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

ANNUAL REPORT 2001

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ABSTRACT

We determined migration timing and abundance of juvenile spring chinook salmon *Oncorhynchus tshawytscha* and juvenile steelhead/rainbow trout *Oncorhynchus mykiss* using rotary screw traps on four streams in the Grande Ronde River basin during the 2001 migratory year (MY 2001) from 1 July 2000 through 30 June 2001. 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 1 July 2000 through 29 January 2001 with a peak in the fall. A 'late' migrant group descended from upper rearing areas from 30 January 2001 through 30 June 2001 with a peak in the spring. The migrant population of juvenile spring chinook salmon in the upper Grande Ronde River in MY 2001 was very low in comparison to previous migratory years. We estimated 51 juvenile spring chinook migrated out of upper rearing areas with approximately 12% of the migrant population leaving as early migrants to overwinter downstream. In the same migratory year, we estimated 16,067 *O. mykiss* migrants left upper rearing areas with approximately 4% of these fish descending the upper Grande Ronde River as early migrants. At the Catherine Creek trap, we estimated 21,937 juvenile spring chinook migrants in MY 2001. Of these migrants, 87% left upper rearing areas early to overwinter downstream. We also estimated 20,586 *O. mykiss* migrants in Catherine Creek with 44% leaving upper rearing areas early to overwinter downstream. At the Lostine River trap, we estimated 13,610 juvenile spring chinook migrated out of upper rearing areas with approximately 77% migrating early. We estimated 16,690 *O. mykiss* migrated out of the Lostine River with approximately 46% descending the river as early migrants. At the Minam River trap, we estimated 28,209 juvenile spring chinook migrated out of the river with 36% migrating early. During the same period, we estimated 28,113 *O. mykiss* with approximately 14% of these fish leaving as early migrants.

Juvenile spring chinook salmon PIT-tagged at trap sites in the fall and in upper rearing areas during winter were used to compare migration timing and survival to Lower Granite Dam of the early and late migrant groups. Juvenile spring chinook tagged on the upper Grande Ronde River were detected at Lower Granite Dam from 4 May to 20 May 2001, with a median passage date of 17 May. Too few fish were collected and tagged to conduct detection rate and survival comparisons between migrant groups. PIT-tagged salmon from Catherine Creek trap were detected at Lower Granite Dam from 27 April to 13 July 2001. Early migrants were detected significantly earlier (median = 10 May) than late migrants (median = 1 June). Also, early migrants from Catherine Creek were detected at a significantly higher rate than fish tagged in upper rearing areas in the winter, suggesting better survival for fish that migrated out of upper rearing areas in the fall. Juvenile spring chinook salmon from the Lostine River were detected at Lower Granite Dam from 2 April through 4 July 2001. Early migrants were detected significantly earlier (median = 27 April) than late migrants (median = 14 May). However, there was no difference in detection rates between early and late migrants. Survival probabilities showed similar patterns as dam detection rates. Juvenile spring chinook salmon from the Minam River were detected at Lower Granite Dam from 8 April through 18 August 2001. Early migrants were detected significantly earlier (median = 28 April) than late migrants (median = 14 May). Late migrants from the Minam River were tagged at the trap in the spring.

Spring chinook salmon parr PIT-tagged in summer 2000 on Catherine Creek and the

Imnaha, Lostine, and Minam rivers were detected at Lower Granite Dam over an 87 d period from 8 April to 3 July 2001. The migratory period of individual populations ranged from 51 d (Imnaha River) to 67 d (Catherine Creek) in length. Median dates of migration ranged from 30 April (Imnaha River) to 17 May (Catherine Creek). Detection rates differed between populations with Catherine Creek spring chinook salmon detected at the lowest rate (8.2%). Imnaha, Lostine, and Minam detection rates were not significantly different from each other. A similar pattern was seen for survival probabilities.

Using mark-and-recapture and scale-aging techniques, we determined the population size and age-structure of spring chinook salmon parr in Catherine Creek and the Lostine River during the summer of 2001. In Catherine Creek, we estimated that 986 mature age-1 parr (precocious males) and 15,032 immature age-0 parr were present during August 2001. We estimated there were 7.5 mature male parr for every anadromous female spawner in Catherine Creek in 2001. We estimated 33,086 immature, age-0 parr inhabited the Lostine River in August 2001. Mature male parr were observed, but not enough were marked to calculate a population estimate.

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 the North Fork Catherine Creek during the summer of 2001. We estimated that 25,736 *O. mykiss* inhabited the mainstem Catherine Creek and 10,338 *O. mykiss* inhabited the North Fork. Scale analysis showed that *O. mykiss* ranged from age-0 to age-3 at both localities.

We PIT-tagged juvenile *O. mykiss* at screw traps on Catherine Creek, and the upper Grande Ronde, Lostine, and Minam rivers during the fall of 2000 (early migrants) and spring of 2001 (late migrants). PIT-tagged fish were detected at Lower Granite Dam in 2001 between 12 April and 18 August. Early migrants from Catherine Creek reached Lower Granite Dam significantly earlier (median = 6 May) than late migrants (median = 14 May). Median arrival date for early migrants from the upper Grande Ronde River was 7 May; and for late migrants was 5 May. In the Lostine River, there was no difference in arrival dates of early migrants (median = 12 May) and late migrants (median = 14 May). Similarly, there was no difference in arrival dates of early migrants (median = 9 May) and late migrants (median = 7 May) from the Minam River.

The *O. mykiss* migrants collected at traps in MY 2001 ranged from 0 to 3 years of age which was consistent with the summer rearing populations. Most early migrants collected at the trap were age-1 with few age-0 or age-2 migrants present. These age-1 migrants would presumably resume their seaward migration the following spring as age-2 smolts. During the late migration period, the proportion of age-2 migrants was greater but never reached over 50% of the total late migrant population. Of the fish with known ages that were PIT-tagged at the traps in MY 2001 and subsequently detected at Snake/Columbia River dams, most (91%) reached the dams as age-2 smolts while four (9%) were age-3. No age-1 smolts were detected in MY 2001.

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EXECUTIVE SUMMARY

Objectives

1. Document the in-basin migration patterns for spring chinook salmon juveniles in Catherine Creek and the upper Grande Ronde, Minam, and Lostine rivers, including the abundance of migrants, migration timing and duration.

2. Estimate and compare smolt detection rates and survival probabilities at mainstem Snake and Columbia river dams for early and late migrating spring chinook salmon from the tributary populations in Catherine Creek and the upper Grande Ronde, Lostine and Minam rivers

3. Estimate and compare smolt detection rates and survival probabilities at mainstem Columbia and Snake River dams for migrants from four local, natural populations of spring chinook salmon 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: Catherine Creek, Lostine, Minam, Imnaha rivers.

5. Determine survival to parr stage for spring chinook salmon in two local, natural populations in the Grande Ronde River basin: Catherine Creek and Lostine River.

6. Investigate the significance of alternate life history strategies of spring chinook salmon in two local, natural populations in the Grande Ronde River basin: Catherine Creek and Lostine River.

7. Document patterns of movement for juvenile *O. mykiss* from tributary populations in Catherine Creek, the upper Grande Ronde, Lostine and the Minam rivers. Include 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 four tributary populations: Catherine Creek and the upper Grande Ronde and Lostine, and Minam rivers.

9. Evaluate methods to estimate the proportion of *O. mykiss* captured during fall trapping that are migrating out of rearing areas and will undertake a smolt migration the following spring.

10. Describe the population characteristics of the juvenile *O. mykiss* population in Catherine Creek.

Accomplishments

We accomplished all of our objectives in 2001.

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, only 19 juvenile spring chinook salmon were captured from 1 July 2000 through 30 June 2001. The catch was expanded to an estimate of 51 juvenile migrants. Approximately 12% of the migrant population left upper rearing areas in Grande Ronde River early (between 1 July 2000 and 29 January 2001) to overwinter downstream. During the same period, 2,645 juvenile *O. mykiss* were captured with the catch expanded to an abundance estimate of 16,067 migrants. Approximately 4% of these fish descended the upper Grande Ronde as early migrants. At the Catherine Creek trap, 7,659 juvenile spring chinook salmon were captured from 1 July 2000 through 30 June 2001 and the catch was expanded to an estimate of 21,937 migrants. Approximately 87% of the Catherine Creek migrant spring chinook salmon population left upper rearing areas early and overwintered downstream. We also captured 4,820 juvenile *O. mykiss* at this trap and expanded this catch to an abundance estimate of 20,586 migrants. Approximately 44% of these migrants left upper rearing areas early to overwinter downstream. At the lower Grande Ronde River trap, 422 juvenile spring chinook salmon were captured as they left the Grande Ronde Valley from 4 October 2000 through 20 June 2001. The catch was expanded to an estimate of 3,376 spring chinook salmon migrants. Approximately 5% of the spring chinook salmon migrant population left the Grande Ronde Valley as early migrants (between 04 October 2000 and 12 January 2001). We also captured 3,511 juvenile *O. mykiss* with a resultant abundance estimate of 46,470 migrants. Approximately 0.5% of the juveniles left the Grande Ronde Valley as early migrants. The estimates of spring chinook salmon and *O. mykiss* juveniles at this trap site were most likely underestimated due to numerous trap stoppages. At the Lostine River trap, 4,418 juvenile spring chinook salmon were captured from 1 July 2000 through 30 June 2001. The catch was expanded to an estimate of 13,610 migrants. Approximately 77% of the spring chinook salmon migrant population left upper rearing areas of the Lostine River early to overwinter downstream. We captured 2,556 juvenile *O. mykiss* during this same period. The catch was expanded to an estimate of 16,690 migrants, of which approximately 46% descended the Lostine river as early migrants to overwinter downstream. At the Minam River trap, 3,454 juvenile spring chinook salmon were captured as they migrated downstream 27 September 2000 through 18 June 2001. The catch was expanded to an estimate of 28,209 migrants with 36% migrating early. During the same period, we caught 1,337 juvenile *O. mykiss* with a resultant population estimate of 28,113. We estimated 14% of these fish left the Minam River as early migrants.

Spring Chinook Salmon

Passive integrated transponders (PIT tags) were used to individually mark fish captured in traps and make subsequent observations at dams on the Snake and Columbia rivers. Juvenile spring chinook salmon PIT-tagged on the upper Grande Ronde River were detected at Lower Granite Dam from 4 May to 20 May 2001, with a median passage date of 17 May. Too few fish were collected to conduct detection rate and survival comparisons between migrant groups. PIT-tagged salmon from Catherine Creek were detected at Lower Granite Dam from 27 April to 13 July 2001. Early migrants were detected earlier (median = 10 May) than late migrants (median = 1 June). The detection rate of juvenile spring chinook salmon that were tagged as they left upper rearing areas in fall (early migrants) and overwintered downstream (12.8%) was significantly higher than the rate for late migrant fish tagged during winter in the upper rearing area (6.9%) suggesting better survival for fish that migrated out of upper rearing areas in the fall. Juvenile spring chinook salmon from the Lostine River were detected at Lower Granite Dam from 2 April through 4 July 2001. Early migrants were detected earlier (median = 27 April) than late migrants (median = 14 May). The detection rate of fish that were tagged as they left the upper rearing area in fall and overwintered in areas downstream (32.9%) was not significantly different from that of fish tagged during winter in upper rearing areas (27.7%). Survival probabilities showed similar patterns as dam detection rates. Survival probabilities for early migrants from Catherine Creek (s = 0.130) were significantly higher than survival probabilities for fish tagged during winter in upper rearing areas of these streams (s = 0.077). Upstream overwinter survival was 20%. In the Lostine River, there was no significant difference in survival probabilities between early migrants (s = 0.329) and those tagged in winter in upper rearing areas (s = 0.277). Upstream overwinter survival was 41%. Juvenile spring chinook salmon from the Minam River were detected at Lower Granite Dam from 8 April through 18 August 2001. Early migrants were detected earlier (median = 28 April) than late migrants (median = 14 May).

Spring chinook salmon parr that were collected by seining and PIT-tagged on Catherine Creek and the Imnaha, Lostine, and Minam rivers in summer 2000 were detected at Lower Granite Dam over an 87 d period from 8 April to 3 July 2001. The migratory period of individual populations ranged from 51 d (Imnaha River) to 67 d (Catherine Creek) in length. Median dates of migration ranged from 30 April (Imnaha River) to 17 May (Catherine Creek). We found significant differences in migration timing between these populations (Kruskal-Wallis P <0.001). Median arrival dates for Lostine and Minam smolts were intermediate and not different from each other (medians = 9 May and 8 May, respectively). Detection rates differed between populations. Catherine Creek detection rates were the lowest (8.2%). Imnaha, Lostine, and Minam detection rates were not significantly different from each other (18.0%, 20.7%, and 22.1%, respectively). A similar pattern was seen for survival probabilities. Minam and Lostine survival probabilities did not differ and were highest (0.228, 0.210, respectively), followed by the Imnaha (0.181), then Catherine Creek with the lowest survival probability (0.087).

During the 2001 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 1999. One age-2 smolt that was tagged on the Lostine River in January of 2000 was detected at the dams in 2001.

Using mark-and-recapture and scale-aging techniques, we determined population size and age-structure of spring chinook salmon parr in Catherine Creek and the Lostine River. In Catherine Creek, we estimated that 986 mature age-1 parr and 15,032 immature age-0 parr were present during August 2001. An average of 26 mature age-1 parr were produced per redd constructed in 1999. An average of 578 immature age-0 parr were produced per redd constructed in 2000. We estimated that 3.8% of the immature age-0 parr inhabiting Catherine Creek in August 2000 matured and were present in Catherine Creek in August 2001. We estimated there were 7.5 mature male parr for every anadromous female spawner in Catherine Creek in 2001.

We estimated 33,086 immature, age-0 parr inhabited the Lostine River in August 2001. An average of 624 immature parr were produced per redd constructed in 2000. Mature male parr were observed, but not enough were marked to calculate a population estimate.

Summer Steelhead

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 North Fork Catherine Creek during the summer of 2001. We estimated that 25,736 *O. mykiss* inhabited the mainstem Catherine Creek and 10,338 *O. mykiss* inhabited the north fork. Scale analysis showed that *O. mykiss* ranged from age-0 to age-3 at both localities. Age-1 fish were the most abundant, accounting for 86.7% in mainstem Catherine Creek and 55.9% in the north fork. *O. mykiss* that were PIT-tagged during the summer of 2000 in the mainstem, north fork, and south fork of Catherine Creek were detected at Lower Granite Dam between 25 April and 25 June 2001. Their detection rate was 2.5%. No difference in size (measured when tagged in the summer) was detected between fish that migrated out of upstream rearing areas the following fall as opposed to the following spring. However, fish that migrated out of upstream rearing areas before the summer of 2001 were larger than all the summer tagged fish (medians = 127 mm, 113 mm, respectively).

Juvenile *O. mykiss* were PIT-tagged at screw traps on Catherine Creek, and the upper Grande Ronde, Lostine, and Minam rivers during the fall of 2000 (early migrants) and spring of 2001 (late migrants). PIT-tagged fish were detected at Lower Granite Dam in 2001 between 12 April and 18 August. Early migrants from Catherine Creek reached Lower Granite Dam earlier (median = 6 May) than late migrants (median = 14 May). Their detection rates were 11.9% (early migrants) and 36.5% (late migrants). Late migrants detected at the dams in 2001 were larger in fork length (median = 150 mm) at tagging than all late migrants tagged (median = 141 mm). There was no difference in length between early migrants that were detected in 2001 (median = 139 mm) and all early migrants tagged (median = 136 mm). Median arrival date for early migrants from the upper Grande Ronde River was 7 May; and for late migrants was 5 May. Their detection rates were 19.7% (early migrants) and 41.7% (late migrants). Late migrants detected at the dams in 2001 were larger (median = 156 mm) at tagging than all late migrants tagged (median = 146 mm). Early migrants detected at the dams in 2001 were also larger (median = 152 mm) at tagging than all early migrants tagged (median = 124 mm). There was no difference in arrival dates of early migrants (median = 12 May) and late migrants (median = 14

May) from the Lostine River. Their detection rates were 4.0% (early migrants) and 53.3% (late migrants). Late migrants detected at the dams in 2001 were larger (median = 171 mm) at tagging than all late migrants tagged (median = 160 mm). Early migrants detected at the dams in 2001 were also larger (median = 161 mm) at tagging than all early migrants tagged (median = 80 mm). There was no difference in arrival dates of early migrants (median = 9 May) and late migrants (median = 7 May) from the Minam River. Their detection rates were 21.9% (early migrants) and 59.7% (late migrants). Late migrants detected at the dams in 2001 were larger (median = 167 mm) at tagging than all late migrants tagged (median = 159 mm). There was no detectable difference in length between early migrants that were detected in 2001 (median = 147 mm) and all early migrants tagged (median = 121.5 mm).

Fifty-four *O. mykiss* were detected at Snake and Columbia River dams in 2001 that had been PIT-tagged during MY 2000 on Catherine Creek, the upper Grande Ronde, or the Lostine rivers.

The *O. mykiss* collected at traps ranged from 0 to 3 years of age. Most early migrants collected at the trap were age-1 with few age-0 or age-2 migrants present. These age-1 migrants would presumably resume their seaward migration the following spring as age-2 smolts. During the late migration period, the proportion of age-2 migrants was greater but never reached over 50% of the total late migrant population. Of the fish with known ages that were PIT-tagged at the traps in MY 2001 and subsequently detected at Snake/Columbia River dams, most (91%) reached the dams as age-2 smolts while four (9%) were age-3. No age-1 smolts were detected in MY 2001.

Management Implications and Recommendations

The Grande Ronde Valley provides more than a migration corridor for juvenile spring 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 Valley. Rearing habitat in the valley is significantly altered and degraded. Four years of data for the upper Grande Ronde River 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 spring 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 spring 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 anadromous female spawner ratios we have observed, it is evident mature male parr hold the potential to make significant gametic contributions to northeast Oregon spring 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 × 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 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.

Though historic estimates of juvenile production in the basin are lacking, 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 spring chinook salmon smolt migration from the Grande Ronde River 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; Tranquilli et al. 1998; and Monzyk et al. 2000) 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 spring 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 and *O. mykiss* in the Grande Ronde River basin. The objectives of this study were to:

1. Document the in-basin migration patterns for spring chinook salmon juveniles in Catherine Creek and the upper Grande Ronde, Minam, and Lostine rivers, including the abundance of migrants, migration timing and duration.

2. Estimate and compare smolt detection rates and survival probabilities at mainstem Snake and Columbia river dams for early and late migrating spring chinook salmon from the tributary populations in Catherine Creek and the upper Grande Ronde, Lostine and Minam rivers.

3. Estimate and compare smolt detection rates and survival probabilities at mainstem Columbia and Snake River dams for migrants from four local, natural populations of spring chinook salmon 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: Catherine Creek, Lostine, Minam, Imnaha rivers.

5. Determine survival to parr stage for spring chinook salmon in two local, natural populations in the Grande Ronde River basin: Catherine Creek and Lostine River.

6. Investigate the significance of alternate life history strategies of spring chinook salmon in two local, natural populations in the Grande Ronde River basin: Catherine Creek and Lostine River.

7. Document patterns of movement for juvenile *O. mykiss* from tributary populations in Catherine Creek, the upper Grande Ronde, Lostine and the Minam rivers. Include 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 four tributary populations: Catherine Creek and the upper Grande Ronde and Lostine, and Minam rivers.

9. Evaluate methods to estimate the proportion of *O. mykiss* captured during fall trapping that are migrating out of rearing areas and will undertake a smolt migration the following spring.

10. Describe the population characteristics of the juvenile *O. mykiss* population in Catherine Creek.

SPRING CHINOOK SALMON INVESTIGATIONS

Methods

For the purpose of this report, we assume that all juvenile spring chinook salmon captured in traps were downstream "migrants". The term "migratory 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 spring chinook salmon referred to in this report were naturally produced unless noted otherwise.

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 2001. We captured, marked, and released parr from 30 July to 2 August on Catherine Creek and 6–10 August on the Lostine River. We conducted subsequent sampling 6–10 August on Catherine Creek and 13–17 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 (not to exceed 1,000). During subsequent sampling, our goal was to capture at least 500 immature parr and as many mature parr (not to exceed 500) as possible in 5 d. We collected scales for age determination from the mature parr captured in each stream. Scales were not collected from immature parr in Catherine Creek and the Lostine River to minimize handling time and stress on the fish. Scale analysis in previous years indicated that most (98.9–100% in Catherine Creek and 100% in the Lostine River) of the immature parr in these streams were age-0 (Appendix Table A-1). We identified mature parr based on body morphology and coloration. Mature parr tended to be longer, deeper-bodied, and more yellowish in color (laterally) than immature parr. Precocious maturation of chinook parr has only been recorded in males. Therefore, all mature parr were assumed to be male. In Catherine Creek and the Lostine River, all parr that did not exhibit signs of early maturity were assumed to be immature, age-0 parr.

Site Description: On both Catherine Creek and the Lostine River, parr were collected (and marked and released) upstream of rotary screw traps, in the length of stream encompassing the majority of the spawning and rearing habitat (Figure 1). Sampling on Catherine Creek occurred from the rotary screw trap (rkm 20) to the confluence of the north and south forks of Catherine Creek (rkm 52). Sampling on the Lostine River occurred from the rotary screw trap (rkm 3) to the Lostine Guard Station (rkm 30). We did not sample a 9 km long canyon within the study area on the Lostine River because it is unsuitable rearing habitat for juvenile spring chinook salmon, although adults do spawn upstream and downstream of this reach. The sampling area on Catherine Creek was divided into four reaches, based roughly on valley and channel morphology. We calculated separate population estimates for each reach. Catherine Creek reach 1 extended upstream from the screw trap (river kilometer, rkm, 32.2) to the Kirby's property (rkm 37.8). Reach 2 extended from the Kirby's property to the Highway 203 bridge just upstream of the artesian well (rkm 44). Reach 3 extended from the Highway 203 bridge to the Merry-Go-Round bridge (rkm 47.5). And, reach 4 extended from the Merry-Go-Round bridge to the North Fork – South Fork confluence (rkm 52).

Marking Phase: Parr were collected for marking along the length of Catherine Creek mentioned above. Parr were collected in 6 segments of stream (about 10 km total) scattered throughout the 27 km of spawning and rearing area on the Lostine River. In most cases, 2–3 snorkelers herded the parr downstream into a seine held perpendicular to the stream flow. Traditional beach seining was also effective in a few areas. 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 near our marking stations. Prior to being marked, fish were anesthetized in an aerated bath containing 40–50 mg/L of tricaine methanesulfonate (MS-222). We marked all mature parr, and any immature parr less than 55 mm fork length (FL), with diluted, non-toxic, acrylic paint. The paint was injected subcutaneously on the ventral surface slightly anterior of the pelvic fin insertion using a Panjet marking instrument (Hart and Pitcher 1969). Immature parr that were 55 mm FL or greater were either paint-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 min in 70% isopropyl alcohol and allowed to dry for 10 min 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 paint-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. Scale samples were collected from most of the mature parr that were handled.

Recapture Phase: Each reach on Catherine Creek was divided into sections approximately 0.4 km in length. Within each reach, we collected parr from 5–7 randomly selected sections. Approximately 9.4 km of Catherine Creek were resampled. Parr were resampled over the length of the Lostine River, from the rotary screw trap to the Lostine Guard Station, except for the 9 km long canyon section. We used the seining methods described above to capture parr. Each fish was inspected for marks and maturity status, and the numbers of mature and immature parr that were unmarked, paint-marked, PIT-tagged, or that had lost their PIT tag (i.e., no tag could be detected, but a recent PIT-tagging scar was evident) were recorded.

Calculations: We used Chapman's modification of the Petersen estimate (Ricker 1975) to determine the abundance of immature and mature parr in Catherine Creek and the Lostine

River. We obtained 95% confidence intervals (CI) using equation (3.7) in Ricker (1975) and values from Appendix II in Ricker (1975). Age composition estimates for the groups of 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 mature parr of each age and obtained 95% confidence intervals from table P in Rohlf and Sokal (1995). Immature parr were assumed to be age-0 and their scales were not collected.

Using parr abundance and age composition estimates from August 2000 (Monzyk et al. 2000) and 2001, and redd count data from 1999 and 2000 spawning ground surveys (ODFW, unpublished data) we determined the following regarding spring chinook salmon populations in Catherine Creek and the Lostine River: 1) the abundance of immature and mature parr, by age class, in August 2001; 2) the percentages of immature, age-0 parr present in each stream in August 2000 that were present in August 2001 as mature or immature age-1 parr; 3) the average number of mature and immature, age-0 parr (in 2001) produced per redd constructed in 2000; and 4) the average number of mature and immature age-1 parr (in 2001) produced per redd constructed in 1999. 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, unpublished data) 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, the Lostine River, and the Minam River were determined by operating rotary screw traps through out the migratory year. The 2001 migratory year (MY 2001) for spring chinook salmon within the Grande Ronde River basin overlaps two calendar years, and began on 1 July 2000 and ended on 30 June 2001. Spring chinook salmon in our study streams exhibit two migrational life-history patterns. Early migrants leave upper rearing areas in the fall and overwinter in downstream habitat before continuing 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. Designations 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.

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 an important 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. In the Wallowa River subbasin, one rotary screw trap was located below the majority of spawning and upper rearing areas on the Lostine River near the town of Lostine at rkm 3 (Figure 1). Although we attempted to fish the traps continuously through the year, there were times when a trap could not be operated due to low flow or freezing conditions. There were also instances when traps were not operating due to debris blockage and mechanical breakdowns. We did not attempt to adjust population estimates for periods when traps were not operating. For this reason, our estimates represent a minimum number of migrants.

The rotary screw traps were equipped with live boxes that safely held hundreds of juvenile spring chinook salmon trapped over 24–72 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. Up to 100 juvenile spring chinook salmon were marked and released each week. On days when a trap stopped operating, the number of recaptured fish and the number of marked fish released the previous day were subtracted from the weekly totals.

Trap efficiency was estimated by

$$\hat{E} = R \;/\; M; \tag{1}$$

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

$$\hat{N} = U \;/\; \hat{E}; \tag{2}$$

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. Total migrant abundance was estimated as the sum of weekly abundance estimates.

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 variance of weekly population estimates. Each bootstrap iteration calculated weekly $\hat{N}^*$ from equations (1 and 2 above) drawing R^* and U^* from the binomial distribution, where asterisks denote bootstrap values, and weekly variance of $\hat{N}^*$ was calculated from the 1,000 iterations. 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 spring chinook salmon release sites. The magnitude of hatchery spring chinook salmon releases into these streams during the spring necessitated modifications to our method of estimating migrant abundance of wild spring chinook salmon 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 (Catherine Creek trap: 18:20 to 22:20; Lostine River trap: 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 spring chinook salmon catch rates. The specific intervals were chosen because a relatively large proportion of the total daily catch was captured during these 4 h time blocks.

Systematic sampling required us to estimate the proportion of the total daily catch captured during our sampling interval. 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 spring chinook salmon 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 before 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 trap 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

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 for each tag group. There were four tag groups for which we estimated migration timing and indexed survival to Lower Granite Dam: the summer tag group (upstream summer-rearing fish), the fall tag group (early migrants, overwintering downstream), the winter tag group, and the spring tag group (late migrants, overwintering upstream). The summer tag groups consisted of age-0 parr tagged during July and August 2000 in their upstream rearing habitat. Fish were caught and PIT-tagged using techniques described in **Egg-to-Parr Survival, Parr Abundance, and Age Composition in Summer**. Summer tag groups were tagged on Catherine Creek, and the Lostine, Minam, and Imnaha rivers. For consistency with previous years' data, fish tagged as they moved downstream past our upper trap sites between September and early December 2000 were designated the fall tag group. Fall tag group fish were tagged at our screw traps on the Lostine, Grande Ronde, and Minam rivers and Catherine Creek . Fish tagged as they moved downstream past our upper trap sites between February and May 2001 were designated as the spring tag group. The spring tag group fish were tagged at our screw traps on the Lostine, Grande Ronde, and Minam rivers and Catherine Creek. These dates encompassed a majority of the early and late migrations. There was very little downstream migration past our traps during December and January, although a few juvenile spring chinook salmon were caught. Winter tag group fish were tagged immediately following completion of tagging of the fall tag group. These fish were caught and tagged a minimum of 8 km above the trap sites to minimize the chance they would pass the trap sites while making localized movements during winter. Winter groups were tagged on the Lostine River and Catherine Creek and were caught using dip nets while snorkeling at night. We attempted to PIT-tag 500 parr for fall, winter, and spring tag groups, and 500 or 1,000 parr for each summer tag group.

With the exception of the summer tag group, fish tagged in the different tag groups represented unique life history strategies. The summer tag group included fish that moved out of upper rearing areas as either early or late migrants, and consequently overwintered in either the lower or upper rearing areas. Therefore, the summer tag group included fish that exhibited both migrational patterns and represented timing and survival for the overall population. The fall tag group represented early migrants that left the upstream rearing areas in the fall and overwintered downstream of our screw traps. Both the winter and spring tag groups represented late migrants that overwintered as parr upstream and migrated out in the spring. The difference between the two groups was that the winter tag group was tagged earlier (December) than the spring tag group (February–May) and therefore experienced overwinter mortality in the upper rearing areas.

During the 2001 migratory 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 were also interrogated for PIT tags upon capture in our screw traps. All recaptured and interrogated fish were identified by their original tag group, insuring the independence of tag groups for analysis. For example, dam detections of fish that were tagged as part of the summer tag group and subsequently recaptured at a river trap as early migrants, were analyzed as summer tagged fish. At the completion of the 2001 migratory 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.

Calculations: *Migration Timing**:*** We estimated the timing of migration past Lower Granite Dam for each tag group 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 have passed 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). 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:

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

Daily products were added for each week and rounded to the nearest integer. Median, first, and last detection dates were reported for each tag group. Medians were determined for detection dates weighted by expanded fish numbers. Median detection dates for the spring tag groups may have reflected the dates fish were tagged in addition to the migration pattern. For this reason, median detection dates for the spring tag groups may have been biased. The time taken for spring tagged parr to reach Lower Granite Dam from the screw trap was summarized for each location.

Survival Indices: For each tag group we calculated two different indices of survival to Lower Granite Dam. These were dam detection rates and Cormack-Jolly-Seber (CJS) survival probabilities. We calculated detection rates for each tag group by dividing the number of first-time PIT-tag detections at all dams by the number of PIT-tagged fish released in each tag group. These detection rates were not adjusted to compensate for fish that may have passed through the hydrosystem without being detected. Therefore, the detection rates were relative and represented the minimum rate for each tag group. We also used the CJS method in the SURPH 2.1 program to calculate the probability of survival to Lower Granite Dam for fish in each tag group (Lady et al. 2001). This method took into account the probability of detection when calculating the probability of survival (detection probability = capture probability × survival probability). Both detection rates and CJS survival probabilities were reported to allow comparison to previous years' detection rate data.

Comparison of Early Life History Strategies: Comparisons were made between early and late migrants from each location to determine if different life histories were associated with differences in timing of migration and survival to Lower Granite Dam.

Migration Timing: Lower Granite Dam detection dates were compared between the fall (early migrants) and winter (late migrants) tag groups from Catherine Creek and the Lostine River to investigate differences in seaward migration timing between the two life history strategies. Comparisons were made using the Mann-Whitney rank sum test on detection dates. Spillway flow, although minimal during this migratory year, was taken into account by rounding the expanded fish numbers to the nearest integer and creating duplicate 'dummy' detection records for any date with an expanded fish number greater than one. For the Minam River, we compared the detection dates for the fall and spring tag groups because parr were not tagged in the winter. We used the Pearson product moment correlation to determine whether the number of parr tagged at the Minam River trap in the spring, by week, was correlated to the number estimated to migrate past the trap. This was done to determine the likelihood that the late migrant median detection date was reflective of the true migration pattern rather than an artifact of the dates of tagging. Detection dates were not compared for early and late migrants from the upper Grande Ronde River due to small sample sizes.

Survival Indices: Fish that emigrated from upper rearing areas at different times of year and overwintered in different habitats were subject to different environmental conditions. Survival may have varied among fish exhibiting the different life histories as a result. For each stream, we evaluated relative success of early and late migrants by using the Maximum Likelihood Ratio Test to test the null hypothesis that survival probabilities of the fall tag group (early migrants) and the winter tag group (late migrants) were the same. We assumed that any difference in survival probabilities between these two groups was due to differential survival in upstream (used by winter tag group) and downstream (used by fall tag group) overwintering habitat.

We were able to use the spring tag group and the winter tag group survival probabilities to indirectly estimate overwinter survival probability for late migrants in the upstream rearing habitat on the Lostine River and Catherine Creek. Overwinter survival probability was calculated by dividing the winter tag group survival probability by the spring tag group survival probability (survival of winter tag group = late migrant overwinter survival x survival of spring tag group). Analogous calculations were performed using the detection rates for comparison with previous years' data.

Population Characteristics and Comparisons: The summer tag groups included the various life history patterns displayed by that population and provided information about the population's overall survival and timing of the smolt migration past the dams. In summer of 2000 and 2001, 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, their rates of detection in the hydrosystem, and their survival probabilities from tagging to the dams on the mainstem Snake River. We conducted tagging operations in late summer (Table 1) so that most fish would be large enough to tag ($\geq$ 55 mm FL). Sampling occurred primarily in areas where spawning adults were concentrated the previous year (Figure 1). The collection and PIT-tagging methods were previously described for the mark-and-recapture studies (*see* **Methods; Egg-to-Parr Survival, Parr Abundance, and Age Composition in Summer**). We caught, PIT-tagged, and released between 490 and 1,050 parr per stream in summer 2000; and between 501 and 1,001 in summer 2001 (Table 1, for all years *see* Appendix Table A-2). Information on the migration timing and detection rates of parr PIT-tagged in summer 2001 will be reported next year.

Migration Timing: We determined if migration timing differed between populations using a Kruskal-Wallis one-way analysis of variance on ranked dates of detection, expressed as day of the year, of expanded fish numbers. (The expansion factor was 1 for all summer 2000-tagged fish migrating in 2001 because there was no spill at Lower Granite Dam for most of the migration period.) When significant differences were found, we used Dunn's pair-wise multiple-comparison procedure ($\alpha = 0.05$) to further analyze the data (SPSS Inc. 1992–1997).

Survival Indices: A χ^2 contingency table analysis was performed to test the null hypothesis that detection rates were the same for all populations (Zar 1984, equation 6.1). If detection rates differed, a Tukey-type multiple comparison on transformed proportions was used to determine which populations differed (Zar 1984, equation 22.13). Survival probabilities were compared between populations using the modeling and hypothesis testing capabilities of Surph 2.1. Several models were developed. The ones that best fit the data were selected using Akaike's information criterion. Final model selection was made using likelihood ratio tests.

Results and Discussion

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

Catherine Creek: We estimated that 986 (95% CI: 545 to 1,971) mature parr and 15,032 (95% CI: 12,598 to 17,931) immature parr inhabited Catherine Creek in August 2001 (Table 2), based on mark-recapture data for the whole study area. This immature parr estimate was lower than the 2000 estimate of 25,997 (Appendix Table A-3). The mature parr estimate was not different than the 2000 estimate. Reach 2, which encompassed the Catherine Creek State Park area, was estimated to have the highest density of parr with 1,089 parr/km (Table 3). Results from scale analyses indicated that all of the mature parr were age-1 (Table 4).

There were 38 and 26 redds counted in the Catherine Creek study area in 1999 and 2000, respectively (ODFW, unpublished data). We estimated that 26 mature, age-1 parr were produced per redd constructed in 1999 (Appendix Table A-4). In relation to the estimated number of eggs laid in 1999, we estimated that 0.6% became parr that remained in freshwater and matured precociously at age-1. We estimated that 578 immature, age-0 parr were produced from each redd constructed in 2000. This was equivalent to an egg-to-parr survival of 13.30% (95% CI:

11.14 to 15.86%), which was similar to the 1998 and 1999 (brood year) egg-to-parr survival estimates of 15.23 and 15.55% respectively and greater than the 1997 survival rate (Table 5). Of the 25,698 immature, age-0 parr estimated to be present in Catherine Creek in August 2000 (Monzyk et al. 2000), 3.84% were estimated to be present as mature, age-1 parr in August 2001 (Appendix Table A-5).

We estimated that there were 7.5 mature, wild, male parr present in the late summer of 2001 for each redd counted a month or two later (*see* **Alternate Life History Strategies** for discussion). We observed 21 mature, hatchery, male parr during our field work in the summer of 2001.

Lostine River: We estimated that 33,086 (95% CI: 25,901 to 42,226) immature parr inhabited the Lostine River in August 2001 (Table 2). We observed mature parr, but did not capture enough to estimate their population. Although we only aged scales from four fish, results indicated that there were age-0 (1 fish) and age-1 (3 fish) mature parr in the Lostine River (Table 4). All mature parr caught in previous years (1998–2000) were age-1 (Appendix Table A-1). Scales were not taken from immature parr. All immature parr in previous years (1998–2000) were age-0 (Appendix Table A-1). For further calculations, we assumed that all immature parr in 2001 were also age-0.

There were 45 and 53 redds counted in the Lostine River study area in 1999 and 2000, respectively (ODFW, unpublished data). We estimated that 624 immature, age-0 parr were produced from each redd constructed in the Lostine River in 2000 (Appendix Table A-4). This was equivalent to an egg-to-parr survival of 14.36% (95% CI: 11.24 to 18.32%,), which was higher than the 1999 egg-to-parr survival of 6.32% (Table 5). Although mature parr were present in the Lostine River, they were not as abundant here as in Catherine Creek and we were unable to calculate production per redd for mature parr or the percentage of age-0 immature parr that remained in freshwater and matured precociously at age-1. Presumably, both values were very small but not zero. We observed two mature, hatchery, male parr during our 2001 summer field work.

In-Basin Migration Timing and Abundance

For the 2001 migratory year (MY 2001), distinct early and late migration patterns were evident at most of our upper trap sites with very few fish caught in the winter months (Figure 2). For the purpose of this report, early migration was considered to encompass the time from 1 July 2000 through 28 January 2001 (end of Julian week 4) and late migration from 29 January 2001 through 30 June 2001. For trap sites where we have previous years of data, the median emigration dates for MY 2001 early migrants tended to occur earlier than in past years while median emigration dates for late migrants tended to occur later than in previous years of this study (Table 6).

Upper Grande Ronde River: The upper Grande Ronde River trap fished for 183 d from 1 July through ice-up on 11 November 2000, and from 18 March through 30 June 2001. Very few migrants were collected at the trap site in MY 2001 (Table 7). During the early migration period, only two individuals were collected, thereby precluding us from determining a meaningful median migration date. During the late migration period, juvenile spring chinook salmon were collected on 12 separate days. The median emigration date for late migrants passing the trap was 10 April and was slightly later than past observations with the exception of MY 1997 (Table 6).

We estimated a minimum of 51 juvenile spring chinook salmon migrants (95% CI: ± 31) moved out of the upper Grande Ronde rearing areas during MY 2001. This estimate is similar to the MY 1997 estimate of 82 fish but considerably less than estimates from other years of this study that have ranged from 1,118 to 25,378 fish (Table 6). The low number of juvenile spring chinook salmon in MY 2001 was not unexpected given that the majority of these fish were produced from the returning adults of the MY 1997 cohort.

Based on weekly trap efficiencies, we estimated that approximately 12% (6 ± 9) of the juvenile spring chinook salmon were early migrants and 88% (45 ± 30) were late migrants. Even with the few migrants passing the trap, the pattern of a dominant late migration in the upper Grande Ronde is consistent for all migratory years studied to date with the exception of MY 1997, when 17% of the migrants moved late (Table 6). It is worth mentioning, however, that only 29 fish were trapped in MY 1997.

Catherine Creek: The Catherine Creek trap fished for 235 d from 1 July through ice-up on 6 December 2000, and from 20 February through 30 June 2001 (Table 7). There was a distinct early and late migration exhibited by juvenile spring chinook salmon at this trap site (Figure 2). Median emigration date for early migrants past the trap was 8 October. This was earlier than the median dates from previous years of this study (Table 6). The median emigration date for late migrants was 24 March and was only slightly later than median emigration dates from previous years of this study (Table 6).

We estimated that a minimum of 21,937 ± 2,330 juvenile spring chinook salmon migrants moved out of the upper Catherine Creek rearing areas during MY 2001. This estimate falls within estimates from previous years of this study (Table 6). Based on weekly trap efficiencies, 87% (18,996 ± 2,213) migrated early and 13% (2,941 ± 728) migrated late. The proportion leaving as late migrants was within the range observed in previous years of this study (Table 6). 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 River, the largest outmigration from Catherine Creek has consistently been observed with early migrants (Table 6).

Grande Ronde Valley: The Grande Ronde Valley trap fished for 162 d from 4 October 2000 through 12 January 2001, and 1 February through 20 June 2001 (Table 7). A distinct late migration was evident; few fish passed the trap in fall and winter (Figure 2). The median emigration date was 22 April and was similar to timing observed in MY 1995, MY 1996 and MY 1998. Timing in MY 1997, MY 1999 and MY 2000 was somewhat later with the median migrant moving past this trap in early May.

We estimated that a minimum of 3,376 ± 1,300 juvenile spring chinook salmon migrants left the Grande Ronde Valley during MY 2001. There were numerous trap stoppages during the peak migration period because of debris blockage and mechanical breakdowns. Therefore, we most likely underestimated the number of juvenile spring chinook salmon migrating past this site. We estimated 152 ± 94 juvenile spring chinook salmon passed the trap as early migrants. As in the past five years, approximately 95% of the spring 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 above the trap site (rkm 164). 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 323 d between 1 July 2000 and 30 June 2001 (Table 7). 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 29 September 2000. This date was earlier than the median emigration dates observed from previous years of this study (Table 6). The earlier migration timing was due in part to a relatively large number of juvenile spring chinook salmon moving past the trap in early July (Figure 2). The median date for late migrants was 20 April 2001 and was only slightly later than observed in past years of this study (Table 6). We estimated that a minimum of 13,610 ± 1,362 juvenile spring chinook salmon migrants moved out of the Lostine River during MY 2001. We estimated approximately 77% (10,478 ± 1,246) of the juvenile spring chinook salmon migrated early and 23% (3,132 ± 549) migrated late. In past years of this study, the proportion leaving as late has ranged from 32% to 52% (Table 6).

Minam River: The Minam River trap fished for 139 d from 27 September through 16 November 2000, and 22 February through 18 June 2001. 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 8 October 2000. The median date for late migrants was 27 March 2001. We estimated that a minimum of 28,209 ± 4,643 juvenile spring chinook salmon moved out of the Minam River during MY 2001. Approximately 36% (10,224 ± 2,820) of the juvenile spring chinook salmon migrated early and 64% (17,985 ± 3,689) migrated late. The early migrant estimate may not be accurate. More early migrants may have moved past our trap than reported here because the trap was not started until late September, thereby potentially missing some of the early migration.

Size of Migrants: A comparison of mean lengths and weights of juvenile spring chinook salmon captured in the traps as early and late migrants and in upper rearing areas in winter and those PIT-tagged and released are given in Tables 8–15. Length frequency distributions of juvenile spring chinook salmon caught in all traps by migration period are shown in Figures 3–7.

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 2000. A similar pattern emerges in Catherine Creek and Lostine River in which the average length of spring chinook salmon collected at our traps increases during the summer months, reaches an early peak in the fall, and decreases slightly by winter (Figure 8). This early peak may indicate that larger individuals in the rearing population have a greater propensity to emigrate as early migrants or migrate sooner than smaller individuals during the early migration period. Larger individuals have been found to migrate sooner than smaller fish in natural populations of spring chinook salmon and coho salmon *Oncorhynchus kisutch* (Scrivener et al. 1994; Irvine and Ward 1989). Similarly, larger hatchery chinook salmon have been found to migrate sooner than smaller individuals (Ewing et al. 1984; Beckman et al. 1998).

Migration Timing and Survival to Lower Granite Dam

Juvenile spring chinook salmon were PIT-tagged at screw traps on Catherine Creek and the upper Grande Ronde, Lostine, and Minam rivers. Parr were also PIT-tagged upstream of the screw traps on Catherine Creek and the Lostine River during the winter. Because of the low number of juveniles collected at the upper Grande Ronde River trap during the 2001 migratory year, no early-migrating and only six late-migrating spring chinook salmon juveniles were PIT-tagged. At the Catherine Creek trap, we PIT-tagged 508 early- and 328 late-migrating spring chinook salmon juveniles that were not previously tagged. In addition, we PIT-tagged 498 spring chinook salmon parr during August 2000 and 522 parr during December 2000 in rearing areas upstream of the trap. At the Lostine River trap, we PIT-tagged 498 early- and 442 late-migrating juvenile spring chinook salmon that were not previously tagged. In addition, 489 parr were tagged in August 2000 and 499 parr in December 2000 from rearing areas above the trap. At the Minam River trap, we PIT-tagged 300 early- and 536 late-migrants that were not previously tagged. In addition, 1,000 parr were PIT-tagged in the Minam River and 1,050 in the Imnaha River in upstream rearing areas during August 2000 (Table 1).

Comparison of Early Life History Strategies: *Migration Timing:* Median arrival dates at Lower Granite Dam for the fall, winter, and spring tag groups PIT-tagged on Catherine Creek were 10 May, 1 June, and 30 May 2001, respectively (Figure 9 and Appendix Table A-6). Median arrival dates at Lower Granite Dam for the fall, winter, and spring tag groups on the Lostine River were 27 April, 14 May, and 12 May 2001, respectively (Figure 10). Median arrival dates at Lower Granite Dam for the fall and spring tag groups on the Minam River were 28 April and 14 May 2001, respectively (Figure 11). Four of the six fish tagged for the spring tag group on the upper Grande Ronde River were detected at Lower Granite Dam, with the median detection date of 17 May (Figure 12). Median detection dates of the spring tag groups may have reflected dates of tagging in addition to the timing of migration, therefore median detection dates for winter tagged parr were probably more representative of the ‘late migrant’ life history.

As in past years, the early migrants, which were tagged during fall and overwintered in lower rearing areas, reached Lower Granite Dam earlier than late migrants (winter tag group) from Catherine Creek and Lostine River (Mann-Whitney rank sum test, $P < 0.001$, both locations). On the Minam River, we did not have a winter tag group to compare with early migrants. However, early migrants from the fall tag group reached Lower Granite Dam earlier than the late migrants in the spring tag group (Mann-Whitney rank sum test, $P < 0.001$). On the upper Grande Ronde River, we did not have a fall or winter tag group to compare with the spring tag group.

Travel times from the screw trap to Lower Granite Dam for late migrants in the spring tag group from the upper Grande Ronde River ranged from 29 to 56 d with a mean of 39.9 d (n = 4) (Appendix Table A-7). This was slightly shorter than travel times reported in previous years of this study (range: 44–57 d). Travel times for late migrants from Catherine Creek ranged from 15 to 110 d with a mean of 63.7 d (n = 100). This was slightly longer than travel times reported from previous years of this study (range: 54–61 d). Travel times for late migrants from the Lostine River ranged from 5 to 90 d with a mean of 23.6 (n = 246). Data from the past four years indicated travel times have remained relatively constant for fish from this population. Travel times for late migrants from the Minam River ranged from 9 to 106 d with a mean of 38.9 (n = 274).

Survival Indices: Detection rates at Snake and Columbia River dams for the fall, winter and spring tag groups from Catherine Creek were 0.128, 0.069, and 0.360, respectively (Table 16 and Appendix Tables A-8 and A-9). Detection rates for the fall, winter and spring tag groups from the Lostine River were 0.329, 0.277, and 0.663, respectively. Detection rates for fall and spring tag groups from the Minam River were 0.420 and 0.605, respectively. Five of the six parr from the spring tag group on the upper Grande Ronde were detected resulting in a detection rate of 0.833.

Survival probabilities to Lower Granite Dam for the fall, winter and spring tag groups from Catherine Creek were 0.130, 0.077, and 0.376, respectively (Table 16 and Appendix Table A-9). Survival probabilities for the fall, winter and spring tag groups from the Lostine River were 0.335, 0.284, and 0.689, respectively. Survival probabilities for the fall and spring tag group from the Minam River were 0.427 and 0.619, respectively.

Detection rates and CJS survival probabilities for Catherine Creek, Lostine, and Minam River fish were highest for the spring tag group (Table 16). We anticipated that this tag group would have the highest survival because it was the only tag group not subject to overwinter mortality after tagging.

For each stream, the survival probability of the fall tag group was compared to that of the winter tag group to determine whether downstream or upstream overwintering habitat conferred better survival. Fish from the fall tag group on Catherine Creek had a higher survival probability than fish from the winter tag group (Maximum Likelihood Ratio Test, P = 0.009, Appendix Table A-10), suggesting better survival for fish that overwintered in the Grande Ronde Valley. This agreed with the results from previous years. The comparison of survival probabilities suggested that downstream habitat conferred better overwinter survival (MY 1997, MY 2000, MY 2001) or that there was no significant difference between upstream and downstream environment in regards to overwinter survival (MY 1995, MY 1996, MY 1998). MY 1999 was the only year in which upstream habitat conferred better overwinter survival. The overwinter survival of fish overwintering in the upper rearing areas was approximately 20% for BY 1999. This rate was one of the lowest observed for Catherine Creek during the past six years of this study (Appendix Table A-11).

In the Lostine River, survival probabilities of the fall tag group and winter tag group were not significantly different (Maximum Likelihood Ratio Test, $P = 0.090$). This was in agreement with most of the previous years' results (Appendix Table A-10). For migratory years 1997–2001, survival probabilities only differed between upstream and downstream overwintering fish for MY 1998 and MY 1999, when fish overwintering downstream had a higher survival. The overwinter survival of fish overwintering in the upper rearing areas on the Lostine River was approximately 41% for BY 1999. This rate is equal to the lowest rate observed for Lostine River during the past five years (Appendix Table A-11).

Population Comparisons: The summer tag groups included the various life history patterns exhibited by a population and allowed us to compare survival and timing between populations and over the years.

Migration Timing: Spring chinook salmon parr that were captured with seines and PIT-tagged on Catherine Creek and the Imnaha, Lostine, and Minam rivers in summer 2000 were detected at Lower Granite Dam over an 87 d period from 8 April to 3 July 2001 (Figure 13 and Appendix Table A-12). The migratory period of individual populations ranged from 51 days (Imnaha River) to 67 days (Catherine Creek) in length. Median dates of detection ranged from 30 April (Imnaha River) to 17 May (Catherine Creek).

Median detection dates differed between populations (Kruskal-Wallis, $P < 0.001$). The median detection date for the Catherine Creek population was the latest (Dunn's pair-wise multiple comparison, $P < 0.05$). The median detection date for the Imnaha population was the earliest ($P < 0.05$). Median detection dates for the Lostine and Minam populations were intermediate and not significantly different from each other ($P > 0.05$). That timing has and continues to differ between 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.

Our findings for migratory year 2001 were generally consistent with past observations (Sankovich et al. 1996; Walters et al. 1997; Tranquilli et al. 1998; Jonasson et al. 1999, Monzyk et al. 2000) (Figure 14). For the Catherine Creek, Imnaha River, and Lostine River populations, the median dates of migration in 2001 fell within the range in medians observed from 1993 to 2000. The median migration date for the Minam River population was later than the medians for 1993 to 2000.

Survival Indices: Of the parr PIT-tagged on Catherine Creek and the Imnaha, Lostine, and Minam rivers during the summer of 2000, 8.2%, 18.0%, 20.7%, and 22.1% (respectively) were detected in the hydrosystem in 2001 (Table 17). These detection rates were significantly different (χ^2, $P < 0.001$). The detection rate of parr PIT-tagged on Catherine Creek was lower than detection rates for those tagged on the Imnaha, Lostine, and Minam rivers (Tukey type multiple comparison on transformed proportions, $\alpha = 0.05$). Detection rates did not differ between Imnaha and Lostine parr, or between Lostine and Minam parr ($\alpha = 0.05$).

Cormack-Jolly-Seber survival probabilities, which took into account the chance that a passing PIT-tagged fish may not have been detected, were 0.087 for parr tagged in Catherine

Creek, 0.181 for Imnaha parr, 0.210 for Lostine parr, and 0.228 for Minam parr. To test for differences in survival probabilities between populations, several models were developed. The best model (Catherine ≠ Imnaha ≠ Lostine = Minam) was selected using Akaike's information criterion. This model (null) was tested against the full model (Catherine ≠ Imnaha ≠ Lostine ≠ Minam) using the maximum likelihood ratio test. The null model was accepted ($P = 0.43$), supporting the conclusion that the survival probabilities of the Lostine and Minam populations were the highest and didn't differ significantly from each other. The survival probability of the Imnaha population was intermediate and that of the Catherine Creek population was the lowest (Table 17).

The detection rate for Catherine Creek parr was the lowest seen over the years of this study and appeared to continue a downward trend observed since MY 1998 (Figure 15 and Appendix Table A-9). The detection rate for the Lostine River parr was higher than or equal to rates observed in previous years. The detection rate for the Minam River parr was higher than rates observed in previous years. The detection rate for the Imnaha River parr was higher than the past two years, but in the middle of the range of detection rates for all the years of the study.

Alternate Life-History Strategies

In northeast Oregon streams almost all of the spring chinook salmon parr migrate seaward as age-1 smolts. Most spend two to three years in the ocean before returning to their natal streams as mature adults to spawn. Over the years of this investigation we have observed two life-history strategies that deviate from this generalized pattern: seaward migration of smolts at age-2 and maturation of age-0 and age-1 parr in freshwater.

Very few of the PIT-tagged spring chinook salmon parr from our study streams have smolted as two year olds (for discussion of this *see* Monzyk et al. 2000). Of the 33,244 parr PIT-tagged on Catherine Creek and the Grande Ronde, Imnaha, Lostine, Minam, and Wenaha rivers during the summers from 1992 to 1999 (Walters et al. 1992, 1997; Sankovich et al. 1996; Tranquilli 1998, Monzyk et al. 2000), only 11 (0.03%) were detected in the hydrosystem as age-2 smolts. We estimated that 1.1% (299) of the immature parr in Catherine Creek during the summer of 2000 were age-1. These fish would have smolted in 2001 at age-2, or they could have matured precociously in the fall of 2000 and never migrated (as suggested by Monzyk et. al. 2000). During the 2001 migratory year, there were no detections of age-2 smolts that had been PIT-tagged as age-0 parr in the summer of 1999 or age-1 parr in the summer of 2000 on Catherine Creek or the Imnaha, Lostine, or Minam rivers. However, one age-2 smolt was detected at the dams during the spring of 2001. This smolt was originally tagged in January of 2000 on the Lostine River and was expected to smolt during the spring of 2000, presumably as a one year old (scales were not taken). Its length (102 mm FL) was within, but at the upper end of, the length range of other parr tagged on the Lostine during the winter of 2000 and detected in the hydrosystem during the spring of 2000.

Precociously mature age-0 or age-1 parr, although uncommon (especially age-0), were also observed in our study streams. We estimated that 7.5 mature, wild, male parr were present for each anadromous female spawner (i.e., redd) in Catherine Creek during the late summer, and early fall of 2001 (Appendix Table A-5). Mature parr were also captured in the Lostine River during the summer of 2001 but we were unable to estimate their population (*see* **Egg-to-Parr Survival, Parr Abundance, and Age Composition in Summer**). 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 exists for mature, wild, male parr to make significant gametic contributions. Twenty-one mature, hatchery, male parr in Catherine Creek and two in the Lostine River were either observed or caught while we were catching and marking wild spring chinook salmon parr during summer 2001. These mature, hatchery parr may also spawn with wild adult females. Given the continual low abundance of anadromous spawners in northeast Oregon streams, mature male parr (wild and hatchery) may be an important component of the breeding population.

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 was necessary to treat all juvenile *Oncorhynchus mykiss* as one population.

We took two approaches to our study of *O. mykiss* in the Grande Ronde River basin. The first approach involved studying the *O. mykiss* population in Catherine Creek upstream of our screw trap during summer to learn more about the characteristics of this population, including abundance, migration characteristics, growth rates, and population size and age structure. The second approach involved using screw traps to study the movement of juvenile *O. mykiss* downstream from tributary habitats in Catherine Creek, the Lostine, Minam, and upper Grande Ronde rivers. We assumed all juvenile *O. mykiss* captured at trap sites were making directed downstream movements and not localized movements. Violation of this assumption would result in positively biased population estimates

Characterization of the *O. mykiss* Population in Catherine Creek and Tributaries During Summer

During the summer of 2001, we continued the investigation of *O. mykiss* in the upper Catherine Creek drainage that began in the summer of 2000. We estimated the abundance, age composition, and size structure of the Catherine Creek and North Fork Catherine Creek *O. mykiss* populations in the summer of 2001. We used PIT tags to learn more about migration patterns, anadromy, and growth rates of *O. mykiss* tagged in the summer of 2000 in Catherine Creek, Little Catherine Creek, North Fork Catherine Creek, and the South Fork Catherine Creek.

Summer Abundance Estimates: *Catherine Creek:* We used mark-and-recapture techniques to estimate the abundance of *O. mykiss* in the mainstem of Catherine Creek during July 2001. *O. mykiss* were collected in Catherine Creek from our screw trap site (rkm 32) upstream 20 kilometers to the confluence of the north and south forks of Catherine Creek. We captured, marked, and released fish in Catherine Creek 16 –19 July 2001. We conducted subsequent sampling at randomly selected 0.4 km sections 23 – 26 July 2001. We fished about 55% of the stream upstream from the trap during resampling. We attempted to mark a sufficient number of fish so that the 95% confidence limits would not exceed 25% of the mean. We collected *O. mykiss* for marking by beach seining, herding them (while snorkeling) into a seine set perpendicular to the stream flow, or by angling. We marked captured *O. mykiss* with paint or a PIT tag. The same procedures described for spring chinook salmon parr handling and marking were used for *O. mykiss* (*see* **SPRING CHINOOK SALMON INVESTIGATIONS; Methods**). Fish that were less than 55 mm fork length were not PIT-tagged. We recorded fork lengths and weights, and collected scales for age analysis from a random subsample of fish. 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 resampling we used the same methods to catch fish as described above. We counted the number of marked and unmarked fish and used Chapman's modification of the Petersen estimate (Ricker 1975) to calculate the abundance of *O. mykiss* in Catherine Creek. We obtained 95% confidence intervals using equation (3.7) in Ricker (1975) and values from Appendix II in Ricker (1975).

North Fork Catherine Creek: Sampling on North Fork Catherine Creek was conducted 26 June through 12 July 2001. The creek was divided into 5 reaches based on valley geomorphology (Table 18). The *O. mykiss* population size was estimated for each reach using methods appropriate to the stream characteristics and the amount of time available for sampling. Abundance estimates for the individual reaches were combined to estimate the total number of *O. mykiss* in the North Fork. A description of sampling methods and data analysis techniques by reach follows.

<u>Reach 1</u>

The *O. mykiss* population in reach 1 was estimated using mark-recapture techniques and the data analysis techniques described above for Catherine Creek. *O. mykiss* were captured and marked 26 – 28 June, and captured and examined for marks 2 – 3 July.

<u>Reaches 2 and 3</u>

A modification of Hankin and Reeves (1988) method of estimating fish abundance using calibrated snorkel counts was used for reaches 2 and 3. We divided the reaches into 61 m long segments. Segments of 61 m in length ensured that they were representative of the reach and at least 10 times longer than the average width of the stream. The time required to sample a 61 m long segment was short enough to allow us to sample many segments per reach. A systematic subsample of segments was snorkeled by a team of two snorkelers independently counting *O. mykiss*. The mean count of the two divers was calculated for each segment snorkeled. A systematic subsample of the snorkeled segments was also depletion sampled. The depletion sampling, using backpack electrofishers, was conducted at least 2 h, but not more than 24 h, after the snorkel counts. During depletion sampling, block nets were set at the upstream and downstream ends of the segment. Two or more passes were made with one or two backpack electrofishers in the downstream direction. Equal time and effort was spent on each pass. Fish caught during each pass were kept in separate aerated buckets and processed after all passes were completed. The depletion estimates were calculated using the Zippen method (for equations *see* Seber and Le Cren 1967; Kohler and Hubert 1999) and were intended to represent the 'true' *O. mykiss* numbers for each segment. A calibration factor of 2.83 was estimated by dividing the sum of the depletion estimates by the sum of the mean diver counts for the units that were both snorkeled and depleted (Hankin and Reeves 1988). The average mean diver count for all segments snorkeled, but not depletion sampled, was then multiplied by the calibration factor to get a 'corrected' diver count for the segment. The sum of the segment counts (using 'corrected' diver counts for segments that were only snorkeled, and depletion estimates when available) was extrapolated to the total length of the reach to provide a population estimate (equation 1 in Hankin 1986). Variance of the population estimate was calculated using equation 3 in Hankin 1986. Sampling methods specific to reaches 2 and 3 are tabulated in Table 19. We assumed that diver counts would underestimate *O. mykiss* numbers in a segment, and that depletion estimates would be more accurate and provide a way to calibrate the diver counts. Our depletion estimates were higher than the diver counts, but the 95% confidence interval of the sum of the depletion estimates was ± 55%. However, we used the depletion estimates to adjust the diver counts in lieu of a better calibration method.

<u>Reaches 4 and 5</u>

We used the stratified sampling design described in Hankin and Reeves (1988) for estimating *O. mykiss* numbers in reaches 4 and 5. Stream habitat units were classified as riffle, pool, side channel, or complex unit and *O. mykiss* numbers were estimated for each type of habitat. Length of each unit was recorded and width was measured or estimated. Our mean diver counts were often greater than the depletion estimates so we used uncalibrated diver counts, or depletion sampling when snorkeling was not possible, to estimate *O. mykiss* numbers in the sampled units. We did not find a correlation between area and number of fish estimated for each unit, so estimates were extrapolated by habitat unit number and type. The *O. mykiss* population estimate for reach 4 was calculated using mean diver counts for pools and riffles extrapolated to the total number of pools and riffles, respectively. Side channels accounted for 0.25% of the total area and less than 1% of the total length of reach 4. Side channels were not snorkeled or electrofished, and *O. mykiss* numbers were assumed to be 0. The population estimate for reach 5 was calculated using mean diver counts for pools and complex units, and depletion sampling for riffles and side channels, most of which were too shallow to snorkel. These estimates were extrapolated to the total number of pools, complex units, riffles, and side channels, respectively. Sampling methods specific to reaches 4 and 5 are tabulated in Table 20.

Lengths and Age-Composition of *O. mykiss* in Summer Rearing Areas: Lengths were measured and scale samples were collected from a subsample of *O. mykiss* that were handled during the mark-recapture and depletion sampling on Catherine Creek and North Fork Catherine Creek. Scales were aged as described for juvenile spring chinook salmon (*see* **SPRING CHINOOK SALMON INVESTIGATIONS**; **Methods; Egg-to-Parr Survival, Parr Abundance, and Age Composition in Summer**) and the information used to estimate the age composition of these populations.

On Catherine Creek, scales were collected for aging from a random subsample of *O. mykiss* that were measured. We assumed the subsample of the aged fish represented the age composition of the total *O. mykiss* population on Catherine Creek. We tested this by performing a Mann-Whitney comparison of ranked lengths of the aged fish and all the *O. mykiss* measured. We assumed that the size distribution of all the fish measured was representative of the size distribution of the whole population.

On North Fork Catherine Creek, fork lengths were measured when fish were captured during collection for marking and depletion sampling. We assumed these lengths were representative of the population. Scales for age analysis were taken from a subsample of *O. mykiss* that were measured. We tested whether the lengths of the aged fish were representative of all the measured fish by performing a Mann-Whitney comparison of the ranked lengths. This test indicated that the aged fish were not representative of all the fish measured ($P = 0.001$). Therefore, an age-length key was created and used to extrapolate the age composition of the population (DeVries and Frie 1996).

Growth Rates: Daily growth rates of PIT-tagged *O. mykiss* were calculated by dividing the difference in fork length of recaptured *O. mykiss* that were tagged in the summer of 2000 by the elapsed time from tagging to recapture. Mean daily growth rates were calculated for each recapture group (fall 2000 screw trap, spring 2001 screw trap, summer 2001).

In-Basin Migration Timing and Abundance

The migration timing and abundance of migrating *O. mykiss* in Catherine Creek, the upper Grande Ronde, Lostine, and Minam rivers were determined by operating rotary screw traps year round. We followed the same methodology for operating screw traps and analyzing data as described for spring chinook salmon (*see* **SPRING CHINOOK SALMON INVESTIGATIONS; Methods; In-Basin Migration Timing and Abundance**).

The 2001 migratory year for summer steelhead within the Grande Ronde River basin overlaps two calendar years, and begins on 1 July 2000 and ends on 30 June 2001. Similar to spring chinook salmon, there is a distinct early migration that peaks at our trap sites in the fall. Early migrants leave upper rearing areas in Catherine Creek, the upper Grande Ronde, Lostine, and Minam rivers 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 then leave their upper rearing areas in spring to initiate their seaward migration or continue to rear for another year in other areas of the Grande Ronde River basin before initiating their seaward migration. Designations 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 early and late migratory groups. We then determined migrant abundance and migration timing at trap sites by migratory group.

Migration Timing to Lower Granite Dam

Detections of PIT-tagged *O. mykiss* at Lower Granite Dam on the Snake River were used to estimate migration timing . Daily detection counts were expanded to account for fish that may have passed undetected in spill at the dam (*see* **SPRING CHINOOK SALMON INVESTIGATIONS; Methods; Migration Timing to Lower Granite Dam**). The fall 2000 tag group included fish that moved past our upper trap sites between September and early December (early migrants). The spring 2001 tag group included fish that moved past our upper trap sites between February and mid June (late migrants). We intended to tag 1,000 *O. mykiss* in the fall and 500 in the spring at each of our trap sites on the upper Grande Ronde River, Catherine Creek, and Lostine River, and Minam River to assess migration timing of early and late migrants from each location. During fall, we tagged *O. mykiss* ≥ 55 mm FL, whereas during spring, only *O. mykiss* ≥115 mm FL were PIT-tagged. In previous years of this study, 115 mm FL was the minimum length of *O. mykiss* detected at Snake and Columbia River dams in the same migratory year they were tagged. Fish under 115 mm FL may not migrate to the dams until the following migratory year. By using this length criterion during spring, we attempted to tag *O. mykiss* that would migrate seaward during 2001. Migration timing was also assessed for fish PIT-tagged at traps during the previous migratory year (i.e. fall 1999 and spring 2000 tag groups) that delayed their migration until MY 2001. Overall migration timing for the Catherine Creek *O. mykiss* population was determined by examining the detections of fish that were PIT-tagged during the summer of 2000 on Catherine Creek and its tributaries.

First, last, and median dates of detection at Lower Granite Dam were determined for the fall tagged fish from each location and the summer tagged fish from Catherine Creek and its tributaries. First and last detection dates were determined for the spring tagged fish from each location. Median detection dates for spring tagged fish were reported only if the number tagged was proportional to the number migrating past the trap, as evaluated by the Pearson product moment correlation of the number tagged by week and the number estimated to pass the same week. Otherwise, it was likely that the median reflected, to some extent, the dates of tagging rather than the true migration pattern of all late migrants. We investigated whether detection dates of early and late migrants differed by using the Mann-Whitney rank sum test on dates of detection of fall tagged and spring tagged fish. We only tested this if we determined that the numbers tagged weekly at the trap in the spring were proportional to the numbers moving past the trap.

Detections at Snake and Columbia River Dams

O. mykiss were PIT-tagged at our upstream screw traps during the fall of 1999 and 2000 and the spring of 2000 and 2001. Dam detections of the PIT-tagged *O. mykiss* were summarized by tag group, location, and tag year. Detection rates were calculated by dividing the number of tagged *O. mykiss* detected by the number tagged.

During the summer of 2000, we captured and PIT-tagged *O. mykiss* in their rearing areas on Catherine Creek above the screw trap, South Fork Catherine Creek, North Fork Catherine Creek, and Little Catherine Creek (Monzyk et al. 2000). Detections of these PIT-tagged fish at the dams on the Snake and Columbia rivers reflected the prevalence of the anadromous (steelhead) life history pattern in this population and the survival of the juveniles before reaching the dams. However, it was impossible to separate these two components. Detection rates for *O. mykiss* PIT-tagged during the summer of 2001 in their upper rearing areas on Catherine Creek and North Fork Catherine Creek will be presented in the 2002 annual report

Length and Age of Migrants

We examined the detections of fish tagged in the fall to determine if there was a relationship between size at the time of tagging and tendency to continue their seaward migration the following spring. Within each fall 2000 tag group, t-tests or Mann-Whitney rank sum tests were used to compare lengths of *O. mykiss* detected at the dams in 2001 to the lengths all *O. mykiss* tagged. For *O. mykiss* tagged in the fall of 1999, a Kruskal-Wallis ANOVA on ranks was used to compare the lengths of those detected at the dams in 2000 and 2001 to all those tagged. The same comparisons were made for *O. mykiss* tagged in the spring of 2000 and 2001 to determine if there was a relationship between size at the time of tagging and tendency to migrate seaward.

O. mykiss lengths at tagging in the summer of 2000, upstream of the Catherine Creek trap, were compared for fish grouped by their subsequent recapture and dam detection history to determine if there was a relationship between fish size and life history. Lengths were compared (t-test) between *O. mykiss* that were recaptured at the Catherine Creek screw trap in the fall of 2000 and those recaptured in the spring of 2001 to determine if size was related to the timing (early or late) of migration out of upper rearing areas. Lengths were also compared between *O. mykiss* that were known to migrate out of upstream rearing habitats before the next summer (fall 2000 and spring 2001 trap recaptures and 2001 dam detections), those that stayed upstream through the next summer (all detections at the Catherine Creek screw trap or upstream recaptures during summer 2001 or later), and all the *O. mykiss* tagged during the summer of 2000 (Kruskal-Wallis ANOVA on ranks and Dunn's pair-wise multiple comparison procedure).

Scale samples taken at the time of tagging allowed us to determine the ages of *O. mykiss* when they migrated past the traps and to extrapolate their age when they were subsequently detected the dams. Scales were analyzed to determine age as described for spring chinook salmon parr (*see* **SPRING CHINOOK SALMON INVESTIGATIONS**; **Methods; Egg-to-Parr Survival, Parr Abundance, and Age Composition in Summer)**.

Results and Discussion

Characterization of the *O. mykiss* Population in Catherine Creek and Tributaries During Summer

Summer Abundance Estimates: We estimated that 25,736 (95% CI: 21,005 – 31,519) *O. mykiss* were present in Catherine Creek above our screw trap (rkm 32) in July 2001 (Table

21). This was similar to the summer 2000 estimate of 22,393 (95% CI: 17,467 – 28,697) fish (Appendix Table B-1).

By combining individual reach results, we estimated that 10,338 (95% CI: 5,137 – 15,539) *O. mykiss* were present in North Fork Catherine Creek in late June/early July of 2001 (Table 21). Estimates by reach indicated that most (86%) of these fish were in the lower 4.5 kilometers of North Fork Catherine Creek, from the mouth upstream to the confluence of Middle Fork Catherine Creek. *O. mykiss* abundance decreased with distance upstream, as exhibited by decreasing estimates from reach 1 (downstream) through reach 5 (furthest upstream). *O. mykiss* were observed as far upstream as rkm 14.6. However, only a few were observed in reach 5.

Length and Age Composition of *O. mykiss* in Summer Rearing Areas: Analysis of scales taken from Catherine Creek *O. mykiss* indicated the presence of age-1, age-2, and age-3 fish, with age-1 being the most abundant (Figure 16 and Appendix Table B-2). Although none of the scales analyzed were age-0, age-0 fish were presumably present in the population. Sampling occurred in early summer before some of the age-0 *O. mykiss* had emerged from the gravel. The length of the smallest fish we aged was 72 mm. However, 13 of the 1,024 fish we measured during our tagging efforts had fork lengths between 45 and 70 mm. It is likely that most of these fish were age-0. Snorkel-seining may have resulted in an under representation of the larger size classes and the small, age-0 fry.

Scale analysis revealed the presence of ages 0–3 *O. mykiss* in North Fork Catherine Creek (Figure 16 and Appendix Table B-2). As seen in the mainstem, age-1 fish were also most common in the north fork. However, there appeared to be a more even distribution of fish amongst all the age classes in the north fork compared to the mainstem. This may have been a result of bias in our sampling methods. Electroshocking was the primary sampling method used in the north fork, whereas snorkel seining was used in the mainstem. The difference in age structure between North Fork Catherine Creek and the mainstem of Catherine Creek could also reflect a relatively higher abundance or resident *O. mykiss* in the north fork compared to the mainstem.

The length distributions of *O. mykiss* reflected the age compositions in Catherine Creek and the North Fork Catherine Creek (Figure 17). The median fork length of *O. mykiss* sampled in Catherine Creek was 111 mm, and in North Fork Catherine Creek was 102 mm.

Growth Rates: The mean daily growth rate of *O. mykiss* tagged upstream of the Catherine Creek trap in the summer of 2000 and recaptured at the Catherine Creek screw trap in the fall of 2000 was 0.173 mm/d (Table 22). Growth rates for *O. mykiss* recaptured in the spring and summer 2001 were lower because the time between length measurements included the winter period when growth would have been minimal.

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 18). For the purpose of this report, early migration was considered to encompass the time from 1 July 2000 through 28 January 2001 and late migration from 29 January through 30 June 2001.

Upper Grande Ronde River: The upper Grande Ronde River trap fished for 183 d from 1 July through ice-up on 11 November 2000, and from 18 March through 30 June 2001 (Table 23). A distinct early migration was not as evident at this trap site as it was at other upper trap sites (Figure 18). Most juvenile *O. mykiss* moved as late migrants during spring months. The median emigration date for early migrants passing the trap was 11 October 2000 and the median emigration date for late migrants was 07 May 2001. The median migration date for late migrants in MY 2001 was later than in previous years of this study (Table 24).

We estimated a minimum of 16,067 juvenile *O. mykiss* (95% CI: ± 4,076) moved out of the upper Grande Ronde River upper rearing areas during MY 2001. This estimate is within estimates from the previous three migratory years study that ranged from 6,108 (MY 1999) to 17,845 fish (MY 2000). Based on weekly trap efficiencies, we estimated approximately 4% (607 ± 84) were early migrants and 96% (15,460 ± 4,075) were late migrants. The pattern of a dominant late migration of juvenile *O. mykiss* in the upper Grande Ronde River is consistent for all migratory years studied to date (Table 24). In previous years, the proportion of late migrants has ranges from 60% (MY 1998) to 95% (MY 1999).

Catherine Creek: The Catherine Creek trap fished for 235 d from 1 July through ice-up on 6 December 2000, and from 20 February through 30 June 2001 (Table 23). There were distinct early and late migrations exhibited by juvenile *O. mykiss* at this trap site (Figure 18). Median emigration date for early migrants was 06 October 2000. The median date for late migrants was 31 March 2001 (Table 24).

We estimated that a minimum of 20,586 ± 4,336 juvenile *O. mykiss* migrated out of the Catherine Creek upper rearing areas during MY 2001. This estimate is within the range of estimates from previous years of this study (Table 24). Based on weekly trap efficiencies, 44% (8,957 ± 938) migrated early and 56% (11,629 ± 4,233) migrated late. The proportion of juvenile *O. mykiss* leaving upper rearing areas as late migrants is only slightly less than proportions from previous years of this study that range from 58 to 75% (Table 24). 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 162 d from 4 October 2000 through 12 January 2001, and 1 February through 20 June 2001 (Table 23). A distinct late migration was evident with few fish passing the trap as early migrants (Figure 18). The median emigration date for fish passing the trap as early migrants was 17 November 2000. The median emigration date for late migrants was 25 April 2001.

We estimated a minimum of 46,470 ± 8,425 juvenile *O. mykiss* migrated out of the Grande Ronde Valley during MY 2001. This estimate is within the range of estimates from previous years of this study. In previous years, estimates have ranged from 46,084 (MY 1997) to 60,266 (MY 2000). However, there were numerous trap stoppages during the peak migration period due to debris blockage and mechanical breakdowns, therefore, we most likely underestimated the number of steelhead out-migrating this year. We estimated 235 ± 54 juvenile *O. mykiss* passed the trap as early migrants and 46,235 ± 8,425 *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 *O. mykiss* that reside in the valley during winter.

Lostine River: The Lostine River trap fished for a total of 323 d from 1 July 2000 through 30 June 2001 (Table 23). Distinct early and late migrations were evident (Figure 18), with few fish captured during summer and winter. The median emigration date of early migrants was 4 October 2000. The date that the median late migrant moved past the trap was 29 April 2001 (Table 24).

We estimated that a minimum of 16,690 ± 3,541 *O. mykiss* migrants moved out of the Lostine River during MY 2001. We estimated that approximately 45% (7,514 ± 1,199) of the juvenile *O. mykiss* migrated early and 55% (9,176 ± 3,332) migrated late. This is a slightly higher percentage than in previous years of this study where the previous maximum proportion of late migrants was 46 % in MY 1998 (Table 24).

Minam River: The Minam River trap fished for 139 d between 27 September through 16 November 2000, and 22 February through 18 June 2001 (Table 23). There were distinct early and late migrations exhibited by juvenile *O. mykiss* at this trap site (Figure 18). Median emigration date for early migrants was 3 October 2000. The median date for late migrants was 29 April 2001 (Table 24).

We estimated that a minimum of 28,113 ± 11,052 juvenile *O. mykiss* migrated out of the Minam River during MY 2001. Based on weekly trap efficiencies, 14% (3,906 ± 6,568) migrated early and 86% (24,207 ± 8,889) migrated late. The migrant estimate may not be accurate. More early migrants may have moved past our trap than reported here because the trap was not started until late September, thereby potentially missing some of the early migration.

Migration Timing to Lower Granite Dam

Upper Grande Ronde River: During MY 2001, we PIT-tagged 61 early- and 475 late-migrating *O. mykiss* at the upper Grande Ronde River trap that were not previously tagged. The median migration date to Lower Granite Dam for the early migrants was 7 May (Figure 19). The first detection was 28 April and the last was 29 June. The late migrants were detected between 22 April and 11 June. A median detection date was not determined because numbers of *O. mykiss* tagged in the spring (by week) were not proportional to the numbers migrating past the trap (Pearson product moment correlation, $P = 0.237$). Travel times from the screw trap to Lower Granite Dam for late migrating *O. mykiss* ranged from 8 to 152 d with a mean of 37.1 d ($n = 180$) (Table 25 and Appendix Table B-3).

Catherine Creek: During MY 2001, we PIT-tagged 561 early- and 266 late-migrating *O. mykiss* at the Catherine Creek trap. The median migration date for the early migrants was 6 May (Figure 20). The first detection was 18 April and the last was 12 June. The late migrants were detected between 22 April and 11 June, with a median detection date of 14 May. The median detection date for early migrants was significantly earlier than the median for late migrants (Mann-Whitney rank sum test, $P = 0.002$; Appendix Table B-4). Travel times from the screw trap to Lower Granite Dam for late migrating *O. mykiss* ranged from 7 to 74 d with a mean of 33.0 d ($n = 88$) (Table 25 and Appendix Table B-3).

Detections of summer tagged *O. mykiss* represented the migration timing of the overall (early and late migrants) Catherine Creek population past Lower Granite Dam. The median date of migration past Lower Granite Dam for *O. mykiss* PIT-tagged during the summer of 2000 on Catherine Creek and its tributaries (including the north and south forks, and Little Catherine Creek) was 8 May (Figure 21 and Appendix Table B-5). Tagged *O. mykiss* from these locations were detected at Lower Granite Dam between 25 April and 25 June.

Lostine River: At the Lostine River trap, we PIT-tagged 421 early- and 345 late-migrating *O. mykiss* that were not previously tagged. The median migration date for the early migrants was 12 May (Figure 22). The first detection was 16 April and the last was 13 June. The late migrants were detected between 13 April and 18 August, with a median detection date of 14 May. The median detection dates for early and late migrants were not significantly different for Lostine River *O. mykiss* smolts (Mann-Whitney rank sum test, $P = 0.829$). However, the power of this test was low given the small sample sizes for early migrants ($n = 13$). Travel times from the screw trap to Lower Granite Dam for late migrating *O. mykiss* ranged from 5 to 109 d with a mean of 17.6 d ($n = 164$) (Table 25 and Appendix Table B-3).

Minam River: At the Minam River trap, we PIT-tagged 32 early- and 454 late-migrating *O. mykiss* that were not previously tagged. The median migration date for the early migrants was 9 May (Figure 23). The first detection was 2 May and the last was 17 May. The late migrants were detected between 26 April and 29 August, with a median detection date of 7 May. The median detection dates for early and late migrants were not significantly different (Mann-Whitney rank sum test, $P = 0.624$). However, the power of this tests was low given the small sample sizes for early migrants ($n = 6$). Travel times from the screw trap to Lower Granite Dam for late migrating *O. mykiss* ranged from 5 to 110 d with a mean of 21.8 d ($n = 240$) (Table 25 and Appendix Table B-3).

Smolt Timing of *O. mykiss* Tagged During MY 2000: Some *O. mykiss* tagged at the upstream traps in MY 2000 as they migrated out of upper rearing areas were detected at Lower Granite Dam in 2001. These fish arrived at Lower Granite Dam slightly earlier than fish tagged in MY 2001. The *O. mykiss* tagged in MY 2000 from the upper Grande Ronde River were detected between 30 April and 6 June, with a median date of 3 May ($n = 7$, Appendix Table B-6). Those from Catherine Creek were detected between 2 April and 26 May, with a median migration date of 4 May ($n = 25$). Those from the Lostine River were detected between 27 April and 7 June, with a median date of 4 May ($n = 22$).

Detections at Snake and Columbia River Dams

Detection rates of *O. mykiss* tagged in fall 2000 ranged from 0.040 for Lostine River fish to 0.219 for Minam River fish (Table 26 and Appendix Table B-7). Some *O. mykiss* migrants tagged at the screw traps in the fall of 1999 did not migrate past the dams until the following migratory year. For example, 14 *O. mykiss* PIT-tagged at the Catherine Creek trap and 11 tagged at the Lostine trap during the fall of 1999 were detected at the dams in 2001 migratory year (Table 26 and Appendix Table B-7).

Detection rates of *O. mykiss* tagged in the spring 2001 (≥ 115 mm FL) ranged from 0.389 for Catherine Creek fish to 0.609 for Minam River fish (Table 27 and Appendix Table B-7). Some *O. mykiss* tagged at the screw traps in the spring of 2000 did not migrate past the dams until the following migratory year. For example, 12 *O. mykiss* that were PIT-tagged at the Catherine Creek trap, 7 tagged at the upper Grande Ronde trap, and 14 tagged at the Lostine trap during the spring of 2000 were not detected at the dams until the 2001 migratory year (Appendix Table B-7).

It was not possible to distinguish between steelhead and resident rainbow parr in their summer rearing habitat. For this reason, dam detections of *O. mykiss* parr PIT-tagged in the summer reflected not just survival to the dam detection sites but also the prevalence of the anadromous life history pattern. A small percentage (2.5%) of wild *O. mykiss* PIT-tagged in Catherine Creek and its tributaries during the summer of 2000 were detected at Snake and Columbia River dams as they migrated seaward (Table 28). Some *O. mykiss* tagged in the summer of 2000 may migrate seaward in 2002 or 2003. Detections of these fish, if any, will be reported in future annual reports.

Length and Age of Migrants

Fork lengths at time of tagging were compared between *O. mykiss* detected at the dams in 2001 and all *O. mykiss* tagged for the various tag groups (Appendix Tables B-5 and B-6). Of all the *O. mykiss* tagged at the traps in the fall of 2000, the larger individuals from the upper Grande Ronde and Lostine rivers tended to be the ones detected at the dams in 2001 (Figure 24). The mean fork length of the *O. mykiss* tagged in the fall of 2000 at the upper Grande Ronde River trap and then detected at the dams in 2001 (148.3 mm) was greater than the mean length of all those tagged on the upper Grande Ronde River in the fall of 2000 (125.5 mm, $P = 0.005$). The median length of the *O. mykiss* tagged in the fall of 2000 at the Lostine River trap and detected at the dams in 2001 (161 mm) was greater than the median of all those tagged on the Lostine River in the fall of 2000 (80 mm, $P < 0.001$). There was no difference in lengths of fish detected at the dams compared to all fish tagged in the fall of 2000 on Catherine Creek and the Minam River. The median length of the *O. mykiss* tagged at the Catherine Creek trap in the fall of 2000 and detected in 2001 (139 mm) did not differ from the median of all those in the same tag group (136 mm, $P = 0.298$). The mean length of the *O. mykiss* tagged at the Minam River trap in the fall of 2000 and detected in 2001 (143.1 mm) did not differ from the mean of all those in the same tag group (116.1 mm, $P = 0.157$), however the power of the test was low due to a small sample size.

As with upper Grande Ronde River and Lostine River *O. mykiss* tagged in the fall of 2000, the larger individuals tagged at the traps in the spring of 2001 tended to be the ones detected at the dams in 2001 (Figure 25). The mean lengths of the *O. mykiss* tagged at the Catherine Creek and Minam River traps in the spring of 2001 and detected in 2001 (149.7 mm and 166.9 mm, respectively) differed significantly from the means of the tag groups (140.0 mm, 159.7 mm respectively, $P < 0.001$). The median lengths of the *O. mykiss* tagged at the upper Grande Ronde River and Lostine River traps in the spring of 2001 and detected in 2001 (156 mm and 171 mm, respectively) differed significantly from the medians of the tag groups (146 mm and 160 mm, respectively, $P < 0.001$).

While some of the differences in length between all tagged fish and those detected at dams could be the result of size-dependent mortality, there is evidence that smaller individuals passing the traps delay their migration until the subsequent migratory year. For instance, the *O. mykiss* migrants that were tagged at screw traps in the fall of 1999 and delayed their migration until the 2001 migratory year were generally smaller than the other fish in that tag group (Figure 26). The median lengths (at tagging) of *O. mykiss* tagged at traps on Catherine Creek and the Lostine River in the fall of 1999 and detected at the dams in 2001 (77 mm and 105 mm, respectively; Appendix Table B-8) were significantly less than the medians of all those tagged (101 mm and 153 mm, respectively) and the medians of those detected in 2000 (148 mm and 157 mm, respectively) for each location ($P < 0.001$).

Similarly, the *O. mykiss* migrants that were tagged at screw traps in the spring of 2000 and delayed their migration until the 2001 migratory year were generally smaller than the other fish in that tag group (Figure 27). The median lengths of *O. mykiss* tagged in the spring of 2000 at Catherine Creek, upper Grande Ronde River, and the Lostine River traps and later detected at the dams in 2001 (78.5 mm, 80 mm, and 89 mm, respectively; Appendix Table B-9) were significantly less than the medians of all those tagged in that tag group (131.5 mm, 133 mm, and 160 mm, respectively) and the medians of that tag group detected in 2000 (152 mm, 155 mm, and 168 mm, respectively) for each location ($P < 0.001$).

Trap recaptures and dam detections suggested that, of the *O. mykiss* PIT-tagged during the summer of 2000 upstream of the Catherine Creek trap, the larger ones were more likely to migrate out of the upstream rearing areas within the subsequent year. The median length (at tagging) of *O. mykiss* that migrated out of the upper rearing area by early summer 2001 was greater than the median length of all those tagged during the summer of 2001 on Catherine Creek and the median length of those known to remain upstream of the Catherine Creek screw trap through the summer of 2001 ($P = 0.001$, Figure 28). As mentioned above, this pattern could also reflect size dependent mortality. Limited trap recaptures of *O. mykiss* PIT-tagged in the summer of 2000 did not reveal a relationship between length (at tagging) and tendency to migrate out of upper rearing in the fall of 2000 (early migrants) as opposed to the spring of 2001 (late migrants, $P = 0.994$, Figure 29 and Appendix Table B-10). However, small sample sizes resulted in low power (0.05) to detect a difference.

The *O. mykiss* collected at traps during the 2001 migratory year ranged from 0 to 3 years of age (Table 29). Most early migrants were age-1 with few age-0 or age-2 migrants passing the trap. These age-1 migrants would presumably resume their seaward migration (and be detected at downstream dams) the following spring as age-2 smolts. The proportion of age-2 migrants was greater during the late migration period, but never reached over 50% of the total late migrant population (Table 29). The majority of late migrants were again age-1 fish. Of the fish with known age that were PIT-tagged at the traps in MY 2001 and subsequently detected at Snake and Columbia River dams (*n*=46), most (91%) reached the dams as age-2 smolts while four (9%) were age-3. No age-1 smolts were detected. Of the five fish with known age tagged in the fall of 1999 and not detected at the dams until the 2001 migratory year, two were age-0 and three were age-1. These fish were age-2 and age-3 when detected at the dams in 2001.

The results of the length and age analyses indicate that most of the smaller individuals (age-0 early migrants and age-1 late migrants) that passed the trap sites tended to rear for another year before undertaking their seaward migration. The larger individuals (age-1 or age-2 early migrants and age-2 or age-3 late migrants) that passed the trap sites tended to undertake their seaward migration during the same migratory year.

FUTURE DIRECTIONS

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

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Table 1. Dates of tagging and number of spring chinook salmon parr PIT-tagged on various northeast Oregon streams during the summers of 2000 and 2001.

Year, stream	Dates of collection and tagging	Number PIT-tagged and released	Distance to Lower Granite Dam (km)
2000			
Catherine Creek	7–10 Aug	500	370–377
Lostine River	14–17 Aug	490	276–290
Minam River	22 Aug, 18–19 Sep	1,000	282–283
Imnaha River	2–30 Aug	1,050	222–243
2001			
Catherine Creek	30 Jul – 2 Aug	503	363–382
Lostine River	6–9 Aug	501	275–301
Minam River	20–23 Aug	996	282–284
Imnaha River	27–28 Aug	1,001	208–240

Table 2. Results from spring chinook salmon mark-and-recapture experiments conducted in Catherine Creek and the Lostine River in August 2001.

Stream, group	Number marked (M)	Number sampled (C)	Number recaptured (R)	Population estimate (N) (95% CI)
Catherine Creek				
immature	1,325	1,382	121	15,032 (12,598–17,931)
mature	111	87	9	986 (545–1,971)
Lostine River				
immature	1,074	1,938	62	33,086 (25,901–42,226)
mature	5	1	0	—

Table 3. Percent of spring chinook salmon parr population and parr density in Catherine Creek by reach in August 2001.

Reach	Length (km)	Percent of total parr population	Density (parr/km)
1	5.6	25	755
2	6.2	40	1,089
3	3.5	22	1,057
4	4.5	13	484

Table 4. Age composition of immature and mature spring chinook salmon parr sampled in Catherine Creek and the Lostine, Minam, and Imnaha rivers in summer 2001. Age was determined by scale analysis.

Stream, group	Number of parr sampled	Percent age-0 (95% CI)	Percent age-1 (95% CI)
Catherine Creek			
Immature	0[a]	—	—
Mature	103	0 (0–3.5)	100 (96.5–100)
Lostine River			
Immature	0[a]	—	—
Mature	4	25.0 (0.6–80.6)	75.0 (19.4–99.4)
Imnaha River			
Immature	67	100 (94.6–100)	0 (0–5.4)
Mature	0[b]	—	—
Minam River			
Immature	212	100 (98.3–100)	0 (0–1.7)
Mature	4	0 (0–60.2)	100 (39.8–100)

[a] *Scales were not taken. We assumed that all immature parr were age-0.*
[b] *Mature parr were rarely observed and none were caught.*

Table 5. Estimated abundance of age-0 spring chinook salmon parr during the summer, and the corresponding egg-to-parr survival of spring chinook salmon in Catherine Creek and the Lostine River for the 1997–2000 brood years.

				Age-0 parr in summer		Egg to age-0 parr survival	
Stream, brood year	Redds[a]	Fecundity[b]	Total eggs	immature	mature	Rate (%)	95% CI
Catherine Creek							
1997	46	4,348	200,008	13,222	0	6.61	(5.02 – 8.91)
1998	34	4,348	147,832	22,505	3	15.23	(11.7 – 19.8)
1999	38	4,348	165,224	25,698	0	15.55	(11.8 – 21.0)
2000	26	4,348	113,048	15,032[e]	0	13.30	(11.14 – 15.86)
2001	131	3,978[f]	524,118	—	—	—	—
Lostine River							
1997	47	4,348	204,356	40,748	0	19.94	(13.41 – 30.99)
1998	28	4,348	121,744	28,084	0	23.07	(14.72 – 38.09)
1999	45	4,348	195,660	12,372	0	6.32	(5.15 – 7.76)
2000	53	4,348	230,444	33,086[e]	0[g]	14.36	(11.24 – 18.32)
2001	98	4,958[h]	485,884	—	—	—	—

[a] *Redds counted above screw traps on Catherine Creek (rkm 32) and Lostine River (rkm 3).*
[b] *Average number of eggs of wild spring chinook salmon spawned at Lookingglass Hatchery (ODFW, unpublished data).*
[c] *Immature parr population estimate x % of immature parr estimated to be age-0.*
[d] *Mature population x % of mature parr estimated to be age-0.*
[e] *All immature parr were assumed to be age-0.*
[f] *Average number of eggs for 12 wild spring chinook salmon females spawned at Lookingglass Hatchery (ODFW, unpublished data).*
[g] *Not enough mature parr were marked to estimate the population size.*
[h] *Average number of eggs for 24 wild spring chinook salmon females spawned at Lookingglass Hatchery (ODFW, unpublished data).*

Table 6. Population estimates, median emigration dates, and percentage of juvenile spring chinook salmon population moving as late migrants past traps sites, 1994 to 2001 migratory years. Early migratory period is from 1 July of the preceding year through 28 January of the migratory year. The late migratory period is from 29 January to 30 June.

		Median emigration date		
Stream, migratory year	Population estimate	Early migrants	Late migrants	Percentage migrating late
Upper Grande Ronde River				
1994	25,398	14 Oct	01 Apr	87
1995	38,725[a]	30 Oct	02 Apr	87
1996	1,118	14 Oct[b]	16 Mar	99
1997	82	14 Nov	26 Apr[b]	17
1998	6,922	31 Oct	23 Mar	65
1999	14,858	16 Nov	31 Mar	84
2000	14,780	30 Oct	03 Apr	74
2001	51	01 Sep[b]	10 Apr	88
Catherine Creek				
1995	17,633[c]	–	21 Mar	–
1996	6,857	19 Oct	11 Mar	27
1997	4,442[c]	–	13 Mar	–
1998	9,881	30 Oct	19 Mar	29
1999	20,311	14 Nov	23 Mar	38
2000	23,991	31 Oct	23 Mar	18
2001	21,937	08 Oct	24 Mar	13
Lostine River				
1997	4,496[c]	–	30 Mar	–
1998	17,539	30 Oct	26 Mar	35
1999	34,267	12 Nov	18 Apr	41
2000	12,250	02 Nov	09 Apr	32
2001	13,610	29 Sep	20 Apr	23
Minam River				
2001	28,209[c]	08 Oct	27 Mar	64

[a] *Trap was located at rkm 257 in MY 1995 .*
[b] *Median date based on small sample size: MY 1996,* n=*4; MY 1997,* n=*6; MY 2001,* n=*2.*
[c] *Trap was started late and may have missed a substantial number of early migrants. Median date of early migrants may not be accurate.*

Table 7. Catch of juvenile spring chinook salmon at five trap locations in the Grande Ronde River basin during the 2001 migratory year. The early migration period was from 1 July 2000 – 28 January 2001. The late migratory group was from 29 January – 30 June 2001.

Trap site	Migratory group	Trapping period	Days fished	Trap catch
Upper Grande Ronde River	Early	01 Jul 00 – 11 Nov 00	99	2
	Late	18 Mar 01 – 30 Jun 01	84	17
Catherine Creek	Early	01 Jul 00 – 06 Dec 00	137	6,981
	Late	20 Feb 01 – 30 Jun 01	91	659[a]
	Late	16 Apr 01 – 22 Apr 01	7	19[b]
Grande Ronde Valley	Early	04 Oct 00 – 12 Jan 01	69	19
	Late	01 Feb 01 – 20 Jun 01	93	403
Lostine River	Early	01 Jul 00 – 28 Jan 01	194	3,596
	Late	29 Jan 01 – 30 Jun 01	116	668[a]
	Late	29 Mar 01 – 07 Apr 01	10	98[b]
	Late	26 Apr 01 – 28 Apr 01	3	56[b]
Minam River	Early	27 Sep 00 – 16 Nov 00	47	1,382
	Late	22 Feb 01 – 18 Jun 01	92	2,072

[a] *Continuous trapping.*
[b] *Trapping with subsampling.*

Table 8. Fork lengths (mm) of juvenile spring chinook salmon collected from the upper Grande Ronde River during MY 2001. Early and late migration period fish were captured with a rotary screw trap at rkm 299. Min. = minimum, Max. = maximum.

	Collected				
Group	*n*	Mean	SE	Min.	Max.
Early migrants	1	96	—	—	—
Late migrants	7	107.9	2.14	100	115
	Tagged and released				
Group	*n*	Mean	SE	Min.	Max.
Early migrants	0	—	—	—	—
Late migrants	6	108.7	2.35	100	115

Table 9. Weights (g) of juvenile spring chinook salmon collected from the upper Grande Ronde River during MY 2001. Early and late migration period fish were captured with a rotary screw trap at rkm 299. Min. = minimum, Max. = maximum.

	Collected				
Group	*n*	Mean	SE	Min.	Max.
Early migrants	1	9.8	—	—	—
Late migrants	5	13.1	0.86	11.3	16.4
	Tagged and released				
Group	*n*	Mean	SE	Min.	Max.
Early migrants	—	—	—	—	—
Late migrants	4	13.6	0.94	12.3	16.4

Table 10. Fork lengths (mm) of juvenile spring chinook salmon collected from Catherine Creek during MY 2001. Winter fish were captured with seines or dipnets in Catherine Creek from rkm 40 to 48. Early and late migration period fish were captured with a rotary screw trap at rkm 32. Min. = minimum, Max. = maximum.

	Collected				
Group	*n*	Mean	SE	Min.	Max.
Early migrants	1,159	81.0	0.25	49	105
Winter group	521	83.2	0.30	65	100
Late migrants	383	87.8	0.39	60	123
	Tagged and released				
Group	*n*	Mean	SE	Min.	Max.
Early migrants	508	84.4	0.28	65	105
Winter group	521	83.2	0.30	65	100
Late migrants	324	88.1	0.42	69	123

Table 11. Weights (g) of juvenile spring chinook salmon collected from Catherine Creek during MY 2001. Winter fish were captured with seines or dipnets in Catherine Creek from rkm 40 to 48. Early and late migration period fish were captured with a rotary screw trap at rkm 32. Min. = minimum, Max. = maximum.

	Collected				
Group	*n*	Mean	SE	Min.	Max.
Early migrants	863	6.0	0.06	1.4	13.4
Winter group	516	5.8	0.07	2.3	10.6
Late migrants	278	7.5	0.15	2.4	23.2
	Tagged and released				
Group	*n*	Mean	SE	Min.	Max.
Early migrants	383	6.7	0.08	3.0	13.4
Winter group	516	5.8	0.07	2.3	10.6
Late migrants	225	7.8	0.17	3.2	23.2

Table 12. Fork lengths (mm) of juvenile spring chinook salmon collected from the Lostine River during MY 2001. Winter fish were captured with dipnets in the Lostine River from rkm 8 to 20. Early and late migration period fish were captured with a rotary screw trap at rkm 3. Min. = minimum, Max. = maximum.

	Collected				
Group	*n*	Mean	SE	Min.	Max.
Early migrants	1,397	91.6	0.33	50	134
Winter group	498	88.7	0.39	63	115
Late migrants	647	100.8	0.47	73	148
	Tagged and released				
Group	*n*	Mean	SE	Min.	Max.
Early migrants	497	95.8	0.37	74	122
Winter group	498	88.7	0.39	63	115
Late migrants	434	100.9	0.57	75	148

Table 13. Weights (g) of juvenile spring chinook salmon collected from the Lostine River during MY 2001. Winter fish were captured with dipnets in the Lostine River from rkm 8 to 20. Early and late migration period fish were captured with a rotary screw trap at rkm 3. Min. = minimum, Max. = maximum.

	Collected				
Group	*n*	Mean	SE	Min.	Max.
Early migrants	1,306	9.4	0.09	1.2	29.2
Winter group	389	7.6	0.11	2.8	17.5
Late migrants	633	12.0	0.20	4.5	49.7
	Tagged and released				
Group	*n*	Mean	SE	Min.	Max.
Early migrants	463	10.2	0.13	4.6	21.1
Winter group	389	7.6	0.11	2.8	17.5
Late migrants	433	12.0	0.24	4.5	35.4

Table 14. Fork lengths (mm) of juvenile spring chinook salmon collected from the Minam River during MY 2001. Early and late migration period fish were captured with a rotary screw trap at rkm 0. Min. = minimum, Max. = maximum.

	Collected				
Group	*n*	Mean	SE	Min.	Max.
Early migrants	514	85.4	0.41	57	115
Late migrants	1,102	90.1	0.24	62	148
	Tagged and released				
Group	*n*	Mean	SE	Min.	Max.
Early migrants	297	85.8	0.52	57	106
Late migrants	536	90.4	0.35	69	148

Table 15. Weights (g) of juvenile spring chinook salmon collected from the Minam River during MY 2001. Early and late migration period fish were captured with a rotary screw trap at rkm 0. Min. = minimum, Max. = maximum.

	Collected				
Group	*n*	Mean	SE	Min.	Max.
Early migrants	487	7.2	0.11	2.3	18.6
Late migrants	1,096	8.1	0.07	2.8	38.5
	Tagged and released				
Group	*n*	Mean	SE	Min.	Max.
Early migrants	270	7.2	0.13	2.3	14.5
Late migrants	532	8.2	0.11	3.5	38.5

Table 16. Comparison of spring chinook salmon parr survival indices based on first-time dam detection rates of PIT-tagged parr and Cormack-Jolly-Seber estimates of survival probabilities, listed by stream and tag group for the 2001 migratory year. Dam detection rate includes all first-time detections at the six Snake River and Columbia River dams with PIT tag detection capability. Survival probability is survival from rearing areas to Lower Granite Dam.

	Number	Dam detection rates		CJS survival probabilities	
Stream, tag group	Released	Rate	95% CI	Probability	95% CI
Catherine Creek					
Fall	508	0.128	0.100–0.160	0.130	0.103–0.162
Winter	522	0.069	0.049–0.094	0.077	0.054–0.106
Spring	328	0.360	0.308–0.414	0.376	0.322–0.433
Lostine River					
Fall	498	0.329	0.288–0.373	0.335	0.294–0.378
Winter	499	0.277	0.238–0.318	0.284	0.245–0.326
Spring	442	0.663	0.617–0.707	0.689	0.641–0.735
Minam River					
Fall	300	0.420	0.364–0.478	0.427	0.371–0.485
Spring	536	0.605	0.562–0.646	0.619	0.576–0.661
Upper Grande Ronde River					
Spring	6	0.833	0.359–0.996		

Table 17. Detection rates and CJS survival probabilities to Lower Granite Dam for spring chinook salmon parr tagged in summer 2000 and detected at Columbia and Snake River dams in 2001. Detection rates and survival probabilities that have a letter in common are not significantly different ($P \leq 0.05$).

Stream	Number released	Dam detection rate (95% CI)		Survival probability (95% CI)	
Catherine Creek	498	0.082	(0.060 – 0.110)	0.087	(0.063 – 0.115)
Imnaha River	1,000	0.180[a]	(0.157 – 0.205)	0.181	(0.158 – 0.206)
Lostine River	489	0.207[ab]	(0.172 – 0.245)	0.210[c]	(0.175 – 0.248)
Minam River	1,000	0.221[b]	(0.196 – 0.248)	0.228[c]	(0.202 – 0.256)

Table 18. Sampling reaches on North Fork Catherine Creek for estimating the population of *O. mykiss* in summer 2001.

Reach	Start location	End location	Length (m)
1	Mouth, rkm 0.0	Middle Fork confluence, rkm 4.51	4,510
2	Middle Fork confluence, rkm 4.51	Jim Creek confluence, rkm 8.56	4,050
3	Jim Creek confluence, rkm 8.56	0.1 mile below Amelia Spring confluence, rkm 12.42	3,860
4	0.1 mile below Amelia Spring confluence, rkm 12.42	North end of meadow just upstream of where trail crosses creek, rkm 14.44	2,020
5	North end of meadow just upstream of where trail crosses creek, rkm 14.44	Falls (barrier to upstream movement by fish), rkm 16.59	2,150

Table 19. Sampling methods specific to reaches 2 and 3 on North Fork Catherine Creek for estimating the population of *O. mykiss* in summer 2001.

Reach information, sampling scheme	Reach 2	Reach 3
Length of reach (m)	4,050	3,860
Number of 61 m segments	66.4	63.3
Frequency of snorkeled segments	1/5	1/6
Number snorkeled segments, % of reach snorkeled	10, 15%	11, 17%
Frequency of depletion sampled segments	1/3 of snorkeled	1/3 of snorkeled
Number snorkeled and depleted segments	4	4

Table 20. Sampling methods specific to reaches 4 and 5 on North Fork Catherine Creek for estimating the population of *O. mykiss* in summer 2001.

Habitat type, sampling scheme	Reach 4	Reach 5
Pools		
total	74	45
snorkeled	16 (every 6th)	15 (every 3rd)
depletion sampled	4 (every 3rd snorkeled)	4 (every 3rd snorkeled)
Riffles		
total	45	53
snorkeled	11 (every 4th)	0
depletion sampled	5 (every 2nd snorkeled)	5 (every 8th)
Side channels		
total	1	5
snorkeled	0	0
depletion sampled	0	1 (every 3rd)
Complex units		
total	0	7
snorkeled	0	4 (every 2nd)
depletion sampled	0	1 (every 2nd snorkeled)

Table 21. Population estimates of *O. mykiss* in the Catherine Creek watershed in summer 2001. Estimation methods: a = mark-recapture, Peterson estimate; b = Hankin and Reeves, equal length units, calibrated snorkel counts; c = Hankin and Reeves, habitat units, uncalibrated snorkel counts.

		Mark-recapture data			Population estimate	
Stream, reach	Method	Marked (M)	Recaptured (R)	Sampled (C)	Number (N)	95% CI
Catherine Creek						
rkm 32 – 52	a	1,321	91	1,790	25,736	21,005–31,519
North Fork Catherine Creek						
1	a	305	9	290	8,905	4,920–17,809
2	b				1,093	698–1,489
3	b				187	85–289
4	c				147	80–214
5	c				11	0–13
All reaches					10,338	5,137–15,539

Table 22. Growth rates (mm/d) of *O. mykiss* tagged 27 June – 31 July 2000 upstream of the Catherine Creek screw trap and recaptured at the screw trap in fall 2000 and spring 2001, and upstream in summer 2001.

			Growth rate (mm/d)	
Season of recapture, location	N	Recapture dates	Mean	95% CI
Fall 2000, trap	20	18 Sep – 5 Dec	0.173	± 0.039
Spring 2001, trap	6	21 Mar – 10 Apr	0.059	± 0.037
Summer 2001, upstream	1	26 Jun	0.073	—

Table 23. Catch of juvenile *O. mykiss* at five trap locations in the Grande Ronde River basin during the 2001 migratory year.

Trap site	Migratory group	Trapping period	Days fished	Trap catch
Upper Grande Ronde River	Early	01 Jul 00 – 11 Nov 00	99	308
	Late	18 Mar 01 – 30 Jun 01	84	2,337
Catherine Creek	Early	01 Jul 00 – 06 Dec 00	137	3,561
	Late	20 Feb 01 – 30 Jun 01	91	1,205[a]
	Late	16 Apr 01 – 22 Apr 01	7	54[b]
Grande Ronde Valley	Early	04 Oct 00 – 12 Jan 01	69	74
	Late	01 Feb 01 – 20 Jun 01	93	3,437
Lostine River	Early	01 Jul 00 – 28 Jan 01	194	1,636
	Late	29 Jan 01 – 30 Jun 01	116	697[a]
	Late	29 Mar 01 – 07 Apr 01	10	193[b]
	Late	26 Apr 01 – 28 Apr 01	3	30[b]
Minam River	Early	27 Sep 00 – 16 Nov 00	47	214
	Late	22 Feb 01 – 18 Jun 01	92	1,123

[a] *Continuous trapping.*
[b] *Trapping with subsampling.*

Table 24. Population estimates, median emigration dates, and percentage of *O. mykiss* population moving as late migrants past traps sites, 1997 to 2001 migratory years. Early migratory period is from 1 July of the preceding year through 28 January of the migratory year. The late migratory period is from 29 January to 30 June.

		Median emigration date		
Stream, migratory year	Population estimate	Early migrants	Late migrants	Percentage migrating late
Upper Grande Ronde River				
1997	15,104	25 Oct	27 Mar	92
1998	10,133	08 Aug	27 Mar	60
1999	6,108	08 Nov	29 Apr	95
2000	17,845	30 Sep	08 Apr	94
2001	16,067	11 Oct	07 May	96
Catherine Creek				
1997	25,229[a]	—	14 Apr	—
1998	20,742	22 Sep	04 Apr	58
1999	19,628	02 Nov	15 Apr	75
2000	35,699	30 Oct	16 Apr	61
2001	20,586	06 Oct	31 Mar	56
Lostine River				
1997	4,309[b]	—	01 May	—
1998	10,271	04 Oct	24 Apr	46
1999	23,643	17 Oct	01 May	35
2000	11,981	19 Oct	17 Apr	44
2001	16,690	04 Oct	29 Apr	55
Minam River				
2001	28,113	3 Oct	29 Apr	86

[a] *Trap not started until week 39. Thereby potentially missing part of the early migration*
[b] *Trap not started until week 43. Thereby potentially missing part of the early migration*

Table 25. Travel time to Lower Granite Dam of wild *O. mykiss* PIT-tagged at upstream screw traps in spring of 2001 and arriving at Lower Granite Dam in 2001.

Stream	Number detected	Travel time (days) Mean	Median	Range
Catherine Creek	88	33.0	33.2	7 – 74
Upper Grande Ronde River	180	37.1	37.3	8 – 152
Lostine River	164	17.6	13.9	5 – 109
Minam River	240	21.8	16.6	5 – 110

Table 26. Detections at Snake and Columbia River dams in 2001 of wild *O. mykiss* juveniles PIT-tagged at screw traps on Catherine Creek and the upper Grande Ronde, Lostine, and Minam rivers during fall 1999 and 2000.

Stream, year tagged	Number tagged in fall	Detections in 2001	Detection rate (95% CI) in 2001	
Catherine Creek				
1999	989	14	0.014	(0.008–0.024)
2000	561	67	0.119	(0.094–0.149)
Upper Grande Ronde River				
1999	110	0	0	(0.000–0.033)
2000	61	12	0.197	(0.106–0.318)
Lostine River				
1999	777	11	0.014	(0.007–0.025)
2000	421	17	0.040	(0.024–0.064)
Minam River				
2000	32	7	0.219	(0.093–0.400)

Table 27. Detections at Snake and Columbia River dams in 2001 of wild *O. mykiss* juveniles PIT-tagged at screw traps on Catherine Creek and the Grande Ronde, Lostine, and Minam rivers during spring 2000 and 2001. All PIT-tagged *O. mykiss* in spring were ≥ 115 mm FL.

Stream, year tagged	Number tagged in spring	Detections in 2001	Detection rate (95% CI) in 2001	
Catherine Creek				
2000	305	2	0.007	(0.001-0.023)
2001	247	96	0.389	(0.328-0.453)
Upper Grande Ronde River				
2000	324	1	0.003	(0.000-0.017)
2001	465	196	0.422	(0.376-0.468)
Lostine River				
2000	442	4	0.009	(0.002-0.023)
2001	323	182	0.563	(0.507-0.618)
Minam River				
2001	442	269	0.609	(0.561–0.654)

Table 28. Detection rates at Snake and Columbia River dams of *O. mykiss* PIT-tagged on Catherine Creek and its tributaries during summer 2000.

Stream	Number released	Number detected in 2001	Detection rate (95% CI)
Catherine Creek	412	22	0.053 (0.034 – 0.080)
North Fork Catherine Creek	117	2	0.017 (0.002 – 0.060)
South Fork Catherine Creek	225	5	0.022 (0.007 – 0.051)
Little Catherine Creek	415	0	0 (0 – 0.009)
Total	1,169	29	0.025 (0.017 – 0.035)

Table 29. Length at age of *O. mykiss* collected from the upper Grande Ronde River, Catherine Creek, the Lostine River, and the Minam River during the early and late migration periods. Min. = minimum, Max. = maximum.

Stream, age class	N	Proportion of total (%)	Fork length (mm)			
			Mean	SE	Min.	Max
			Early Migrants			
Upper Grande Ronde River						
0	5	14.7	93.8	3.09	86	101
1	29	85.3	132.1	2.82	109	163
Catherine Creek						
0	14	14.0	102.6	4.49	69	135
1	80	80.0	140.6	1.72	99	183
2	6	6.0	183.2	8.25	164	219
			Late Migrants			
Upper Grande Ronde River						
0	1	0.6	62.0	—	—	—
1	94	53.7	96.4	1.29	64	130
2	79	45.1	154.3	1.81	116	197
3	1	0.6	186.0	—	—	—
Catherine Creek						
0	6	4.1	73.7	2.67	62	81
1	95	64.6	92.5	1.44	62	128
2	43	29.3	150.7	1.74	122	171
3	3	2.0	165.7	2.19	163	170
Lostine River						
1	16	53.3	97.3	3.58	70	128
2	14	46.7	160.9	4.63	139	192
Minam River						
1	32	72.7	91.1	1.98	68	121
2	10	22.7	163.4	6.25	134	187
3	2	4.5	207.0	2.00	205	209

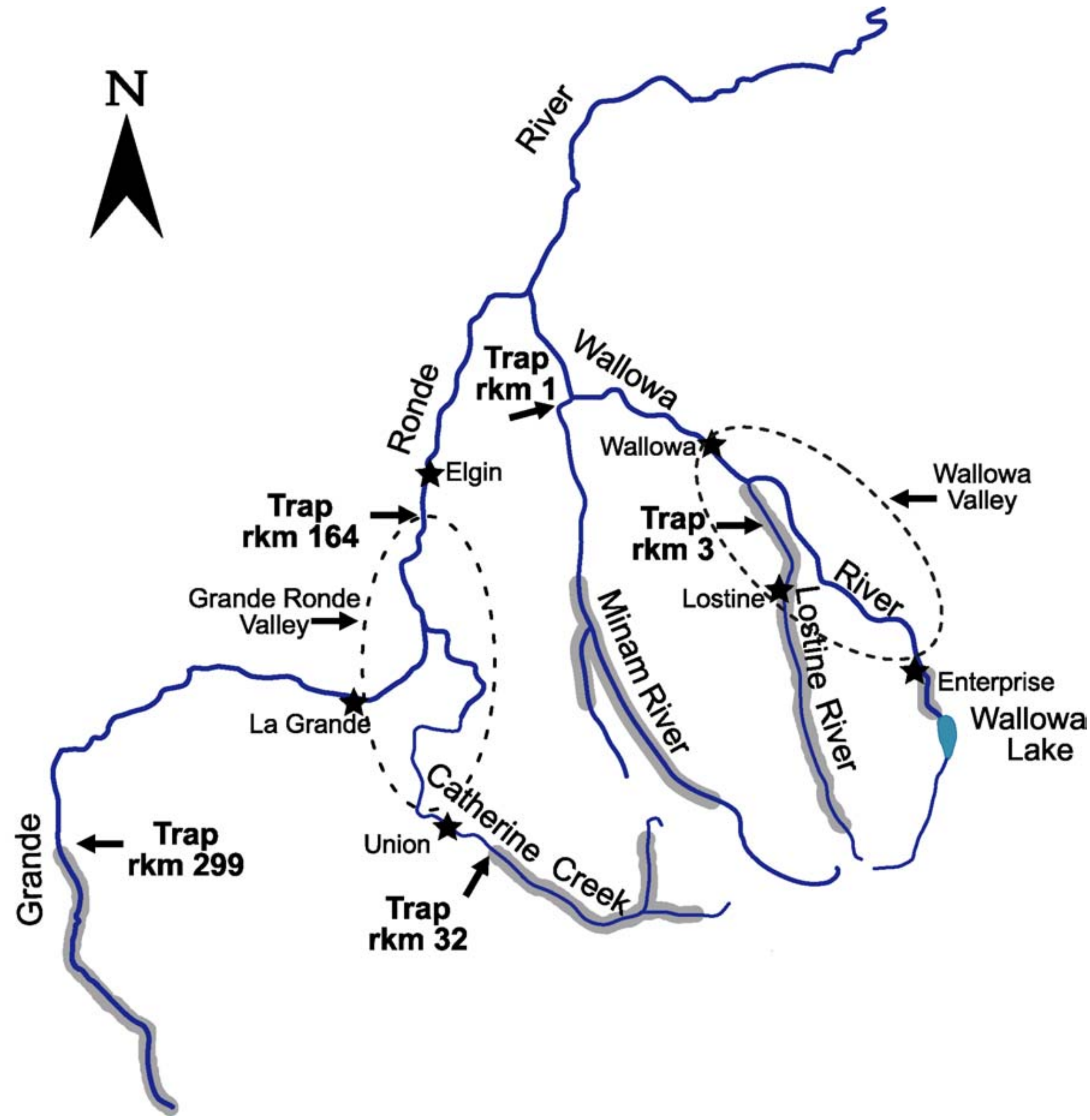

Figure 1. Locations of fish traps in the Grande Ronde River basin during the study period. Shaded areas delineate spring chinook salmon spawning and upper rearing areas in each study stream. Dashed lines indicate the Grande Ronde River and Wallowa River valleys.

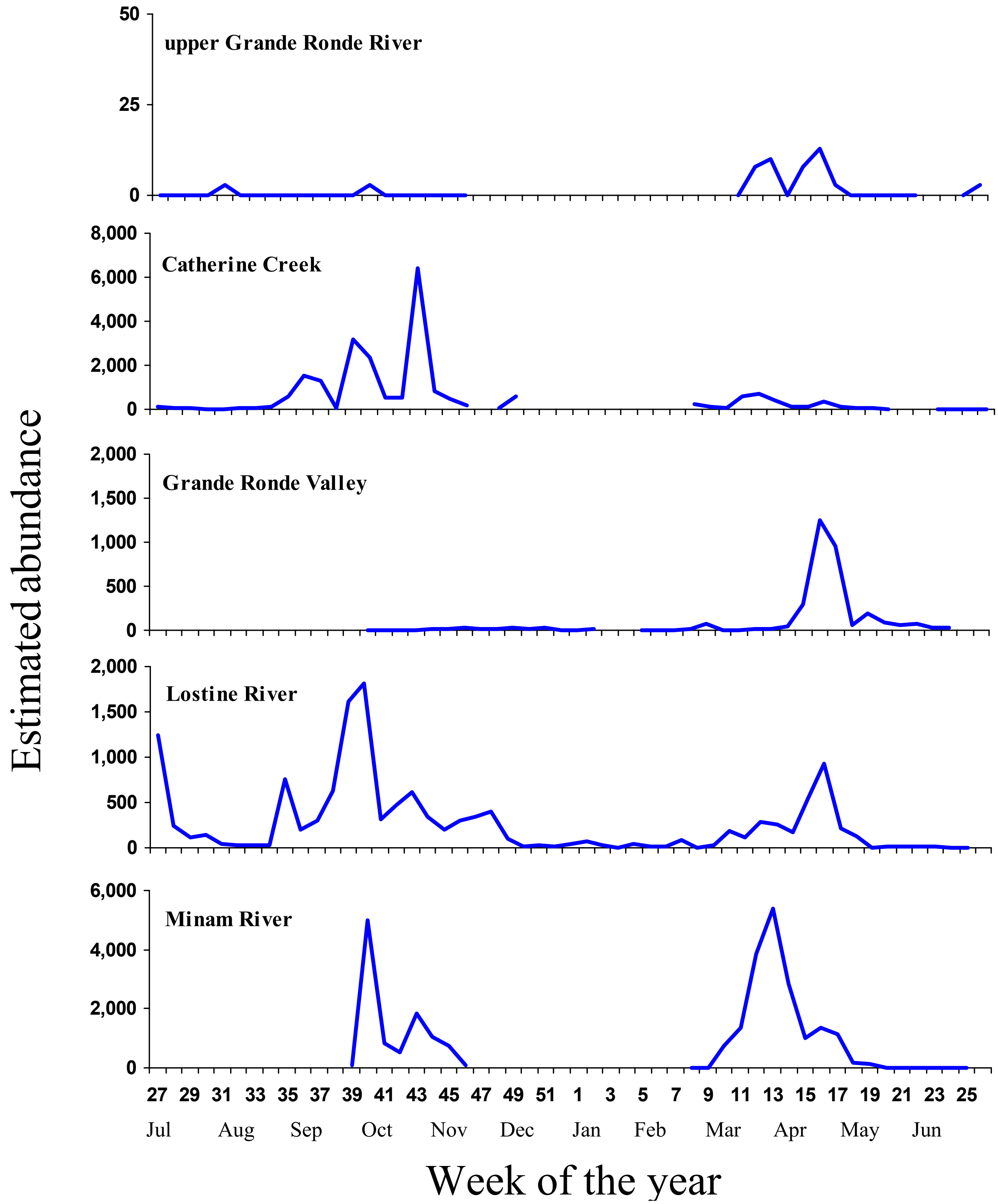

Figure 2. Estimated migration timing and abundance of juvenile spring chinook salmon migrants captured by rotary screw traps during the 2001 migratory year. Traps were located at rkm 299 and 164 of the Grande Ronde River, rkm 32 of Catherine Creek, rkm 3 of the Lostine River, and rkm 0 of the Minam River.

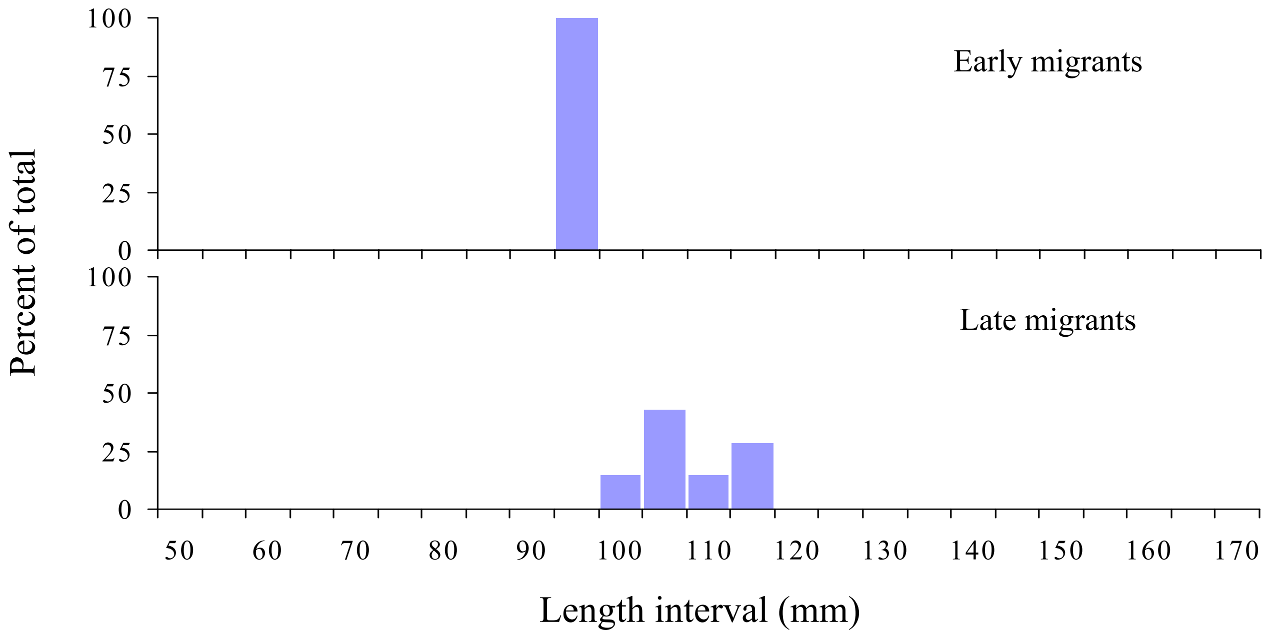

Figure 3. Length frequency distribution (fork length) of juvenile spring chinook salmon migrants captured at the upper Grande Ronde River trap (rkm 299) by migration period, during the 2001 migratory year. Only two early migrants and 17 late migrants were collected.

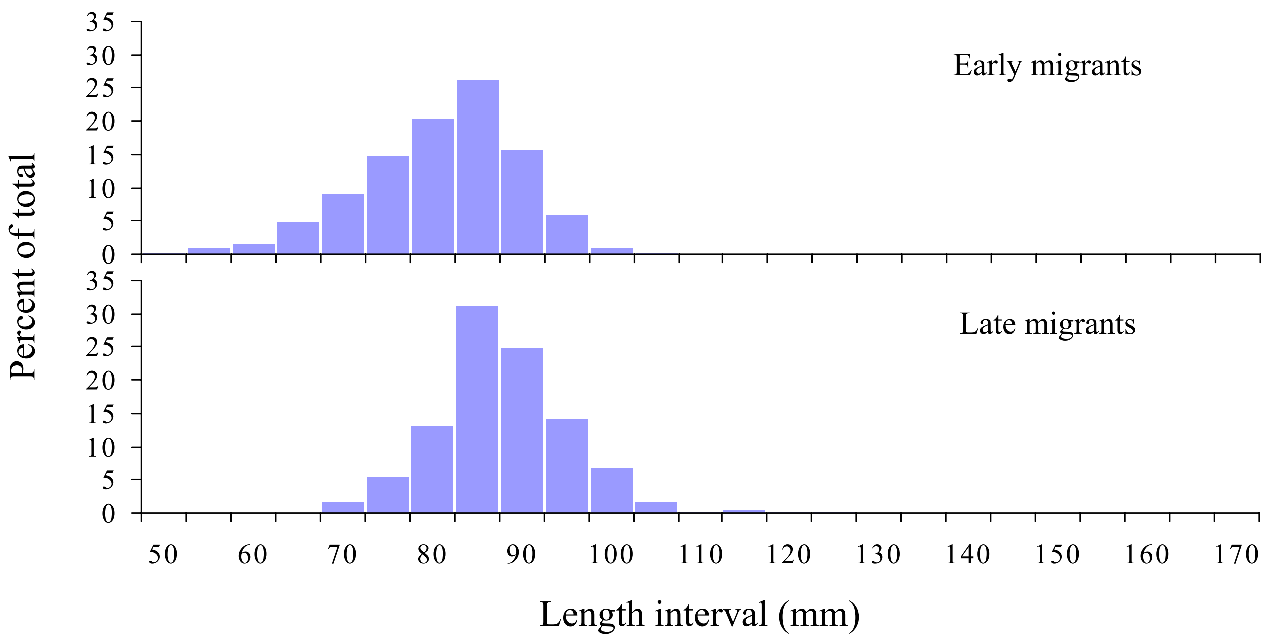

Figure 4. Length frequency distribution (fork length) of juvenile spring chinook salmon migrants captured at the Catherine Creek trap (rkm 32) by migration period, during the 2001 migratory year.

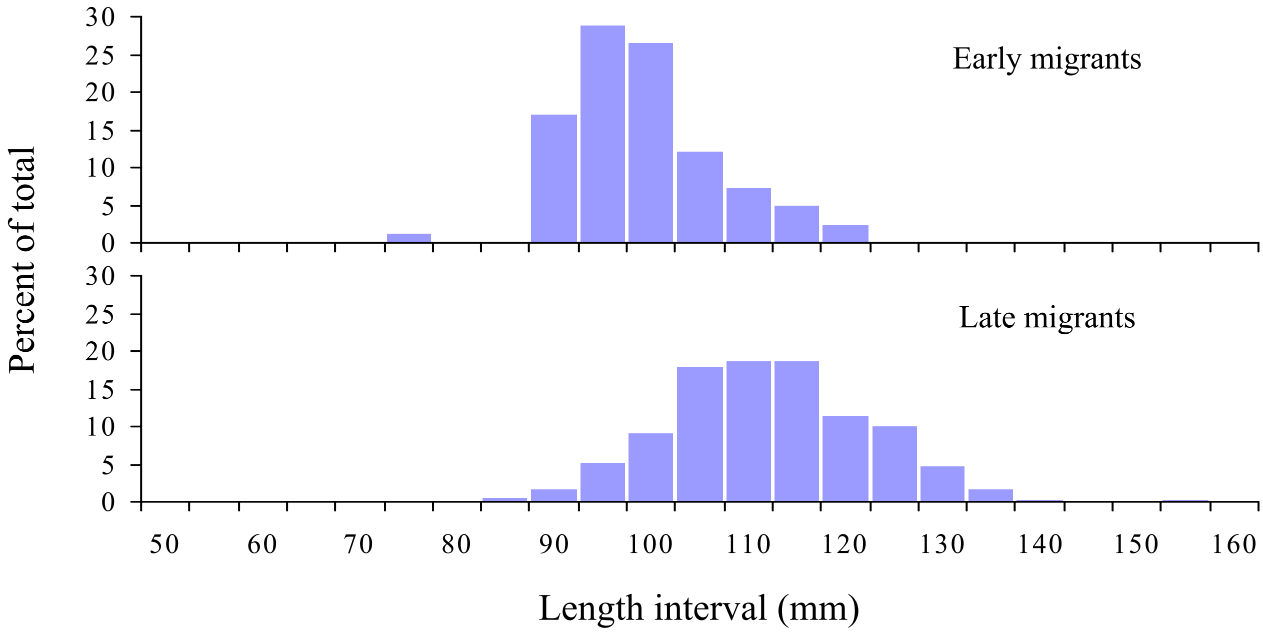

Figure 5. Length frequency distribution (fork length) of juvenile spring chinook salmon migrants captured at the Grande Ronde Valley trap (rkm 164) by migration period, during the 2001 migratory year.

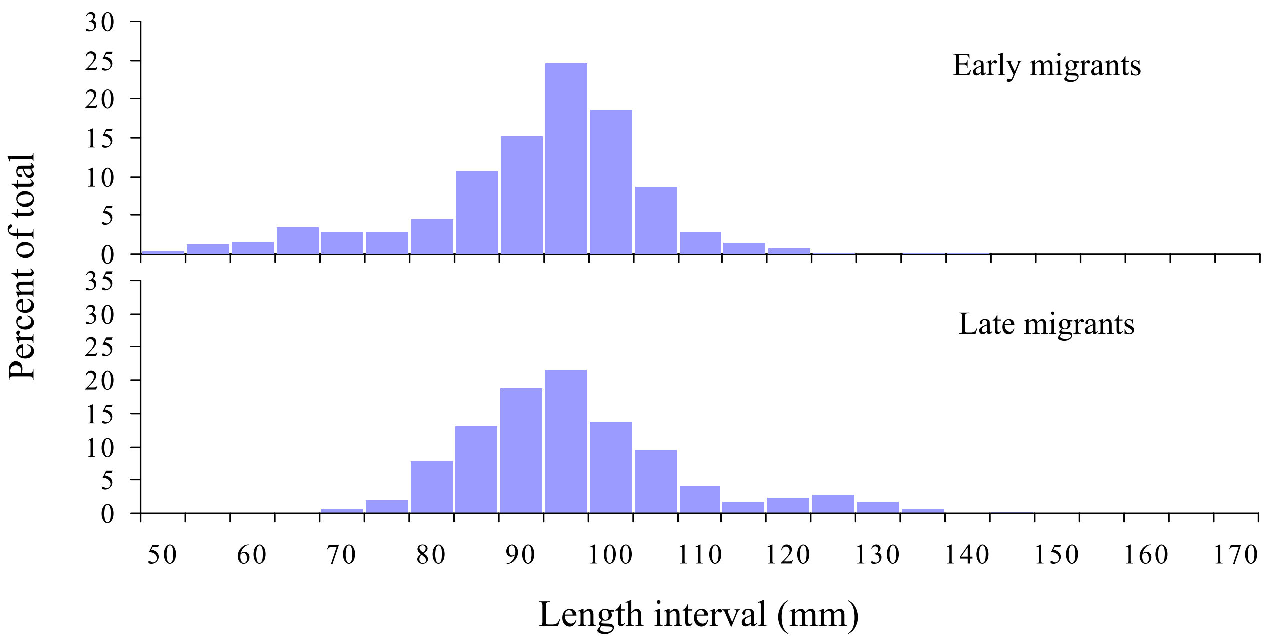

Figure 6. Length frequency distribution (fork length) of juvenile spring chinook salmon migrants captured at the Lostine River trap (rkm 3) by migration period, during the 2001 migratory year.

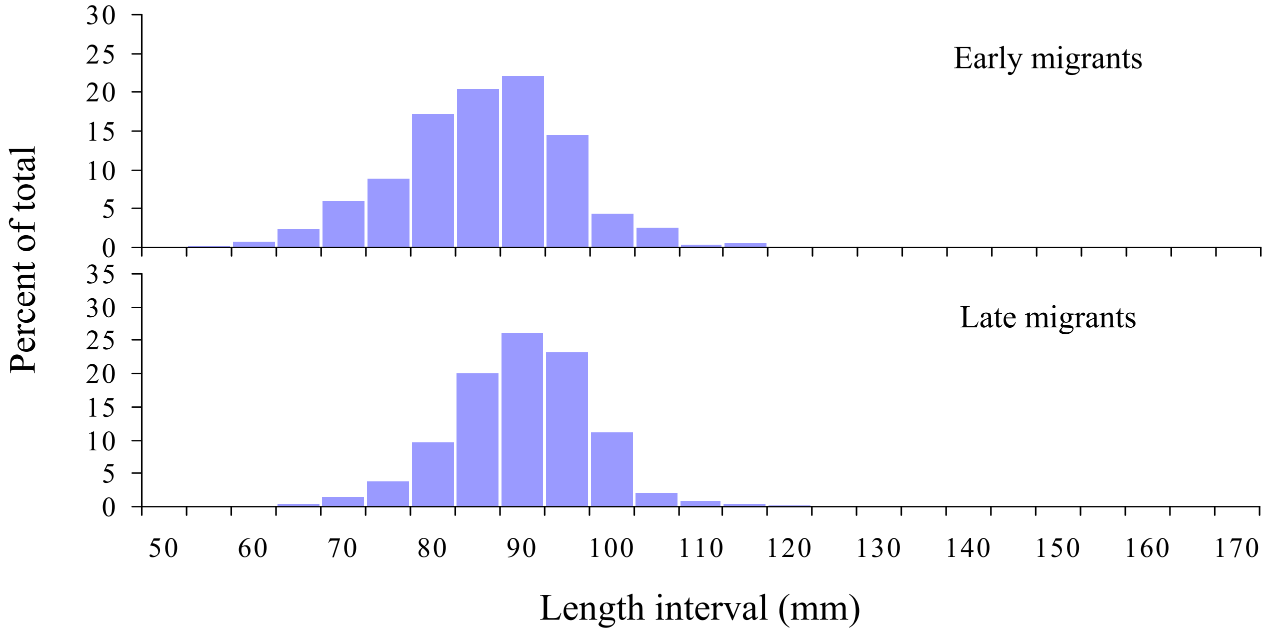

Figure 7. Length frequency distribution (fork length) of juvenile spring chinook salmon migrants captured at the Minam River trap (rkm 0) by migration period, during the 2001 migratory year.

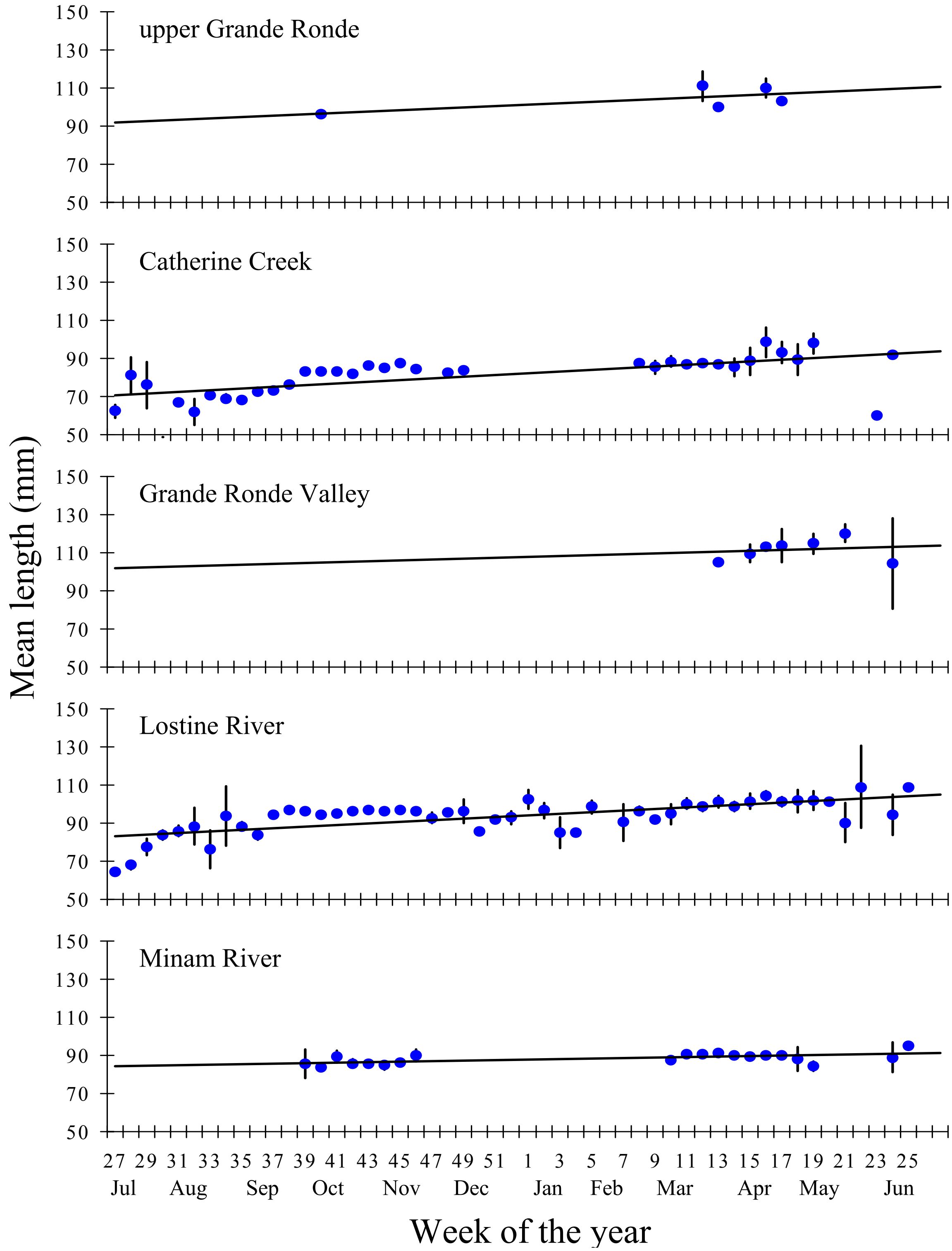

Figure 8. Weekly mean fork lengths (mm) with standard error for spring chinook salmon captured in rotary screw traps in the Grande Ronde and Wallowa basins during migratory year 2001.

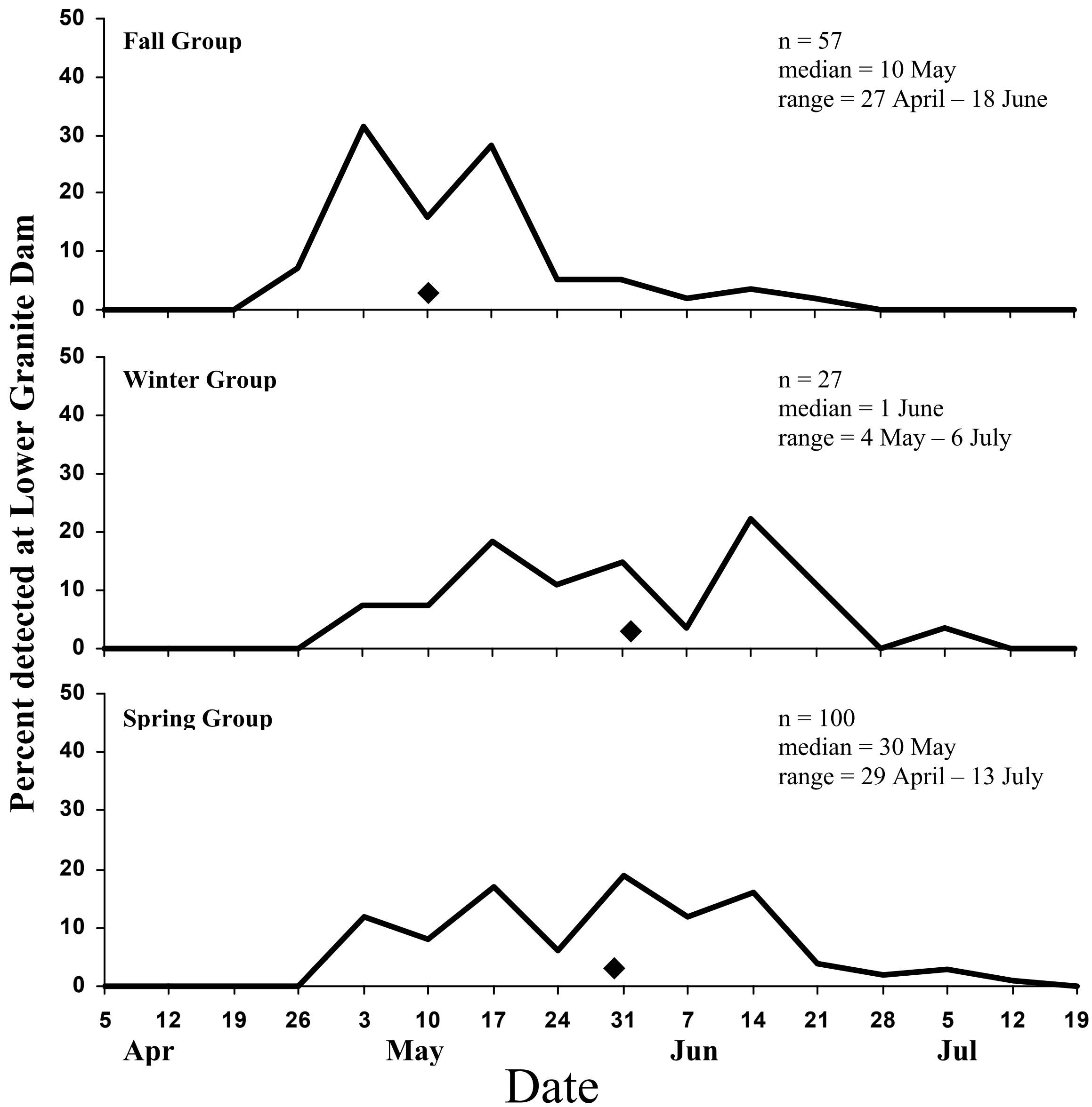

Figure 9. Dates of detection in 2001 at Lower Granite Dam for the fall, winter, and spring tag groups of juvenile spring chinook salmon PIT-tagged on Catherine Creek, expressed as a percentage of the total detected for each group. ◆ = median arrival date. Detections were expanded for spillway flow.

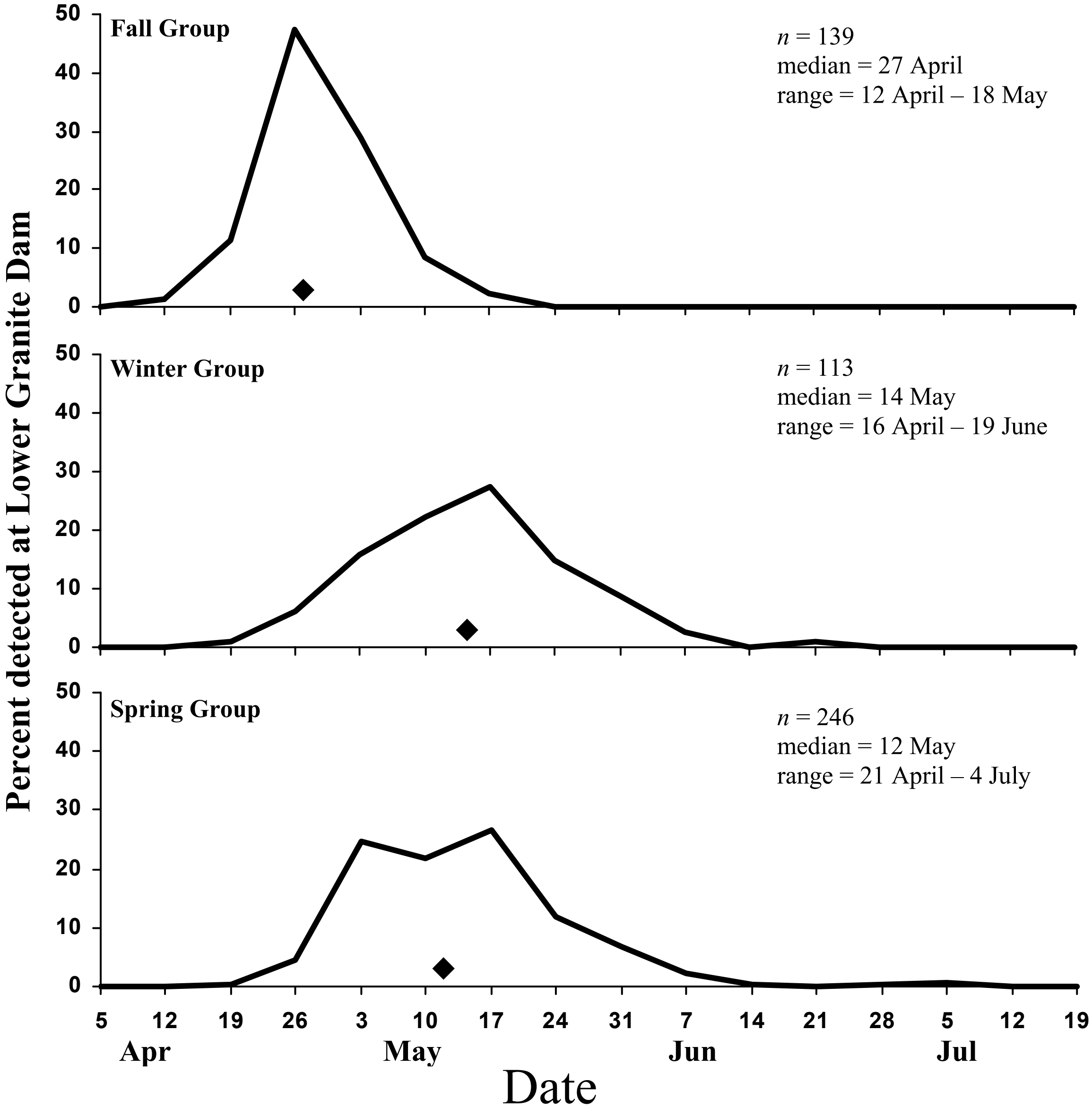

Figure 10. Dates of detection in 2001 at Lower Granite Dam for the fall, winter, and spring tag groups of juvenile spring chinook salmon PIT-tagged on the Lostine River, expressed as a percentage of the total detected for each group. ◆ = median arrival date. Detections were expanded for spillway flow.

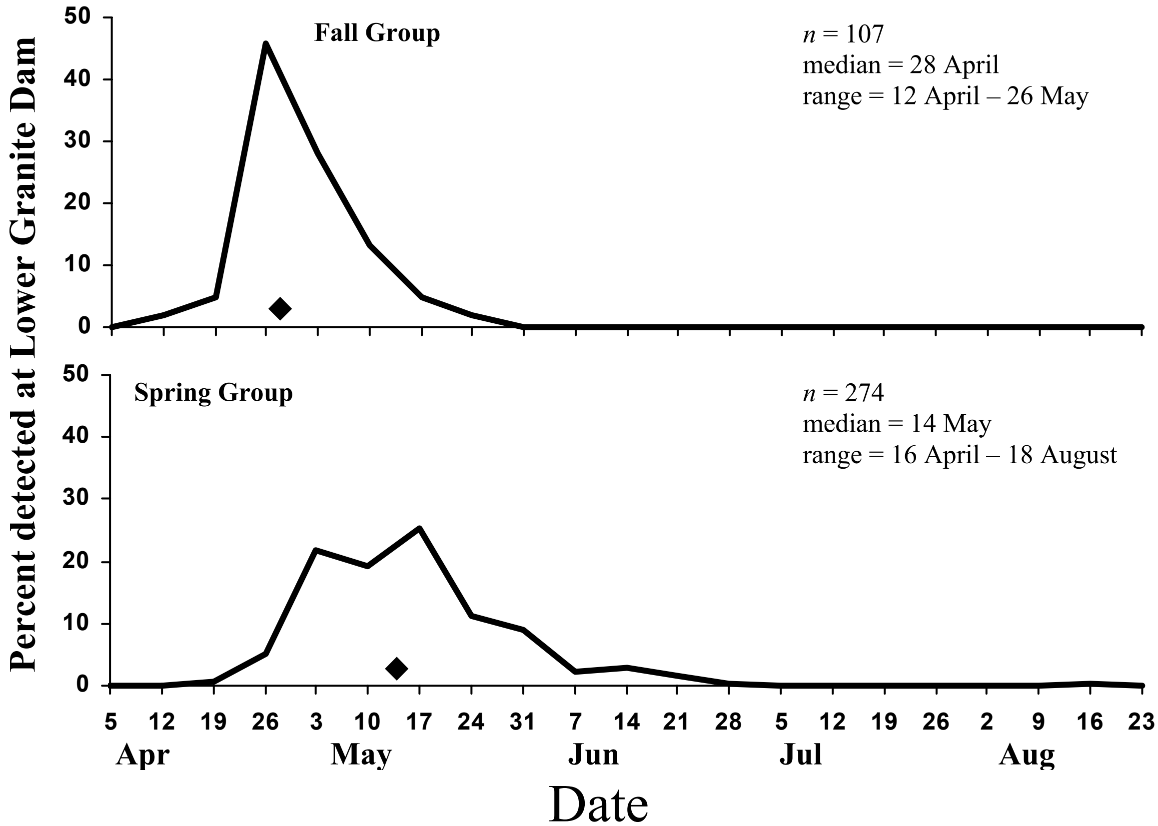

Figure 11. Dates of detection in 2001 at Lower Granite Dam for fall and spring tag groups of juvenile spring chinook salmon PIT-tagged on the Minam River, expressed as a percentage of the total detected for each group. ◆ = median arrival date. Detections were expanded for spillway flow.

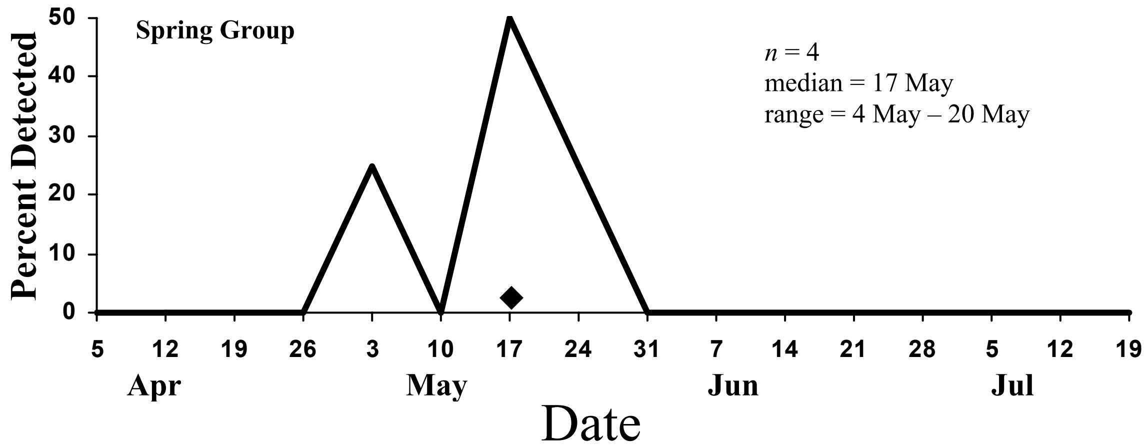

Figure 12. Dates of detection in 2001 at Lower Granite Dam for the spring tag group of juvenile spring chinook salmon PIT-tagged on the upper Grande Ronde River, expressed as a percentage of the total detected. ◆ = median arrival date. Detections were expanded for spillway flow.

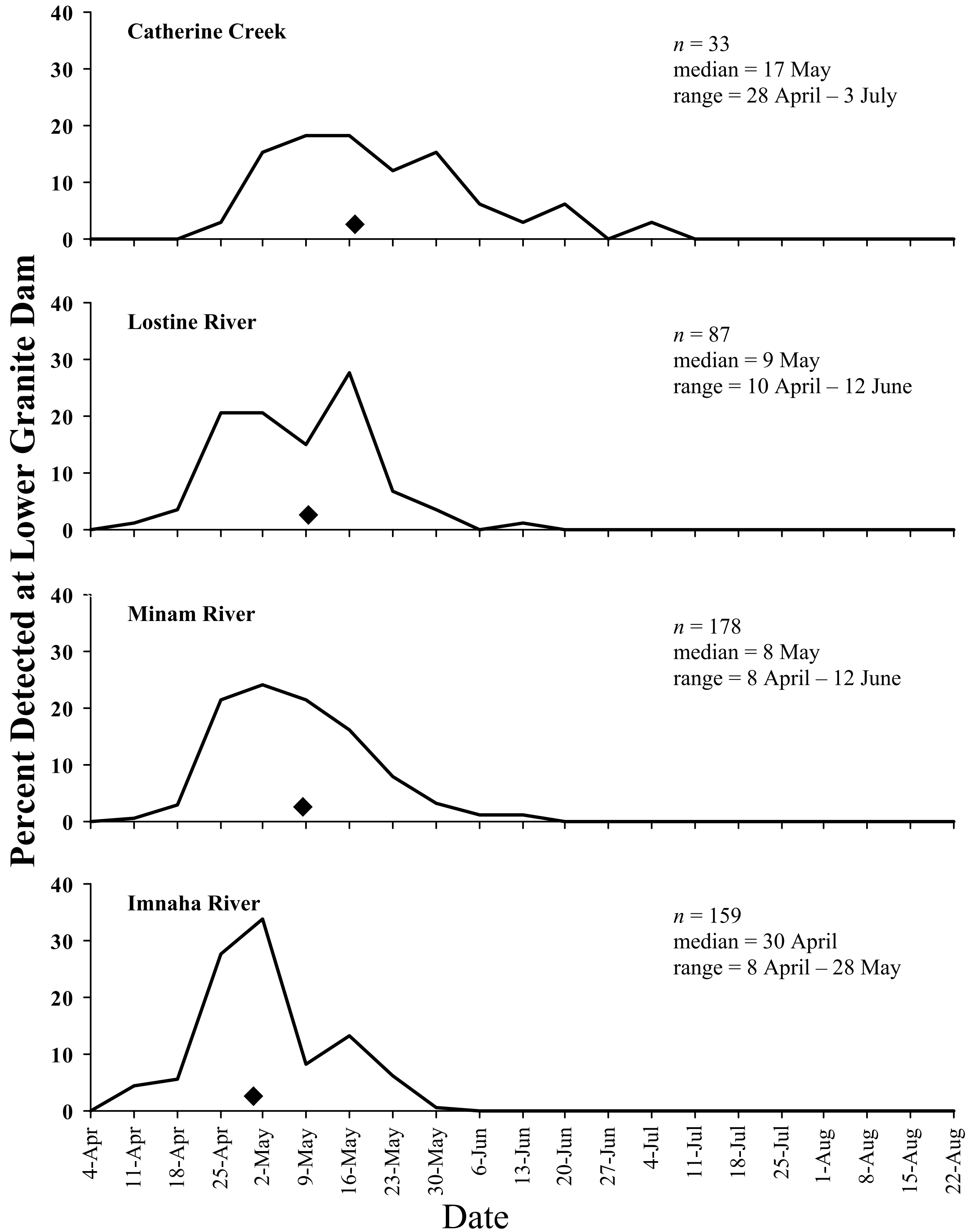

Figure 13. Dates of detection in 2001 at Lower Granite Dam of spring chinook salmon PIT-tagged as parr on Catherine Creek and the Imnaha, Lostine, and Minam rivers during the summer of 2000, summarized by week and expressed as a percentage of the total detected for each group. ◆ = median arrival date. No spill occurred on the dates of fish detection, so numbers were not adjusted.

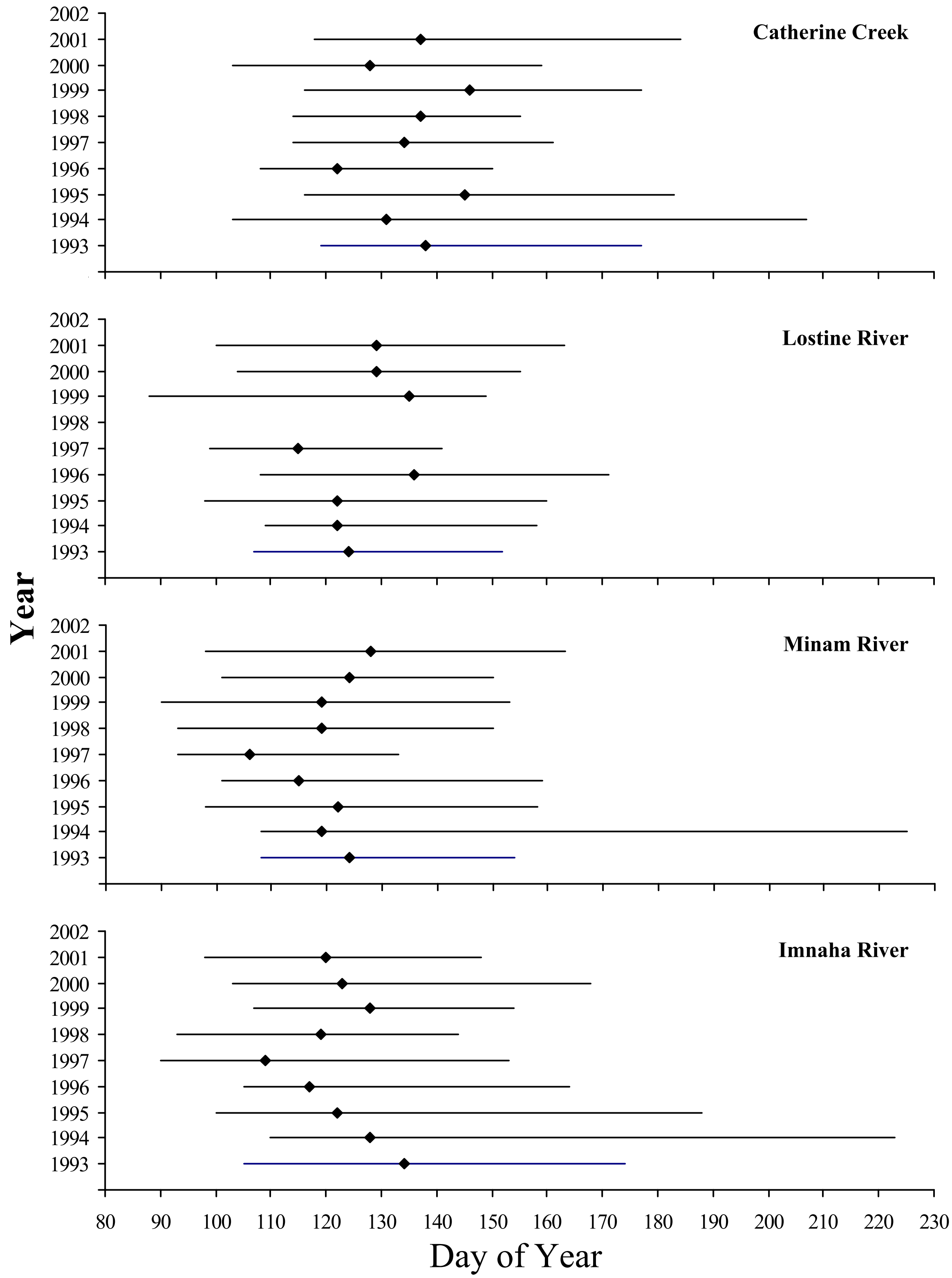

Figure 14. Median (diamonds) and first and last (bars) detection dates at Lower Granite Dam for wild chinook smolts tagged as parr during the summer in Catherine Creek, Lostine, Minam, and the Imnaha rivers, for migratory years 1993–2001.

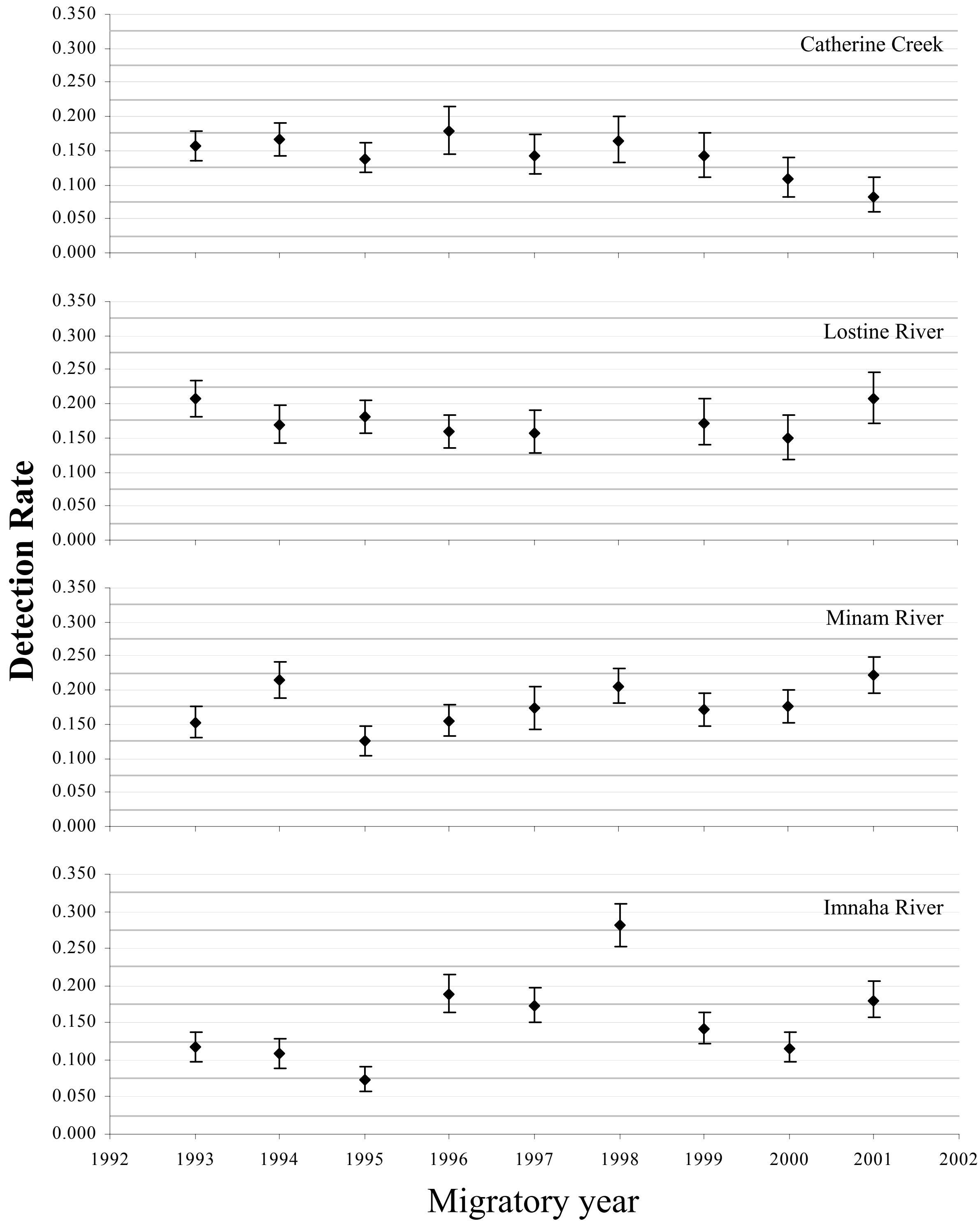

Figure 15. Dam detection rates and 95% CI for spring chinook salmon parr PIT-tagged during the summer in Catherine Creek and the Lostine, Minam, and Imnaha rivers, for migratory years 1993–2001.

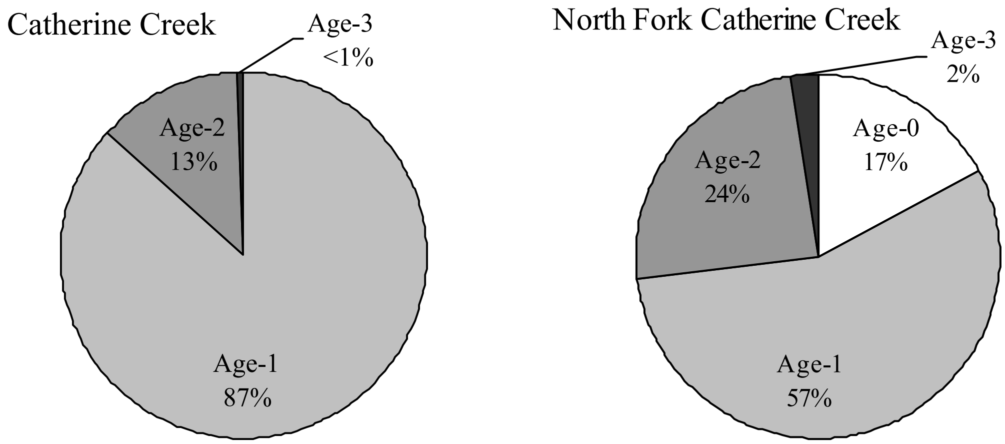

Figure 16. Age composition of the *O. mykiss* populations in Catherine Creek and North Fork Catherine Creek during early summer 2001. Age was determined by scale analysis.

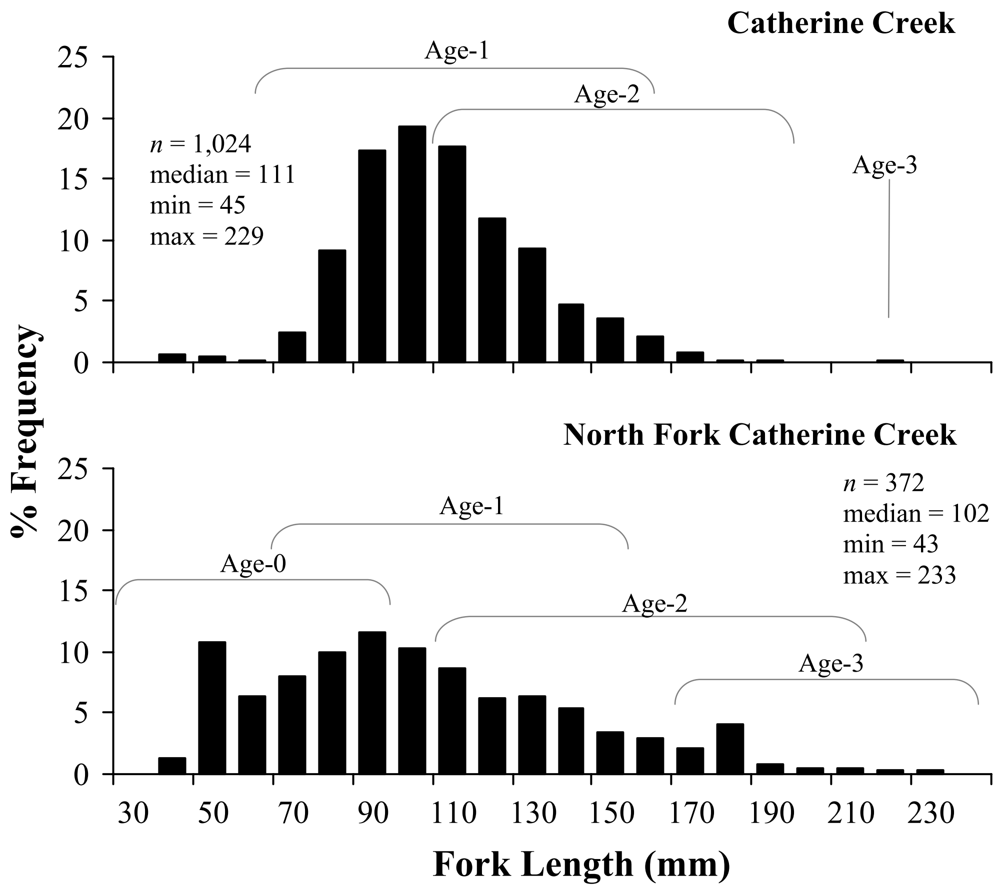

Figure 17. Fork lengths of *O. mykiss* in Catherine Creek and North Fork Catherine Creek measured during the summer of 2001. Frequencies are expressed as a percent of the total number measured (*n*) on each stream. The ranges of lengths associated with each age class are shown in addition to the median, minimum, and maximum lengths of *O.mykiss* measured.

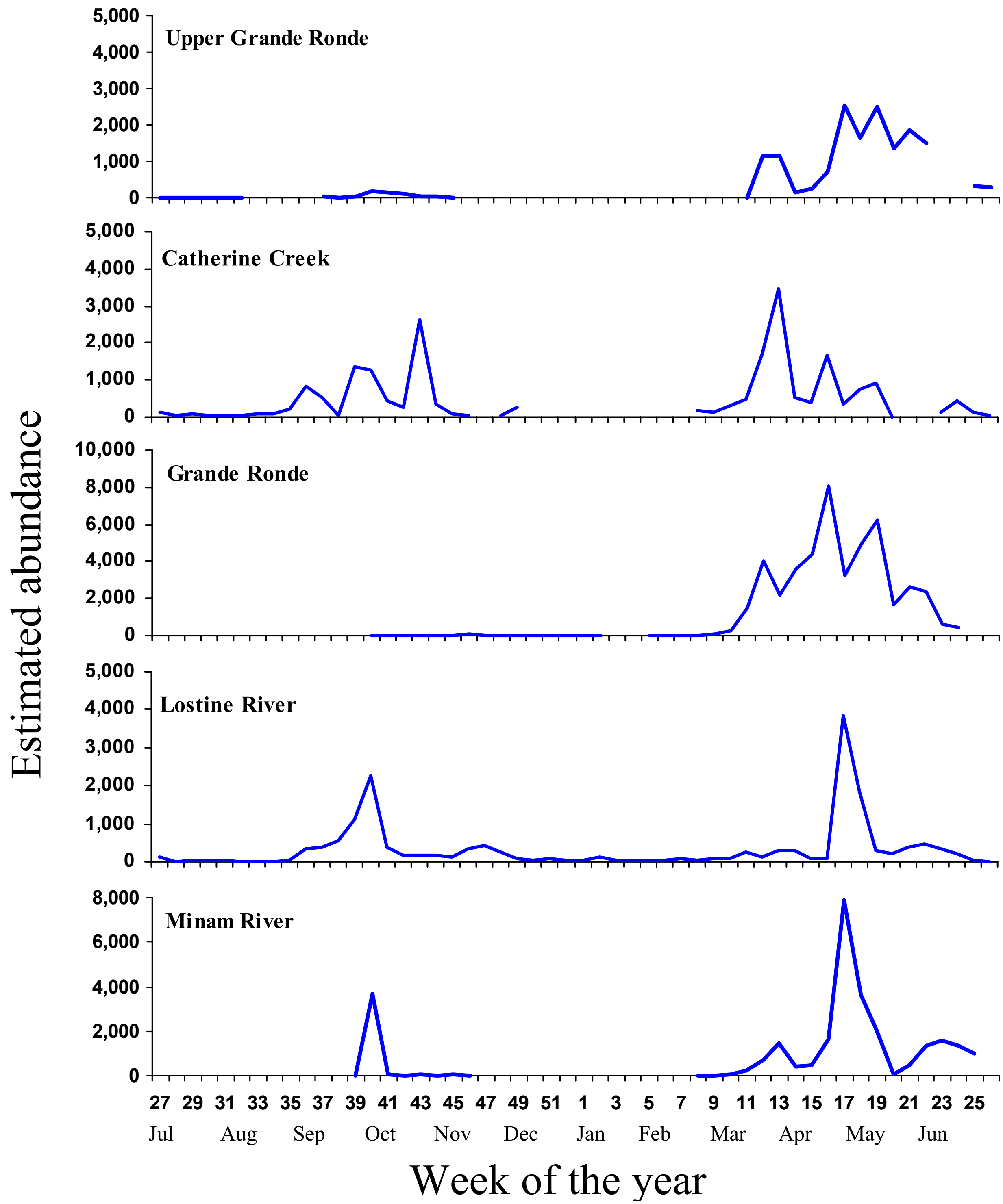

Figure 18. Estimated abundance and migration timing of *O. mykiss* migrants captured by rotary screw traps, during migratory year 2001. Traps were located at rkm 299 and 164 of the Grande Ronde River, rkm 32 of Catherine Creek, rkm 3 of the Lostine River, and rkm 0 of the Minam River.

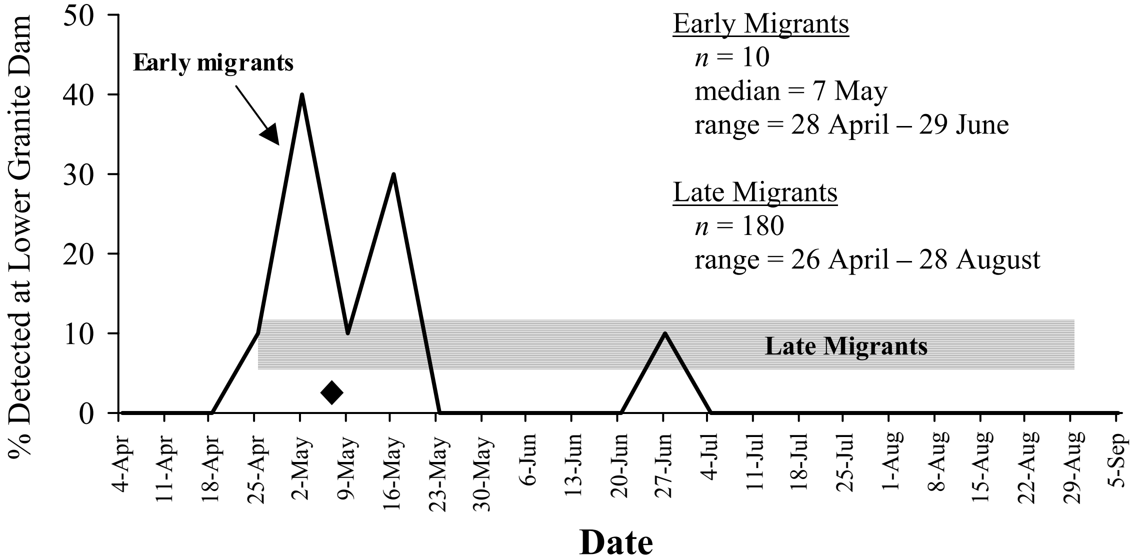

Figure 19. Migration timing by tag group of *O. mykiss* PIT-tagged on the upper Grande Ronde River and subsequently detected at Lower Granite Dam during the 2001 migratory year. ◆ = median detection date. Detection numbers were expanded for spillway flow. Shaded area shows range of migration timing by late migrant tag group. Median detection date was not calculated because tagging was not proportional to migration past the screw trap, and thus may not represent migration timing of the population.

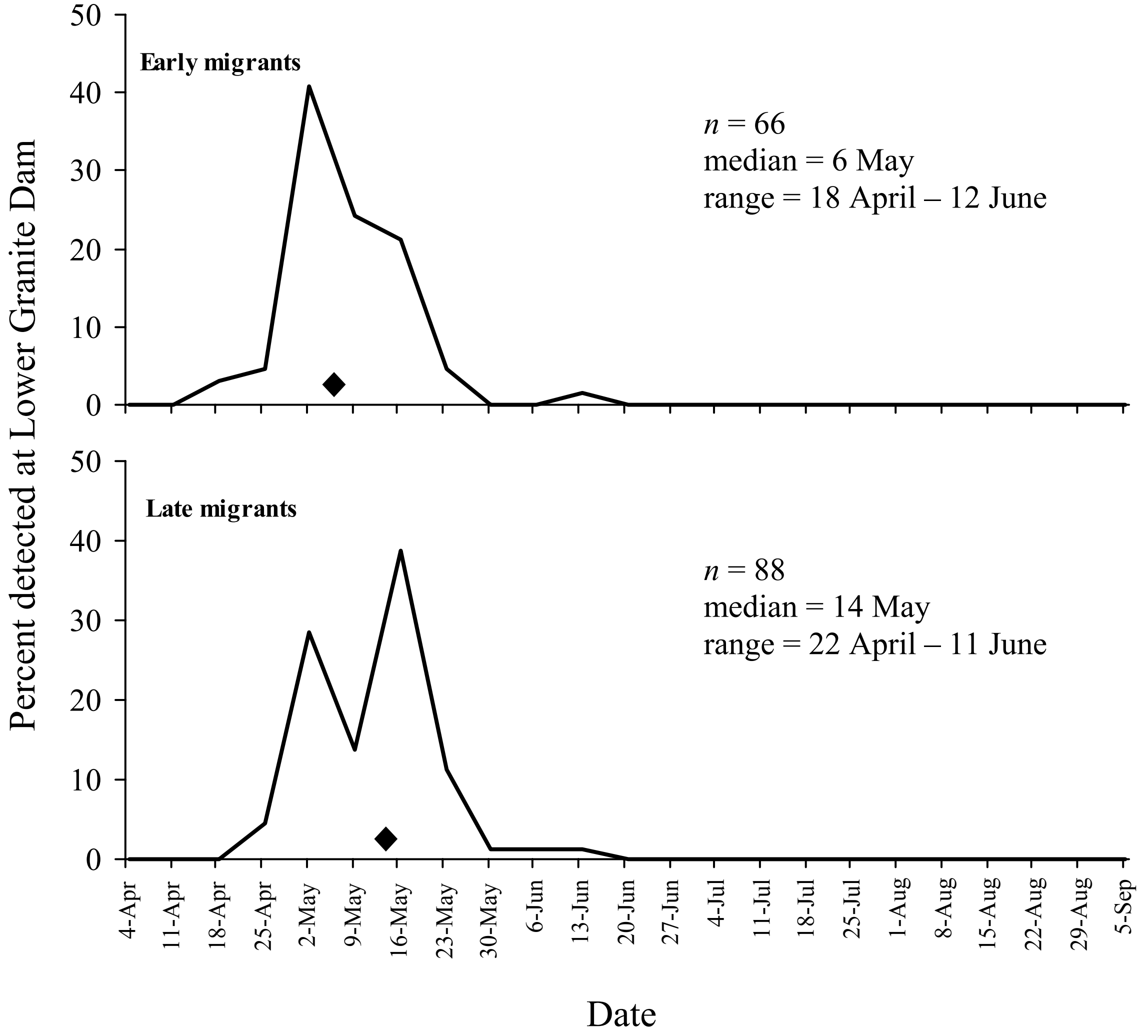

Figure 20. Migration timing by tag group of *O. mykiss* PIT-tagged on Catherine Creek and subsequently detected at Lower Granite Dam during migratory year 2001. ◆ = median detection date. Detection numbers were expanded for spillway flow.

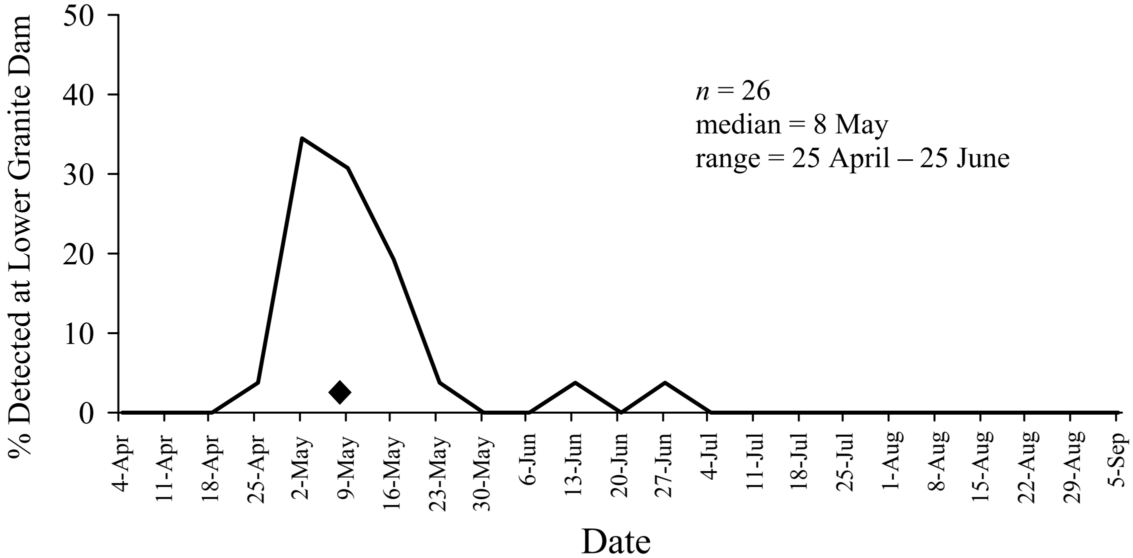

Figure 21. Dates of detection in 2001 at Lower Granite Dam of *O. mykiss* PIT-tagged as parr on Catherine Creek, North Fork Catherine Creek, and South Fork Catherine Creek during the summer of 2000. ◆ = median detection date. Detection numbers were expanded for spillway flow.

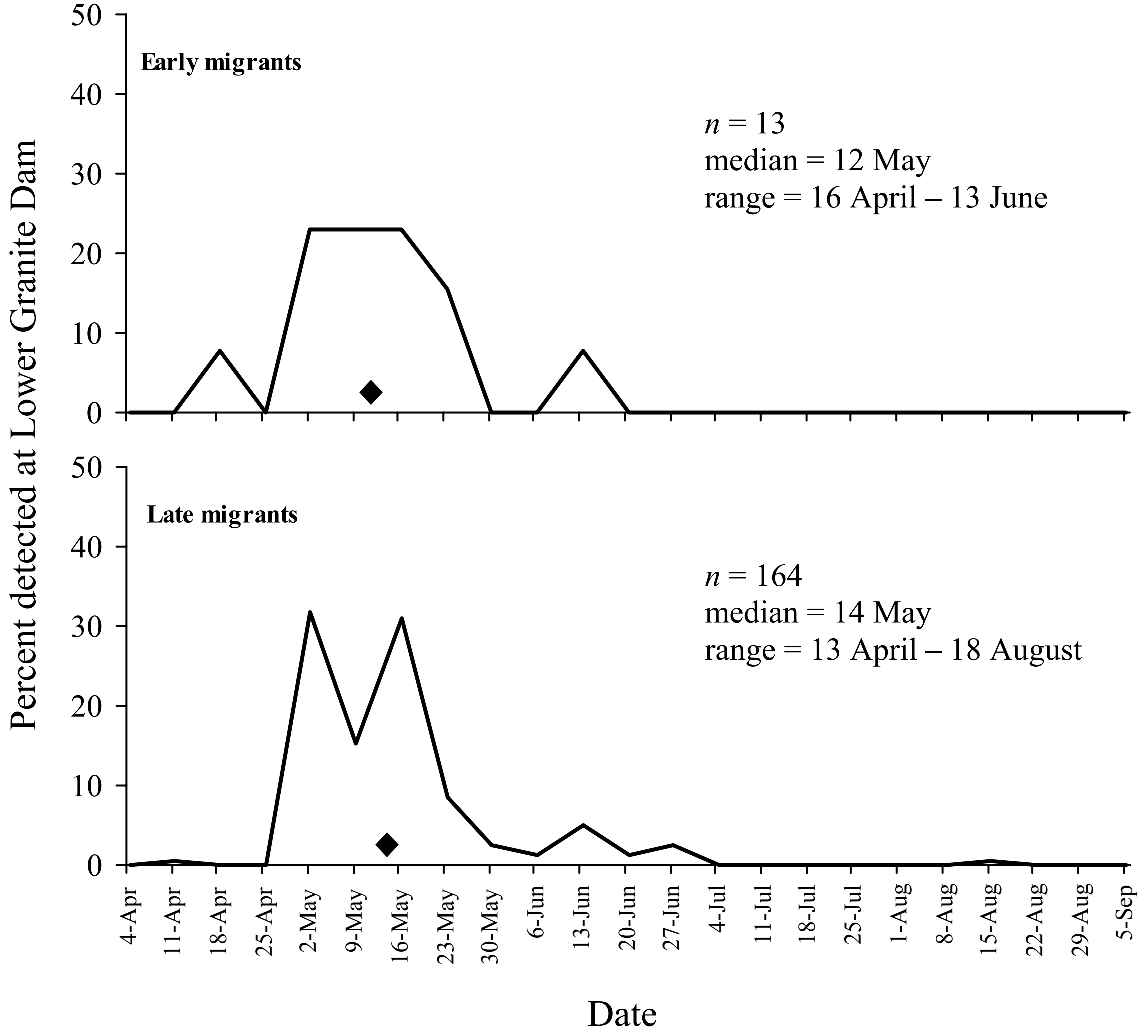

Figure 22. Migration timing by tag group of *O. mykiss* PIT-tagged on the Lostine River and subsequently detected at Lower Granite Dam during the 2001 migratory year. ◆ = median detection date. Detection numbers were expanded for spillway flow.

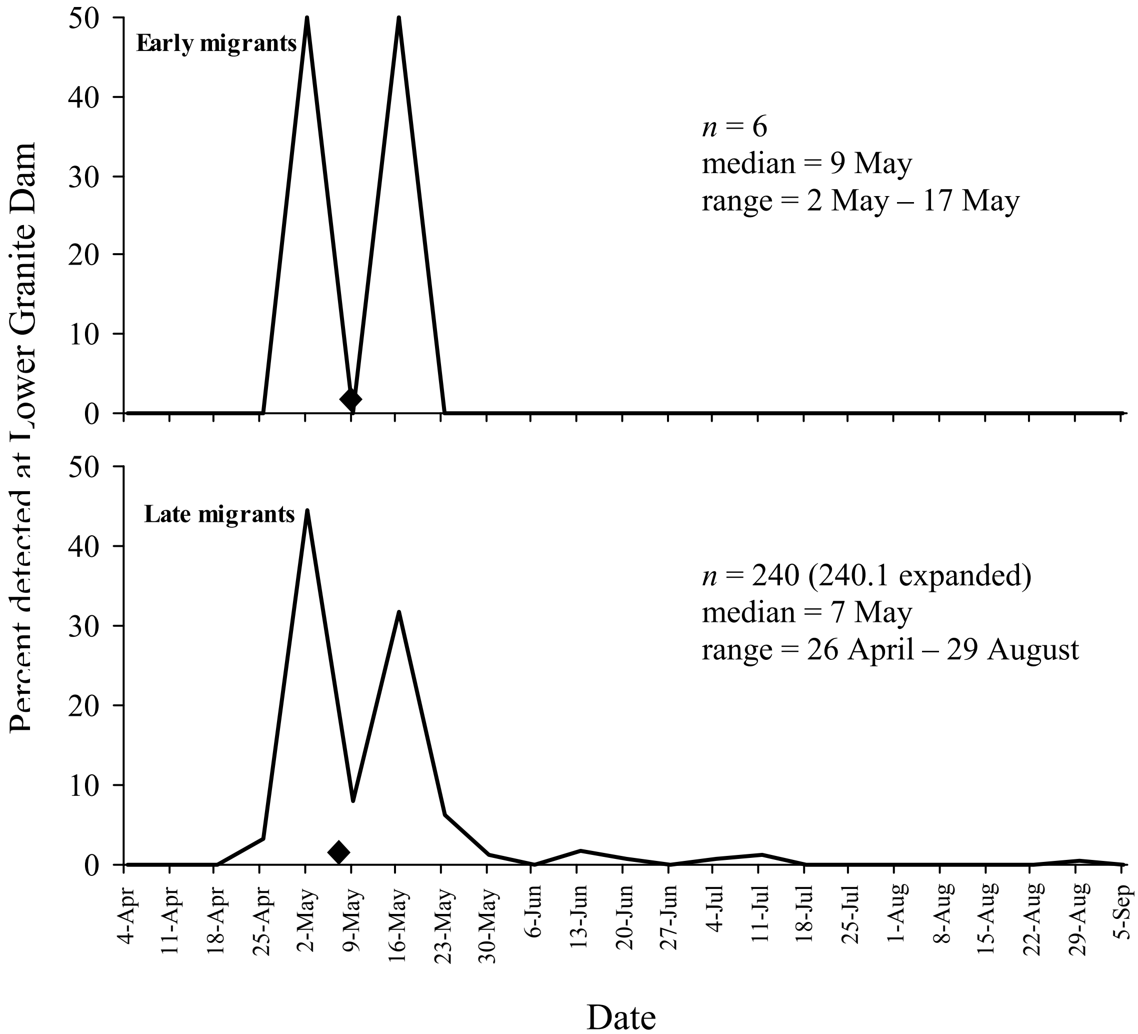

Figure 23. Migration timing by tag group of *O. mykiss* PIT-tagged on the Minam River and subsequently detected at Lower Granite Dam during the 2001 migratory year. ◆ = median detection date. Detection numbers were expanded for spillway flow.

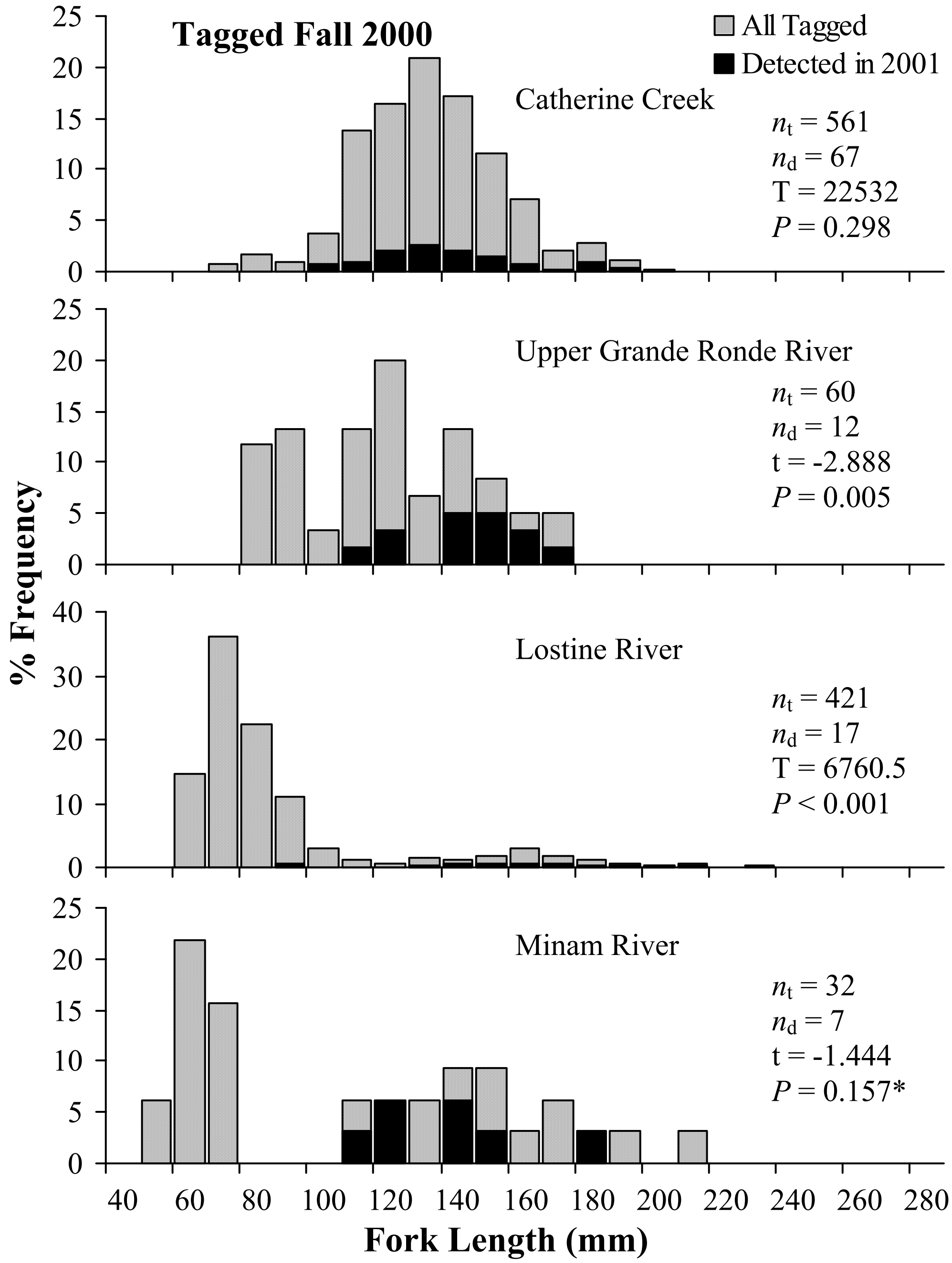

Figure 24. Fork lengths of all *O. mykiss* PIT-tagged at screw traps on Catherine Creek and the upper Grande Ronde, Lostine, and Minam rivers in the fall of 2000 and detected at Snake River or Columbia River dams in 2001 compared to lengths of all *O. mykiss* in the same tag group. Frequency is expressed as the percent of the total number tagged (n_t). 'n_d' is the number detected, 'T' is test statistic for the Mann-Whitney Rank Sum Test, 't' is the test statistic for the t-test, '*P*' is the p-value associated with the rank sum or t-test. * Power of the t-test is < 0.80 at $\alpha = 0.05$.

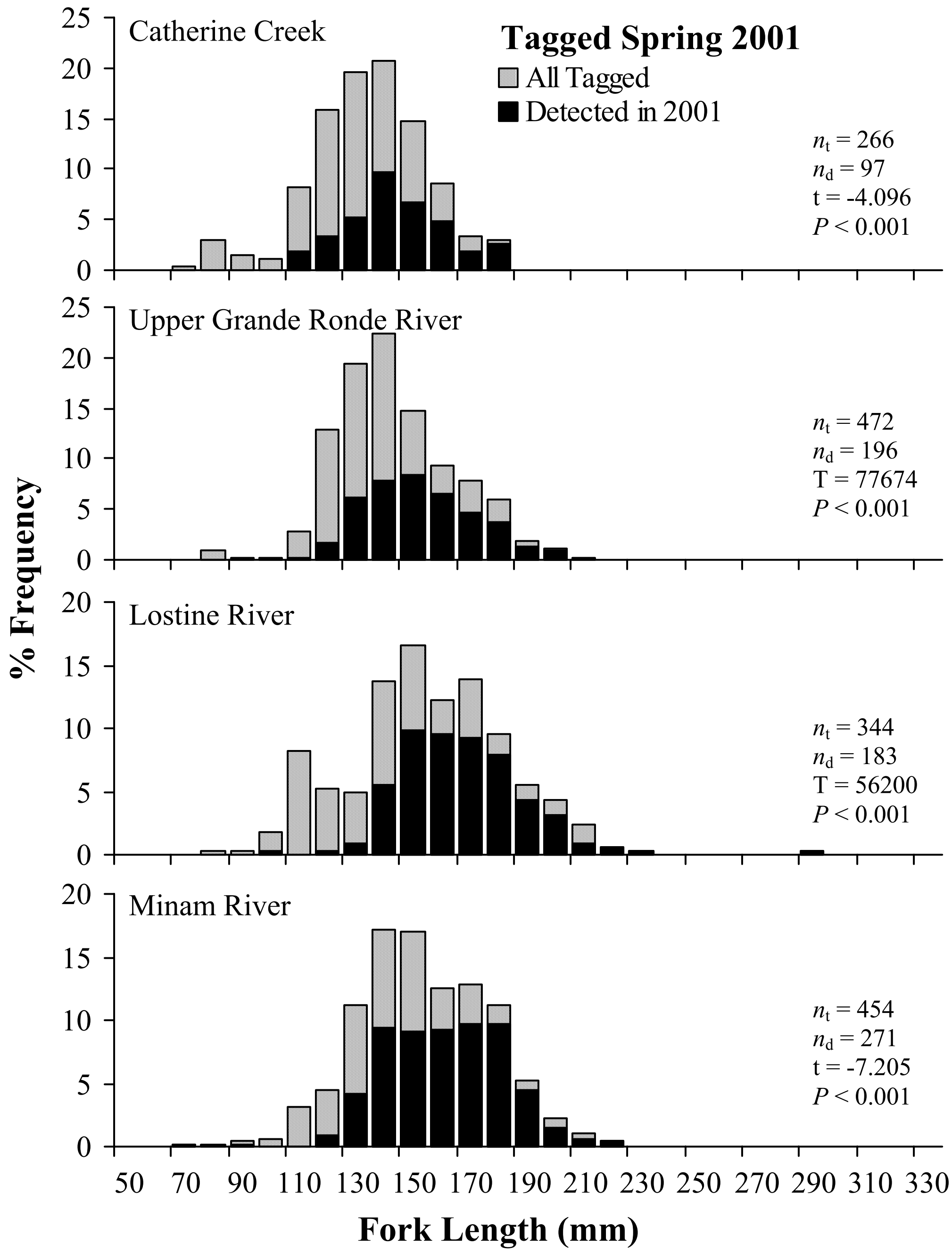

Figure 25. Fork lengths of all *O. mykiss* PIT-tagged at screw traps on Catherine Creek and the upper Grande Ronde, Lostine, and Minam rivers in the spring of 2001 and detected at Snake River or Columbia River dams in 2001 compared to lengths of all *O. mykiss* in the same tag group. Frequency is expressed as the percent of the total number tagged (n_t). 'n_d' is the number detected, 'T' is test statistic for the Mann-Whitney Rank Sum Test, 't' is the test statistic for the t-test, '*P*' is the p-value associated with the rank sum or t-test.

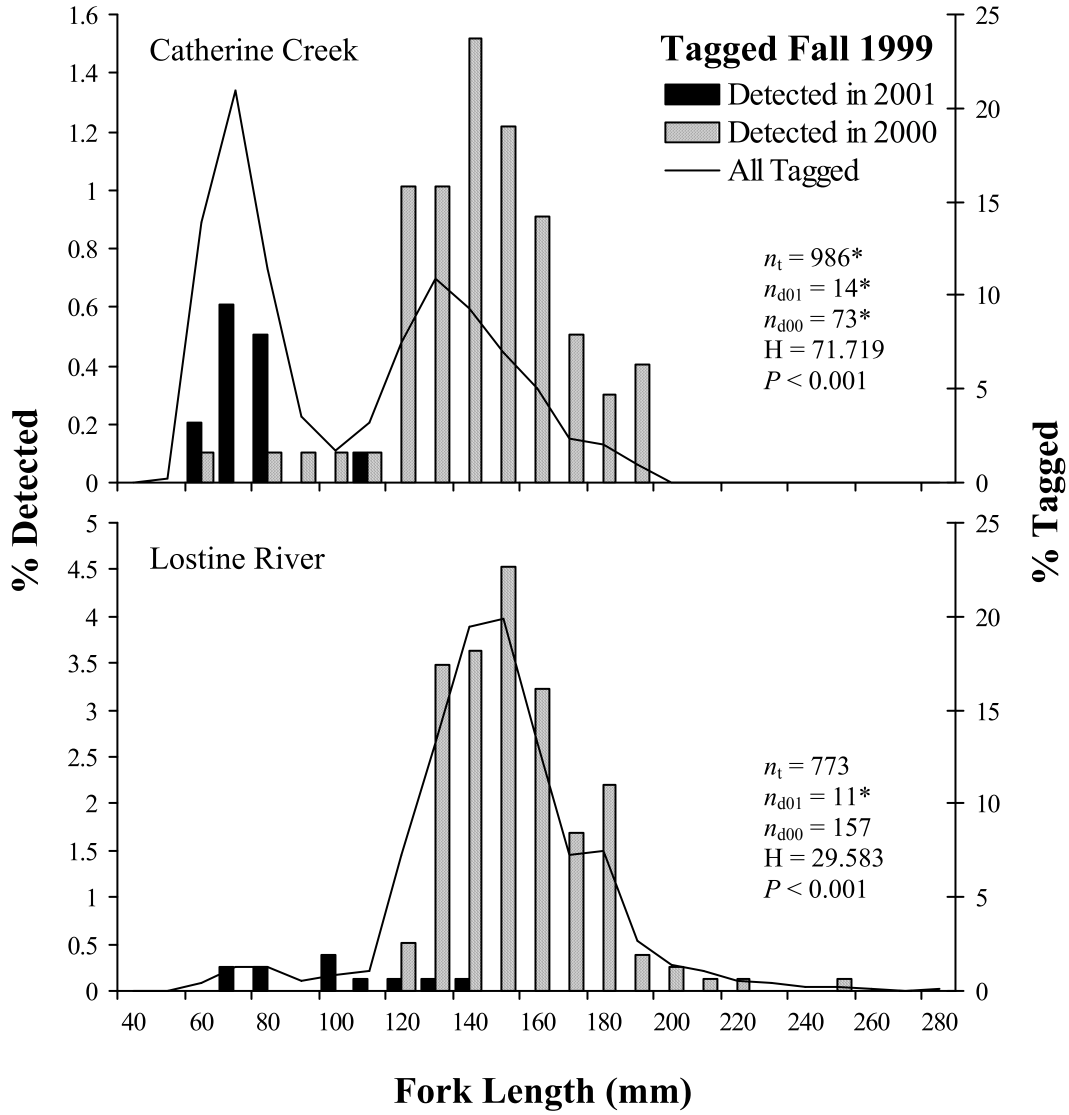

Figure 26. Lengths at time of tagging of *O. mykiss* that were PIT-tagged at Catherine Creek and Lostine River screw traps during the fall of 1999 (t), lengths of those also detected at the dams in 2001 (d01), and lengths of those also detected at the dams in 2000 (d00). Frequency is expressed as the percent of the total number tagged. 'H' is the test statistic for the Kruskal-Wallis one-way ANOVA on ranks of the lengths. '*P*' is the p-value associated with the ANOVA.
* Median length of the group was significantly different ($\alpha = 0.05$, Dunn's all pair-wise multiple comparison procedure).

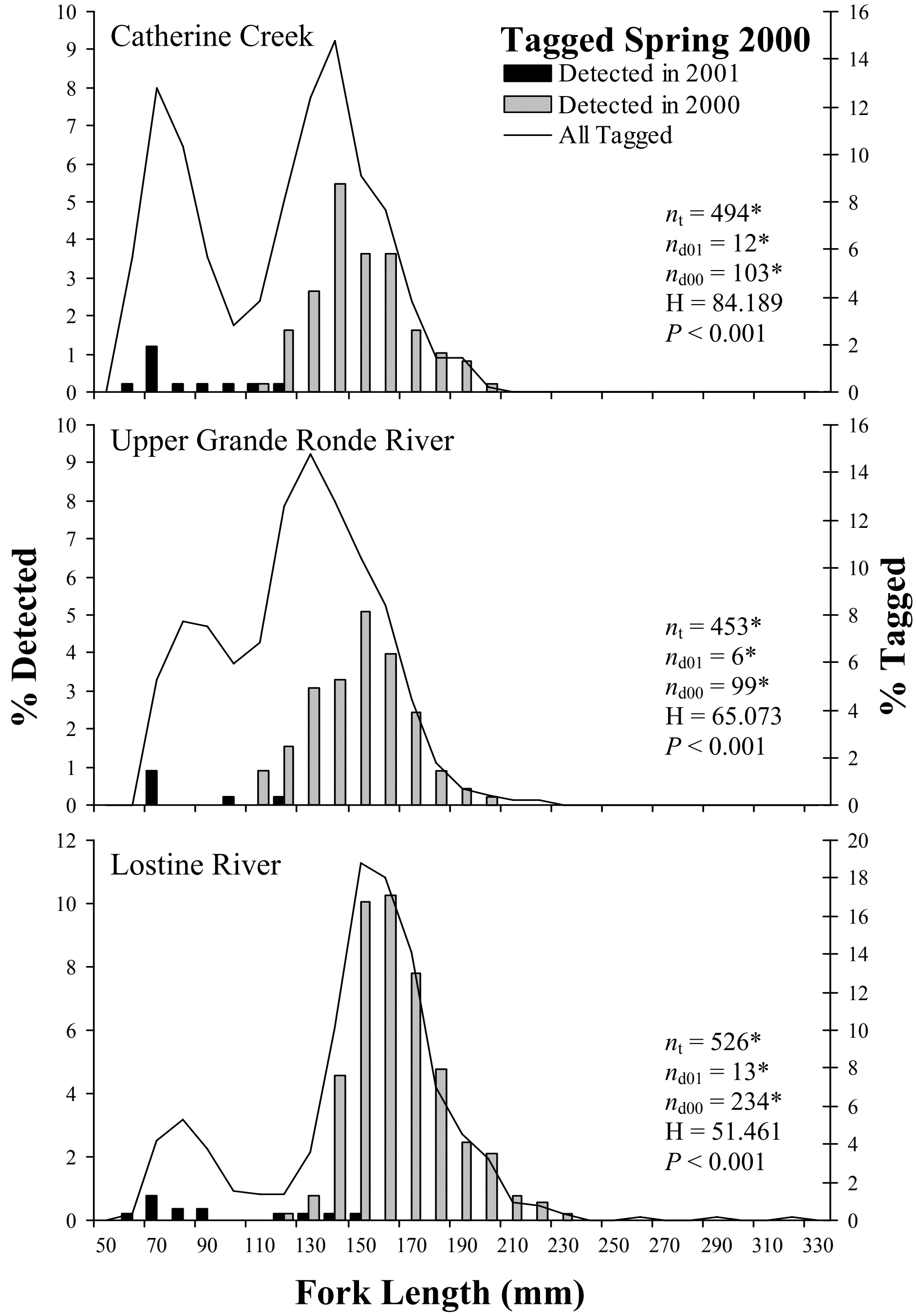

Figure 27. Lengths at time of tagging of *O. mykiss* that were tagged at Catherine Creek and upper Grande Ronde and Lostine River screw traps during the spring of 2000 (t), lengths of those also detected at the dams in 2001 (d01), and lengths of those also detected at the dams in 2000 (d00). Frequency is expressed as the percent of the total number tagged. 'H' is the test statistic for the Kruskal-Wallis one-way ANOVA on ranks of the lengths. '*P*' is the p-value associated with the ANOVA. * Median length of the group was significantly different ($\alpha = 0.05$, Dunn's all pair-wise multiple comparison procedure).

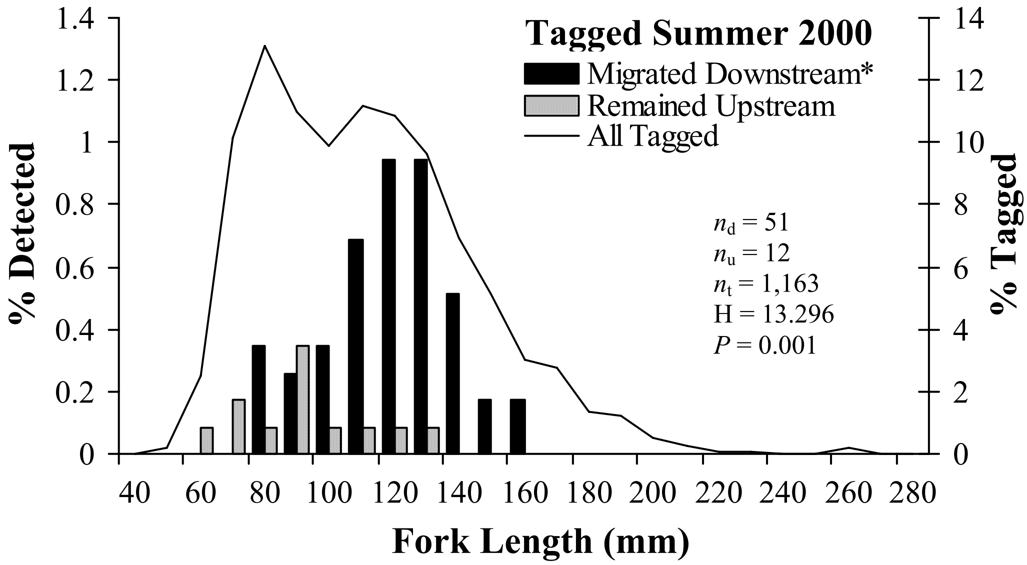

Figure 28. Lengths of *O. mykiss* that were tagged upstream of the screw trap on Catherine Creek during the summer 2000 (t), lengths of those migrating downstream from upper rearing habitats by late spring 2001 (d), and lengths of those known to remain upstream through summer 2001 (u). Frequency is expressed as the percent of the total number tagged. 'H' is the test statistic for the Kruskal-Wallis one-way ANOVA on ranks of the lengths. 'P' is the p-value associated with the ANOVA. * Median length was significantly different (α = 0.05, Dunn's all pair-wise multiple comparison procedure).

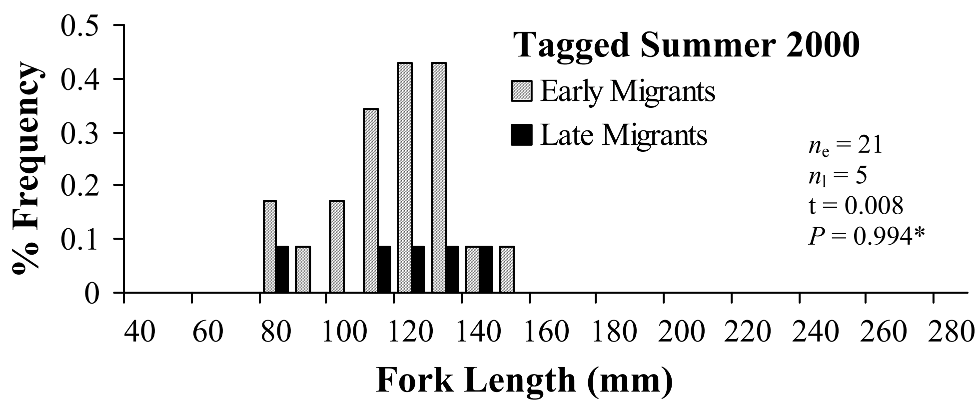

Figure 29. Lengths at tagging of *O. mykiss* that were tagged upstream of the screw trap on Catherine Creek during the summer of 2000 and recaptured at the screw trap in the fall of 2000 (early migrants) and the spring of 2001 (late migrants). Frequency is expressed as the percent of the total number tagged (1,163). 'n_e' is the number of fall migrants, 'n_l' is the number of spring migrants, 't' is the test statistic for the t-test, 'P' is the p-value associated with the t-test. * Power < 0.80.

APPENDIX A

A Compilation of Spring Chinook Salmon Data

Appendix Table A-1. Ages of immature and mature, wild spring chinook salmon parr collected in summer rearing areas of Catherine Creek, and the Lostine, Minam, and Imnaha rivers, 1998 - 2001. Ages were determined by analysis of scales collected from a random subsample of fish caught for PIT-tagging.

	Immature parr			Mature parr		
Stream, year	Age-0	Age-1	% Age-0	Age-0	Age-1	% Age-1
Catherine Creek:						
1998	208	0	100.0	0	113	100.0
1999	204	0	100.0	1	209	99.5
2000	258	3[a]	98.9	0	106	100.0
2001	—	—	—	0	103	100.0
Lostine River:						
1998	231	0	100.0	0	20	100.0
1999	201	0	100.0	0	23	100.0
2000	110	0	100.0	0	31	100.0
2001	—	—	—	1	3	75.0[b]
Minam River:						
1998	—	—	—	0	1	100.0[b]
1999	—	—	—	—	—	—
2000	70	0	100.0	—	—	—
2001	212	0	100.0	0	4	100.0[b]
Imnaha River:						
1998	—	—	—	0	3	100.0[b]
1999	—	—	—	—	—	—
2000	—	—	—	—	—	—
2001	67	0	100.0	—	—	—

[a] *These parr were collected in early August and it is possible that they were on their way to maturing precociously but their maturity characteristics had not yet developed (*see *Monzyk et al. 2000).*

[b] *Note small sample size.*

Appendix Table A-2. Dates of tagging and number of spring chinook salmon parr PIT-tagged on various northeast Oregon streams, 1998–2001.

Year, stream	Dates of collection and tagging	Number tagged and released	Distance to Lower Granite Dam (km)
1998:			
Catherine Creek	3–7 August	502	354–375
Lostine River	10–13 August	506	274–302
Minam River	17–19 August	1,006	280–284
Imnaha River	24–26 August	1,009	237–243
1999:			
Catherine Creek	2–5 August	499	358–374
Lostine River	9–11 August	509	277–301
Minam River	16–18 August	998	279–283
Imnaha River	23–25 August	982	208–241
2000:			
Catherine Creek	7–10 August	500	370–377
Lostine River	14–17 August	490	276–290
Minam River	22 August, 18–19 September	1,000	282–283
Imnaha River	28–30 August	1,000	222–243
2001:			
Catherine Creek	30 July – 2 August	503	363–382
Lostine River	6–9 August	501	275–301
Minam River	20–23 August	996	282–284
Imnaha River	27–28 August	1,001	208–240

Appendix Table A-3. Spring chinook salmon parr mark-recapture population estimates on Catherine Creek and the Lostine River during summer, 1998–2001. All fish were captured by snorkel-seining.

Stream, parr maturity, origin	Year	Census data: Marked (M)	Census data: Recaptured (R)	Census data: Captured (C)	Population estimate (N)	95% CI
Catherine Creek:						
Immature, wild	1998	1,050	49	628	13,222	10,047 – 17,819
	1999	1,003	52	1,187	22,505	17,239 – 29,341
	2000	1,262	47	987	25,997	19,651 – 35,151
	2001	1,325	121	1,382	15,032	12,598 – 17,931
Mature, wild	1998	73	9	57	429	237 – 858
	1999	117	21	136	735	490 – 1,155
	2000	123	14	87	727	445 – 1,254
	2001	111	9	87	986	545 – 1,971
Mature, hatchery	2000	18	5	11	38	18 – 88
Lostine River:						
Immature, wild	1998	1,010	22	926	40,748	27,403 – 63,324
	1999	1,000	17	504	28,084	17,926 – 46,377
	2000	974	89	1,141	12,372	10,075 – 15,185
	2001	1,074	62	1,938	33,086	25,901 – 42,226
Mature, wild	1998	14	1	9	75[a]	23 – 136
	1999	10	0	15	176[a]	—
	2000	35	3	32	297[a]	121 – 743
	2001	5	0	1	12[a]	—

[a] *Population estimate is biased because R is not greater than or equal to 3 or M x C is not greater than 4N.*

Appendix Table A-4. Number of spring chinook salmon parr and number of parr produced per redd in Catherine Creek and the Lostine River during summer, by brood year, age, and maturity. Number of parr by maturity and age were calculated using mark-recapture population estimates and age ratios for immature and mature parr determined by scale analysis.

		Number of age-0 parr			Number of age-1 parr		
Stream, brood year	Redds	Immature	Mature	Parr/redd	Immature	Mature	Parr/redd
Catherine Creek							
1996	15	—	—	—	0	429	29
1997	46	13,222	0	287	0	731	16
1998	34	22,505	4	662	299	703	29
1999	38	25,698	0	676	0	986	26
2000	26	15,032	0	578	—	—	—
Lostine River							
1996	27	—	—	—	0	(a)	0
1997	47	40,748	(a)	867	0	(a)	0
1998	28	28,084	(a)	1,003	0	297	11
1999	45	12,372	0	275	0	(a)	0
2000	53	33,086	(a)	624	—	—	—

[a] *Too few mature parr were captured for population estimate.*

Appendix Table A-5. Proportion of immature age-0 spring chinook salmon parr from one summer that remain in freshwater and mature by the next summer, and number of mature male parr present in relation to the number of redds counted.

Stream, year	Estimated mature parr[a]	Percentage of immature parr from previous summer maturing at age-1	Potential for mature male parr to spawn with wild adult females	
			Redds[b]	Mature parr /redd
Catherine Creek:				
1998	429	—	34	12.6
1999	735	5.5	38	19.3
2000	703	3.2	26	27.0
2001	986	3.8	131	7.5
Lostine River:				
1998	(c)	—	28	(c)
1999	(c)	(c)	45	(c)
2000	297	1.1	53	5.6
2001	(c)	(c)	98	(c)

[a] *Mark-recapture estimates.*
[b] *Redd information from ODFW spawning ground surveys.*
[c] *Too few mature parr captured to estimate the population size.*

Appendix Table A-6. Dates of detection at Lower Granite Dam of spring chinook salmon smolts PIT-tagged at screw traps as early and late migrants and during the winter. Parentheses indicate that median might be biased and reflect when fish were tagged. Numbers of fish detected were expanded for spillway flow.

					Detection dates		
Stream, migratory year	Tag group	Migrant group	Number tagged	Number detected	Median	First	Last
Catherine Creek:							
2000	Fall	Early	677	56	05/03	04/12	05/29
	Winter	Late	500	22	05/09	04/25	06/01
	Spring	Late	431	52	(05/12)	04/21	07/02
2001	Fall	Early	494	57	05/10	04/27	06/18
	Winter	Late	538	27	06/01	05/04	07/06
	Spring	Late	329	100	(05/30)	04/29	07/13
Upper Grande Ronde River:							
2000	Fall	Early	493	45	05/08	04/12	06/06
	Winter	Late	500	22	05/26	05/09	07/16
	Spring	Late	495	91	(05/11)	04/15	07/20
2001	Spring	Late	6	4	(05/17)	05/04	05/20
Lostine River:							
2000	Fall	Early	514	59	04/18	04/03	05/13
	Winter	Late	511	51	05/09	04/20	07/02
	Spring	Late	355	65	(05/22)	04/14	7/16
2001	Fall	Early	500	139	04/27	04/12	05/18
	Winter	Late	500	113	05/14	04/16	06/19
	Spring	Late	445	246	(05/12)	04/21	07/04
Minam River:							
2001	Fall	Early	300	107	04/28	04/12	05/26
	Spring	Late	539	274	(05/14)	04/16	08/18

Appendix Table A-7. Travel time to Lower Granite Dam of juvenile spring chinook salmon PIT-tagged at upstream screw traps in the spring and arriving at Lower Granite Dam the same year. Bold mean indicates normal distribution of travel times. Bold median indicates non-normal distribution.

Stream, migratory year	Number detected	Travel time (days)		
		Mean	Median	Range
Catherine Creek:				
2000	52	53.9	**50.5**	20 – 95
2001	100	**63.7**	64.5	15 – 110
Upper Grande Ronde River:				
2000	91	**49.7**	50.5	12 – 98
2001	4	**39.9**	37.5	29 – 56
Lostine River:				
2000	65	**33.6**	32.5	5 – 90
2001	246	26.1	**23.6**	5 – 90
Minam River:				
2001	274	**38.9**	39.5	9 – 106

Appendix Table A-8. Detection rates of juvenile spring chinook salmon PIT-tagged on the upper Grande Ronde River, Catherine Creek, and the Lostine, Minam, and Imnaha rivers by tag group and dam site during the 2001 migratory year. Detection rates are presented as a percentage of the total fish tagged and released. Numbers of fish detected are in parentheses.

Stream, tag group	Number released	Lower Granite	Little Goose	Lower Monumental	McNary	John Day	Bonneville	Total
Upper Grande Ronde River:								
Spring	6	66.67 (4)	16.67 (1)	0.00 (0)	0.00 (0)	0.00 (0)	0.00 (0)	83.33 (5)
Catherine Creek:								
Summer	498	6.63 (33)	1.61 (8)	0.00 (0)	0.00 (0)	0.00 (0)	0.00 (0)	8.23 (41)
Fall	508	11.22 (57)	1.18 (6)	0.20 (1)	0.20 (1)	0.00 (0)	0.00 (0)	12.80 (65)
Winter	522	5.17 (27)	1.72 (9)	0.00 (0)	0.00 (0)	0.00 (0)	0.00 (0)	6.90 (36)
Spring	328	30.49 (100)	5.18 (17)	0.30 (1)	0.00 (0)	0.00 (0)	0.00 (0)	35.98 (118)
Lostine River:								
Summer	489	17.79 (87)	2.66 (13)	0.20 (1)	0.00 (0)	0.00 (0)	0.00 (0)	20.65 (101)
Fall	498	27.91 (139)	4.62 (23)	0.20 (1)	0.20 (1)	0.00 (0)	0.00 (0)	32.93 (164)
Winter	499	22.65 (113)	4.21 (21)	0.40 (2)	0.40 (2)	0.00 (0)	0.00 (0)	27.66 (138)
Spring	450	54.67 (246)	10.22 (46)	1.56 (7)	0.44 (2)	0.00 (0)	0.00 (0)	66.89 (301)
Minam River:								
Summer	1,000	17.80 (178)	3.70 (37)	0.40 (4)	0.20 (2)	0.00 (0)	0.00 (0)	22.10 (221)
Fall	300	35.67 (107)	5.67 (17)	0.00 (0)	0.67 (2)	0.00 (0)	0.00 (0)	42.00 (126)
Spring	536	51.12 (274)	7.84 (42)	1.12 (6)	0.19 (1)	0.00 (0)	0.19 (1)	60.45 (301)
Imnaha River:								
Summer	1,000	15.90 (159)	2.00 (20)	0.00 (0)	0.10 (1)	0.00 (0)	0.00 (0)	18.00 (180)

Appendix Table A-9. PIT tag detection rates, CJS survival probabilities, and numbers of fish tagged and detected for juvenile spring chinook salmon by stream, 1993-2001 migratory years.

Stream, migratory year	Tag group	Number tagged	Number detected	Detection rate: Rate	Detection rate: 95% CI	CJS survival probability: Probability	CJS survival probability: 95% CI
Catherine Creek:							
1993	summer	1,096	171	0.156	0.135 - 0.179	0.178	0.151 - 0.212
1994	summer	1,000	166	0.166	0.143 - 0.191	0.226	0.186 - 0.279
1995	summer	1,000	138	0.138	0.117 - 0.161	0.154	0.129 - 0.184
1995	fall	502	100	0.199	0.165 - 0.237	0.238	0.193 - 0.297
1995	winter	482	116	0.241	0.203 - 0.281	0.279	0.230 - 0.343
1995	spring	348	157	0.451	0.398 - 0.505	0.506	0.441 - 0.578
1996	summer	499	89	0.178	0.146 - 0.215	0.277	0.205 - 0.406
1996	summer(trap)	102	14	0.137	0.077 - 0.220	0.431	0.140 - 6.335
1996	fall	508	144	0.283	0.245 - 0.325	0.358	0.296 - 0.446
1996	winter	295	40	0.136	0.099 - 0.180	0.312	0.163 - 1.008
1996	spring	276	119	0.431	0.372 - 0.492	0.591	0.480 - 0.755
1997	summer	585	84	0.144	0.116 - 0.175	0.176	0.139 - 0.225
1997	fall	403	82	0.203	0.165 - 0.246	0.365	0.256 - 0.588
1997	winter	102	7	0.069	0.028 - 0.136	0.078	0.033 - 0.222
1997	winter(trap)	86	21	0.244	0.158 - 0.349	0.302	0.187 - 0.597
1997	spring	78	29	0.372	0.265 - 0.489	0.413	0.292 - 0.580
1998	summer	495	81	0.164	0.132 - 0.199	0.211	0.164 - 0.276
1998	summer(trap)	175	31	0.177	0.124 - 0.242	0.190	0.131 - 0.275
1998	fall	598	116	0.194	0.163 - 0.228	0.238	0.194 - 0.293
1998	winter	438	101	0.231	0.192 - 0.273	0.278	0.226 - 0.345
1998	spring	453	208	0.459	0.413 - 0.506	0.517	0.459 - 0.583
1999	summer	502	71	0.141	0.112 - 0.175	0.157	0.122 - 0.212
1999	fall	656	114	0.174	0.146 - 0.205	0.202	0.166 - 0.250
1999	winter	494	116	0.235	0.198 - 0.275	0.285	0.230 - 0.367
1999	spring	502	181	0.361	0.318 - 0.404	0.448	0.379 - 0.545
2000	summer	497	54	0.109	0.083 - 0.139	0.151	0.109– 0.217
2000	fall	677	108	0.160	0.133 - 0.189	0.212	0.170– 0.269
2000	winter	500	56	0.112	0.086 - 0.143	0.138	0.102– 0.191
2000	spring	431	130	0.302	0.259 - 0.347	0.452	0.359– 0.598
2001	summer	498	41	0.082	0.060 - 0.110	0.087	0.063– 0.115
2001	fall	508	65	0.128	0.100 - 0.160	0.130	0.103– 0.162
2001	winter	522	36	0.069	0.049 - 0.094	0.077	0.054– 0.106
2001	spring	328	118	0.360	0.308 - 0.414	0.376	0.322– 0.433

Appendix Table A-9. Continued.

Stream, migratory year	Tag group	Number tagged	Number detected	Detection rate		CJS survival probability	
				Rate	95% CI	Probability	95% CI
Upper Grande Ronde River:							
1993	summer	921	204	0.221	0.195 - 0.250	0.287	0.237– 0.365
1994	summer	1,001	90	0.090	0.073 - 0.109	0.144	0.110– 0.197
1994	fall	405	110	0.272	0.229 - 0.318	0.348	0.284– 0.432
1994	winter	505	58	0.115	0.088 - 0.146	0.248	0.152– 0.519
1994	spring	573	189	0.330	0.291 - 0.370	0.462	0.387– 0.563
1995	summer	999	142	0.142	0.121 - 0.165	0.173	0.144– 0.209
1995	fall	424	87	0.205	0.168 - 0.247	0.228	0.184– 0.281
1995	winter	433	62	0.143	0.112 - 0.180	0.151	0.115– 0.199
1995	spring	368	204	0.554	0.502 - 0.606	0.609	0.545– 0.683
1996	fall	5	1	0.200	0.005 - 0.716	–	– –
1996	spring	327	118	0.361	0.309 - 0.416	0.512	0.404– 0.690
1997	fall	27	4	0.148	0.042 - 0.337	–	– –
1997	spring	1	1	1.000	0.500 1.000	–	– –
1998	fall	592	150	0.253	0.219 - 0.290	0.286	0.244– 0.334
1998	winter	124	13	0.105	0.057 - 0.173	0.113	– –
1998	spring	513	240	0.468	0.424 - 0.512	0.548	0.487– 0.622
1999	fall	500	130	0.260	0.222 - 0.301	0.269	0.229– 0.315
1999	winter	420	42	0.100	0.073 - 0.133	0.117	0.082– 0.182
1999	spring	535	270	0.505	0.461 - 0.548	0.538	0.486– 0.600
2000	fall	493	107	0.217	0.181 - 0.256	0.341	0.260– 0.476
2000	winter	500	56	0.112	0.086 - 0.143	0.133	0.099– 0.183
2000	spring	495	191	0.386	0.343 - 0.430	0.560	0.472– 0.680
2001	spring	6	5	0.833	0.359 - 0.996	–	– –
Grande Ronde River at Elgin:							
2001	spring	4	3	0.750	0.194 - 0.994	–	– –
Lostine River:							
1993	summer	1,001	207	0.207	0.182 - 0.233	0.250	0.214– 0.296
1994	summer	725	123	0.170	0.143 - 0.199	0.237	0.188– 0.309
1995	summer	1,002	181	0.181	0.157 - 0.206	0.215	0.183– 0.255
1996	summer	978	155	0.158	0.136 - 0.183	0.237	0.191– 0.306
1997	summer	527	83	0.157	0.127 - 0.191	0.213	0.160– 0.310
1997	fall	519	135	0.260	0.223 - 0.300	0.312	0.247– 0.465
1997	winter	390	106	0.272	0.228 - 0.319	0.445	0.334– 0.650
1997	spring	476	246	0.517	0.471 - 0.563	0.769	0.630– 1.009

Appendix Table A-9. Continued.

Stream, migratory year	Tag group	Number tagged	Number detected	Detection rate: Rate	Detection rate: 95% CI	CJS survival probability: Probability	CJS survival probability: 95% CI
Lostine River:							
1998	fall	500	193	0.386	0.343 - 0.430	0.448	0.391– 0.514
1998	winter	504	156	0.310	0.269 - 0.352	0.349	0.301– 0.403
1998	spring	466	328	0.704	0.660 - 0.745	0.784	0.728– 0.845
1999	summer	506	87	0.172	0.140 - 0.208	0.180	0.145– 0.234
1999	fall	501	167	0.333	0.292 - 0.377	0.422	0.349– 0.538
1999	winter	491	139	0.283	0.244 - 0.325	0.305	0.259– 0.363
1999	spring	600	363	0.605	0.565 - 0.644	0.744	0.664– 0.857
2000	summer	509	76	0.149	0.119 - 0.183	0.212	0.159– 0.294
2000	fall	514	137	0.267	0.229 - 0.307	0.317	0.267– 0.380
2000	winter	511	114	0.223	0.188 - 0.262	0.397	0.296– 0.576
2000	spring	355	159	0.448	0.395 - 0.501	0.660	0.546– 0.823
2001	summer	489	101	0.207	0.172 - 0.245	0.210	0.175– 0.248
2001	fall	498	164	0.329	0.288 - 0.373	0.335	0.294– 0.378
2001	winter	499	138	0.277	0.238 - 0.318	0.284	0.245– 0.326
2001	spring	450	301	0.669	0.623 - 0.712	0.695	0.648– 0.741
Minam River:							
1993	summer	1,000	152	0.152	0.130 - 0.176	0.187	0.155– 0.230
1994	summer	997	213	0.214	0.189 - 0.240	0.293	0.249– 0.350
1995	summer	996	124	0.124	0.105 - 0.147	0.153	0.124– 0.191
1996	summer	998	154	0.154	0.132 - 0.178	0.208	0.169– 0.264
1997	summer	589	102	0.173	0.143 - 0.206	0.270	0.181– 0.693
1998	summer	1,010	207	0.205	0.180 - 0.231	0.228	0.199– 0.259
1999	summer	1,006	172	0.171	0.148 - 0.196	0.180	0.155– 0.210
2000	summer	998	175	0.175	0.152 - 0.200	0.239	0.199– 0.292
2001	summer	1,000	221	0.221	0.196 - 0.248	0.228	0.202– 0.256
2001	fall	300	126	0.420	0.364 - 0.478	0.427	0.371– 0.485
2001	spring	536	324	0.604	0.562 - 0.646	0.619	0.576– 0.661
Imnaha River:							
1993	summer	1,003	117	0.117	0.097 - 0.138	0.142	0.115– 0.180
1994	summer	998	108	0.108	0.090 - 0.129	0.136	0.109– 0.173
1995	summer	996	73	0.073	0.058 - 0.091	0.083	0.064– 0.108
1996	summer	997	188	0.189	0.165 - 0.214	0.268	0.222– 0.330
1997	summer	1,017	176	0.173	0.150 - 0.198	0.216	0.179– 0.276
1998	summer	998	280	0.281	0.253 - 0.310	0.325	0.290– 0.366
1999	summer	1,009	143	0.142	0.121 - 0.165	0.173	0.141– 0.219
2000	summer	982	114	0.116	0.097 - 0.138	0.141	0.115– 0.172
2001	summer	1,000	180	0.180	0.157 - 0.205	0.181	0.158– 0.206

Appendix Table A-9. Continued.

Stream, migratory year	Tag group	Number tagged	Number detected	Detection rate: Rate	Detection rate: 95% CI	CJS survival probability: Probability	CJS survival probability: 95% CI
Wenaha and South Fork Wenaha rivers							
1993	summer	751	142	0.189	0.162 - 0.219	0.214	0.180 – 0.254
1994	summer	998	129	0.129	0.109 - 0.152	0.144	0.121 – 0.172
1995	summer	999	120	0.120	0.101 - 0.142	0.146	0.119 – 0.180
1996	summer	997	158	0.158	0.136 - 0.183	0.212	0.172 – 0.271
1997	summer	62	16	0.258	0.155 - 0.385	–	– –

Appendix Table A-10. Comparisons of overwinter survival of spring chinook salmon parr in rearing areas upstream (above screw trap) and downstream (below screw trap) on Catherine Creek and the Lostine and Grande Ronde rivers. Screw traps are located on Catherine Creek at rkm 32, Lostine River at rkm 3, and Grande Ronde River at rkm 299, except migratory year 1995 when the upper Grande Ronde River trap was at rkm 257. *P*-value is based on the maximum likelihood ratio test comparing the fit of the null model (fall tag group survival probability = winter tag group survival probability) to the fit of the full model (fall tag group survival probability ≠ winter tag group survival probability).

	Catherine Creek		Lostine River		Grande Ronde River	
Migratory year	Area with higher overwinter survival	*P*-value	Area with higher overwinter survival	*P*-value	Area with higher overwinter survival	*P*-value
1994	—	—	—	—	Equivalent	0.331
1995	Equivalent	0.278	—	—	Downstream	0.020
1996	Equivalent	0.766	—	—	—	—
1997	Downstream	0.016	Equivalent	0.133	—	—
1998	Equivalent	0.289	Downstream	0.014	Downstream	<0.001
1999	Upstream	0.025	Downstream	0.014	Downstream	0.002
2000	Downstream	0.031	Equivalent	0.211	Downstream	<0.001
2001	Downstream	0.009	Equivalent	0.090	—	—

Appendix Table A-11. Overwinter survival rates of spring chinook salmon parr overwintering upstream of screw traps on Catherine Creek and the Lostine and Grande Ronde rivers. Screw traps are located on Catherine Creek at rkm 32, Lostine River at rkm 3, and Grande Ronde River at rkm 299, except migratory year 1995 when the upper Grande Ronde River trap was at rkm 257. Survival rates were calculated by dividing the CJS survival probability of the winter tag group by the CJS survival probability of the spring tag group.

Migratory year	Brood year	Overwinter survival in upper rearing areas		
		Catherine Creek	Lostine River	Upper Grande Ronde River
1994	1992	—	—	0.54
1995	1993	0.55	—	0.25
1996	1994	0.53	—	—
1997	1995	0.19	0.58	—
1998	1996	0.54	0.45	0.21
1999	1997	0.64	0.41	0.22
2000	1998	0.31	0.60	0.24
2001	1999	0.20	0.41	—

Appendix Table A-12. Median, first, and last migration dates to Lower Granite Dam for spring chinook salmon smolts PIT-tagged as parr during the previous summer, 1993–2001 migratory years. Migration date is date of detection at Lower Granite Dam. DOY = day of year.

	Number	Median		First		Last	
Stream, migratory year	detected	Date	DOY	Date	DOY	Date	DOY
Catherine Creek:							
1993	125	05/18	138	04/29	119	06/26	177
1994	91	05/11	131	04/13	103	07/26	207
1995	88	05/25	145	04/26	116	07/02	183
1996	60	05/01	122	04/17	108	05/29	150
1997	51	05/14	134	04/24	114	06/10	161
1998	43	05/17	137	04/24	114	06/04	155
1999	20	05/26	146	04/26	116	06/26	177
2000	30	05/07	128	04/12	103	06/07	159
2001	33	05/17	137	04/28	118	07/03	184
Upper Grande Ronde River:							
1993	117	05/17	137	04/23	113	06/20	171
1994	57	05/29	149	04/23	113	08/29	241
1995	89	05/29	149	04/12	102	07/01	182
Lostine River:							
1993	136	05/04	124	04/17	107	06/01	152
1994	77	05/02	122	04/19	109	06/07	158
1995	115	05/02	122	04/08	98	06/09	160
1996	129	05/15	136	04/17	108	06/19	171
1997	43	04/25	115	04/09	99	05/21	141
1999	19	05/15	135	03/29	88	05/29	149
2000	36	05/08	129	04/13	104	06/03	155
2001	87	05/09	129	04/10	100	06/12	163
Imnaha River:							
1993	74	05/14	134	04/15	105	06/23	174
1994	65	05/08	128	04/20	110	08/11	223
1995	41	05/02	122	04/10	100	070/7	188
1996	158	04/26	117	04/14	105	06/12	164
1997	98	04/19	109	03/31	90	06/02	153
1998	159	04/29	119	04/03	93	05/24	144
1999	41	05/08	128	04/17	107	06/03	154
2000	63	05/02	123	04/12	103	06/16	168
2001	159	04/30	120	04/08	98	05/28	148

Appendix Table A-12. Continued.

Stream, migratory year	Number detected	Median date	Median DOY	First date	First DOY	Last date	Last DOY
Minam River:							
1993	113	05/04	124	04/18	108	06/03	154
1994	120	04/29	119	04/18	108	08/13	225
1995	71	05/02	122	04/08	98	06/07	158
1996	117	04/24	115	04/10	101	06/07	159
1997	49	04/16	106	04/03	93	05/13	133
1998	123	04/29	119	04/03	93	05/30	150
1999	50	04/29	119	03/31	90	06/02	153
2000	74	05/03	124	04/10	101	05/29	150
2001	178	05/08	128	04/08	98	06/12	163
Wenaha and South Fork Wenaha rivers:							
1993	84	04/28	118	04/14	104	05/15	135
1994	93	04/24	114	04/18	108	06/06	157
1995	76	04/26	116	04/09	99	05/15	135
1996	105	04/21	112	04/13	104	05/16	137
1997	10	04/16	106	04/09	99	04/23	113

APPENDIX B

A Compilation of *Oncorhynchus mykiss* Data

Appendix Table B-1. Population estimates of wild *O. mykiss* in Catherine Creek and its tributaries above the screw trap (rkm 32) during summer.

Stream, year	Sampling methods	Estimation methods	Population estimate N	Population estimate 95% CI
Catherine Creek				
2000	Snorkel seine, hook and line	Mark-recapture	22,393	17,461–28,689
2001	Snorkel seine	Mark-recapture	25,736	21,005–31,519
South Fork Catherine Creek				
2000	electrofishing	Mark-recapture	9,971	5,892–18,002
North Fork Catherine Creek				
2001	Snorkel observation, electrofishing, snorkel seine	Mark-recapture, Hankin and Reeves	10,338	5,137–15,539

Appendix Table B-2. Age composition of *O. mykiss* sampled in Catherine Creek and two tributaries in summer 2000 and 2001. Age was determined by scale analysis.

Stream, year sampled	Age	N[a]	Length range (FL, mm)	Percent of population	95% CI
Catherine Creek					
2000	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
2001	0	0		(b)	
	1	196	72-163	86.7	81.6-90.7
	2	29	114-200	12.8	8.8-17.9
	3	1	221	0.4	0.0-2.4
South Fork Catherine Creek					
2000	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
North Fork Catherine Creek					
2001	0	8	52-98	17.3[c]	—
	1	106	70-159	55.9[c]	—
	2	52	118-213	24.4[c]	—
	3	6	178-215	2.5[c]	—

[a] *Number of fish for which age was determined.*
[b] *The fork lengths of 13 of the 1,024 (1.3%)* O. mykiss *measured on Catherine Creek were less than 72 mm. It is likely that some of these fish are age-0.*
[c] *Percentage of population in each age class calculated using an age-length key.*

Appendix Table B-3. Travel time to Lower Granite Dam of wild *O. mykiss* PIT-tagged at screw traps in spring and detected at the dam in the same migratory year. Bold mean indicates normal distribution of travel times. Bold median indicates non-normal distribution.

Stream	Migratory year	Number detected	Travel time (days) Mean	Median	Range
Upper Grande Ronde River	2000	73	**33.0**	31.2	6 – 78
	2001	180	36.7	**37.3**	8 – 152
Catherine Creek	2000	63	27.6	**26.6**	7 – 91
	2001	88	33.0	**33.2**	7 – 74
Lostine River	2000	166	17.2	**11.7**	4 – 66
	2001	164	17.6	**13.9**	5 – 109
Minam River	2001	240	21.8	**16.6**	5 – 110

Appendix Table B-4. Detections dates at Lower Granite Dam of wild *O. mykiss* PIT-tagged at screw traps as early and late migrants. Numbers of fish detected were expanded for spillway flow. Median detection dates that have a letter in common are not significantly different (Mann-Whitney rank sum test, $P < 0.05$). Parentheses indicate that correlation between the number tagged and the number migrating past the trap during spring was not determined and the median might be biased. * indicates no correlation between the number tagged and the number migrating, so median was biased.

Stream, migratory year	Season of tagging	Number tagged	Number detected	Detection dates Median	First	Last
Upper Grande Ronde River						
2000	Fall	110	7	04/30	04/18	05/26
	Spring	462	73	(05/07)	03/31	06/28
2001	Fall	61	10	05/07	04/28	06/29
	Spring	475	180	05/05*	04/26	08/28
Catherine Creek						
2000	Fall	989	43	04/20	04/02	06/29
	Spring	502	63	(05/06)	04/06	06/10
2001	Fall	561	66	05/06 a	04/18	06/12
	Spring	266	88	05/14 a	04/22	06/11
Lostine River						
2000	Fall	777	116	05/10	03/26	06/16
	Spring	532	166	(05/06)	04/13	06/13
2001	Fall	421	13	05/12 b	04/16	06/13
	Spring	345	164	05/14 b	04/13	08/18
Minam River						
2001	Fall	32	6	05/09 c	05/02	05/17
	Spring	454	240	05/07 c	04/26	08/29

Appendix Table B-5. Detections dates at Lower Granite Dam of wild *O. mykiss* that were PIT-tagged in the upper rearing areas of the Catherine Creek during summer 2000 and detected in 2001. Numbers of fish detected were expanded for spillway flow.

Stream	Number tagged	Number detected	Detection dates		
			Median	First	Last
Catherine Creek	412	19	05/08	04/25	06/25
North Fork Catherine Creek	117	2	05/07	05/01	05/12
South Fork Catherine Creek	225	5	05/06	05/02	05/14
Little Catherine Creek	415	0	—	—	—
Total	1,169	26	05/08	04/25	06/25

Appendix Table B-6. Detection dates at Lower Granite Dam of wild *O. mykiss* PIT-tagged at screw traps during fall and spring in migratory year 2000 and detected at the dam in migratory year 2001.

Stream	Number detected	Detection dates		
		Median	First	Last
Upper Grande Ronde River	7	05/03	04/30	06/06
Catherine Creek	25	05/04	04/02	05/26
Lostine River	22	05/04	04/27	06/07

Appendix Table B-7. Detection rates at Snake and Columbia River dams of wild *O. mykiss* PIT-tagged at screw traps during spring and fall. MY = Migratory year.

Stream, year and season of tagging		MY	Number tagged	Detections during MY			Detections during MY+1			All detections		
				Number	Rate	95% CI	Number	Rate	95% CI	Number	Rate	95% CI
Upper Grande Ronde River												
1999	Fall	2000	110	16	0.145	0.085-0.225	0	0.000	0.000-0.033	16	0.145	0.085-0.225
2000	Spring[a]	2000	324	99	0.306	0.256-0.359	1	0.003	0.000-0.017	100	0.309	0.259-0.362
	Spring[b]	2000	126	0	0.000	0.000-0.029	5	0.040	0.013-0.090	5	0.040	0.013-0.090
	Fall	2001	61	12	0.197	0.106-0.318	—	—	—	12	0.197	0.106-0.318
2001	Spring[a]	2001	465	196	0.422	0.376-0.468	—	—	—	196	0.422	0.376-0.468
	Spring[b]	2001	7	0	0.000	0.000-0.410	—	—	—	0	0.000	0.000-0.410
Catherine Creek												
1999	Fall	2000	989	73	0.074	0.058-0.092	14	0.014	0.008-0.024	87	0.088	0.071-0.107
2000	Spring[a]	2000	305	103	0.338	0.285-0.394	2	0.007	0.001-0.023	105	0.344	0.391-0.401
	Spring[b]	2000	186	0	0.000	0.000-0.020	10	0.054	0.026-0.097	10	0.054	0.026-0.097
	Fall	2001	561	67	0.119	0.094-0.149	—	—	—	67	0.119	0.094-0.149
2001	Spring[a]	2001	247	96	0.389	0.328-0.453	—	—	—	96	0.389	0.328-0.453
	Spring[b]	2001	19	1	0.053	0.001-0.260	—	—	—	1	0.053	0.001-0.260
Lostine River												
1999	Fall	2000	777	157	0.202	0.174-0.232	11	0.014	0.007-0.025	168	0.216	0.188-0.247
2000	Spring[a]	2000	442	234	0.529	0.482-0.577	4	0.009	0.002-0.023	238	0.538	0.491-0.586
	Spring[b]	2000	82	0	0.000	0.000-0.044	9	0.110	0.051-0.198	9	0.110	0.051-0.198
	Fall	2001	421	17	0.040	0.024-0.064	—	—	—	17	0.040	0.024-0.064
2001	Spring[a]	2001	323	182	0.563	0.507-0.618	—	—	—	182	0.563	0.507-0.618
	Spring[b]	2001	21	1	0.048	0.001-0.238	—	—	—	1	0.048	0.001-0.238
Minam River												
2000	Fall	2001	32	7	0.219	0.093-0.400	—	—	—	7	0.219	0.093-0.400
2001	Spring[a]	2001	442	269	0.609	0.561-0.654	—	—	—	269	0.609	0.561-0.654
	Spring[b]	2001	12	2	0.167	0.021-0.484	—	—	—	2	0.167	0.021-0.484

[a] *Only* O. mykiss *≥115 mm FL at time of tagging.*

[b] *Only* O. mykiss *<115 mm FL at time of tagging.*

Appendix Table B-8. Fork lengths of *O. mykiss* PIT-tagged at screw traps on Catherine Creek and the upper Grande Ronde, Lostine, and Minam rivers in the fall (early migrants), summarized by dam detection history. Bold type indicates whether lengths are normally distributed (Kolmogorov-Smirnov, P > 0.05), in which case mean is bold, or not normally distributed (median is bold).

Stream, migratory year tagged	Migratory year detected	N	Length at tagging (mm)						
			Median	Mean	95% CI	Percentile 25th	Percentile 75th	Minimum	Maximum
Upper Grande Ronde River									
2000	(a)	108	**132.5**	133.7	± 4.9	121.5	148	71	205
2001	(a)	60	124	**125.5**	± 6.7	100.5	144.5	86	180
	2001	12	152	**148.3**	± 12.7	133.5	160.5	115	180
Catherine Creek									
2000	(a)	986	**101**	110.6	± 2.3	76	142	60	200
	2000	73	148	**148.5**	± 5.7	132.8	162	67	195
	2001	14	77	**80.2**	± 7.6	73	86	61	118
2001	(a)	561	**136**	137.7	± 1.8	124	150.3	76	204
	2001	67	139	**141.9**	± 5.4	126.3	151.8	102	195
Lostine River									
2000	(a)	773	**153**	154.5	± 1.9	140	168	66	286
	2000	157	157	**159.3**	± 3.3	144	170	121	259
	2001	11	**105**	105	± 14.0	85	119	79	141
2001	(a)	421	**80**	90.5	± 2.9	73	91	61	235
	2001	17	161	**157.6**	± 18.2	145.8	177.5	95	212
Minam River									
2001	(a)	32	**121.5**	116.1	± 17.3	69	152.5	58	218
	2001	7	147	**143.1**	± 21.3	126	154.5	114	183

[a] *Data represents entire tag group, regardless of detection history.*

Appendix Table B-9. Fork lengths of *O. mykiss* PIT-tagged at upper screw traps on Catherine Creek and the upper Grande Ronde, Lostine, and Minam rivers in the spring (late migrants), summarized by dam detection history. 'NA' in Detection Year indicates data for whole tag group. Bold type indicates whether lengths are normally distributed (Kolmogorov-Smirnov, P > 0.05), in which case mean is bold, or not normally distributed (median is bold).

Stream, migratory year tagged	Migratory year detected	N	Length at tagging (mm)						
			Median	Mean	95% CI	Percentile 25th	Percentile 75th	Minimum	Maximum
Upper Grande Ronde River									
2000	(a)	453	**133**	130.6	2.7	107.8	152	71	225
	2000	99	155	**154.0**	3.7	139.3	166	115	208
	2001	6	**80**	90.7	22.7	77	109	72	126
2001	(a)	472	**146**	149.4	1.9	134	162.5	81	219
	2001	196	**156**	158.2	2.7	145	171	115	207
Catherine Creek									
2000	(a)	494	**131.5**	122.8	3.1	86	150	61	210
	2000	103	**152**	154.8	3.6	143	166.8	120	210
	2001	12	78.5	**88.1**	12.6	73	103.5	70	125
2001	(a)	266	141	**140.0**	2.5	127	153	77	190
	2001	97	150	**149.7**	3.6	137.8	161	114	190
Lostine River									
2000	(a)	526	**160**	155.0	3.1	145	175	66	329
	2000	234	**168**	170.1	2.4	157	179	123	236
	2001	13	**89**	100.6	18.0	79.5	127.5	66	158
2001	(a)	344	160	**161.0**	3.0	144	179	84	292
	2001	183	171	**172.9**	3.2	157	185	104	292

[a] *Data represents entire tag group, regardless of detection history.*

Appendix Table B-9. Continued.

Stream, migratory year tagged	Migratory year detected	N	Length at tagging (mm) Median	Mean	95% CI	Percentile 25th	75th	Minimum	Maximum
Minam River									
2001	(a)	454	159	**159.7**	2.2	143	177	78	227
	2001	271	167	**166.9**	2.5	150.3	183	78	227

Appendix Table B-10. Fork lengths of *O. mykiss* PIT-tagged upstream of the screw trap on Catherine Creek and its tributaries during summer 2000, summarized by migration history. Bold type indicates whether lengths are normally distributed (Kolmogorov-Smirnov, $P > 0.05$), in which case mean is bold, or not normally distributed (median is bold).

Group or migration history	N	Length at tagging (mm) Median	Mean	95% CI	Percentiles 25th	75th	Minimum	Maximum
All PIT-tagged	1,163	**113**	116.5	± 1.9	90.0	136.8	59	263
Fall 2000 trap recaptures	21	124	**121.5**	± 8.5	111.8	135.8	83	152
Spring 2001 trap recaptures	5	125	**121.4**	± 27.7	106.0	140.5	88	142
Migrated past trap before summer 2001	51	127	**125.2**	± 5.7	113.0	138.8	83	170
Still upstream after spring 2001	12	92	**95.8**	±13.0	83.5	106.0	63	136
Detected at dams during 2001	29	130	**128.9**	± 8.0	113.8	142.5	85	170