites. The magnitude of hatchery chinook releases into these streams during the spring necessitated modifications to our method of estimating migrant abundance of wild chinook at the trap sites. During low catch periods, the trap was fished continuously throughout a 24 h period as described above. 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.

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). We estimated this proportion by fishing the trap over several 24 h periods prior to the hatchery release period. We counted the number of fish trapped during the 4 h interval and the remaining 20 h interval within each 24 h period. The proportion of the total daily catch captured during the sampling interval (*i*) was estimated by

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

were $\hat{P}_i$ 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,* and *C* is the total number of fish caught throughout the 24 h sampling periods.

We did not attempt to mark and release fish for the purpose of estimating trap efficiency during systematic sampling. Abundance of wild juvenile chinook at each trap during the systematic sampling period was estimated by

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

where $\hat{N}_s$ is the estimated number of fish migrating past the trap during systematic sampling, U_i is the total number of fish captured during interval *i*, $\hat{P}_i$ is the proportion of daily catch from equation (4), and $\hat{E}$ is the estimated trap efficiency. Trap efficiency during systematic sampling was calculated from equation (1) by using mark/recapture numbers from one week prior to and after the systematic sampling period. Abundance for the total migration at the Catherine Creek and Lostine River traps was determined by summing the continuous and systematic sampling estimates.

Variance for $\hat{N}_s$ at each traps during systematic sampling 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. Variance of total migrant abundance was determined by summing the variance from the continuous and systematic sampling estimates.

Migration Timing and Survival to Lower Granite Dam

Comparison of Early Life History Strategies: 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 (i.e. early migrants, winter group, late migrants). During the 2000 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 early migration that peaks at our trap sites in the fall. Early migrants leave summer rearing areas in the upper Grande Ronde River, Catherine Creek, and the Lostine River and overwinter in downstream habitat. They continue their seaward migration out of the basin the following spring. Late migrants exhibit another life history strategy whereby they remain in upper rearing areas throughout fall and winter, and initiate their seaward migration in spring. To determine if there were differences in survival between early and late migrants within populations of spring chinook salmon, we planned to tag 500 early migrants, 500 late migrants as well as 500 spring chinook salmon overwintering in upstream rearing habitat (hereafter referred to as winter tag-group). To be consistent with previous years of this study, fish that moved past our upper trap sites between September and early December were tagged as early migrants. Fish tagged as late migrants moved past our upper trap sites between February and May. These times encompassed a majority of the early and late migrations, although a few juvenile chinook salmon will continue to be caught at trap sites throughout the winter months. The winter tag-group fish were tagged immediately following completion of early migrant tagging. These fish were tagged at a minimum of 8 rkm above the trap sites to ensure that they would be unlikely to pass the trap sites while making localized movements during winter. We also tagged 500 to 1,000 chinook salmon parr rearing in Catherine Creek, and the Lostine, Imnaha and Minam rivers in late summer 1999 as part of our investigation into parr strategies (Objectives 4-6).

Thus, there are four tag groups used to estimate migration timing and index survival to Lower Granite Dam: summer tag-group (upstream summer-rearing fish), early migrants, late migrants, and winter tag-group (upstream overwintering fish). Fish tagged in these groups do not necessarily represent unique life history strategies. For example, the summer tag-group includes fish that could move out of upper rearing areas as either early or late migrants, and consequently overwinter in either the lower or upper rearing areas. Therefore, the summer tag-group includes fish that exhibit all possible life histories and, as such, depicts timing and survival for the overall population. Furthermore, the winter tag-group and the late migrant tag group share the same life-history characteristic (i.e. both overwinter upstream) but are tagged at different times in the year.

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-rearing group and subsequently recaptured at a river trap as early migrants, were analyzed as summer tagged fish.

At the completion of the 2000 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. For each stream, we evaluated relative success of early and late migrants by using goodness-of-fit test to compare the survival indices of the early migrant tag-group to the winter tag-group. It is assumed that any difference in survival indices between these two groups is attributable to differential survival in upstream and downstream overwintering habitat. We assessed fish survival in upstream overwintering habitat by dividing the survival index of the winter tag-group by the corresponding index for the late migrant tag-group. This proportion was then expressed as the percentage of fish in upper rearing areas that survived 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.

To further examine survival of tag-groups and the accuracy of first-time detection rates as an index of survival, we estimated survival probabilities to Lower Granite Dam using Cormack-Jolly-Seber (CJS) models in the program SURPH (Smith et al. 1994). We made similar comparisons as described above to evaluate relative success of early and late migrants. For each stream, we performed two-sample t-tests on the survival probabilities of early migrant and the winter tag-group to evaluated relative success of early and late migrant life-history strategies. We also used survival probabilities to assess overwintering survival of fish using upstream habitat following similar methods described above. We divided the survival probabilities of the winter tag group by the corresponding survival probabilities for the late migrant tag group and expressed the result as the percentage of fish in upper rearing areas that survived winter.

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.

Population Comparisons: In summer of 1999 and 2000, we PIT-tagged parr from populations in Catherine Creek and the Lostine, Minam, and Imnaha rivers in order to monitor and compare their migration timing as smolts to Lower Granite Dam and their rates of detection in the hydrosystem. We conducted tagging operations in late summer (Table 1) so that few fish would be too short to tag (<55 mm fork length). 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 above previously for the mark-and-recapture experiments (see **SPRING CHINOOK SALMON INVESTIGATIONS; Methods**; **Egg-to-Smolt Survival, Abundance, and Age Composition of Parr in Summer**). In summer 1999, we released from 499 to 998 PIT-tagged parr in each stream (Table 1). We released from 490 to 1050 PIT-tagged parr in each stream in summer 2000 (Table 1). Information on the migration timing and detection rates of parr PIT-tagged in summer 2000 will be reported next year.

We estimated the timing with which fish from the different populations migrated through Lower Granite Dam in the same manner as described above in **Comparison of Early Life History Strategies**. To determine if migration timing differed among populations, we performed a Kruskal-Wallis test on the dates of detection, expressed as day of the year, of expanded fish numbers. When significant differences were found, we used a multiple-comparison procedure ($\alpha = 0.05$) to further analyze the data.

First-time detection rates of fish from the different streams were calculated in the manner outlined above in **Comparison of Early Life History Strategies**. Furthermore, we calculated CJS survival estimates for the different populations and performed a One-way ANOVA ($\alpha = 0.05$) to detect differences. If significant differences were detected, we compared populations with Tukey's multiple pair-wise comparisons.

Table 1. Dates of tagging and number of chinook salmon parr PIT-tagged on various northeast Oregon streams in 1999 and 2000.

Year and stream	Dates of collection and tagging	Number of parr PIT-tagged and released	Kilometers upstream from Lower Granite Dam
1999			
Catherine Creek	2-5 Aug	497	358-374
Lostine River	9-11 Aug	509	277-301
Minam River	16-18 Aug	998	279-283
Imnaha River	23-25 Aug	982	208-241
2000			
Catherine Creek	7-10 Aug	500	370-377
Lostine River	14-17 Aug	490	276-290
Minam River	22 Aug, 18-19 Sep	1000	282-283
Imnaha River	28-30 Aug	1050	222-243

Results and Discussion

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

Catherine Creek: From the information obtained during our mark-and-recapture experiments, we estimated that 703 (95% CI: 459-1,125) mature parr and 25,997 (95% CI: 18,164-38,753) immature parr inhabited Catherine Creek in August 2000 (Table 2). Results from scale analyses indicated that all the mature parr were age-1 (Table 3). Of the immature parr collected for scale analysis, 98.9% (258 of 261) were age-0 (Table 3). This translates to an estimate of 25,698 immature age-0 parr and 299 immature age-1 parr present in Catherine Creek. It should be noted, however, that two of the three age-1 parr reported as immature were relatively small (103 and 109 mm FL, respectively) when compared to the length range for that year class (100-148 mm FL). The ability to determine maturation of smaller fish based on body morphology and coloration is suspect. Furthermore, all three fish were collected in early August and the maturity characteristics may not have been fully present at this time.

There were 34 and 38 redds counted in the Catherine Creek study area in 1998 and 1999, respectively. Thus, we estimated that 21 mature, age-1 parr and 8 immature, age-1 parr were produced per redd constructed in 1998. Additionally, 676 immature, age-0 parr were produced from each redd constructed in 1999. This production estimate is similar to that of 1998 where an estimated 662 immature, age-0 parr were produced per redd. Of the 22,505 immature, age-0 parr estimated to be present in Catherine Creek in August 1998 (Jonasson et al. 1999), 3.1% were estimated to have matured precociously and been present in August 2000.

Lostine River: We estimated 297 (95% CI: 121-743) mature parr and 12,372 (95% CI: 10,076-15,192) immature parr inhabited the Lostine River in August 2000 (Table 2). Results from scale analyses indicated that all of the mature parr sampled for scales were age-1 and all immature parr were age-0 (Table 3).

There were 28 and 45 redds counted in the Lostine River above our trap in 1998 and 1999, respectively. Thus, we estimated that 10.6 mature, age-1 parr were produced per redd constructed in 1998. An estimated 1% of the immature, age-0 parr estimated to be present in the Lostine River in 1999 were present in August 2000 as mature age-1 parr. For the 1999 brood year, we estimated 275 immature, age-0 parr were produced from each redd constructed in the Lostine River in 1999.

Table 2. Results from mark-and-recapture experiments conducted in Catherine Creek and the Lostine River in August 2000.

Stream/group	Number marked (M)	Number sampled (C)	Number recaptured (R)	Population estimate (95% CI)
Catherine Creek				
Immature	1,262	987	47	25,997 (18,164-38,753)
Mature	141	98	19	703 (459-1,125)
Lostine River				
Immature	974	1,141	89	12,372 (10,076-15,190)
Mature	35	32	3	297 (121-743)

Table 3. Age composition of immature and mature chinook salmon parr sampled in Catherine Creek and the Lostine River in August 2000. Age was determined from scale analysis.

Stream/group	*n*	Percent age-0 (95% CI)	Percent age-1 (95% CI)
Catherine Creek			
Immature	261	98.9 (96.9-99.7)	1.1 (0.3-3.1)
Mature	106	0.0 (0.0-3.5)	100.0 (96.5-100)
Lostine River			
Immature	110	100.0 (96.6-100)	0.0 (0.0-3.4)
Mature	31	0.0 (0.0-11.2)	100.0 (88.8-100)

An interesting note regarding chinook salmon spawning in 2000, is that an estimated 27 mature male parr were present for every redd in Catherine Creek and 5.6 mature male parr per redd in the Lostine River. Precocious male chinook salmon parr are capable of fertilizing eggs and producing viable offspring in a hatchery environment (Robertson 1957, Unwin et al. 1999) and may play an important role in the fertilization of eggs in the wild (Gebhards 1960). However, it is still unclear how much, if any, this life history strategy contributes to the wild population. Therefore, we can conclude only that the potential existed for mature male parr to have made significant gametic contributions. 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.

We estimated egg-to-parr survival for the 1999 brood year to be 15.7% in Catherine Creek and 6.3% in the Lostine River (Table 4). For Catherine Creek, this survival rate is similar to the 1998 brood year. However, for the Lostine River, there is a considerable decrease in survival from the 1998 brood year.

Table 4. Estimated abundance of several life stages and egg-to-parr survival rate of spring chinook salmon in Catherine Creek and Lostine River, 1997–2000 broods.

Stream	Brood year	Redds[a]	Eggs[b]	Summer parr	Egg to parr survival (%)
Catherine Creek	1997	46	200,008	13,222	6.6
	1998	34	147,832	22,505	15.2
	1999	38	165,224	25,997	15.7
	2000	26	113,048	--	--
Lostine River	1997	47	204,356	40,748	19.9
	1998	28	121,744	28,084	23.1
	1999	45	195,660	12,372	6.3
	2000	53	230,444	--	--

[a] Redds counted above rotary screw trap at Catherine Creek rkm 32 and Lostine River rkm 3.
[b] Assumptions: 4,348 eggs/female and 1 female/redd.

In-Basin Migration Timing and Abundance

Distinct early and late migration patterns were evident at our upper trap sites (Figure 2). For the purpose of this report, early migration was considered to encompass the time from 1 July 1999 through 28 January 2000 and late migration from 29 January 2000 through 30 June 2000.

Upper Grande Ronde River: The upper Grande Ronde River trap fished for 212 d from 1 July through ice-up on 4 December 1999, and from 23 February through 30 June 2000. Distinct early and late migrations were evident at this trap site (Figure 2), with few juveniles captured during summer and winter months. The median emigration date for early migrants passing the trap was 30 October (Table 5) and was similar to timing observed in MY 95, 96, and 98. Timing in MY 97 and 99 was somewhat later with the median date of late migrants moving past our upper trap in mid-November. The median date that late migrants moved past the trap was 3 April and was only slightly later than past observations that ranged from 15 to 31 March.

We estimated a minimum of 14,780 juvenile spring chinook salmon migrants (95% confidence interval: ±2,078) moved out of the upper Grande Ronde River rearing areas during MY 00. This estimate is slightly greater than the MY 99 estimate of 13,180 fish. Trap efficiencies for the early and late migrants averaged 54.8% and 39.3%, respectively. Based on weekly trap efficiencies, we estimated that approximately 26% (3,839 ± 386) were early migrants and 74% (10,941 ± 2,033) were late migrants. The pattern of a dominant late migration in the upper Grande Ronde River is consistent for all migration years studied to date with the exception of MY 97, when 98% of the migrants moved early. It is worth mentioning, however, that MY 97 was exceptional in that only 29 fish were trapped.

Catherine Creek: The Catherine Creek trap fished for 277 d from 1 July through ice-up on 23 December 1999, and from 14 January through 30 June 2000. There were distinct early and late migrations exhibited by juvenile spring chinook at this trap site (Figure 2). Median emigration date for early migrants past the trap was 31 October (Table 5). The median date for late migrants was 23 March.

We estimated that a minimum of 23,991 ± 2,342 juvenile spring chinook salmon migrants moved out of the upper Catherine Creek rearing areas during MY 00. This estimate is greater than, yet on the same order of magnitude as estimates from previous years of this study that range from 3,951 (MY 97) to 18,680 (MY95). Trap efficiencies at Catherine Creek averaged 41.7% and 30.0% for early and late migrants, respectively. Based on weekly trap efficiencies, 82% (19,769 ± 2,156) migrated early and 18% (4,222 ± 914) migrated late. The proportion leaving as early migrants was larger than observed in previous years of this study (range 48 to 76%). The Catherine Creek population appears to be different from the upper Grande Ronde population with respect to the proportion of early and late migrants. In contrast with upper Grande Ronde, the largest outmigration from Catherine Creek has consistently been observed with early migrants.

Grande Ronde Valley: The Grande Ronde Valley trap fished for 233 d between 1 July 1999 and 25 June 2000. A distinct late migration was evident; few fish passed the trap in fall and winter (Figure 2). The median emigration date was 5 May (Table 5) and was similar to timing observed in MY 97 and MY 99. Timing in MY 95, MY 96 and MY 98 was somewhat earlier with the median migrant moving past this trap in late April.

We estimated that a minimum of 23,016 ± 6,893 juvenile spring chinook salmon migrants left the Grande Ronde Valley during MY 00. The estimate is within the same order of magnitude as from MY 94 (28,225), MY 95 (36,405), and MY 99 (14,537) but is one order of magnitude higher than our estimates in MY 96 through MY 98. An estimated 755 ±301 juvenile chinook passed the trap as early migrants. As in the past five years, approximately 97% of the chinook salmon passed our trap as late migrants. These data indicate 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.

Lostine River: The Lostine River trap fished for a total of 260 d from 6 July 1999 through 30 June 2000. Distinct early and late migrations were evident (Figure 2), with few fish captured during summer and winter. The median emigration date of early migrants was 2 November 1999. The date that the median late migrant moved past the trap was 9 April 2000 (Table 5).

We estimated that a minimum of 12,250 ± 887 juvenile spring chinook salmon migrants moved out of the Lostine River during MY 00. Weekly trap efficiencies averaged 42.9% for both early and late migrants. We estimated that approximately 68% (8,370 ± 835) of the juvenile spring chinook migrated early and 32% (3,880 ± 299) migrated late.

Wallowa River: The Wallowa River trap fished for 168 d between 6 July 1999 and 23 March 2000. The pattern of fish movement at this trap was very similar to that seen upriver at the Lostine trap. Based on PIT-tagged chinook recaptures, trap-to-trap travel times ranged from 1 to 80 d with a mean of 4.7 d (n = 244). The short travel time between traps suggest Lostine River spring chinook salmon use the valley portion of the Wallowa River primarily as a migration corridor and that early migrants move below the Wallowa River trap site for overwintering. Furthermore, because migration patterns at this trap so closely reflect those at the Lostine River trap, we discontinued operation of this trap on 23 March 2000.

We estimated that a minimum of 21,495 ± 4,293 juvenile spring chinook salmon moved through the Wallowa Valley as early migrants during MY 00 and overwintered downstream. The large number of early migrants passing the Wallowa Valley trap suggest that a large portion of these fish originated from rearing areas other than the Lostine River.

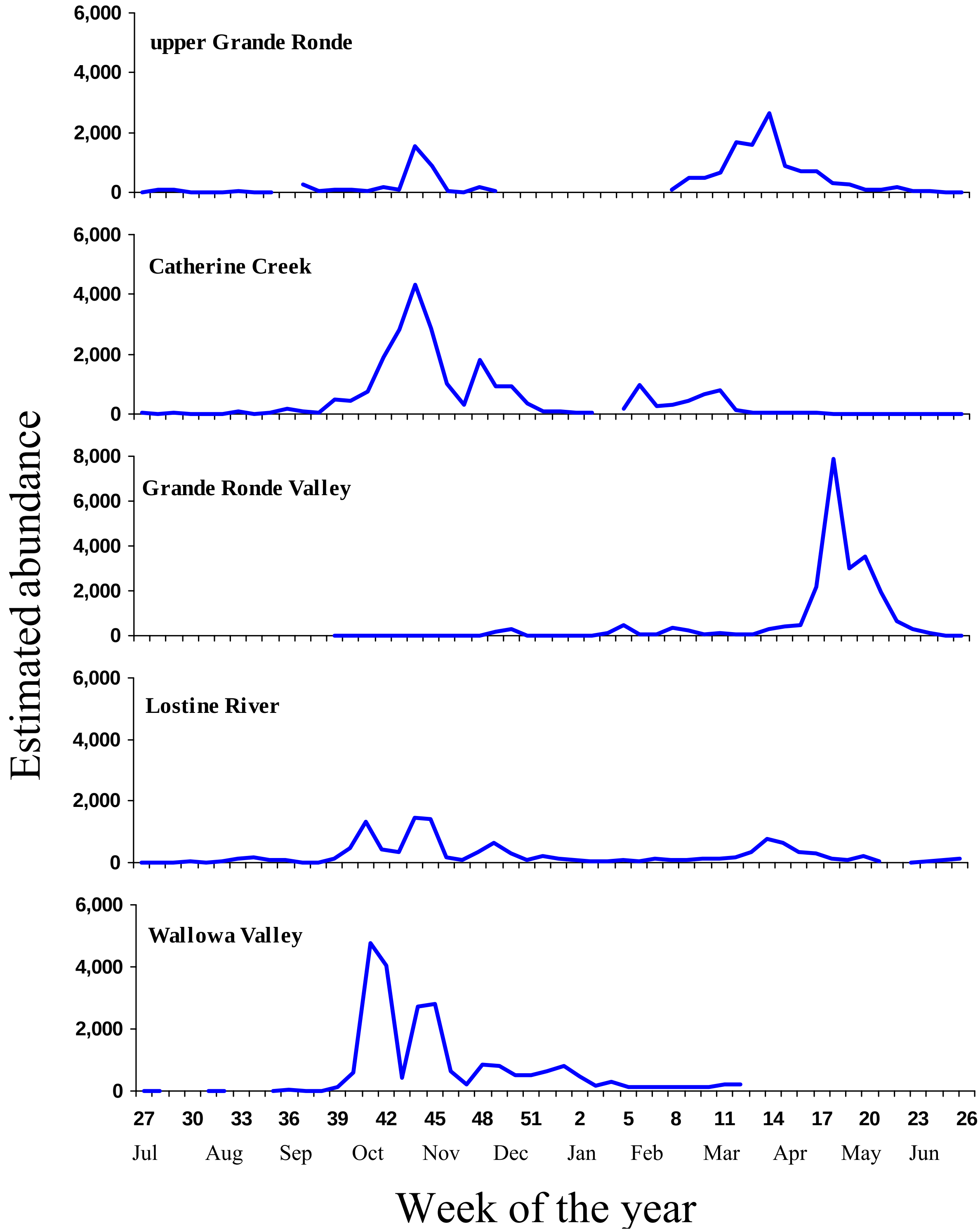

Figure 2. Estimated migration timing and abundance of juvenile spring chinook salmon migrants captured by rotary screw traps. During the 2000 migration year, traps were located at rkm 299 and 164 of the Grande Ronde River, rkm 32 of Catherine Creek, rkm 3 of the Lostine River, and rkm 27 of the Wallowa River.

Table 5. Seasonal catch of juvenile chinook salmon at five trap locations in the Grande Ronde River Basin. The early migration period was from 1 July 1999 - 28 Jan 2000. The late migration period was from 29 Jan - Jul 1 2000.

Trap site	Migratory group	Trapping period	Median emigration date	Days fished	Trap catch
Upper Grande Ronde	Early	02 Jul 99 - 08 Dec 00	30 Oct	97	2,266
	Late	23 Feb 00 - 30 Jun 00	03 Apr	115	4,063
Catherine Creek	Early	02 Jul 99 - 28 Jan 00	31 Oct	138	8,312
	Late	31 Jan 00 - 30 Jun 00	23 Mar	128	978[a]
				9	2[b]
Grande Ronde Valley	Early	02 Jul 99 - 28 Jan 00	12 Dec	96	157
	Late	29 Jan 00 - 25 Jun 00	05 May	137	1,816
Lostine River	Early	06 Jul 99 - 28 Jan 00	02 Nov	147	3,394
	Late	29 Jan 00 - 30 Jun 00	09 Apr	105	1,810[a]
				8	112[b]
Wallowa River Valley	Early	06 Jul 99 - 28 Jan 00	31 Oct	134	4,993
	Late	29 Jan 00 - 23 Mar 00	--	34	337

[a] Continuous trapping.
[b] Trapping with 4 h subsampling.

Size of Migrants: A comparison of mean lengths and weights of juvenile spring chinook salmon captured in the upper Grande Ronde River and those PIT-tagged and released are given in Tables 6 and 7. A comparison of mean lengths and weights of juvenile spring chinook salmon captured from Catherine Creek and those PIT-tagged and released are given in Tables 8 and 9. A comparison of mean lengths and weights of juvenile spring chinook salmon captured in the Lostine River and those PIT-tagged and released are given in Tables 10 and 11. Length frequency distributions of juvenile spring chinook salmon caught in all traps by migration period are shown in Figures 3 through 7.

Weekly mean lengths of migrants increased over time at each of the traps (Figure 8). As in previous years, migrants captured at the Grande Ronde Valley trap generally were larger than fish captured at the upper Grande Ronde River and Catherine Creek traps in MY 00. Size data collected from fish that were PIT-tagged at the upper traps during early and late migration periods and recaptured at the Grande Ronde Valley trap shows that fish grow before leaving the valley in spring, whether they overwinter in the valley or pass through in the spring (Table 12). Conversely, chinook tagged at the Lostine River trap and recaptured at the Wallowa Valley trap show very little growth (Table 12).

Table 6. Fork lengths of juvenile chinook salmon collected from the upper Grande Ronde River during the 2000 migration year. Winter fish were captured with seines or dipnets in the upper Grande Ronde River from rkm 320 to 323. Early and late migration period fish were captured with a rotary screw trap at rkm 299.

	Collected			
		Fork length (mm)		
Group	*n*	Mean	SE	Range
Early migrants	800	79.9	0.41	51–128
Winter group	500	74.1	0.35	57–99
Late migrants	1,090	88.4	0.28	64–122
	Tagged and released			
		Fork length (mm)		
Group	*n*	Mean	SE	Range
Early migrants	492	79.3	0.47	60–102
Winter group	500	74.1	0.35	57–99
Late migrants	492	89.2	0.40	64–111

Table 7. Weights of juvenile chinook salmon collected from the upper Grande Ronde River during the 2000 migration year. Winter fish were captured with seines or dipnets in the upper Grande Ronde River from rkm 320 to 323. Early and late migration period fish were captured with a rotary screw trap at rkm 299.

	Collected			
		Weight (g)		
Group	*n*	Mean	SE	Range
Early migrants	749	6.06	0.092	1.3–21.7
Winter group	500	4.67	0.071	1.8–11.0
Late migrants	983	7.59	0.078	2.5–22.2
	Tagged and released			
		Weight (g)		
Group	*n*	Mean	SE	Range
Early migrants	476	5.89	0.099	2.0–12.6
Winter group	500	4.67	0.071	1.8–11.0
Late migrants	434	7.63	0.111	2.5–16.4

Table 8. Fork lengths of juvenile chinook salmon collected from Catherine Creek during the 2000 migration year. Winter fish were captured with seines or dipnets in Catherine Creek from rkm 42 to 50. Early and late migration period fish were captured with a rotary screw trap at rkm 32.

	Collected			
		Fork length (mm)		
Group	*n*	Mean	SE	Range
Early migrants	1,475	84.1	0.24	42–112
Winter group	500	85.8	0.30	68–104
Late migrants	633	90.6	0.32	68–126
	Tagged and released			
		Fork length (mm)		
Group	*n*	Mean	SE	Range
Early migrants	678	85.7	0.30	66–107
Winter group	500	85.8	0.30	68–104
Late migrants	434	91.0	0.39	68–126

Table 9. Weights of juvenile chinook salmon collected from Catherine Creek during the 2000 migration year. Winter fish were captured with seines or dipnets in Catherine Creek from rkm 42 to 50. Early and late migration period fish were captured with a rotary screw trap at rkm 32.

	Collected			
		Weight (g)		
Group	*n*	Mean	SE	Range
Early migrants	1,397	6.89	0.058	1.5–14.6
Winter group	486	6.73	0.074	3.5–12.6
Late migrants	610	8.06	0.096	3.0–20.4
	Tagged and released			
		Weight (g)		
Group	*n*	Mean	SE	Range
Early migrants	678	7.18	0.080	2.9–14.6
Winter group	486	6.73	0.074	3.5–12.6
Late migrants	411	8.23	0.123	3.7–20.4

Table 10. Fork lengths of juvenile chinook salmon collected from the Lostine River during the 2000 migration year. Winter fish were captured with dipnets in the Lostine River from rkm 8 to 31. Early and late migration period fish were captured with a rotary screw trap at rkm 3.

	Collected			
		Fork length (mm)		
Group	*n*	Mean	SE	Range
Early migrants	1,521	94.6	0.27	63–127
Winter group	511	84.0	0.38	67–131
Late migrants	1,095	94.3	0.30	72–144
	Tagged and released			
		Fork length (mm)		
Group	*n*	Mean	SE	Range
Early migrants	521	97.2	0.43	69–127
Winter group	511	84.0	0.38	67–131
Late migrants	353	95.60	0.60	72–153

Table 11. Weights of juvenile chinook salmon collected from the Lostine River during the 2000 migration year. Winter fish were captured with dipnets in the Lostine River from rkm 8 to 31. Early and late migration period fish were captured with a rotary screw trap at rkm 3.

	Collected			
		Weight (g)		
Group	*n*	Mean	SE	Range
Early migrants	1,399	10.38	0.092	2.7–24.0
Winter group	164	5.93	0.104	3.5–9.9
Late migrants	1,086	9.76	0.110	3.5–34.2
	Tagged and released			
		Weight (g)		
Group	*n*	Mean	SE	Range
Early migrants	548	11.10	0.138	4.0–22.7
Winter group	164	5.93	0.104	3.5–9.9
Late migrants	424	9.96	0.185	3.5–34.2

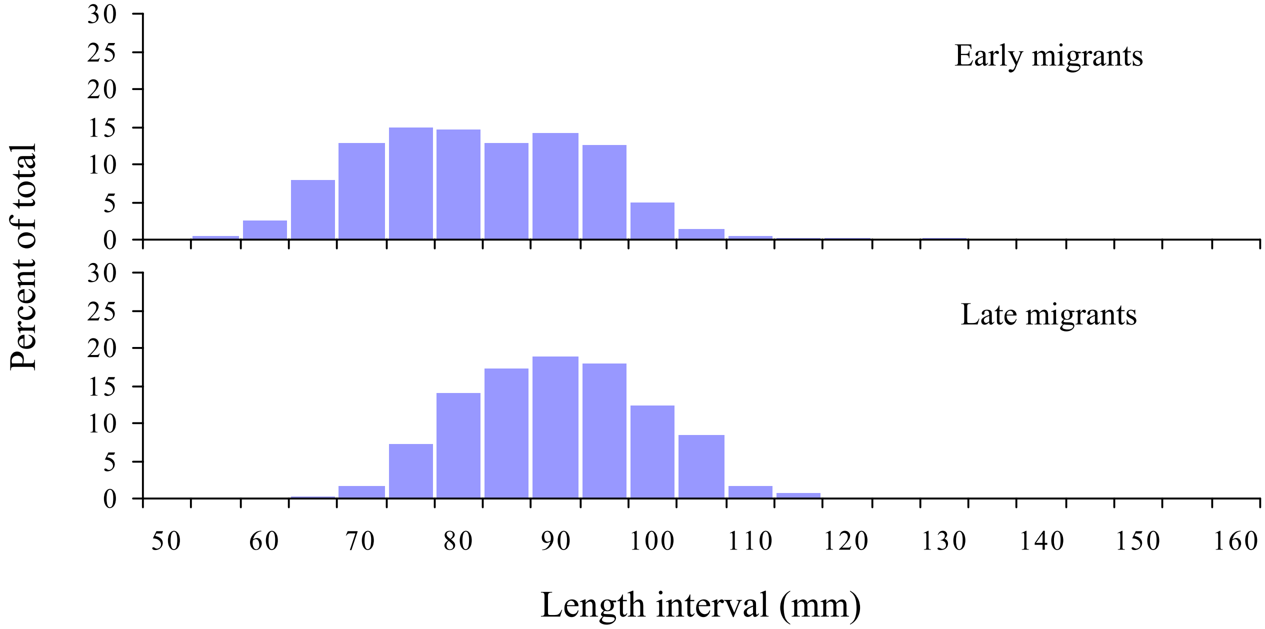

Figure 3. Length frequency distribution (fork length) of juvenile spring chinook salmon migrants captured at the upper Grande Ronde River trap (rkm 299) by migration period, during the 2000 migration year.

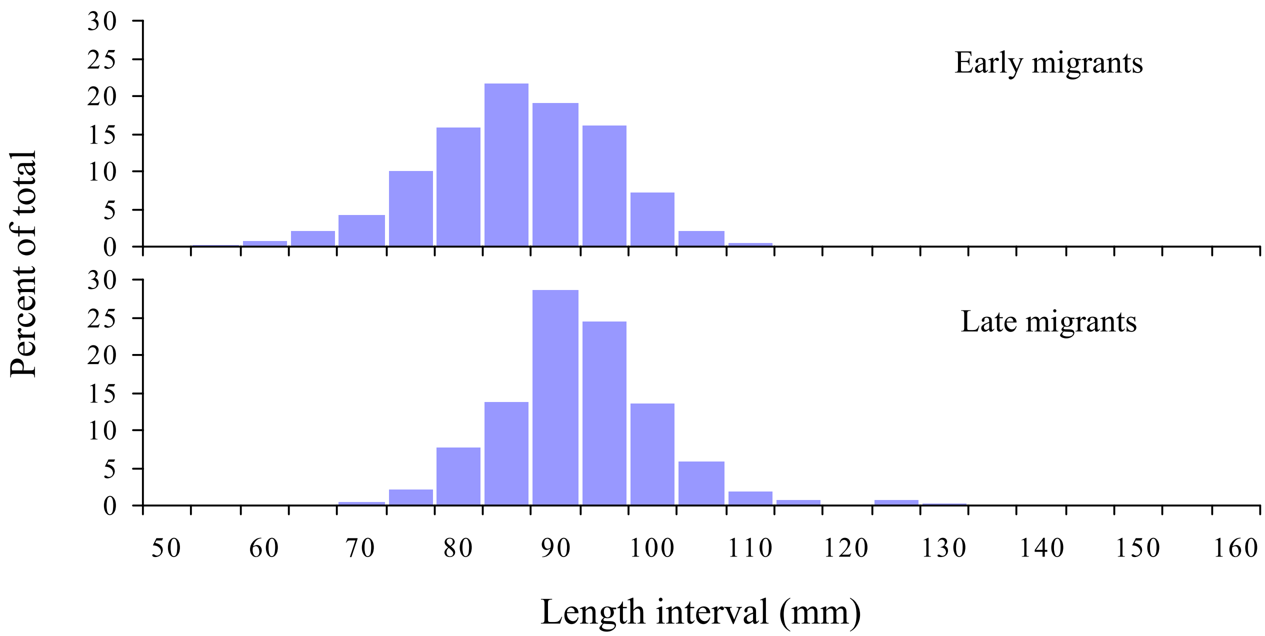

Figure 4. Length frequency distribution (fork length) of juvenile spring chinook salmon migrants captured at the Catherine Creek trap (rkm 32) by migration period, during the 2000 migration year.

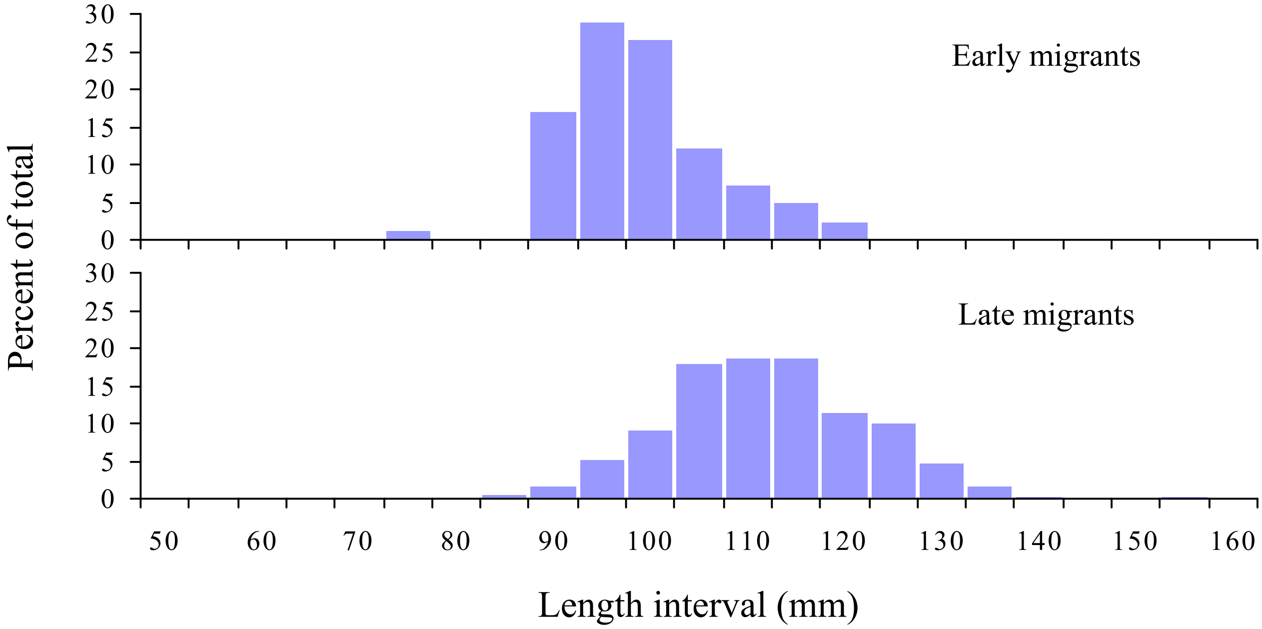

Figure 5. Length frequency distribution (fork length) of juvenile spring chinook salmon migrants captured at the Grande Ronde Valley trap (rkm 164) by migration period, during the 2000 migration year.

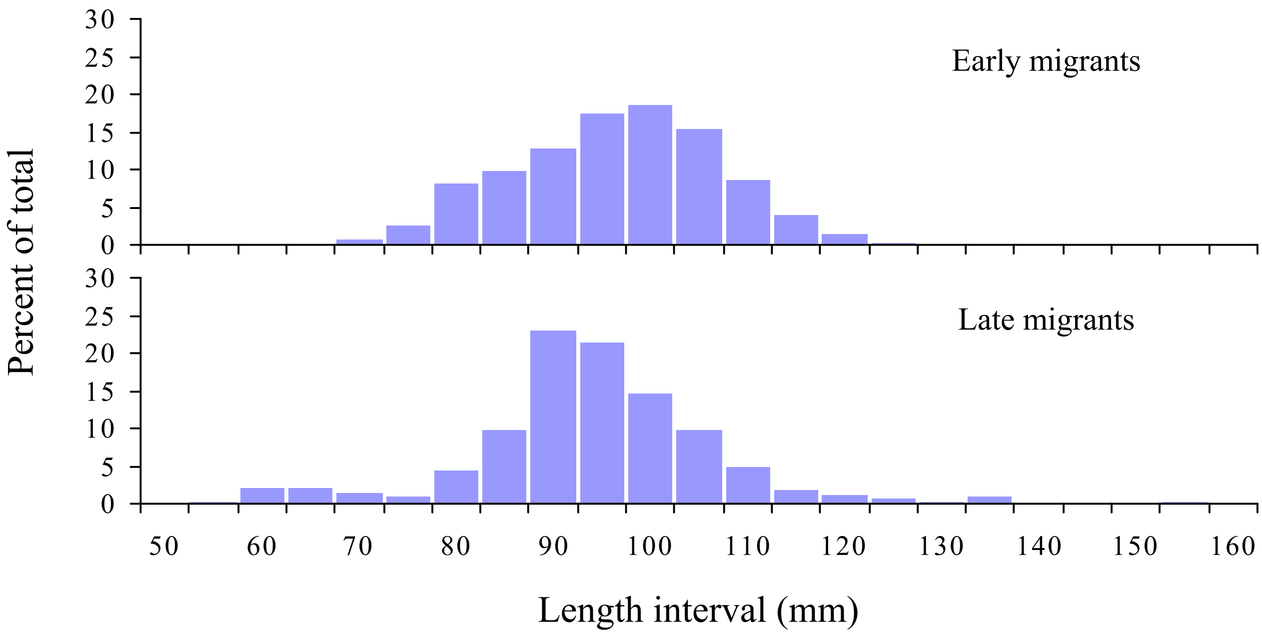

Figure 6. Length frequency distribution (fork length) of juvenile spring chinook salmon migrants captured at the Lostine River trap (rkm 3) by migration period, during the 2000 migration year.

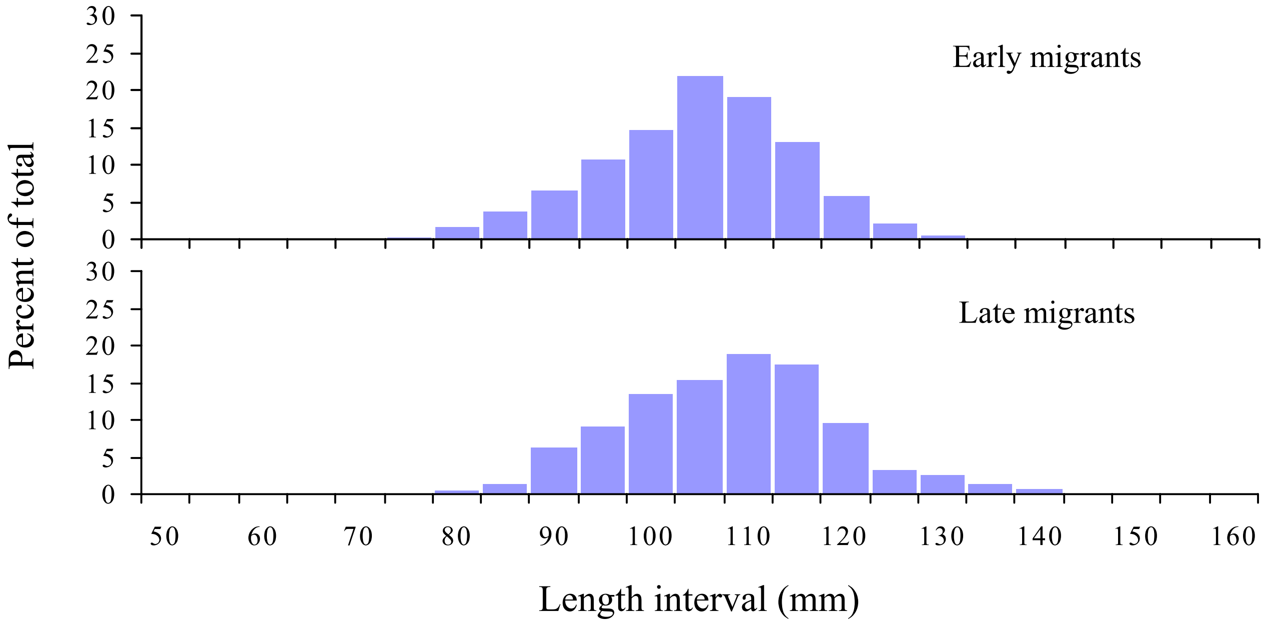

Figure 7. Length frequency distribution (fork length) of juvenile spring chinook salmon migrants captured at the Wallowa Valley trap (rkm 27) by migration period, during the 2000 migration year.

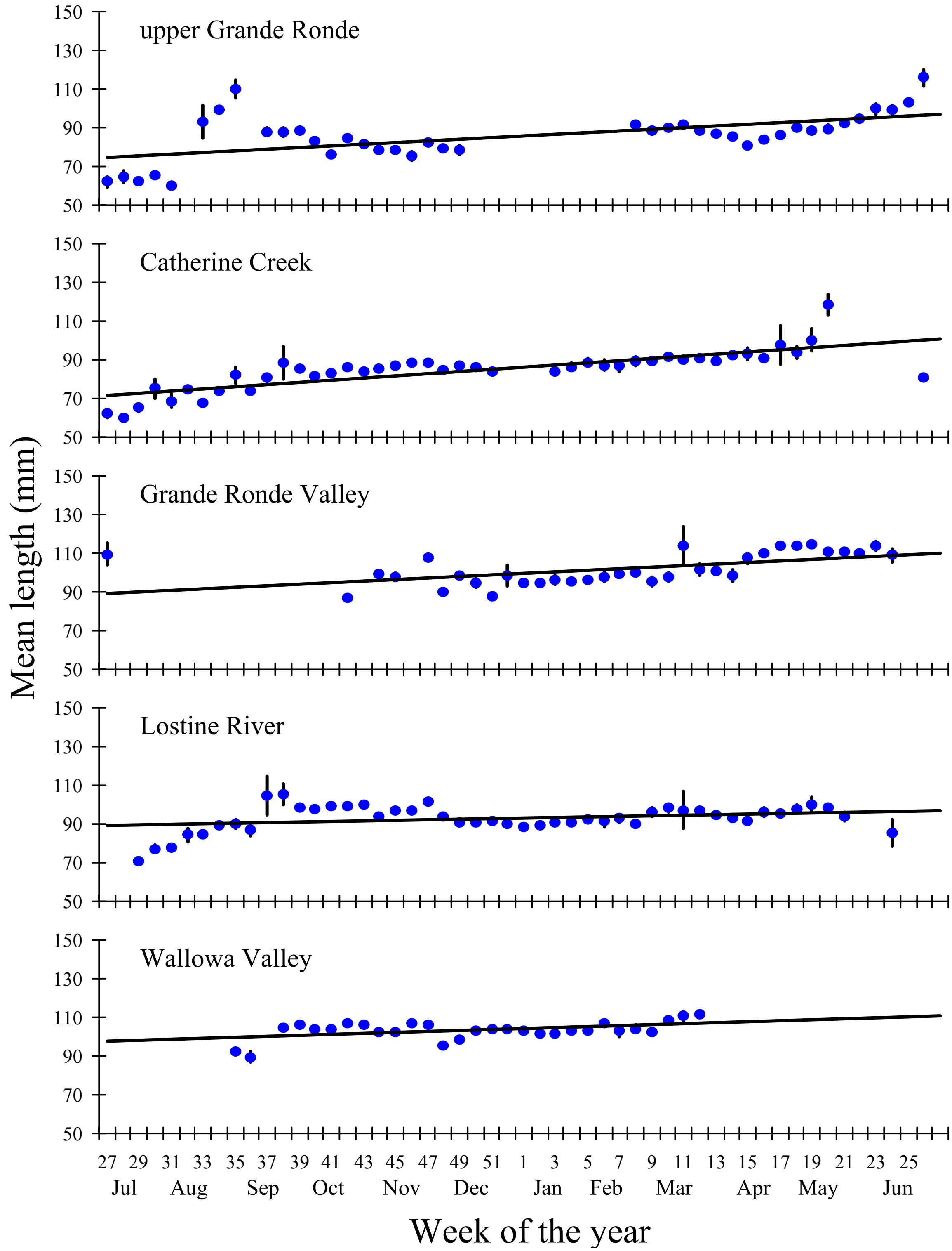

Figure 8. Weekly mean fork lengths with standard error for spring chinook salmon captured in rotary screw traps in the Grande Ronde and Wallowa subbasins during migration year 2000.

Table 12. Mean fork lengths 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 the late migration period. Standard errors are in parentheses.

Trap site of tagging, tag group	*n*	Mean fork length (mm) Tagging	Recapture
Upper Grande Ronde River			
Early migrants	15	78.9 (2.88)	99.4 (7.40)
Winter group	16	79.1 (1.30)	100.4 (6.78)
Late migrants	21	86.5 (1.78)	95.5 (7.04)
Catherine Creek			
Early migrants	11	87.4 (1.87)	109.3 (3.83)
Winter group	8	89.4 (1.44)	120.9 (2.23)
Late migrants	21	92.0 (2.12)	112.9 (5.79)
Lostine River			
Early migrants	149	98.9 (0.77)	98.8 (0.76)
Winter group	4	92.8 (2.43)	94.8 (4.84)
Late migrants	4	98.3 (9.19)	99.0 (10.21)

Migration Timing and Survival to Lower Granite Dam

Comparison of Early Life History Strategies: At the upper Grande Ronde River trap, we PIT-tagged 493 early-migrating and 496 late-migrating chinook salmon juveniles that were not previously tagged. At the Catherine Creek trap, we PIT-tagged 677 early-migrating and 431 late-migrating spring chinook salmon juveniles that were not previously tagged. During winter, an additional 500 juveniles were PIT-tagged from each of the rearing areas upstream from the upper Grande Ronde River and Catherine Creek traps. At the Lostine River trap, we PIT-tagged 514 early-migrating and 355 late-migrating juvenile chinook salmon that were not previously tagged. During winter, we captured and PIT-tagged an additional 511 juveniles from rearing areas above the trap.

Migration Timing: PIT-tagged fish from the upper Grande Ronde River ($n = 158$) were detected at Lower Granite Dam from 12 April to 20 July 2000, with 50% of the fish passing the dam by 12 May 2000 (Figure 9). PIT-tagged fish from Catherine Creek ($n = 160$) were detected at Lower Granite Dam from 12 April to 2 July 2000, with 50% of the fish passing the dam by 6 May 2000 (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 ($n = 211$) were detected at Lower Granite Dam from 3 April through 26 July 2000, with 50% of the fish passing the dam by 6 May 2000 (Figure 11).

Travel times to Lower Granite Dam for late migrants from the upper Grande Ronde River ranged from 12 to 98 d with a mean of 49.8 d (n = 91). Travel times for late migrants from Catherine Creek ranged from 21 to 95 d with a mean of 54.0 d (n = 52). Travel times for Lostine River late migrants ranged from 5 to 90 d with a mean of 33.8 d (n = 65). 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 44 to 57 d.

Median arrival dates at Lower Granite Dam for fish PIT-tagged at the upper Grande Ronde River as early-migrants, winter tag-group, and late-migrants were 9 May, 26 May, and 11 May 2000, respectively (Figure 9). Medians for fish PIT-tagged at Catherine Creek as early migrants, winter tag-group, and late migrants were 4 May, 9 May, and 11 May 2000, respectively (Figure 10). Medians for fish PIT-tagged at the Lostine River trap were 17 April (early migrants), 10 May (winter tag-group), and 22 May (late migrants; Figure 11). As in past years, the early migrants that were tagged during fall and overwintered in lower rearing areas were the earliest migrants to reach Lower Granite Dam from the upper Grande Ronde River, Catherine Creek, and Lostine River.

Survival Indices: Survival indices based on detection rates for Catherine Creek, Lostine, and upper Grande Ronde River fish were highest for the late migrant tag-group (Table 13). We anticipated that this tag group would have the highest detection rate since it is the only tag group not subject to overwinter mortality after tagging (i.e., tagged after February).

Early migrants from the upper Grande Ronde were detected at a significantly higher rate than the winter tag-group ($\chi^2 = 19.96$, $P < 0.001$), 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 early migrants to the winter tag-group overwintering in upper rearing areas. A comparison of the detection rates of the winter tag-group and late migrants from the upper Grande Ronde indicated that overwinter survival of fish remaining in upper rearing areas was approximately 29% for BY 98. This rate is comparable to past estimates that have ranged from 20 to 33%.

Early migrants from Catherine Creek were detected at a higher rate than the winter tag-group ($\chi^2 = 5.37$, $P = 0.01$), suggesting better overwinter survival for fish 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 (e.g. MY 2000), in other years the opposite is true, and in still others, there appears to be no difference in the survival of fish

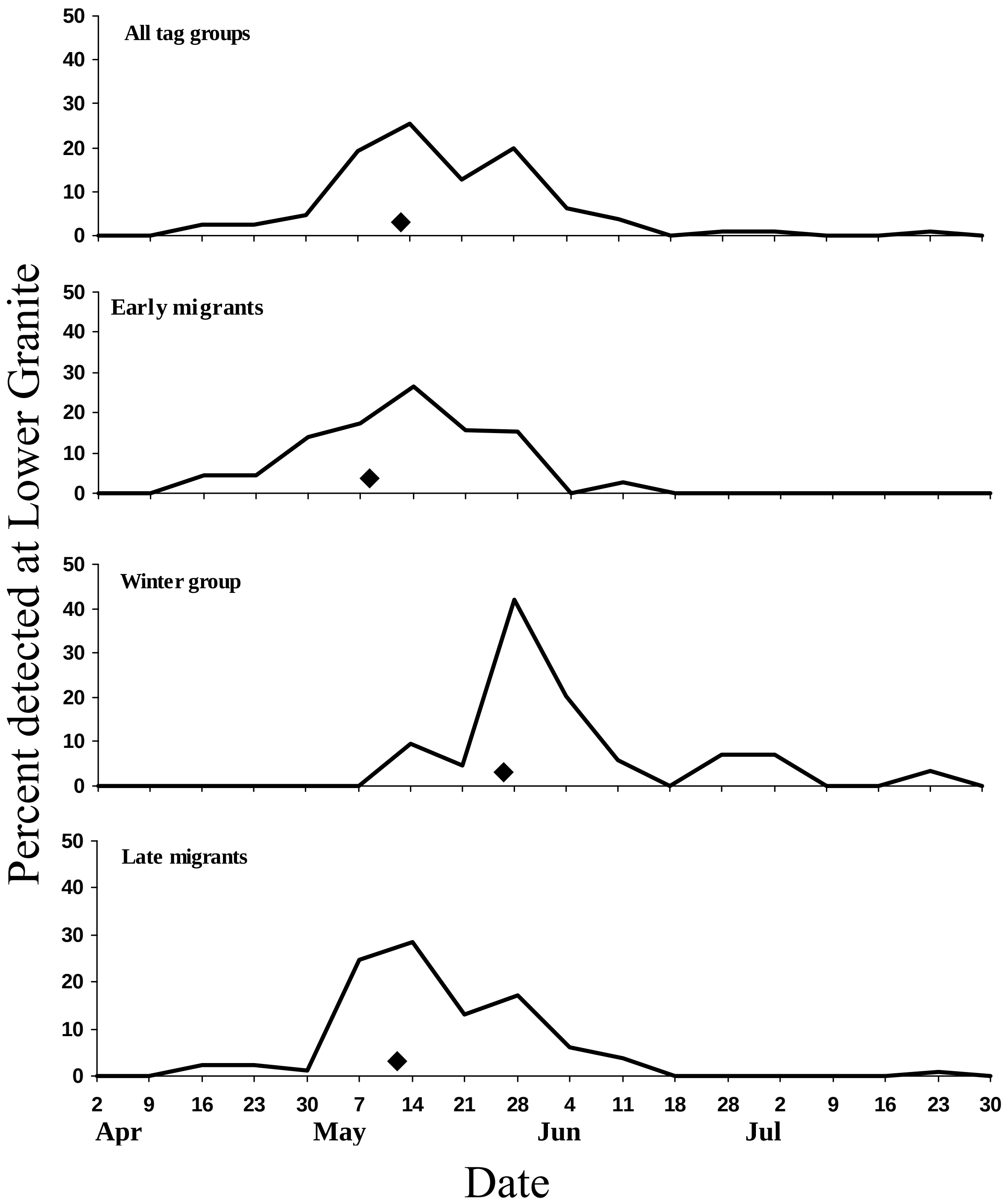

Figure 9. Migration timing by tag group of juvenile spring chinook salmon PIT-tagged on the upper Grande Ronde River and subsequently detected at Lower Granite Dam during the 2000 migration year. ◆ = median arrival date. Data were expanded for spillway flow.

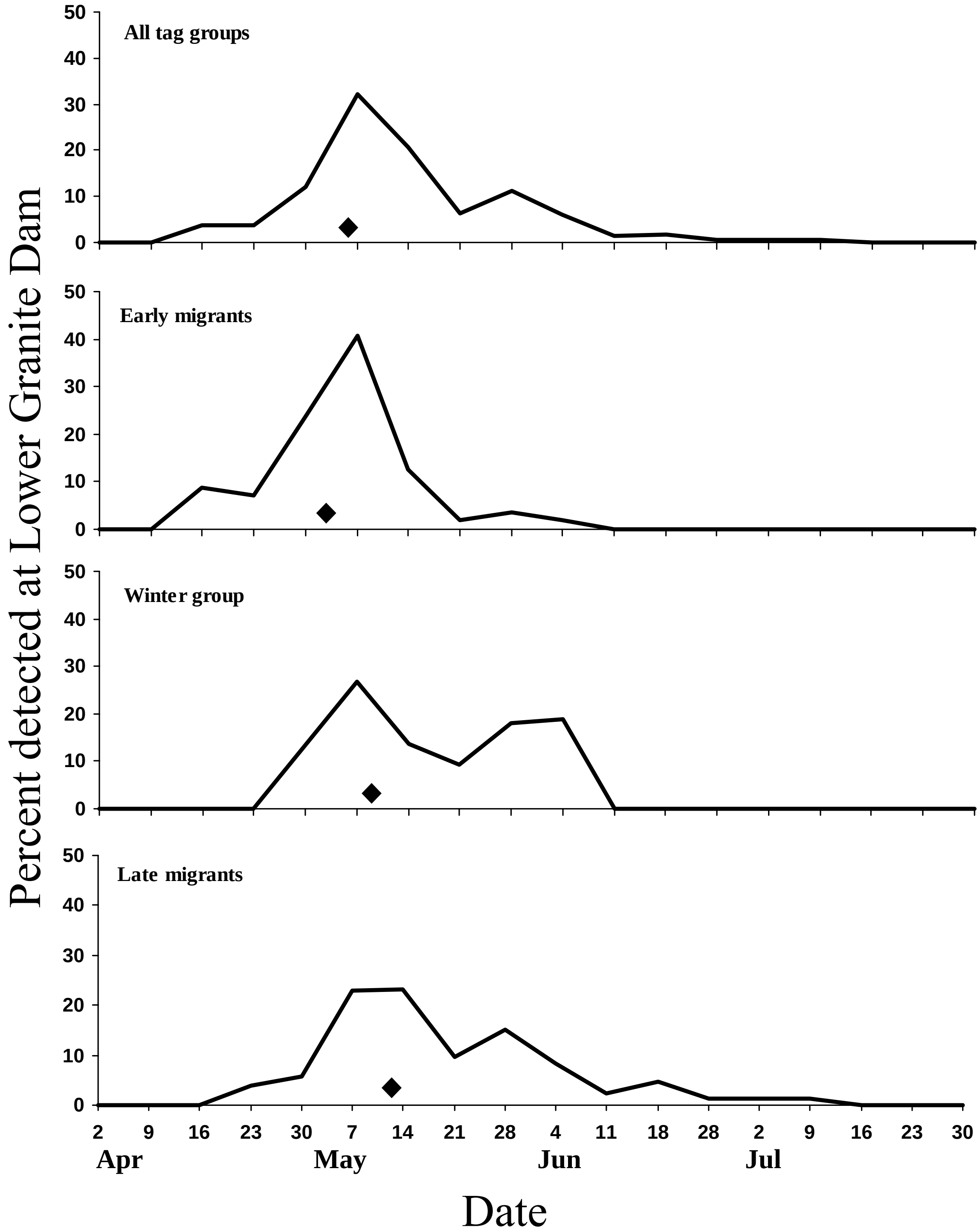

Figure 10. Migration timing by tag group of juvenile spring chinook salmon PIT-tagged on Catherine Creek and subsequently detected at Lower Granite Dam during the 2000 migration year. ◆ = median arrival date. Data were expanded for spillway flow.

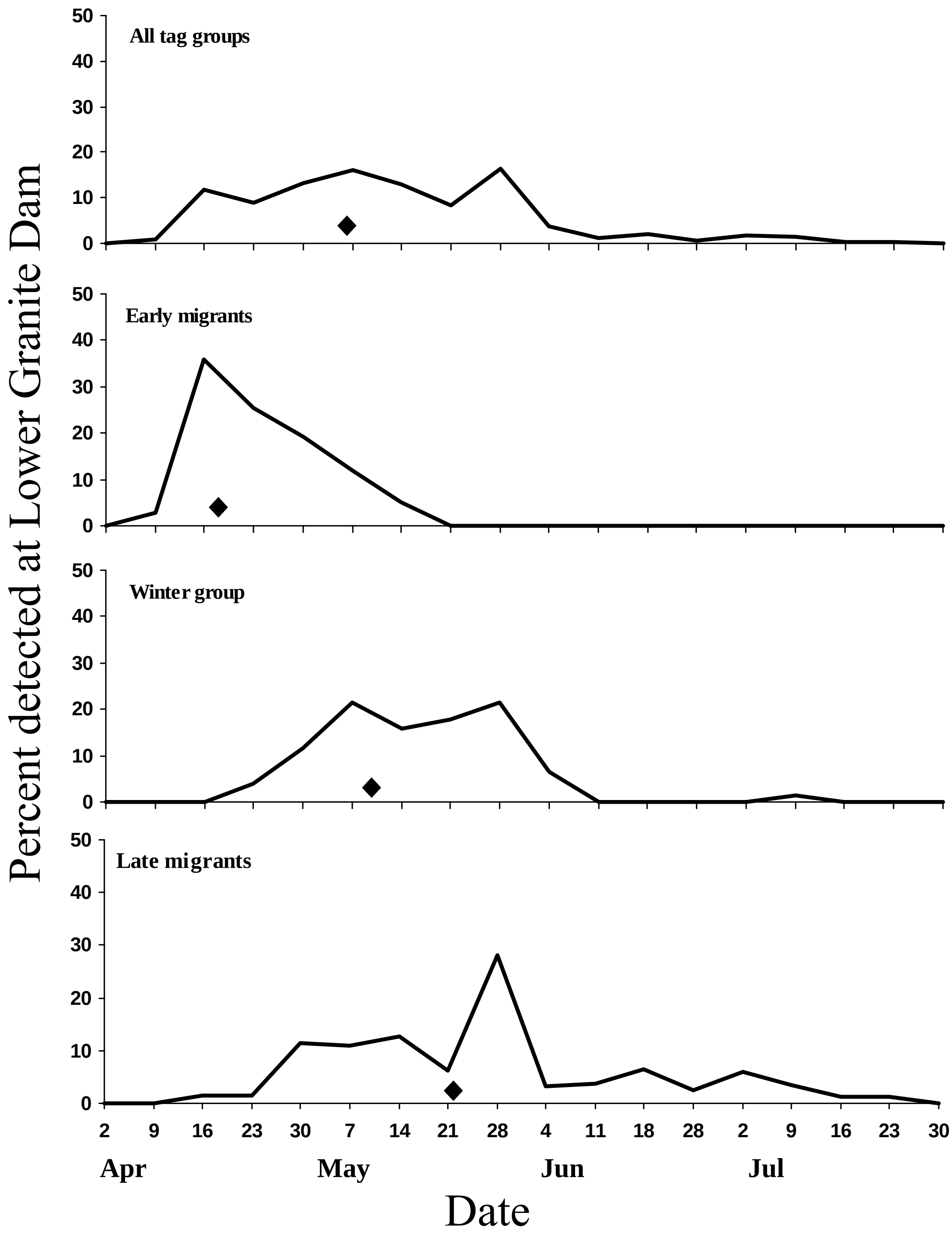

Figure 11. Migration timing by tag group of juvenile spring chinook salmon PIT-tagged on the Lostine River and subsequently detected at Lower Granite Dam during the 2000 migration year. ◆ = median arrival date. Data were expanded for spillway flow.

Table 13. 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 2000 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								
Early migrant	493	9.1	6.1	3.2	1.8	0.0	1.4	21.7
Winter group	500	4.4	4.2	1.0	1.6	0.0	0.0	11.2
Late migrant	495	18.4	10.7	4.6	3.0	0.0	1.8	38.6
Catherine Creek								
Summer	497	6.0	3.2	0.6	0.8	0.2	0.0	10.9
Early migrant	677	8.3	4.4	1.9	0.9	0.1	0.3	16.0
Winter group	500	4.4	2.6	1.6	2.4	0.2	0.0	11.2
Late migrant	431	12.1	9.5	3.2	3.0	0.7	1.6	30.2
Lostine River								
Summer	509	7.1	4.9	1.6	0.6	0.0	0.8	14.9
Early migrant	514	11.5	9.7	2.3	2.5	0.2	0.4	26.7
Winter group	511	10.0	7.0	2.0	2.0	0.4	1.0	22.3
Late migrant	355	18.3	13.0	5.6	5.6	0.6	1.7	44.8
Minam River								
Summer	998	7.4	5.5	1.9	1.7	0.5	0.5	17.5
Imnaha River								
Summer	982	6.4	3.3	1.0	0.5	0.1	0.3	11.6

overwintering in upper versus lower rearing areas. Comparing detection rates of the winter tag-group and late migrants from Catherine Creek indicates that overwinter survival of fish overwintering in the upper rearing areas was approximately 37% for BY 98. This rate is within the highly variable range measured thus far during the study (BY 93: 53%; BY 94: 32%; BY 95: 19%; and BY 96: 50%; BY 97: 65%).

In the Lostine River, detection rates of early migrant and the winter tag groups were not significantly different ($\chi^2 = 2.86$, $P > 0.05$). A comparison of the detection rates of the winter tag-group and late migrants from the Lostine River indicated that overwinter survival of fish remaining in upper rearing areas was approximately 50% for BY 98. This rate is comparable to past estimates of overwinter survival of 53% (BY 95), 44% (BY96), and 47% (BY 97).

CJS Survival Estimates: Survival probabilities based on CJS estimates were highly correlated to survival indices based on first-time dam detection rates (Pearson's r = 0.97) although survival indices were consistently lower than corresponding survival probabilities (Table 14). This difference was expected since we did not adjust our survival index data to compensate for tagged fish that may have passed through the hydrosystem without being detected. Comparison of survival probabilities between early migrants and the winter tag group gave similar results to those based on dam detection rates. In the upper Grande Ronde River, survival of early migrants was significantly higher than the winter tag group indicating better survival for those fish that left upper rearing areas to overwinter in the Grande Ronde Valley ($P < 0.001$, Table 14). In Catherine Creek, early migrant survival was significantly higher ($P = 0.029$, Table 14) than the winter tag group survival also suggesting better survival for fish that overwintered in the Grande Ronde Valley. Survival of early migrants in the Lostine River was not significantly different than winter tag group survival ($P = 0.287$, Table 14).

Overwintering survival rates of late migrants based on survival probabilities were also similar to those based on dam detection rates. Comparing survival probabilities of the winter tag-group and late migrants from the upper Grande Ronde indicated that late migrant overwintering survival was approximately 24% for BY 98 (as compared to 29% based on detection rates). In Catherine Creek, overwinter survival of fish overwintering in the upper rearing areas was approximately 31% for BY 98 (compared to 37% with dam detections). In the Lostine river, overwinter survival of fish remaining in upper rearing areas was approximately 59% for BY 98 (versus 50% with dam detection rates).

In all populations, fish that leave upper rearing areas in fall arrive at Lower Granite Dam earlier than fish that leave in 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.

Table 14. Comparison of survival indices based on first-time dam detection rates and survival probabilities based on Cormack-Jolly-Seber model listed by stream and tag group for the 2000 migration year. Dam detection rate is the sum of first-time detections at the eight Snake/Columbia River dams. Survival probability is survival from rearing areas to Lower Granite dam.

Stream and tag group	Number released	Dam detection rate	CJS survival probability (SE)
Grande Ronde River			
Early migrants	493	0.217	0.341 (0.051)
Winter group	500	0.112	0.133 (0.020)
Late migrants	495	0.386	0.560 (0.051)
Catherine Creek			
Early migrants	677	0.160	0.212 (0.025)
Winter group	500	0.112	0.138 (0.021)
Late migrants	431	0.302	0.452 (0.057)
Lostine River			
Early migrants	514	0.267	0.317 (0.028)
Winter group	511	0.221	0.397 (0.066)
Late migrants	355	0.448	0.660 (0.068)

Population Comparisons: Chinook salmon parr that were captured with seines and PIT-tagged on Catherine Creek and the Imnaha, Lostine, and Minam rivers in summer 1999 were detected at Lower Granite Dam over a 68 d period from 10 April to 16 June 2000 (Figure 12). The migratory period of individual populations ranged from 50 d (Minam River) to 66 d (Imnaha River) in length. Median dates of migration ranged from 2 May (Imnaha River) to 7 May (Catherine Creek and Lostine River). Median migration times were significantly different among populations (Kruskal-Wallis P <0.001). Multiple pair-wise comparisons indicated that the median migration time of the Catherine Creek population was significantly later than the Imnaha River and Minam River populations. Similarly, the migration timing of the Lostine River population was significantly later than the Minam River population. We could not detect a significant difference in migration timing between Lostine and Imnaha River populations with the sequential Dunn-Sidak comparison method. However, the P-value for this pair-wise comparison was relatively low (P = 0.018) and the non-significant result is probably due to the conservative nature and low power of this test (Sokal and Rohlf 1995).

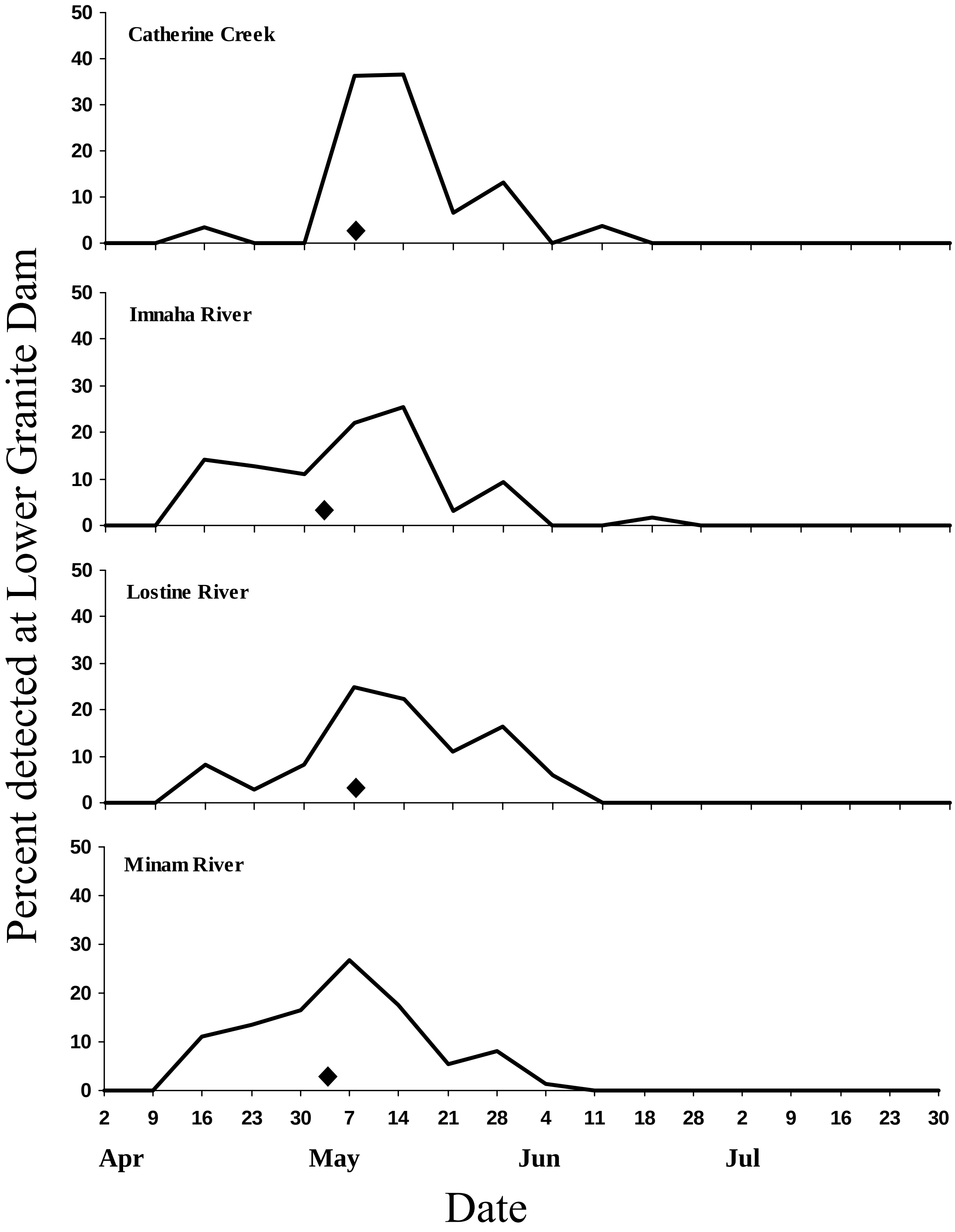

Figure 12. Migration timing at Lower Granite Dam during migration year 2000 for juvenile spring chinook salmon PIT-tagged as parr on Catherine Creek and the Imnaha, Lostine, and Minam rivers during summer 1999. ◆ = median arrival date. Data were expanded for spillway flow.

Our findings in 2000 were generally consistent with past observations (Sankovich et al. 1996; Walters et al. 1997; Tranquilli et al. 1998; Jonasson et al. 1999). For each population, the median date of migration in 2000 fell within the range in medians observed from 1993 to 1999. Comparisons of timing between populations yielded results that had been obtained in the past, except that this is the first year we did not detect differences between the Minam and Imnaha River populations. That timing has and continues to differ among populations demonstrates 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, 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 Imnaha, Lostine, and Minam rivers in the summer of 1999, 10.9, 11.6, 14.9, and 17.5% were detected in the hydrosystem in 2000 (Table 15). The detection rates for Catherine Creek and Lostine River fell below the range reported in past years. Detection rates for the Imnaha and Minam Rivers were within the mid-range of detection rates observed for these populations in past years. Survival probabilities based on CJS estimates were significantly different among populations (ANOVA $P = 0.002$, Table 15). The Minam River population had a significantly higher survival rate than the Catherine Creek and Imnaha River populations.

Table 15. Dam detection rates and survival probabilities to Lower Granite Dam for chinook salmon parr populations tagged in summer 1999 and detected at dams in 2000. Survival probabilities that have a letter in common are not significantly different ($P < 0.05$).

Stream	Number released	Dam detection rate (%)	Survival probability (SE)	
Catherine Creek	497	10.9	0.151 [a]	(0.026)
Lostine River	509	14.9	0.212 [ab]	(0.032)
Minam River	998	17.5	0.239 [b]	(0.023)
Imnaha river	982	11.6	0.141 [a]	(0.014)

During the 2000 migration year, there were no detections of age-2 smolts that had been PIT-tagged as parr on Catherine Creek and the Imnaha, Lostine and Minam rivers in summer 1998. We estimated previously that there were no immature, age-1 parr (i.e., fish that would presumably become age-2 smolts) in Catherine Creek or the Lostine River in summer 1999 (Jonasson et al. 1999). To date, the information we have gathered regarding age-2 smolts indicates this life history is rare among northeast Oregon chinook salmon. Of 30,273 parr PIT-tagged on Catherine Creek and the Grande Ronde, Imnaha, Lostine, Minam, and Wenaha rivers from 1992 to 1998 (Walters et al. 1992, 1997; Sankovich et al. 1996; Tranquilli 1998), only 11 (0.04%) were detected in the hydrosystem as age-2 smolts. Eight of these 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.

Another 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. Therefore, the frequency of the age-2 smolt life history is in part determined by the abundance of immature, age-1 parr. Our research indicated that there was no immature, age-1 parr in Catherine Creek and the Lostine River in 1998, 1999, or 2000 (Tranquilli et al. 1998; Jonasson et al. 1999; see **SPRING CHINOOK SALMON INVESTIGATIONS; Results and Discussion; Egg-to-Parr Survival, Abundance, and Age Composition of Parr in Summer** in this report). These results are 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, 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.

SUMMER STEELHEAD INVESTIGATIONS

Methods

In the Grande Ronde River basin, most steelhead populations are sympatric with rainbow trout populations and only steelhead smolts can be visually differentiated from resident rainbow trout. For this reason, it is necessary to treat all juvenile *Oncorhynchus mykiss* as one population for the purpose of this report. Furthermore, we assume all juvenile *O. mykiss* captured at trap sites were making directed downstream movements and not localized movements (i.e. non-migrants). Violation of this assumption would result in a positively biased population estimate.

Abundance and Age Composition of *Oncorhynchus mykiss* in Summer

We used mark-and-recapture and scale-aging techniques to estimate the abundance and age structure of *O. mykiss* in the mainstem of Catherine Creek during June-July 2000. We captured, marked, and released fish in Catherine Creek from 26 June to 12 July 2000. We conducted subsequent sampling during 13-20 July. We also conducted a mark-recapture estimate of *O. mykiss* in South Fork Catherine Creek. We captured, marked and released fish in this tributary during 5-24 July 2000. Subsequent sampling occurred during 25-31 July. Our goal for each population estimate was to mark a sufficient number of fish so that the upper and lower limits of the confidence interval would not exceed 25% of the mean.

We collected *O. mykiss* for marking either by either beach seining, herding them (while snorkeling) into a seine set perpendicular to the stream flow, or by angling. In the South Fork

Catherine Creek, we used a backpack electrofisher (Smith-Root Model 12). Captured fish were held in aerated, 19 L buckets or in aerated, 19 L carboys attached to pack frames and transferred periodically to live cages anchored in shaded areas of the stream. The live cages were located near designated marking stations. In the mainstem Catherine Creek, fish were collected (marked and released) in a 20-km reach from the rotary screw trap to the confluence of the South Fork (see Figure 1 for rotary screw trap locations). In South Fork Catherine Creek, fish were collected from its confluence to the upper headwaters (11.0 km) including portions of Pole and Sand Pass creeks.

Prior to being marked, fish were anesthetized in an aerated bath containing 40 to 50 mg/L of tricaine methanesulfonate (MS-222). We marked fish with either Alcian Blue dye or PIT tags. The dye was applied with a tattoo machine, slightly anterior of the pelvic fins of each fish. PIT tags were injected manually with a modified hypodermic syringe as described by Prentice et al. (1986, 1990) and Matthews et al. (1990, 1992). Syringes were disinfected for 10 minutes in 70% isopropyl alcohol between each use then allowed to dry for an additional 10 minutes. 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 (1 mm), and weight (0.1 g) of PIT-tagged fish. We also collected scales for age analysis from a random sample of *O. mykiss* in each sample reach. All fish were handled and marked at stream temperatures of 15°C or less and released in the area of capture on the day they were processed.

During subsequent sampling, we collected *O.mykiss* from eleven randomly selected reaches of approximately 1.6 km each on Catherine Creek and eight reaches on South Fork Catherine Creek. We used seining, angling, and electrofishing methods outlined above to capture fish. Each fish was inspected for marks and the numbers of unmarked, dye-marked, and PIT-tagged fish were recorded. We also recorded the number of fish that had lost their PIT tag (i.e., no tag could be detected, but a PIT-tagging scar was evident).

We used the adjusted Petersen estimate (Ricker 1975) to determine the abundance of *O. mykiss* in Catherine Creek and South ForkCatherine Creek. Ninety-five percent confidence intervals were obtained using equation (3.7) and values from Appendix II in Ricker (1975). Estimates of the age composition of *O. mykiss* were based on results from scale analyses. Scale impressions were made on acetate slides and inspected on a microfiche reader at 42x magnification. Age was determined by counting the number of annuli present. We calculated the proportion of fish at each age and obtained 95% confidence intervals from table P in Rohlf and Sokal (1995).

In-Basin Migration Timing and Abundance

The timing and abundance of migrating *O. mykiss* in the upper Grande Ronde River, Catherine Creek and the Lostine River were determined by operating rotary screw traps year round. We followed the same methodology for operating screw traps and analyzing data as we employed for spring chinook (see **SPRING CHINOOK SALMON INVESTIGATIONS; Methods; In-Basin Migration Timing and Abundance**). We also collected scales for age analysis from a random sample of *O. mykiss* at each trap.

The 2000 migratory year (MY 00) for summer steelhead overlaps two calendar years, and begins on 1 July 1999 and ends on 30 June 2000. Similar to spring chinook, there is a distinct early migration that peaks at our trap sites in the fall. Early migrants leave summer rearing areas in the upper Grande Ronde River, Catherine Creek, and the Lostine River and overwinter in downstream habitat. A proportion of these fish continue their seaward migration out of the basin the following spring. Late migrants exhibit another life history strategy whereby they remain in upper rearing areas throughout fall and winter, and initiate their seaward migration in spring. Designation of early and late migratory groups were based on trends in capture rates at trap sites. A common period of diminished capture rates occurs at our trap sites in winter and was used to classify fish into migratory groups. We then determined migration timing and abundance by migratory group.

Migration Timing to Lower Granite Dam

PIT tag technology allows fish to be individually marked and subsequently observed without being sacrificed. First-time detections of PIT-tagged *O. mykiss* at Snake and Columbia River dams were used to estimate migration timing. During the 2000 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. To assess differences in migration timing between early and late migrants within populations of *O. mykiss*, we planned to tag 1000 early migrants and 500 late migrants at each of our trap sites on the upper Grande Ronde River, Catherine Creek, and Lostine River. Fish that moved past our upper trap sites between September and early December were tagged as early migrants. Fish tagged as late migrants moved past our upper trap sites between February and May. We estimated migration timing of individual tag groups at Lower Granite Dam by expanding daily numbers of PIT tag detections (see **SPRING CHINOOK SALMON INVESTIGATIONS; Methods**; **Migration Timing to Lower Granite Dam**). To determine if migration timing differed among populations, we performed a Kruskal-Wallis test on the dates of detection, expressed as day of the year, of expanded fish numbers. When significant differences were found, we used a Dunn-Sidak multiple-comparison procedure ($\alpha = 0.05$) to further analyze the data (Sokal and Rohlf 1995). We used a combination of scale analysis, length-frequency histograms, and linear regression procedures to investigate the relationship of age and length on migration timing to Lower Granite Dam.

Because an unknown proportion of the migrating *O. mykiss* may rear below our trap sites for an additional year before moving on to the Snake and Columbia Rivers, we could not estimate unbiased survival probabilities for the early- and late-migrant tag groups.

Results and Discussion

Abundance and Age Composition of *O. mykiss* in Summer

From information obtained during our mark-and-recapture experiments, we estimated 22,393 *O. mykiss* inhabited the mainstem Catherine Creek in July 2000. The 95% confidence interval calculated for this estimate provided a lower limit of 17,467 and an upper limit of 28,697 fish. Results from scale analyses indicated that *O. mykiss* ranged from age-0 to age-3 with age-1 parr being the most abundant (Table 16). Gear selectivity was probably biased against age-0 parr so this age-class was under represented. We estimated 9,971 *O. mykiss* inhabited South Fork Catherine Creek in July 2000. The lower and upper bounds of the 95% confidence interval were 5,892 and 18,002 fish, respectively. Compared to the mainstem Catherine Creek, South Fork Catherine Creek had a slightly higher percentage of age-1 fish (Table 16).

Table 16. Age composition of *Oncorhynchus mykiss* sampled in Catherine Creek and South Fork Catherine Creek in summer 2000. Age was determined based on scale analysis.

Stream	Age class	*n*	Length range (mm)	Percent	95% CI
Catherine Creek	0	4	65–72	2.6	1.2–7.0
	1	92	69–160	59.9	52.1–67.6
	2	46	113–218	29.9	23.2–37.7
	3	12	163–263	7.8	4.6–13.5
South Fork	0	3	59–69	6.1	1.7–16.7
	1	35	86–167	71.4	57.0–82.3
	2	7	123–177	14.3	6.7–26.8
	3	4	159–198	8.1	2.8–18.8

In-Basin Migration Timing and Abundance

Distinct early and late migrations were evident at most of our upper trap sites with few fish captured during winter months (Figure 13). For the purpose of this report, early migration was considered to encompass the time from 1 July 1999 through 28 January 2000 and late migration from 29 January through 30 June 2000.

Upper Grande Ronde River: The upper Grande Ronde River trap fished for 212 d from 1 July through ice-up on 4 December 1999, and from 23 February through 30 June 2000. A distinct early migration was not as evident at this trap site as it was at other upper trap sites (Figure 13). Most juvenile *O. mykiss* moved as late migrants during spring months. The median emigration date for early migrants passing the trap was 30 September 1999 and the median emigration date for late migrants was 8 April 2000 (Table 17)

We estimated a minimum of 17,845 juvenile *O. mykiss* (95% CI: ± 3,526) moved out of the upper Grande Ronde rearing areas during MY 00. This estimate is greater than estimates from the previous three migratory years study to date that have ranged from 6,125 (MY 98) to 12,835 fish (MY 97). Trap efficiencies for the early and late migrants averaged 31.4% and 19.7%, respectively. Based on weekly trap efficiencies, we estimated approximately 6% (1,047 ± 350) were early migrants and 94% (16,798 ± 3,508) were late migrants. The pattern of a dominant late migration of juvenile *O. mykiss* in the upper Grande Ronde is consistent for all migration years studied to date. In previous years, the proportion of late migrants has ranges from 79% (MY 98) to 96% (MY 98).

Catherine Creek: The Catherine Creek trap fished for 275 d from 1 July through ice-up on 23 December 1999, and from 14 January through 30 June 2000. There were distinct early and late migrations exhibited by juvenile *O. mykiss* at this trap site (Figure 13). Median emigration date for early migrants was 30 October 1999. The median date for late migrants was 16 April 2000 (Table 17).

We estimated that a minimum of 35,699 ± 5,326 juvenile *O. mykiss* migrated out of the upper Catherine Creek rearing areas during MY 00. This estimate is greater than estimates from previous years of this study that range from 19,059 (MY 98) to 23,310 (MY97). Trap efficiencies at Catherine Creek averaged 18.6% and 10.6% for early and late migrants, respectively. Based on weekly trap efficiencies, 39% (13,912 ± 2,282) migrated early and 61% (21,787 ± 4,856) migrated late. The proportion of juvenile *O. mykiss* leaving upper rearing areas as early migrants is consistent with the proportions from previous years of this study that range from 23 to 54%. The Catherine Creek population appears to be different from the upper Grande Ronde population in that a greater proportion of the overall migrant population tends to leave upper rearing areas before the onset of winter.

Grande Ronde Valley: The Grande Ronde Valley trap fished for 233 d between 1 July 1999 and 25 June 2000. A distinct late migration was evident with few fish passing the trap as early migrants (Figure 13). The median emigration date for fish passing the trap as early migrants was 5 December 1999. The median emigration date for late migrants was 8 May 2000 (Table 17).

We estimated a minimum of 60,266 ± 21,176 juvenile *O. mykiss* migrated out of the Grande Ronde Valley during MY 00. This estimate is greater than but within the same order of magnitude as estimates from MY 97 (46,084) and MY 99 (47,281). An estimated 2,874 ± 950 juvenile *O. mykiss* passed the trap as early migrants and 57,392 ± 21,155 *O. mykiss* passed the trap as late migrants. As in past years, late migrants dominate the catch at this trap. These data indicate that most juvenile *O. mykiss* 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.

Lostine River: The Lostine River trap fished for a total of 260 d from 6 July 1999 through 30 June 2000. Distinct early and late migrations were evident (Figure 13), with few fish captured during summer and winter. The median emigration date of early migrants was 19

October 1999. The date that the median late migrant moved past the trap was 17 April 2000 (Table 17).

We estimated that a minimum of 11,981 ± 1,646 *O. mykiss* migrants moved out of the Lostine River during MY 00. Weekly trap efficiencies averaged 17.0% for early migrants and 22.9% for late migrants. We estimated that approximately 56% (6,716 ± 1,400) of the juvenile *O. mykiss* migrated early and 44% (5,265 ± 865) migrated late. This is consistent with previous years of this study in which the proportion of early migrants has ranged from 41% (MY 97) to 65% (MY 99).

Wallowa River: The Wallowa River trap fished for 168 d between 6 July 1999 and 23 March 2000. The pattern of fish movement at this trap was very similar to that seen upriver at the Lostine trap. Based on PIT-tagged *O. mykiss* recaptures, trap-to-trap travel times ranged from 1 to 90 d with a mean of 4.5 d (n = 100). As with spring chinook, the short travel time between traps suggest *O. mykiss* from the Lostine River use the valley portion of the Wallowa River primarily as a migration corridor and that early migrants move below the Wallowa River trap site for overwintering. Furthermore, because migration patterns at this trap so closely reflect those at the Lostine River trap, we discontinued operation of this trap on 23 March 2000.

We estimated that a minimum of 18,355 ± 5,889 juvenile *O. mykiss* moved through the Wallowa Valley as early migrants during MY 00 and overwintered downstream. The large number of early migrants passing the Wallowa Valley trap suggest that a large portion of these fish originated from rearing areas other than the Lostine River.

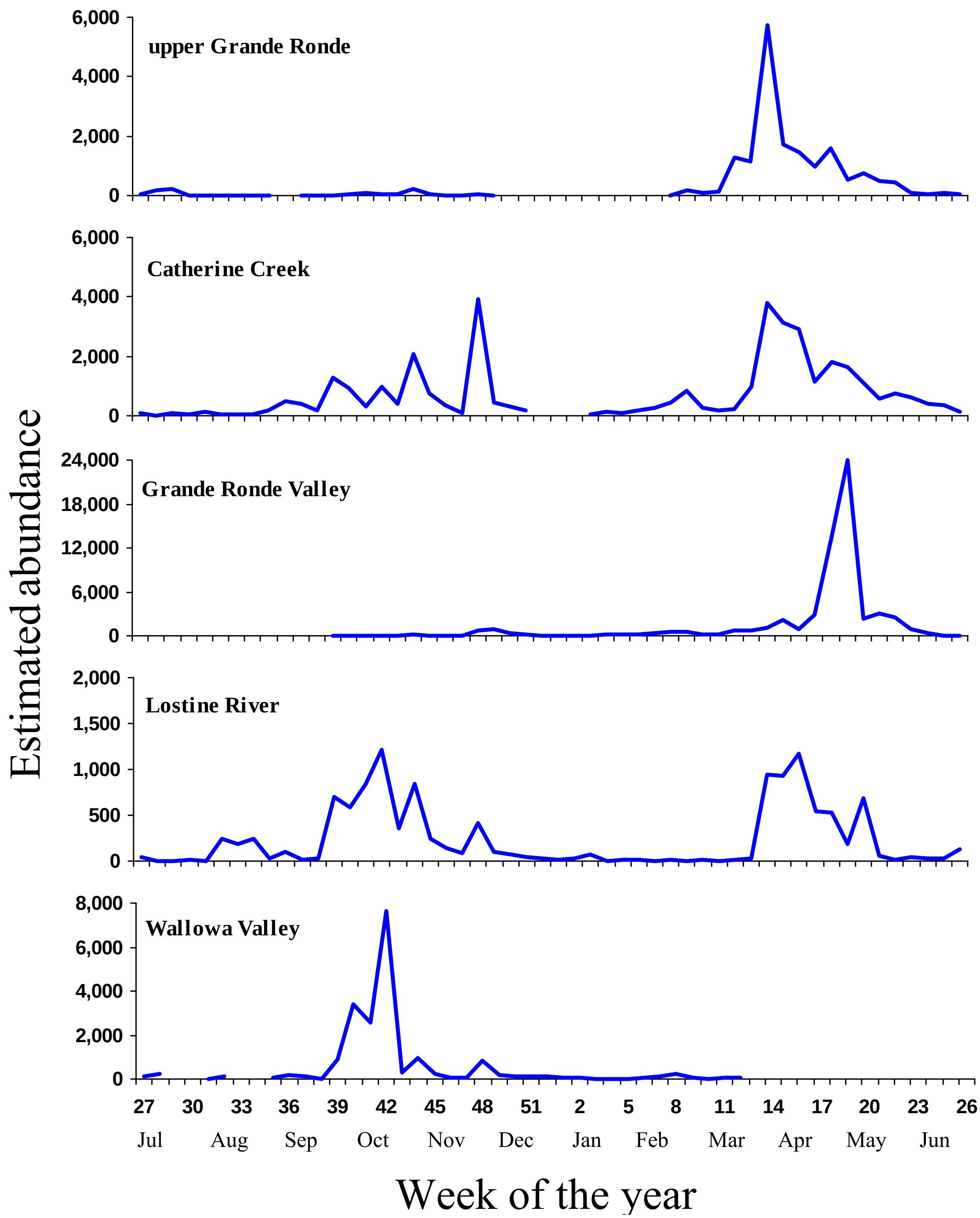

Figure 13. Estimated migration timing and abundance of *Oncorhynchus mykiss* captured by rotary screw traps during the 2000 migration year. Traps were located at rkm 299 and 164 of the Grande Ronde River, rkm 32 of Catherine Creek, rkm 3 of the Lostine River, and rkm 27 of the Wallowa River.

Table 17. Catch of juvenile *Oncorhynchus mykiss* at five trap locations in the Grande Ronde River Basin during the 2000 migration year.

Trap site	Migratory group	Trapping period	Median emigration date	Days fished	Trap catch
Upper Grande Ronde	Early	02 Jul 99 - 08 Dec 00	30 Sep	97	226
	Late	23 Feb 00 - 01 Jul 00	08 Apr	115	2,237
Catherine Creek	Early	02 Jul 99 - 28 Jan 00	30 Oct	138	2,399
	Late	31 Jan 00 - 01 Jul 00	16 Apr	128	1,992[a]
				9	92[b]
Grande Ronde Valley	Early	02 Jul 99 - 28 Jan 00	05 Dec	96	389
	Late	29 Jan 00 - 25 Jun 00	08 May	137	3,558
Lostine River	Early	06 Jul 99 - 28 Jan 00	19 Oct	147	1,034
	Late	29 Jan 00 - 01 Jul 00	17 Apr	105	1,024[a]
				8	128[b]
Wallowa River Valley	Early	06 Jul 99 - 28 Jan 00	16 Oct	134	1,852
	Late	29 Jan 00 - 23 Mar 00	--	34	150

[a] Continuous trapping.
[b] Trapping with 4 h subsampling.

Migration Timing to Lower Granite Dam

At the upper Grande Ronde River trap, we PIT-tagged 110 early- and 462 late-migrating *O. mykiss* that were not previously tagged. At the Catherine Creek trap, we PIT-tagged 989 early- and 502 late-migrating *O. mykiss* that were not previously tagged. At the Lostine River trap, we PIT-tagged 777 early- and 532 late-migrating *O. mykiss* that were not previously tagged.

Migration Timing: PIT-tagged fish from the upper Grande Ronde River (n = 80) were detected at Lower Granite Dam from 31 March to 28 June 2000, with 50% of the fish passing the dam by 7 May 2000 (Figure 14). PIT-tagged fish from Catherine Creek (n = 106) were detected at Lower Granite Dam from 2 April to 29 June 2000, with 50% of the fish passing the dam by 3 May 2000 (Figure 15). PIT-tagged fish from the Lostine River (n = 282) were detected at Lower Granite Dam from 26 March through 16 June 2000, with 50% of the fish passing the dam by 8 May 2000 (Figure 16). There was a significant difference in median arrival time among populations with Lostine River *O. mykiss* arriving later than Catherine Creek fish (Kruskal-Wallis $P < 0.001$).

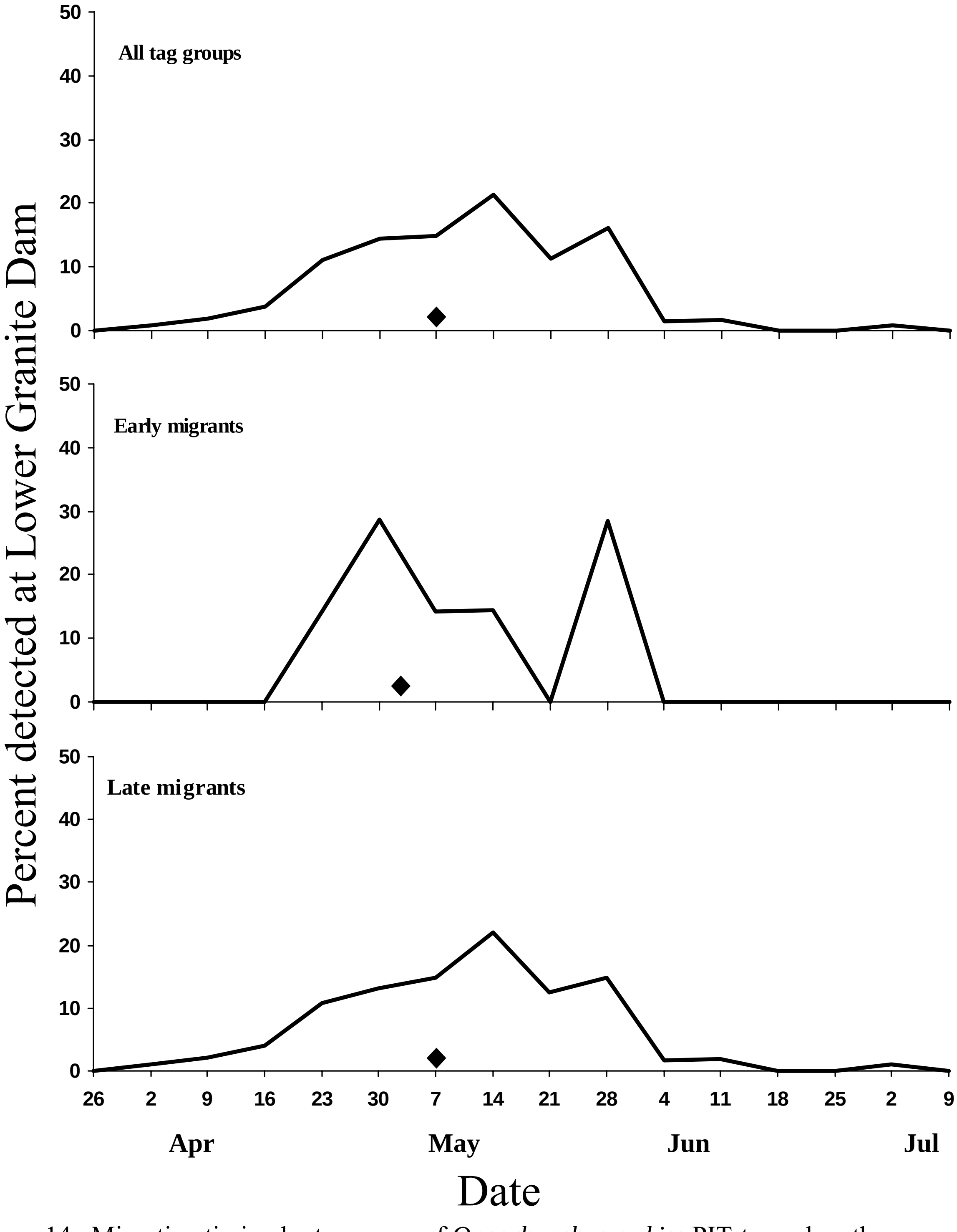

Figure 14. Migration timing by tag group of *Oncorhynchus mykiss* PIT-tagged on the upper Grande Ronde River and subsequently detected at Lower Granite Dam during the 2000 migration year. ◆ = median arrival date. Data were expanded for spillway flow.

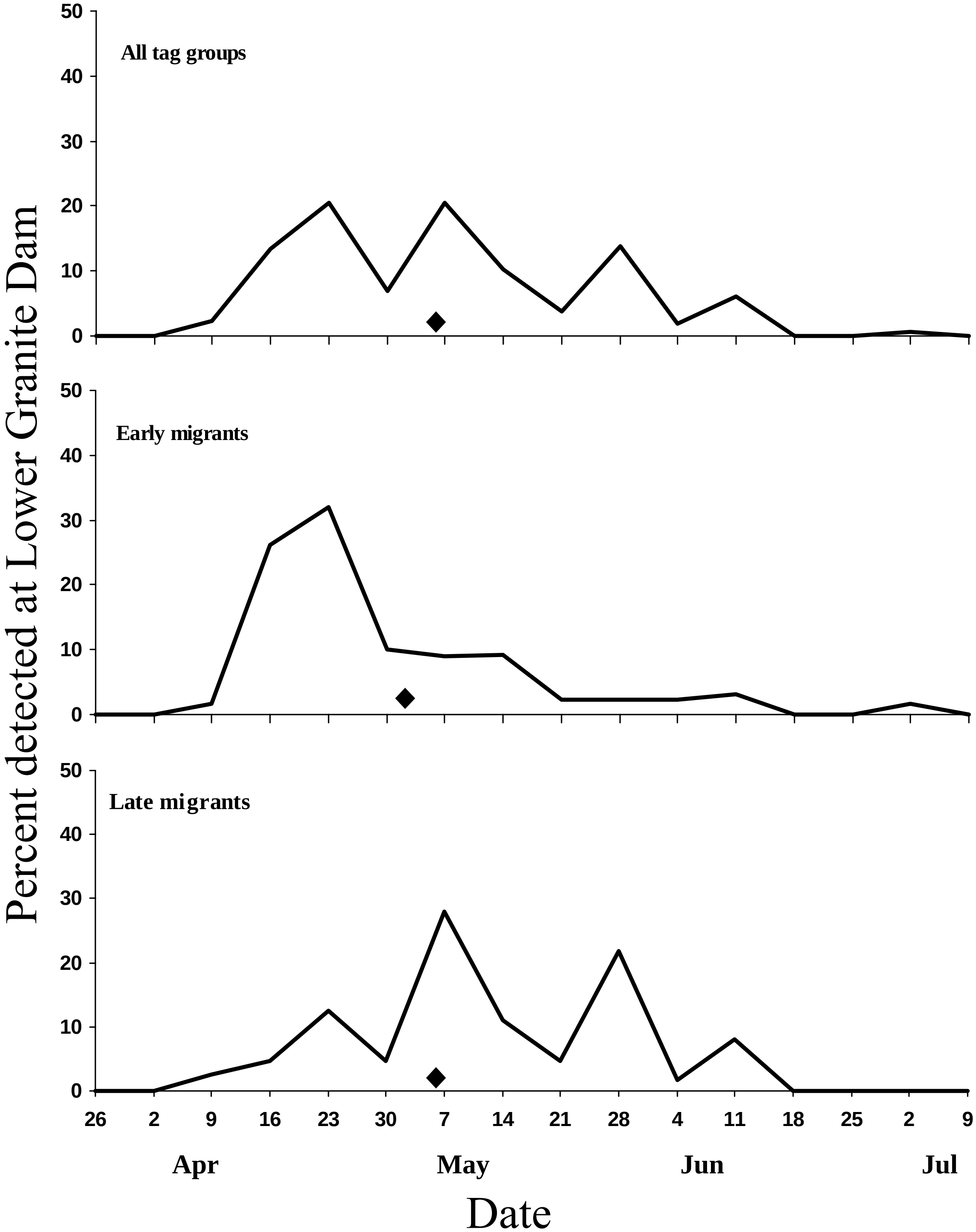

Figure 15. Migration timing by tag group of *Oncorhynchus mykiss* PIT-tagged on Catherine Creek and subsequently detected at Lower Granite Dam during the 2000 migration year. ◆ = median arrival date. Data were expanded for spillway flow.

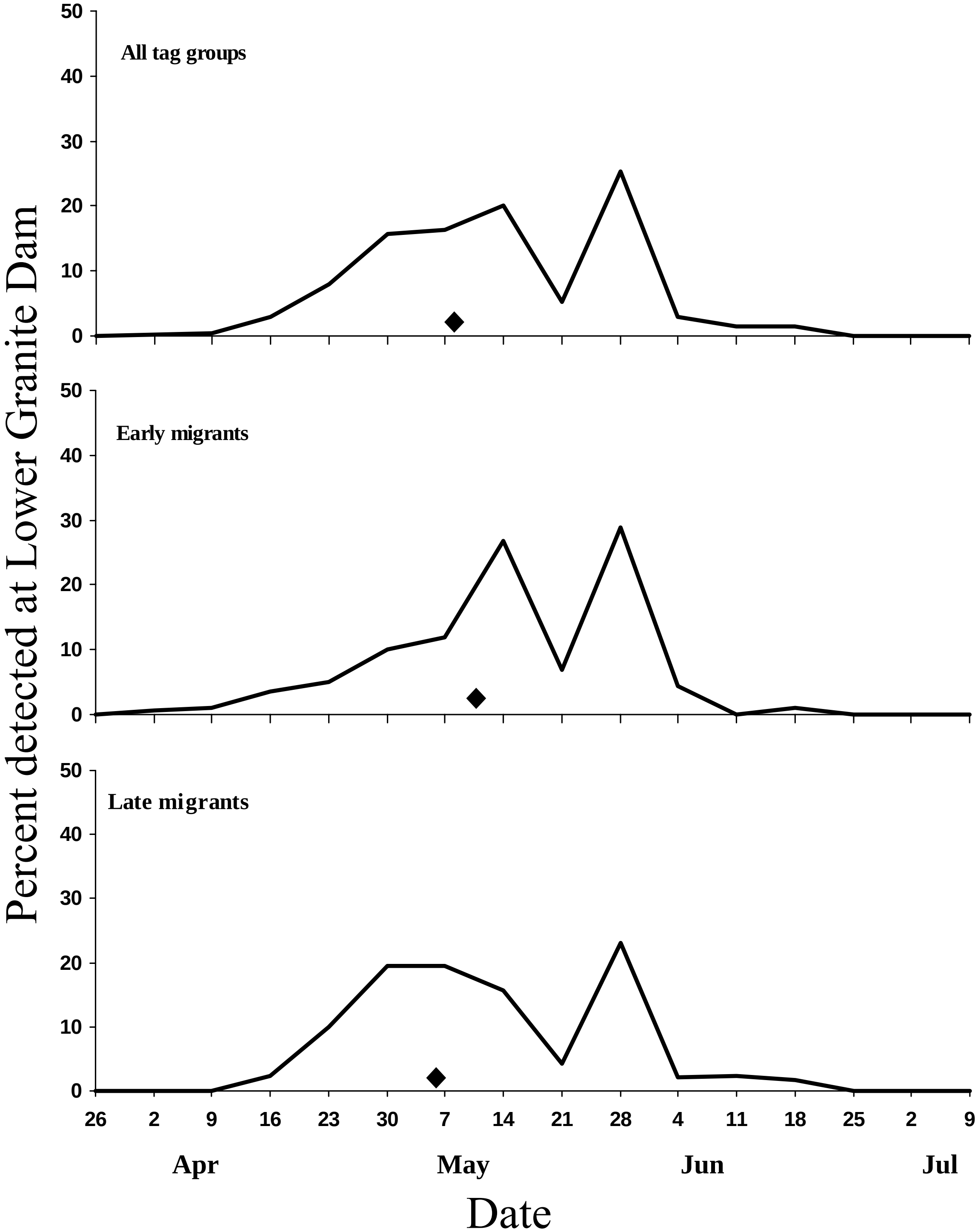

Figure 16. Migration timing by tag group of *Oncorhynchus mykiss* PIT-tagged on the Lostine River and subsequently detected at Lower Granite Dam during the 2000 migration year. ◆ = median arrival date. Data were expanded for spillway flow.

Median arrival dates at Lower Granite Dam for fish PIT-tagged at the upper Grande Ronde River trap as early migrants and late migrants were 2 May and 7 May 2000, respectively (Figure 14). Median arrival dates for fish PIT-tagged at the Catherine Creek trap as early migrants and late migrants were 20 April and 6 May 2000, respectively (Figure 15). Medians for fish PIT-tagged at the Lostine River trap were 10 May (early migrants) and 6 May (late migrants; Figure 16).

Travel times to Lower Granite Dam for late migrating *O. mykiss* from the upper Grande Ronde River ranged from 6 to 78 d with a mean of 33.0 d ($n = 73$). Travel times for late migrants from Catherine Creek ranged fro 7 to 91 d with a mean of 27.6 d ($n = 63$). Travel times for Lostine River late migrants ranged from 4 to 66 d with a mean of 17.2 d ($n = 166$). Furthermore, for late migrants in each population, there was a significant inverse relationship between travel time and fork length of individual fish. Although the relationship was significant in each population, the r^2 values were low (range: 0.11 - 0.40) indicating factors other than fork length also influenced the travel time of individual fish.

Length and Age of Migrants: The three populations differed significantly from each other in mean fork length of *O. mykiss* (ANOVA $P < 0.001$). Lostine River fish were the largest and Catherine Creek fish were the smallest (Table 18). Of the late migrants that had a known age at length and were subsequently detected at the dams ($n = 22$), all but two (91%) were age-2 smolts. The two age-1 smolts detected at downstream dams were tagged in the upper Grande Ronde River and were relatively large for their age class (119 mm, 156 mm, Table 19).

Table 18. Fork lengths of *Oncorhynchus mykiss* collected and PIT-tagged at rotary screw traps from the upper Grande Ronde River, Catherine Creek, and Lostine River during the 2000 migration year. Fish detected at Snake and Columbia river dams were a subset of the original tagged and released groups.

Trap site	Migratory group	Number of fish	Fork length (mm) Mean	SE	Range
Collected					
Upper Grande Ronde	Early	179	129.8	2.06	53–231
	Late	904	126.7	1.04	63–225
Catherine Creek	Early	1,364	106.0	1.04	42–250
	Late	1,044	113.6	1.09	55–210
Lostine River	Early	797	154.1	0.99	66–286
	Late	739	156.0	1.39	66–370
Tagged and released					
Upper Grande Ronde	Early	108	133.7	2.49	71–205
	Late	453	130.6	1.40	71–225
Catherine Creek	Early	986	110.5	1.19	60–200
	Late	494	122.8	1.60	61–210
Lostine River	Early	773	154.5	0.98	66–286
	Late	526	155.0	1.57	66–329
Detected at Snake and Columbia River Dams					
Upper Grande Ronde	Early	16	149.1	4.91	124–180
	Late	101	154.0	1.89	115–208
Catherine Creek	Early	73	148.5	2.84	67–195
	Late	104	154.8	1.82	120–210
Lostine River	Early	157	159.3	1.69	121–259
	Late	237	170.1	1.23	123–236

Table 19. Length at age for late migrant *Oncorhynchus mykiss* collected at rotary screw traps on the upper Grande Ronde River, Catherine Creek, and the Lostine River. Min. = minimum, Max. = maximum.

			Fork length (mm)		
Stream	Age class	N	Mean	Min.	Max.
Upper Grande Ronde	1	54	101.9	62	156
	2	158	148.0	83	213
	3	5	205.6	189	225
Catherine Creek	1	72	77.7	60	137
	2	64	154.5	110	191
	3	1	199	--	--
Lostine River	1	7	104.9	75	146
	2	16	169.4	139	190
	3	1	222	--	--

FUTURE DIRECTIONS

We will continue this early life history study of spring chinook and summer steelhead in Catherine Creek, the upper Grande Ronde River, and Lostine River. In MY 2001, we will extend this study to include the Minam River. As we obtain more information on age-specific fecundities of wild spring chinook and age structure of spawning populations, we will improve our estimates of egg-to-parr and egg-to-smolt survival.

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