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

ANNUAL REPORT 2007

Project Period: 1 February 2007 to 31 January 2008

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Funded by:

U. S. Department of Energy
Bonneville Power Administration
Division of Fish and Wildlife
Portland, OR 97208-3621

Project Number 1992-026-04
Contract Number 36760

June 2008

ABSTRACT

This study was designed to document and describe the status and life history strategies of spring Chinook salmon and summer steelhead in the Grande Ronde River Subbasin. We determined migration timing, abundance, and life-stage survival rates for juvenile spring Chinook salmon *Oncorhynchus tshawytscha* and summer steelhead *O. mykiss* in four streams in the subbasin during migratory year 2007 from 1 July 2006 through 30 June 2007. As observed in previous years of this study, spring Chinook salmon and steelhead exhibited fall and spring movements out of their natal rearing areas, but did not begin their smolt migration through the Snake and lower Columbia River hydrosystem until spring. In this report we provide estimates of abundance and timing of migrants leaving each study stream, their survival and timing to Lower Granite Dam, and estimates of abundance of spring Chinook salmon parr and summer steelhead parr in Catherine Creek and spring Chinook salmon parr in Lostine River during summer. We also document aquatic habitat conditions using water temperature and stream flow in four study streams in the subbasin.

CONTENTS

CONTENTS (continued)

Page

TABLES

Number | Page

FIGURES

Number | Page

FIGURES (continued)

APPENDIX TABLES

Number | Page

APPENDIX TABLES (continued)

EXECUTIVE SUMMARY

Objectives

1. Document the in-basin migration patterns and estimate egg-to-migrant survival for spring Chinook salmon juveniles in Catherine Creek and the upper Grande Ronde, Minam, and Lostine rivers.

2. Determine overwinter mortality and the relative success of fall (early) migrant and spring (late) migrant life history strategies for spring Chinook salmon from tributary populations in Catherine Creek and the upper Grande Ronde, and Lostine rivers, and the relative success of fall (early) migrant and spring (late) migrant life history strategies for spring Chinook salmon from the Minam River.

3. Estimate and compare smolt survival probabilities at main stem Columbia and Snake River dams for migrants from four local, natural populations of spring Chinook salmon in the Grande Ronde River and Imnaha River subbasins.

4. Document the annual migration patterns for spring Chinook salmon juveniles from four local, natural populations in the Grande Ronde River and Imnaha River subbasins: Catherine Creek, Lostine, Minam, and Imnaha rivers.

5. Document patterns of movement for juvenile steelhead from tributary populations in Catherine Creek, the upper Grande Ronde, Lostine and the Minam rivers including data on migration timing, duration, and smolt abundance.

6. Estimate and compare survival probabilities to main stem Columbia and Snake River dams for summer steelhead from four tributary populations: Catherine Creek and the upper Grande Ronde, Lostine, and Minam rivers.

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

Accomplishments

We accomplished all of our objectives in 2007.

Findings

Spring Chinook Salmon

We determined migration timing and abundance of juvenile spring Chinook salmon *Oncorhynchus tshawytscha* using rotary screw traps on four streams in the Grande Ronde River Subbasin from 12 September 2006 through 11 June 2007. Based on migration timing and abundance, we distinguished two distinct life history strategies of juvenile spring Chinook salmon. 'Early' migrants left upper rearing areas from 12 September 2006 to 11 January 2007 with a peak in the fall. 'Late' migrants left upper rearing areas from 14 February 2007 to 11 June 2007 with a peak in the spring. At the upper Grande Ronde River trap, we estimated 17,109 juvenile spring Chinook salmon migrated out of upper rearing areas with approximately 31% leaving as early migrants. At the Catherine Creek trap, we estimated 13,831 juvenile spring Chinook salmon migrated out of upper rearing areas with 79% leaving as early migrants. At the Lostine River trap, we estimated 46,183 juvenile spring Chinook salmon migrated out of upper rearing areas with 74% leaving as early migrants. At the Minam River trap, we estimated 37,719 juvenile spring Chinook salmon migrated out of the river with 67% leaving as early migrants.

Juvenile spring Chinook salmon that were PIT-tagged in natal rearing areas of Catherine Creek and the Imnaha, Lostine, and Minam rivers during the summer of 2006 were detected at Lower Granite Dam between 4 April and 24 May 2007. Arrival timing to Lower Granite Dam was not significantly different among the four study streams ($P = 0.381$). Median arrival dates at Lower Granite Dam ranged from 23 April to 4 May. Survival probabilities were significantly lower for Chinook salmon PIT-tagged as parr in Catherine Creek (0.042) than for parr in the Lostine, Minam, and Imnaha rivers (0.159, 0.175, and 0.178, respectively) which were not significantly different from each other.

Chinook salmon tagged at the traps were detected at Lower Granite Dam between 5 April and 13 June 2007. Although there was overlap in arrival dates, median arrival dates for early migrants were before that of late migrants for all four streams. Early migrant survival probabilities to Lower Granite Dam ranged from 0.203 to 0.250, and late migrants ranged from 0.310 to 0.602. Among the four populations, the upper Grande Ronde River and Catherine Creek populations generally had lower rates of survival than the Lostine and Minam River populations.

During migratory year (MY) 2007, upper Grande Ronde and Catherine Creek juvenile spring Chinook salmon that overwintered downstream of trap sites (early migrants) survived at higher rates than juveniles that overwintered upstream of the traps (late migrants). For the Lostine River population, survival rates between fish that overwintered downstream or upstream of the trap were equivalent.

Summer Steelhead

We determined migration timing and abundance of juvenile steelhead/rainbow trout *Oncorhynchus mykiss* using rotary screw traps on four streams in the Grande Ronde River Subbasin during MY 2007. Based on migration timing and abundance, we distinguished early and late migration patterns, similar to those of spring Chinook salmon. For MY 2007, we estimated 12,632 steelhead migrants left upper rearing areas of the upper Grande Ronde River with 13% of these fish leaving as early migrants. We estimated 13,715 steelhead migrants left upper rearing areas in Catherine Creek with 73% of these fish leaving as early migrants. We estimated 13,162 steelhead migrated out of the Lostine River, with approximately 74% of these fish leaving as early migrants. We estimated 11,831 steelhead migrated from the Minam River with 28% of these fish leaving as early migrants.

The steelhead collected at trap sites during MY 2007 were comprised of four age groups. Early migrants ranged from 0 to 3 years of age, whereas late migrants ranged from 1 to 3 years of age. Smolts detected at Snake River and lower Columbia River dams ranged from 1 to 3 years of age with age-2 fish making up the highest percentage of seaward migrants.

Juvenile steelhead PIT-tagged at screw traps on Catherine Creek, and the upper Grande Ronde, Lostine, and Minam rivers were detected at Lower Granite Dam from 2 April to 12 June 2007. Median arrival dates for early migrants ranged from 5 May to 14 May. Median arrival dates for late migrants ranged from 7 May to 13 May.

The survival probability for steelhead tagged in the Catherine Creek drainage during the summer of 2006 was 0.072 for fish tagged in the main stem. We were not able to estimate survival probability in Little Catherine Creek because no fish were detected at Lower Granite Dam. Survival probabilities to Lower Granite Dam for early migrating steelhead ranged from 0.084 to 0.160. Survival probabilities to Lower Granite Dam for late migrants ranged from 0.179 to 0.684. Fish from Catherine Creek had consistently lower rates of survival than fish from the upper Grande Ronde, Lostine and Minam rivers.

Stream Condition

Daily mean water temperature typically fell within DEQ standards in all four study streams while the 2005 BY of spring Chinook salmon were in the Grande Ronde River Subbasin (1 August 2005–30 June 2007). The 2005 BY encountered daily mean water temperature in excess of the DEQ standard of 17.8°C for 43 of 596 days in the upper Grande Ronde River, 26 of 661 days Catherine Creek, 0 of 698 days in the Lostine River, and 59 of 698 days Minam River. Daily mean water temperatures in excess of 17.8°C occurred intermittently while eggs may have been being deposited in redds (August 2005), intermittently during parr rearing stages (June–August 2006), and during several days of early dispersal (August–September 2006) in the upper Grande Ronde River, Catherine Creek and the Minam River. Daily mean water temperature did not exceed 17.8°C on any day in the Lostine River. Temperatures preferred by juvenile Chinook salmon (10–15.6°C) occurred for 20% of the hours logged in the upper Grande Ronde River, 18% of the hours logged in Catherine Creek, 23% of the hours logged in the Lostine River and 16% of the hours logged in the Minam River. These optimal temperatures tended to occur May–June and August–October in all four study streams. Maximum water temperature considered lethal to Chinook salmon was encountered 10 of 596 days in the upper Grande Ronde River, two of 661 days in Catherine Creek, and 11 of 698 days in the Minam River. The moving mean of maximum daily water temperature showed that temperatures below the limit for healthy growth (4.4°C) occurred more often than temperature above the limit for healthy growth (18.9°C) in all four study streams. With the exception of the upper Grande Ronde River during January of 2006, stream discharge was relatively low and stable August through March. Spring run-off typically occurred April–May through July–August with peak flows occurring mid-May in all four study streams.

Management Implications and Recommendations

Rearing of juvenile spring Chinook salmon and summer steelhead in the Grande Ronde River Subbasin is not confined to the areas in which the adults spawn. Some of the juvenile spring Chinook salmon and steelhead from each of the study streams move out of natal rearing areas to overwinter in downstream areas of the subbasin before migrating toward the ocean as smolts the following spring or later. These movements of spring Chinook salmon and steelhead show that lower river habitats in the subbasin are used for more than migratory corridors, and point to a need for adequate habitat protection in all areas of the subbasin. Migration timing continues to vary between years and populations; therefore the need exists to manage the hydrosystem to maximize survival throughout the entire migratory period of Snake River spring/summer Chinook salmon and steelhead smolts.

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. The Grande Ronde River Subbasin is divided into three watershed areas: the Upper Grande Ronde River Watershed, the Lower Grande River Watershed, and the Wallowa River Watershed. The Upper Grande Ronde River Watershed includes the Grande Ronde River and tributaries from the headwaters to the confluence with the Wallowa River. The Lower Grande Ronde River Watershed includes the Grande Ronde River and tributaries, excluding the Wallowa River, from the Wallowa River to the confluence with the Snake River. The Wallowa River Watershed includes the Wallowa River and tributaries, including the Lostine and Minam rivers, from the headwaters to its confluence with the Grande Ronde River.

Historically, the Grande Ronde River Subbasin 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. Snake River spring/summer Chinook salmon, including Grande Ronde River spring Chinook salmon, were listed as threatened under the Endangered Species Act (ESA) in 1992. Snake River steelhead, including Grande Ronde River summer steelhead, were listed as threatened under the ESA in 1997. Six spring Chinook salmon populations have been identified in the subbasin (TRT 2003): Wenaha River; Wallowa–Lostine River (includes Wallowa River, Lostine River, Bear Creek and Hurricane Creek); Minam River; Catherine Creek (includes Catherine and Indian creeks); Upper Grande Ronde River (includes the upper Grande Ronde River and Sheep Creek); and Lookingglass Creek, of which the endemic spring Chinook salmon population is considered extinct. Four summer steelhead populations have been identified in the subbasin (TRT 2003): Lower Grande Ronde River (includes the main stem Grande Ronde River and all tributaries, except Joseph Creek, upstream to the confluence of the Wallowa River); Joseph Creek; Wallowa River (includes Minam and Lostine rivers); and Upper Grande Ronde River (includes the main stem upper Grande Ronde River, Lookingglass Creek, Catherine Creek, Indian Creek, and tributaries).

Anadromous fish production in the subbasin is limited by two overarching factors (Nowak 2004). Adult escapement of salmon and steelhead is limited by out-of-subbasin issues, such as juvenile and adult passage problems at Columbia and Snake River dams and out-of-subbasin overharvest, and is insufficient to fully seed the available habitat (Nowak 2004). The carrying capacity of the habitat and fish survival have been reduced within the subbasin by land management activities which have contributed to riparian and instream habitat degradation. Impacts to fish and aquatic habitats have included water withdrawal for irrigated agriculture, human residential development, livestock overgrazing, mining, channelization, low stream flows, poor water quality, mountain pine beetle damage, logging activity, and road construction (Nowak 2004). Many of these impacts have been reduced in recent years as management practices become more sensitive to fish and aquatic habitats, but the effects of past management remain (Nowak 2004).

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). This project is acquiring knowledge of juvenile migration patterns, smolt production, rates of survival, and juvenile winter rearing habitat within the subbasin. This project collects data to obtain life stage specific survival estimates (egg-to-parr, parr-to-smolt, and smolt-to-adult), and includes an evaluation of the importance and frequency at which alternative life history tactics are utilized by spring Chinook salmon populations in northeast Oregon.

The spring Chinook salmon and summer steelhead smolt migration from the Grande Ronde River Subbasin occurs in spring. Data from Lookingglass Creek (Burck 1993), Catherine Creek, Grande Ronde River, and Lostine River (Keefe et al. 1994, 1995; Jonasson et al. 1997, Van Dyke et al. 2001) indicate a substantial number of juveniles move out of upper rearing areas during fall and overwinter downstream within the Grande Ronde River Subbasin. 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.

Juvenile Chinook salmon that leave upper rearing areas in Catherine Creek and the upper Grande Ronde River in fall overwinter in the Grande Ronde Valley. Much of the habitat in these mid-reaches of the Grande Ronde River is degraded. Stream conditions in the Grande Ronde River below the city of 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 (Jonasson et al. 2006). Therefore winter rearing habitat quantity and quality in the Grande Ronde River valley may be important factors limiting spring Chinook salmon smolt production in the Grande Ronde River.

Juvenile steelhead that leave the upper rearing areas in fall and spring may continue rearing within the subbasin for an extended period of time (6 months to several years) before continuing on the smolt migration during the spring. Therefore rearing habitat is not limited to the areas where steelhead are spawned.

Numerous enhancement activities have been undertaken in an effort to recover spring Chinook salmon populations in the Grande Ronde River Subbasin. 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 collected by this project will serve as the foundation for assessing the effectiveness of programs currently underway.

SPRING CHINOOK SALMON INVESTIGATIONS

Methods

For the purpose of this report, we assume all juvenile spring Chinook salmon captured in traps were downstream “migrants”. A migratory year (MY) in the Grande Ronde River Subbasin begins on 1 July, which is the earliest calendar date juvenile spring Chinook salmon are expected to begin their migration to the ocean. The migratory year ends on 30 June the following calendar year. The term “brood year” (BY) refers to the calendar year in which eggs were fertilized. All spring Chinook salmon referred to in this report were naturally produced unless noted otherwise.

In-Basin Migration Timing and Abundance

We determined the in-basin migration timing and abundance of juvenile spring Chinook salmon in the upper Grande Ronde River, Catherine Creek, and the Lostine and Minam rivers by operating rotary screw traps during MY 2007. Spring Chinook salmon in each study stream exhibit two migratory life history patterns. Early migrants leave upper rearing areas in fall to overwinter in downstream habitat before continuing their seaward migration out of the subbasin the following spring. Late migrants exhibit another life history strategy whereby they overwinter in the upper rearing areas prior to initiating their seaward migration in spring. Designations of early and late migration periods were based on trends in capture rates at trap sites. A common period of diminished capture rates occur at all four trap sites in winter and was used to separate fish into early and late migration periods. We determined migration timing and abundance for both of these periods.

In the Grande Ronde River Subbasin, we operated four rotary screw traps (Figure 1). In the Upper Grande Ronde River Watershed, 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, and a second trap was located in Catherine Creek below spawning and upper rearing areas near the town of Union at rkm 32. In the Wallowa River Watershed, 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, and another trap was located on the Minam River below spawning and rearing areas at rkm 0. Although the intent was to operate the traps continuously through the year, there were times when a trap could not be operated due to high or low river flows or freezing conditions. There were also instances when traps were not operating due to debris blockage and mechanical breakdowns. No attempt was made to adjust population estimates for periods when traps were not operating. For this reason, estimates represent a minimum number of migrants.

Sampling and Marking: 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 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 scanned for PIT tags. Before scanning or marking, fish were anesthetized in an aerated bath containing 40–50 mg/L of tricaine methanesulfonate (MS-222). PIT tags were injected manually with a modified hypodermic syringe as described by Prentice et al. (1986, 1990) and Matthews et al. (1990, 1992) for fish with fork length (FL) greater than 54 mm. Syringes were disinfected for 10 min in 70% isopropyl alcohol and allowed to dry between each use. A portable tagging station that consisted of a computer, PIT tag reader, measuring board, and electronic balance was used to record the tag code, fork length (±1 mm), and weight (±0.1 g) of tagged fish. Fork lengths (mm) and weights (g) were measured from at least 100 juvenile spring Chinook salmon each week when possible. All fish were handled and marked at stream temperatures of 16°C or less and released within 24 hours of being tagged. River height was recorded daily from permanent staff gauges and 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. Chinook salmon fry and sexually mature parr were not included in migrant abundance estimates. Trap efficiency was determined by releasing a known number of marked fish above each trap and enumerating recaptures. Immature parr that exceeded 54 mm in FL were either caudal fin-clipped or PIT-tagged, whereas fish less than 55 mm in FL were marked with a caudal fin clip only. 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

$$\hat{E}_j = R_j / M_j , \tag{1}$$

where $\hat{E}_j$ is the estimated trap efficiency for week j, R_j is the number of marked fish recaptured during week j, and M_j is the number of marked fish released upstream during week j.

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

$$\hat{N}_j = U_j / \hat{E}_j , \tag{2}$$

where $\hat{N}_j$ is the estimated number of fish migrating past the trap for week j , U_j is the total number of unmarked fish captured that week, and $\hat{E}_j$ is the estimated trap efficiency for week j. 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 less than 10 fish were recaptured in a week, bootstrap variance estimates were greatly expanded. For this reason, consecutive weeks were combined 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 $\hat{N}_j^*$ from equations (1 and 2) drawing Rj^* and U_j^* from the binomial distribution, where asterisks denote bootstrap values. Variance of $\hat{N}_j^*$ 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

$$95\%\,CI = 1.96\sqrt{V}\ , \tag{3}$$

where *V* is the estimated total variance determined from the bootstrap.

The upper Grande Ronde River, Catherine Creek, and Lostine River traps were located below hatchery spring Chinook salmon release sites. The magnitude of hatchery spring Chinook salmon releases into these streams during the spring required modifications to the methods used for estimating migrant abundance of wild spring Chinook salmon at the trap sites. During low hatchery spring Chinook salmon 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 2 or 4 h interval 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 2 and 4 h time blocks.

Systematic sampling required estimating the proportion of the total daily catch captured during each sampling interval. This proportion was estimated by fishing the trap over several 24 h periods prior to systematic sampling. The number of fish trapped during the 2 or 4 h sampling interval and the number in the remaining interval within each 24 h period were counted. The proportion of the total daily catch captured during the sampling interval (*i*) was estimated by

$$\hat{P}_i = S_i / C\ , \tag{4}$$

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

Estimates of trap efficiency could not be obtained during systematic sampling, so trap efficiency was calculated using mark–recapture numbers from one week before and after the systematic sampling period. Abundance of wild juvenile spring Chinook salmon at each trap during the systematic sampling period was estimated by

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

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 (9), and $\hat{E}$ is the estimated trap efficiency. Abundance for the total migration at the Catherine Creek, upper Grande Ronde, 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

Detections of PIT tagged fish at Lower Granite Dam (the first Snake River dam encountered) were used to estimate migration timing, while survival probabilities to Lower Granite Dam were estimated using detections of PIT tagged fish at Snake and Columbia River dams. Both estimates were calculated for summer, fall, winter, and spring tag groups.

The summer tag groups consisted of age-0 parr tagged during July and August 2006 in their upstream rearing habitat. This group included fish that moved out of upper rearing areas either as early or late migrants, and consequently overwintered either in the lower or the upper rearing areas, respectively before continuing their downstream migration. Therefore, the summer tag group represented timing and survival for the population as a whole.

Summer tag group fish were captured using snorkel–seining methods, whereby 2 or 3 snorkelers herded parr downstream into a seine held perpendicular to the stream flow. Traditional beach seining was also used in a few areas. Captured fish were held in aerated, 19-L buckets and transferred periodically to live cages anchored in shaded areas of the stream near marking stations. The goal was to PIT-tag 500 parr per stream on Catherine Creek and the Lostine River, and 1,000 parr per stream on the Minam and Imnaha rivers for the summer tag groups.

The fall tag groups represented early migrants that left the upstream rearing areas in the fall and overwintered downstream of screw traps. For consistency with previous years' data, fish tagged as they moved downstream past the upper trap sites between 1 September 2006 and 28 January 2007 were designated the fall tag group. Early migrants were captured, tagged, and released at the screw traps on the upper Grande Ronde River, Catherine Creek, Lostine River, and Minam River. The goal was to PIT-tag 500 fish at each trap throughout the early migration.

Both the winter and spring tag groups represented late migrants that overwintered as parr upstream of the screw traps and migrated downstream in the spring. The winter group was tagged earlier in the upper rearing areas (December 2006) than the spring group, which were tagged at the screw trap as migrants (29 January–30 June 2007). Therefore, the winter tag group experienced overwinter mortality after tagging while the spring tag group did not. Winter tag group fish were caught, tagged, and released 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. Fish were caught using dip nets while snorkeling at night. The goal was to PIT-tag 500 fish in the upper Grande Ronde River, Catherine Creek, and the Lostine River for winter tag groups.

Spring migrants were captured, tagged, and released at the screw traps on the upper Grande Ronde River, Catherine Creek, Lostine River, and Minam River. The goal was to PIT-tag 500 fish at each trap throughout the spring migration.

During MY 2007, all fish were scanned for PIT tags upon capture in all screw traps. Additionally, PIT tag interrogation systems were used in juvenile bypass systems at seven of eight Snake River and Columbia River dams to monitor fish passage. All recaptured and interrogated fish were identified by their original tag group, insuring the independence of tag groups for analysis. At the completion of MY 2007, detection information was obtained from juvenile PIT tag interrogation sites at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, and Bonneville dams.

Calculations: *Migration Timing:* The timing of migration past Lower Granite Dam was estimated for each tag group by expanding total daily numbers of PIT tag detections relative to the proportion of river outflow and spill. This procedure was necessary because some fish may have passed undetected over the spillway and the amount of spill varies throughout the migration season. The proportion of fish that passed over the spillway was assumed to be directly related to the proportion of flow spilled. This assumption conforms fairly well to data obtained using non-species-specific hydroacoustic methods (Kuehl 1986). It was also assumed that there was no temporal variation either in the proportion of fish diverted from turbine intakes into the bypass system or in the proportion of fish that passed through the surface bypass collector. These assumptions were made 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 the 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 in a particular tag group migrating past Lower Granite Dam by day ($\hat{N}_d$) was estimated by multiplying the number of fish from the tag group that were detected each day by a daily expansion factor calculated using Lower Granite Dam forebay water flow data obtained from the U.S. Army Corps of Engineers at the DART website (www.cbr.washington.edu/dart/river.html):

$$\hat{N}_d = D_d \times \frac{O_d + L_d}{O_d}, \tag{6}$$

where D_d is the number of PIT tagged fish from a tag group detected at Lower Granite Dam on day *d*, O_d is the outflow (kcfs) measured at Lower Granite Dam forebay on day *d*, and L_d is the spill at Lower Granite dam spill (kcfs) on day *d*. Each daily estimate was rounded in the nearest integer. Daily estimates were added for each week to obtain weekly migration timing estimates for each tag group, which were reported graphically. First and last arrival dates were reported for each tag group. The median arrival date of each tag group was determined from the daily estimates. Late migrants are tagged while fish are actively migrating seaward, whereas PIT tagged early migrants stop migrating and overwinter prior to resuming seaward migration in the spring. Simulated chi-square tests using the number of PIT tag releases and the estimated number of migrants for each week have shown that these two variables are independent when both trap efficiency estimates and annual peaks in movement vary (random). Therefore, median arrival dates may be biased on the distribution of PIT tag releases. In hopes of reducing this bias we used winter tag group to represent the late migrants when comparing migration timing differences with early migrants. The travel times for the spring tag groups to reach Lower Granite Dam from the screw traps were summarized for each location.

Survival Probabilities: The probability of survival to Lower Granite Dam for fish in each tag group was calculated using the Cormack–Jolly–Seber method in the SURPH 2.2b program (Lady et al. 2001). This method takes into account the probability of detection when calculating the probability of survival.

Overwinter Survival: Survival probabilities for the winter tag group and the spring tag group were used to indirectly estimate the overwinter survival ($\hat{S}_{s,overwinter}$) for late migrants in the upstream rearing habitat on the upper Grande Ronde River, Catherine Creek, and the Lostine River:

$$\hat{S}_{s,overwinter} = \frac{\hat{S}_{s,winter}}{\hat{S}_{s,spring}} \tag{7}$$

where $\hat{S}_{s,winter}$ is the survival probability to Lower Granite Dam for the winter tag group from stream *s, and* $\hat{S}_{s,spring}$ is the survival probability to Lower Granite Dam for the spring tag group from stream *s*.

Population Characteristics and Comparisons: The summer tag groups include the various life history patterns displayed by a population and provides information about the population's overall survival and timing past the dams. In summer of 2005 and 2006, PIT tagged parr from populations in Catherine Creek and the Lostine, Minam, and Imnaha rivers were used to monitor and compare their migration timing as smolts to Lower Granite Dam and their survival probabilities from tagging to the dams on the Snake River. Tagging operations were conducted in late summer (Table 1) so that most fish would be large enough to tag (FL $\geq$ 55 mm). Sampling occurred primarily in areas where spawning adults were concentrated the previous year.

Migration Timing: Differences in migration timing between populations were determined using a Kruskal–Wallis one-way ANOVA on ranks on dates of arrival, expressed as day of the year, of expanded total daily PIT tag detections (see expansion explanation in **Migration Timing and Survival to Lower Granite Dam: *Calculations*: *Migration Timing***). When significant differences were found, the Dunn's pairwise multiple comparison procedure was used ($\alpha = 0.05$) to compare arrival dates among populations.

Survival Probabilities: Survival probabilities were compared between populations using the modeling and hypothesis testing capabilities of Surph 2.2b (Lady et al. 2001). Several possible models describing differences of survival probabilities among populations were developed, and the model that best-fit the data was selected using Akaike's Information Criterion. This model of best fit was tested against the full (H_a) or null (H_o) model using likelihood ratio tests to determine if there were statistically significant differences in survival probabilities between populations.

Comparison of Life History Strategies within Populations: Tests were performed to determine if the early or late migrant life histories were associated with differences in migration timing to Lower Granite Dam, and survival to main stem Snake and Columbia River dams.

Migration Timing: Timing of migration past Lower Granite Dam was compared between the fall (early migrants) and winter (late migrants) tag groups from upper Grande Ronde River, Catherine Creek, and the Lostine River to investigate differences in migration timing. Comparisons were made using the Mann–Whitney rank sum test on arrival dates. Spillway flow (and the passage of undetected PIT tagged fish at the dam) was taken into account when expanding daily detections (see expansion explanation in **Migration Timing and Survival to Lower Granite Dam: *Calculations*: *Migration Timing***). A winter tag group was not available for the Minam River, so no comparison of median arrival dates were made for this population.

Survival Probabilities: Fish that moved out of upstream rearing areas overwintered in different habitats than fish that remained upstream, and each group was subject to different environmental conditions. Selecting different overwintering habitats may have implications on overwinter survival. For each stream, relative success of early and late migrants was evaluated 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. Any difference in survival probabilities between these two groups was assumed to be due to differential survival in upstream (used by winter tag group) and downstream (used by fall tag group) overwintering habitat. Since the fall group was tagged before the winter group, a lower survival estimate for the fall tag group could be due to elapsed time rather than a difference in over wintering conditions.

Results and Discussion

In-Basin Migration Timing and Abundance

Upper Grande Ronde River: The upper Grande Ronde River trap fished for 152 d between 19 September 2006 and 13 June 2007 (Table 2). There was a distinct early and late migration exhibited by juvenile spring Chinook salmon at this trap site (Figure 2). Systematic subsampling comprised 17 of the 94 d the trap was fished during late migration period, and a total of 261 juvenile Chinook salmon were caught during this period. The median emigration date for early migrants passing the trap was 20 October 2006, and the median emigration date for late migrants passing the trap was 13 March 2007 (Appendix Table A-1). These dates fall within the range of median dates previously recorded for this study but tended to be earlier than most years.

We estimated a minimum of 17,109 (95% CI, ± 1,708) juvenile spring Chinook salmon migrated out of the upper Grande Ronde River rearing areas during MY 2007 (Appendix Table A-1). Based on the total minimum estimate, 31% (7,846 ± 306) of the juvenile spring Chinook salmon were early migrants and 69% (11,753 ± 1,680) were late migrants. A dominant late migration in the upper Grande Ronde River is consistent with most migratory years studied (Appendix Table A-1).

Catherine Creek: The Catherine Creek trap fished for 164 d between 18 September 2006 and 11 June 2007 (Table 2). There was a distinct early migration exhibited by juvenile spring Chinook salmon at this trap site, but there was not a distinct peak in the late migration in MY 2007 (Figure 2), which was similar to the patterns observed since MY 2000. Systematic subsampling comprised 6 of the 104 d the trap was fished during late migration period, and a total of 46 juvenile Chinook salmon were caught during this period. The median emigration date for early migrants passing the trap was 14 October 2006, and the median emigration date for late migrants was 29 March 2007. The early median emigration dates was within the range of median dates reported from previous years of this study, however the late median emigration date was the latest recorded to date in this study (Appendix Table A-1).

We estimated a minimum of 13,831 ± 1,032 juvenile spring Chinook salmon migrated out of the upper Catherine Creek rearing areas during MY 2007. This migrant estimate was within the range of population estimates previously reported for this study (Appendix Table A-1). Based on the total minimum estimate, 79% (10,936 ± 788) migrated early and 21% (2,895 ± 667) migrated late. In contrast with migrants from the upper Grande Ronde River, the principal migration from Catherine Creek has consistently been observed during the early migrant period.

Lostine River: The Lostine River trap fished for 230 d between 12 September 2006 and 15 June 2007 (Table 2). Distinct early and late migrations were evident at this trap site (Figure 2). Systematic subsampling comprised 15 of the 118 d the trap was fished during the late migration period, and a total of 1,056 juvenile Chinook salmon were caught during this period. The median emigration date for early migrants was 14

October 2006, and the median date for late migrants was 7 April 2006. Both dates were within the range reported in previous years of this study (Appendix Table A-1).

We estimated a minimum of 46,183 ± 4,827 juvenile spring Chinook salmon migrated out of the Lostine River during MY 2007. Based on the minimum estimate, 74% (34,250 ± 4,720) of the juvenile spring Chinook salmon migrated early and 26% (11,933 ± 1,013) migrated late. The percentage of late migrants is within the range reported from previous years of this study (Appendix Table A-1). The Lostine River population appears to be similar to the Catherine Creek population in that the largest emigration has been observed during the early migrant period (Appendix Table A-1).

Minam River: The Minam River trap fished for 181 d between 11 September 2006 and 15 June 2007 (Table 2). Distinct early and late migrations were evident (Figure 2). The median emigration date of early migrants was 5 November 2006, and the median date for late migrants was 22 March 2007.

We estimated a minimum of 37,719 ± 5,767 juvenile spring Chinook salmon migrated out of the Minam River during MY 2007. Based on the minimum estimate, 69% (25,875 ± 5,517) of the juvenile spring Chinook salmon migrated early and 31% (11,844 ± 1,680) migrated late. The percentage of late migrants is within the range reported from previous years of this study (Appendix Table A-1).

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 3 and 4. Length frequency distributions of juvenile spring Chinook salmon caught in all traps by migration period are shown in Figure 3. Weekly mean lengths of migrants generally increased over time at each of the traps (Figure 4).

Migration Timing and Survival to Lower Granite Dam

Population Comparisons: During July–August 2006, Chinook salmon parr were PIT-tagged and released in upper rearing areas on Catherine Creek, the Lostine, Minam and Imnaha rivers (Table 1). Parr were captured in summer rearing areas upstream of screw traps. Information on the migration timing and survival of parr PIT-tagged in summer 2007 will be reported in 2008.

Migration Timing: Spring Chinook salmon parr PIT-tagged on Catherine Creek and the Imnaha, Lostine, and Minam rivers during summer 2006 were detected at Lower Granite Dam from 4 April to 24 May 2007 (Appendix Table A-2). The period of detection at Lower Granite Dam among the four populations ranged from 30 d (Catherine Creek) to 49 d (Imnaha River) in length. Median dates of arrival ranged from 23 April to 4 May (Figure 5). Median dates of arrival at Lower Granite Dam were not significantly different among the four populations during MY 2007 (Kruskal–Wallis, $P = 0.381$). The median arrival date for the Catherine Creek population was the earliest observed during this study, but the other three populations were within the previously-observed range of median arrival dates (Appendix Table A-2).

Survival Probabilities: Survival probabilities to Lower Granite Dam for parr tagged in the summer of 2006 were 0.042 for Catherine Creek, 0.159 for the Lostine River, 0.175 for the Minam River, and 0.178 for the Imnaha River population. Hypothesis testing indicated that the model Catherine ≠ Lostine = Minam = Imnaha had the best fit ($P < 0.001$). The survival probability for the Catherine Creek population was significantly lower than the other three populations, which did not differ significantly from each other (Table 5). Survival probabilities for the MY 2007 Catherine Creek population were the lowest observed for this study. Survival probabilities for the Lostine, Minam and Imnaha populations were within the range previously reported, and were relatively higher than survival probabilities reported in recent years (Appendix Table A-3).

Comparison of Early Life History Strategies: Juvenile spring Chinook salmon that were not previously marked were PIT-tagged at screw traps on the upper Grande Ronde River, Catherine Creek, Lostine River, and Minam River. Parr were also tagged upstream of the screw traps on the upper Grande Ronde River, Catherine Creek, and Lostine River during the winter. Total numbers of fish tagged in each group for each study stream is provided in Table 6.

Migration Timing: Median arrival dates at Lower Granite Dam for the fall, winter and spring tag groups on the upper Grande Ronde River were 11 May, 15 May, and 14 May 2007, respectively (Figure 6). Median arrival dates at Lower Granite Dam for the fall, winter, and spring tag groups tagged on Catherine Creek were 2 May, 13 May, and 13 May 2007, respectively (Figure 7). Median arrival dates at Lower Granite Dam for the fall, winter, and spring tag groups from the Lostine River were 17 April, 12 May, and 11 May 2007, respectively (Figure 8). Median arrival dates at Lower Granite Dam for the fall and spring tag groups on the Minam River were 16 April and 12 May 2007, respectively (Figure 9). Median arrival dates for fall tag groups from the Lostine and Minam rivers were earlier than previously observed, but all other median arrival dates were within the range previously observed at all trap sites (Appendix Table A-2).

As in past years, early migrants (fall tag group) reached Lower Granite Dam earlier than late migrants (winter tag group) from Catherine Creek, the upper Grande Ronde and Lostine rivers (each Mann–Whitney rank-sum test, $P < 0.001$). There was no winter tag group to compare with early migrants for the Minam River.

Upper Grande Ronde River late migrants took 10 to 73 d with a median of 55 d ($n = 79$) to travel from the screw trap to Lower Granite Dam. Travel times for Catherine Creek late migrants ranged from 14 to 83 d with a median of 46 d ($n = 42$). Travel times for Lostine River late migrants ranged from 6 to 84 d with a median of 35 d ($n = 109$). Travel times for Minam River late migrants ranged from 9 to 62 d with a median of 33 d ($n = 40$). Median travel time during MY 2007 was faster in Catherine Creek and the Minam River than previously observed. Travel time in the upper Grande Ronde and the Lostine River fell within the range previously observed (Appendix Table A-4).

Survival Probabilities: Survival probabilities to Lower Granite Dam for the fall, winter, and spring tag groups from the upper Grande Ronde River were 0.242, 0.138, and 0.373, respectively. Survival probabilities to Lower Granite Dam for the fall, winter and spring tag groups from Catherine Creek were 0.203, 0.088, and 0.310, respectively. Survival probabilities for the fall, winter and spring tag groups from the Lostine River were 0.223, 0.135, and 0.589, respectively. Survival probabilities for the fall and spring tag group from the Minam River were 0.250 and 0.602, respectively. Survival probabilities are generally higher for the spring tag groups because fish are not subject to the same overwinter mortality that the other tag groups experience (Table 6).

Overwinter survival of BY 2005 (MY 2007) fish in the upper rearing areas on the upper Grande Ronde River was 37%, and is within the range previously reported for this study (Appendix Table A-5). During MY 2007, fish that overwintered downstream of the upper Grande Ronde River trap survived at a significantly higher rate compared to fish that overwintered upstream of the trap (Maximum Likelihood Ratio test, $P = 0.012$). We have previously observed higher survival rates for fish overwintering downstream of the trap during MY 1995 and MY 1998-2000 (Appendix Table A-6). Upstream overwintering conferred better survival in MY 2004-2005, and survival rates were equivalent between overwintering habitats in MY 1994 and 2006 (Appendix Table A-6).

Overwinter survival of BY 2005 fish in the upper rearing areas on Catherine Creek was 28%, and was within the range previously observed during this study (Appendix Table A-5). During MY 2007, fish that overwintered downstream of the Catherine Creek trap survived at a significantly higher rate compared to fish that overwintered upstream of the trap (Maximum Likelihood Ratio test, $P < 0.001$). We have observed higher survival rates for fish overwintering downstream of the Catherine Creek trap in MY 1997 and MY 1999-2000 (Appendix Table A-6). However, overwinter survival has been mostly equivalent between upstream and downstream habitats (7 of 13 migratory years) while upstream habitats did confer better survival in MY 1999 and MY 2004 (Appendix Table A-6).

Overwinter survival of BY 2005 fish in the upper rearing areas on the Lostine River was 23%, and was the lowest percentage observed during this study (Appendix Table A-5). During MY 2007, the difference in survival between fish that overwintered upstream and downstream of the Lostine River trap was not significant (Maximum Likelihood Ratio test, $P = 0.115$). For the Lostine River, we have observed equivalent survival for upstream and downstream overwintering habitats for seven of ten years analyzed. The remaining three comparisons indicated higher survival rates for downstream-rearing fish (Appendix Table A-6).

SUMMER STEELHEAD INVESTIGATIONS

Methods

In the Grande Ronde River Subbasin, most steelhead populations are sympatric with rainbow trout populations and only steelhead smolts and mature adults can be visually differentiated from resident rainbow trout. For this reason all *Oncorhynchus mykiss* are referred to as steelhead in this report, even though some of these fish may be resident rainbow trout.

We studied the steelhead in Catherine Creek upstream of our screw trap in summer from 2000 to 2006 to learn more about the abundance, migration characteristics, growth rates, and size and age structure of the population. The abundance, growth rates, size and age structure of steelhead in Catherine Creek upstream of our screw trap in summer 2006 was reported in Van Dyke et al. (2008) and the migration timing and survival of these fish is reported in this report. We also used screw traps to study the movement of juvenile steelhead downstream from tributary habitats in Catherine Creek and the Lostine, Minam, and upper Grande Ronde rivers. We assumed all juvenile steelhead captured at trap sites were making directed downstream movements and not localized movements. Violation of this assumption would result in positively biased population estimates.

In-Basin Migration Timing and Abundance

The migration timing and abundance for steelhead in the upper Grande Ronde River, Catherine Creek, Lostine River, and Minam River were determined by operating rotary screw traps year round. As with spring Chinook salmon, summer steelhead exhibit two migrational life history patterns in the Grande Ronde River Subbasin (Van Dyke et al. 2001), so the same methodology described for operating screw traps and analyzing data for spring Chinook salmon was used for steelhead (*see* **SPRING CHINOOK SALMON INVESTIGATIONS; Methods; In-Basin Migration Timing and Abundance**).

Fork lengths (mm) and weights (g) were measured from randomly-selected steelhead caught each week at rotary screw traps throughout the migratory year. The same methodology described for spring Chinook salmon was used to sample and mark steelhead (*see* **SPRING CHINOOK SALMON INVESTIGATIONS; Methods; In-Basin Migration Timing and Abundance; *Sampling and Marking***). In previous years of this study, steelhead less than 115 mm in FL were not tagged in spring because fish in this size range were not detected at Snake or Columbia River dams during the same spring they were tagged. Although these criteria targeted only seaward migrating steelhead for the spring tag group, it failed to characterize the migration behavior of all the fish that migrated out of natal rearing areas in spring. Beginning in MY 2004, we tagged all size steelhead to fully document the level of alternate life history strategies used by each of the four populations. In addition, scale samples were taken during both migration periods. During the fall migration period, scales were taken from a subsample of steelhead (10 fish/10 mm FL group). During the spring migration period, scales were collected from a random sample of steelhead migrants regardless of size. Descriptive statistics and an age–length key were used to describe the age structure of early and late migrants collected at each trap site.

Migration Timing and Survival to Lower Granite Dam

Migration Timing: Detections of PIT tagged steelhead at Lower Granite Dam were used to estimate migration timing past this Snake River dam in the same manner as described for spring Chinook salmon (see **SPRING CHINOOK SALMON INVESTIGATIONS; Methods; Migration Timing and Survival to Lower Granite Dam**). The summer tag group represents steelhead tagged upstream of the upper trap site at the beginning of a migratory year (July) and was only conducted in Catherine Creek drainage in 2006. The fall tag group represents fish that moved downstream of the upper trap sites between 1 September and 28 January (early migrants). The spring tag group represents fish that moved downstream of the upper trap sites between 29 January and 30 June (late migrants). During the summer of 2006, the goal was to PIT-tag 500 steelhead in the main stem of Catherine Creek, and 500 fish in Little Catherine Creek. At each trap site the goal was to PIT-tag 600 steelhead for the fall tag group, and 500 fish for the spring tag group to assess migration timing of early and late migrants from each location.

Survival Probabilities: We monitored PIT tagged steelhead migration behavior the same as described for spring Chinook salmon (*see* **SPRING CHINOOK SALMON INVESTIGATIONS; Methods; Migration Timing and Survival to Lower Granite Dam**) using the three tag groups described above. However, since steelhead tagged during each migratory year of the study have been detected at the dams across more than one migratory year (Reischauer et al. 2003), survival probabilities were analyzed for each tag group by combining detection histories for every migratory year that fish were observed. Survival probabilities were calculated using the SURPH2.2b program (Lady et al. 2001).

Length and Age Characterization of Smolt Detections: We compared steelhead lengths at tagging, grouped by dam detection history, to investigate the relationship between size, migration patterns, and survival to the dams. The fork lengths of all steelhead tagged in the fall of 2006 were compared to the fork lengths of those subsequently detected at the dams in the spring of 2007 using a Mann–Whitney rank-sum test. The fork lengths of all steelhead tagged in the fall of 2005 were compared to the lengths of those detected in 2006 and 2007 using a Kruskal–Wallis one-way ANOVA on ranks. In addition, the fork lengths of steelhead tagged in the spring of 2007 were compared to the fork lengths of those subsequently detected at the dams in the spring of 2007 using a Mann–Whitney rank-sum test. The age structure of steelhead tagged at the traps and the age structure of the subset detected at the dams in the spring of 2007 were characterized. Only steelhead in which scale samples provided a known age at time of tagging were used for this analyses.

Migration Pattern of the Summer Tag Group: We summarized median length of steelhead tagged upstream of the Catherine Creek trap during the summer by year of tagging to investigate whether size at tagging was related to migration behavior. Individual lengths of fish were grouped by subsequent recapture events and dam detection history.

Results and Discussion

In-Basin Migration Timing and Abundance

Upper Grande Ronde River: The upper Grande Ronde River trap fished for 152 d between 19 September 2006 and 13 June 2007 (Table 7). Systematic subsampling comprised 17 of the 94 d the trap was fished during late migration period. A distinct early migration was not as evident at this trap site as most juvenile steelhead moved as late migrants during spring months, which is consistent with previous years of this study (Figure 10). The median emigration date for early migrants passing the trap was 20 October 2006 and the median emigration date for late migrants was 10 April 2007. Both median migration dates were within the range previously reported for this study (Appendix Table B-1).

We estimated a minimum of 12,632 (95% CI, ± 1,766) juvenile steelhead migrated out of upper rearing areas of the upper Grande Ronde River during MY 2007, which is within estimates from previous migratory years (Appendix Table B-1). Based on the total minimum estimate, 13% (1,625 ± 186) were early migrants and 87% (11,007 ± 1,757) were late migrants. The pattern of a dominant late migration of juvenile steelhead in the upper Grande Ronde River is consistent for all migratory years studied to date (Appendix Table B-1).

Catherine Creek: The Catherine Creek trap fished for 164 d between 18 September 2006 and 11 June 2007 (Table 7). Systematic subsampling comprised 6 of the 104 d the trap was fished during late migration period. There were distinct early and late migrations exhibited by juvenile steelhead at this trap site (Figure 10). Median emigration date for early migrants was 16 October 2006, and the median date for late migrants was 4 May 2007. Both median migration dates were within the range previously reported for this study (Appendix Table B-1).

We estimated a minimum of 13,715 ± 1,704 juvenile steelhead migrated out of the upper rearing areas of Catherine Creek during MY 2007. Based on the total minimum estimate, 73% (9,948 ± 1,588) migrated early and 27% (3,767 ± 619) migrated late. The proportion of juvenile steelhead leaving upper rearing areas as late migrants is consistent with the proportions from previous years of this study (Appendix Table B-1). The Catherine Creek population appears to be different from the upper Grande Ronde River population in that a larger proportion of the overall migrant population tends to leave upper rearing areas as early migrants.

Lostine River: The Lostine River trap fished for 230 d between 12 September 2006 and 15 June 2007 (Table 7). Systematic subsampling comprised 15 of the 118 d the trap was fished during late migration period. Distinct early and late migrations were evident at this trap site (Figure 10). The median emigration date of early migrants was 5 October 2006, and the median emigration date for late migrants was 28 April 2007. Both median dates are within the range reported in previous years of this study (Appendix Table B-1).

We estimated a minimum of 13,162 ± 1,867 steelhead migrated out of the Lostine River during MY 2007. Based on the total minimum estimate, 74% (9,767 ± 1,761) of the juvenile steelhead migrated early and 26% (3,395 ± 619) migrated late.

Minam River: The Minam River trap fished for 181 d between 11 September 2006 and 15 June 2007 (Table 7). Distinct early and late migrations were evident at this trap site (Figure 10). The median emigration date for early migrants was 1 October 2006, and the median emigration date for late migrants was 30 April 2007. Both median migration dates were within the range previously reported for this study (Appendix Table B-1).

We estimated a minimum of 11,831 ± 3,330 juvenile steelhead migrated out of the Minam River during MY 2007. Based on the total minimum estimate, 28% (3,330 ± 1,488) migrated early and 72% (8,501 ± 2,979) migrated late.

Age of Migrants at Traps: The steelhead collected at trap sites during MY 2007 were comprised of four age-groups. Early migrants ranged from 0 to 3 years of age while late migrants ranged in age from 1 to 3 years of age (Table 8). The age structure varied between migrant periods within and among trap sites. We believe that scale samples did not completely represent the entire migration period at any trap site so comparisons between percentages by age among populations were not analyzed.

Migration Timing and Survival to Lower Granite Dam

The total number of steelhead tagged in each tag group for each study stream is provided in Appendix Table B-2. Detections of the summer tag group from Catherine Creek and tributaries represented both early and late migrant groups that originated from this drainage.

Migration Timing: The median arrival dates at Lower Granite Dam for the fall and spring tag groups on the upper Grande Ronde River were 9 May and 13 May, respectively (Figure 11). The median arrival dates for the summer, fall and spring tag groups on Catherine Creek were 12 May, 5 May, and 9 May, respectively (Figure 12). The median arrival dates for the fall and spring tag groups on Lostine River were 13 May and 10 May, respectively (Figure 13). The median arrival dates for the fall and spring tag groups on Minam River were 14 May and 7 May, respectively (Figure 14).

Travel times from the screw trap to Lower Granite Dam for the spring tag group from the four study streams are presented in Table 9. Travel time to Lower Granite Dam for the spring tag group from the upper Grande Ronde River ranged from 9 to 83 d with a median of 24 d. Travel times to Lower Granite Dam for the spring tag group from Catherine Creek ranged from 8 to 59 d with a median of 28 d. Travel times to Lower Granite Dam for the spring tag group from Lostine River ranged from 7 to 48 d with a median of 9 d. Travel times to Lower Granite Dam for the spring tag group from Minam River ranged from 5 to 63 d with a median of 12 d.

Survival Probabilities: The survival probabilities of wild steelhead PIT-tagged during the summer of 2006 and detected at the dam during MY 2007 was 0.072 for Catherine Creek and we could not calculate a survival probability for Little Catherine Creek because no fish were detected at Lower Granite Dam (Table 10). Survival probabilities of steelhead tagged in fall 2006 could not be calculated for the Minam River and ranged from 0.084 to 0.160 among the remaining three trap sites (Table 10). Survival probabilities of steelhead tagged in the spring 2007 (FL ≥ 115 mm) could not be calculated for the Lostine River and ranged from 0.179 to 0.684 among the remaining three trap sites (Table 10). Estimated survival for the spring tag group in Catherine Creek and the upper Grande Ronde River were the lowest since we began making the calculation in 2000 (Appendix Table B-3). Some steelhead from all three tag groups do not migrate past the dams until the following migratory year. Therefore, detections of tagged fish from these groups during subsequent migratory years may change the survival probabilities reported for each tag group in future reports. At least one PIT tagged fish captured and released in the Middle, North and South forks of Catherine Creek, Little Catherine Creek, and Milk Creek have been detected at the dams, indicating the anadromous life history is present in all these tributaries (Appendix Table B-3).

Length and Age Characterization of Smolt Detections: Of all the early migrating steelhead tagged at all four traps in the fall of 2006, the larger individuals from each trap tended to be the ones detected at the dams in 2007 (Mann–Whitney, $P < 0.05$, Figure 15). This pattern was also observed the previous migratory year for early migrants tagged in fall 2005 at all traps except the upper Grande Ronde River trap (Kruskal–Wallis, $P < 0.05$, Figure 16). There were no detections in 2007 of steelhead tagged during fall 2005 at the upper Grande Ronde River trap therefore we could not test this pattern. The spring tag group of 2007 also showed a pattern of the larger individuals being detected at the dams that spring (Mann–Whitney, $P < 0.05$, Figure 17). Summaries of fork lengths at the time of tagging for all steelhead tagged for the various tag groups and for those detected at the dams are provided in Appendix Tables B-4, B-5, and B-6. While differences between medians of an entire tag group and those detected at dams could be the result of greater size-dependent mortality rate for smaller fish, there is evidence that smaller individuals passing the traps delay their migration past the dams until the subsequent migratory year (Appendix Tables B-4, B-5, and B-6).

Of the 164 early migrating age-0 fish tagged in the four study streams, none were observed at the dams the following spring while 26 of the 347 age-1 and 10 of the 63 age-2 early migrants were observed the following spring at the dams. As in past years, age-2 smolts (age-1 early migrants) made up the highest weighted percentage of all observations in MY 2007 (Table 11). Late migrant smolts consisted of age 1 to 3 years in 2007, but data collected in previous years have indicated that steelhead smolts from the Grande Ronde River Subbasin range in age from 1 to 4 years. Peven et al. (1994) found that steelhead smolts from the mid-Columbia River ranged in age from 1 to 7 years with most occurring as age-2 and age-3 fish. Even though the proportion of steelhead smolts within age-groups has been shown to vary considerably between migratory years (Ward and Slaney 1988), results from all years of this study indicate that the majority of the steelhead originating from the subbasin smolt as age-2 fish.

Migration Pattern of the Summer Tag Group: Like the migrant tag groups, the larger steelhead of a summer tag group were more likely than smaller fish of the same tag group to be detected at the dams within the subsequent spring. Trap recaptures and dam detections of the steelhead tagged upstream of the Catherine Creek trap during the past six summers also showed that larger fish (median FL $\geq$ 115 mm) were more likely to migrate out of the upstream rearing areas by spring while smaller fish (median FL $\leq$ 101 mm) were more likely to migrate out more than one year after tagging (Appendix Table B-6).

STREAM CONDITION INVESTIGATIONS

Methods

Stream Temperature and Flow

An initial assessment of stream condition was conducted in all four study streams. General stream condition sampling was based on protocols described by The Oregon Plan for Salmon and Watersheds (OPSW 1999) and stream flow data provided by the United States Geologic Survey (USGS) and the Oregon Water Resources Department (OWRD) La Grande District Water Master. Stream temperature and stream flow was characterized in all four study streams for the entire in-basin life history of juvenile spring Chinook salmon from BY 2005 which extended from 1 August 2005 (spawning) to 1 July 2007 (the end of MY 2007). Daily mean values were generated using data logged between 00:00 and 23:59. Stream temperature was recorded to the nearest 0.1°C every hour using a temperature data logger located at each trapping site. Descriptive statistics were used to characterize water temperature in each study stream with standards of three optimal or lethal temperature ranges for juvenile Chinook salmon (OPSW 1999). The cumulative effects from prolonged exposure to high water temperature were characterized using a seven-day moving mean of the daily maximum, and were calculated by averaging each day's maximum temperature and the maximum temperatures for the preceding three days and following three days (n = 7).

Stream discharge was obtained from data logged at upper Grande Ronde River (station 13317850; rkm 321.9), Catherine Creek (station 13320000; rkm 38.6), Lostine River (station 13330300; rkm 1.6) and Minam River (station 13331500; rkm 0.4) gauging stations that measured discharge (cubic foot per second, cfs) every 15 minutes. Average daily discharge was converted to the nearest 0.001 cubic meters per second (m^3/s).

Results and Discussion

Stream Temperature and Flow

Upper Grande Ronde River: Water temperatures during the second year of the in-basin life history of BY 2005 upper Grande Ronde River Chinook salmon ranged from a low of 0.0°C to a high of 28.2°C. We were unable to characterize a 103 day period during the winter of 2005 (28 September 2005 - 8 January 2006). Daily mean water temperature exceeded the DEQ standard of 17.8°C on 43 of 596 days in the upper Grande Ronde River. Water temperature was within the range preferred by juvenile Chinook salmon (10–15.6°C; OPSW 1999) during 5,298 of 14,276 hours logged in the upper Grande Ronde River. The DEQ lethal limit of 25°C was exceeded for 34 hours during ten of the 596 days. The seven-day moving mean of the maximum temperature showed that water temperatures below the range expected to support healthy growth (4.4–18.9°C; OPSW 1999) were encountered for longer durations than high water temperatures (Figure 18). Moving mean temperatures exceeded 18.9°C on 109 days while the 2005 cohorts eggs were deposited into spawning gravel, upper rearing, dispersal, and emigration seaward. Moving mean temperatures were less than 4.4°C on 201 days (12 January–8 March 2005) during incubation, winter rearing, and dispersal for the first couple days of spring migration.

Due to the unavailability of discharge data collected by OWRD at the time of submission of this report, stream flow characteristics were analyzed only for the first 14 months of the in-basin life history of BY 2005 upper Grande Ronde River Chinook salmon. Average daily discharge (station located at the upper end of summer rearing distribution) during this time ranged from a low of 0.176 to a high of 8.893 m^3/s (Figure 19). Discharge was less than 1.00 m^3/s on 143 of 144 days from August through late December 2005. Discharge was 1.00 m^3/s or greater on 63 of 65 days from late April through June 2006, with annual peak flow of 8.893 m^3/s occurring 21 May 2006. In addition to the usual spring increase, stream discharge exceeded 1.00 m^3/s for 23 days during the winter (23 December 2005–14 February 2006) peaking at 7.363 m^3/s on 4 January 2006.

Catherine Creek: Water temperatures during the majority of the in-basin life history of BY 2005 Catherine Creek Chinook salmon ranged from a low of 0.0°C to a high of 25.1°C. We were not able to characterize a 38 day (19 December 2006–28 January 2007) period in which this cohort was over-wintering in Catherine Creek. Daily mean water temperature exceeded the DEQ standard of 17.8°C on 26 of 661 days in Catherine Creek. Water temperature was within the range preferred by juvenile Chinook salmon (10–15.6°C; OPSW 1999) during 2,859 of 15,835 hours logged in Catherine Creek. The DEQ lethal limit of 25°C was exceeded for four hours during two of the 661 days. The seven-day moving mean of the maximum temperature showed that water temperatures below the range expected to support healthy growth (4.4–18.9°C; OPSW 1999) were encountered for longer durations than high water temperatures (Figure 18). Moving mean temperatures exceeded 18.9°C on 87 days during the in basin life history of this cohort. Of these, a total of 28 days (8-31 August 2005) were during spawning and incubation of eggs, and 59 days (2 July–7 September 2006) in which the majority of young of the year parr were rearing and dispersing. Moving mean temperatures were less than 4.4°C on 178 days (12 November 2006–3 March 2007) during incubation, rearing, and parr dispersal.

Due to the unavailability of discharge data collected by OWRD at the time of submission of this report, stream flow characteristics were analyzed only for the first 14 months of the in-basin life history of BY 2005 Catherine Creek Chinook salmon. Average daily discharge (station located in the lower end of summer rearing distribution) during this time ranged from a low of 0.566 to a high of 29.736 m^3/s (Figure 19). Discharge was less than 2.00 m^3/s on 230 of 236 days from August 2005 through late March 2006. Discharge was 2.00 m^3/s or greater on 108 days from late April through mid-July, with annual peak flow of 29.736 m^3/s on 20 May 2006.

Lostine River: Water temperatures during the in-basin life history of BY 2005 Lostine River Chinook salmon ranged from a low of 0.0°C to a high of 20.8°C. Daily mean water temperature did not exceed the DEQ standard of 17.8°C during any of the 698 days logged in the Lostine River. Water temperature was within the range preferred by juvenile Chinook salmon (10–15.6°C; OPSW 1999) during 3,803 of 16,704 hours logged in the Lostine River. The DEQ lethal limit of 25°C was not exceeded on any of the 698 days. The seven-day moving mean of the maximum temperature showed that water temperatures below the range expected to support healthy growth (4.4–18.9°C; OPSW 1999) were encountered for longer durations than high water temperatures (Figure 18). Moving mean temperatures exceeded 18.9°C on six days (4-9 August 2005) when the eggs of this cohort were being deposited in the spawning gravel, and nine days (21-29 July 2006) during the period when the majority of young of the year parr were rearing in habitats within the spawning grounds. Moving mean temperatures were less than 4.4°C on 99 days (18 November 2005–24 February 2006) during incubation of the 2005 cohort and 90 days (25 November 2006–1 March 2007) during dispersal and winter rearing.

Average daily discharge (station located at the lower end of summer rearing distribution) during the entire in-basin life history of the 2005 cohort ranged from a low of 0.263 to a high of 45.595 m^3/s (Figure 19). Discharge was greater than 7.5 m^3/s on 69 of 75 days from late April through mid-July 2006, with annual peak flow occurring on 20 May 2006 and 5 June 2007. Discharge was less than 7.5 m^3/s on 266 of 272 days from mid-July through April 2007. In addition to the usual spring increase, stream discharge exceeded 7.5 m^3/s for a five day period in mid November with a peak of 32.002 m^3/s on 7 November 2006. Spring flows between 1 March and 30 June were on average lower in 2007 than in 2006 (9.05 m^3/s and 11.44 m^3/s respectively).

Minam River: Water temperatures during the in-basin life history of BY 2005 Minam River Chinook salmon ranged from a low of 0.0°C to a high of 26.2°C. Daily mean water temperature exceeded the DEQ standard of 17.8°C on 59 of 698 days in the Minam River. Water temperature was within the range preferred by juvenile Chinook salmon (10–15.6°C; OPSW 1999) during 2,799 of 16,723 hours logged in the Minam River. The DEQ lethal limit of 25°C was exceeded on 11 out of the 698 days (15 hours, 1–8 August 2005, and 16 hours, 22 July–8 August 2005). The seven-day moving mean of the maximum temperature showed that water temperatures below the range expected to support healthy growth (4.4–18.9°C; OPSW 1999) were encountered for longer durations than high water temperatures (Figure 18). Moving mean temperatures exceeded 18.9°C on 35 days (4 August–7 September 2005) when the eggs of this cohort were being deposited in the spawning gravel, and 63 days (11 July–11 September 2006) when the majority of young of the year parr were rearing in habitats within the spawning grounds. Moving mean temperatures were less than 4.4°C on 110 days (8 November 2005–11 March 2006) while the 2005 cohort was incubating, and 106 days (30 October 2006–1 March 2007) during parr dispersal, and winter rearing.

Average daily discharge (station located at the lower end of summer rearing distribution) during the entire in-basin life history of the 2005 cohort ranged from a low of 1.558 to a high of 112.714 m^3/s (Figure 19). Discharge was greater than 9.0 m^3/s on 113 of 114 days from late March through mid-July 2006, with annual peak flow occurring on 20 May 2006 and 5 June 2007. Discharge was less than 9.0 m^3/s on 203 of

218 days from mid-July 2006 through late February 2007. In addition to the usual spring increase, stream discharge exceeded 9.0 m^3/s for a seven day period in mid-November with a peak of 33.418 m^3/s on 11 November 2006. Spring flows between 1 March and 30 June were on average lower in 2007 than in 2006 (19.20 m^3/s and 29.98 m^3/s respectively).

FUTURE DIRECTIONS

We will continue this early life history study of spring Chinook salmon and summer steelhead in Catherine Creek and the upper Grande Ronde, Lostine, and Minam rivers. This project will continue to provide key metrics to monitor and evaluate the success of restoration efforts for spring Chinook salmon and steelhead in the Grande Ronde Subbasin.

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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 2005 and 2006.

Year, Stream	Dates of collection and tagging	Number PIT-tagged and released	Distance to Lower Granite Dam (km)
2006			
Catherine Creek	24–27 Jul	501	363–383
Lostine River	7–10 Aug	500	271–308
Minam River	28–31 Aug	1,000	276–290
Imnaha River	5–6 Sep	1,000	221–233
2007			
Upper Grande Ronde	27–29 Aug	1,003	418–428
Catherine Creek	30 Jul–2 Aug	1,002	363–383
Lostine River	14–17 Aug	1,001	271–308
Minam River	20–23 Aug	1,006	276–290
Imnaha River	4–6 Sep	1,000	221–233

Table 2. Catch of juvenile spring Chinook salmon at four trap locations in the Grande Ronde River Subbasin during MY 2007. The early migration period starts 1 July 2006 and ends 28 January 2007. The late migration period starts 29 January and ends 30 June 2007. The period a trap operated was used to identify the total number of days fished with percentage in parentheses during each migration period.

Trap site	Migration period	Period trap operated	Days fished / days operated	Trap catch
Upper Grande Ronde River	Early	19 Sept 06–27 Nov 06	58/70 (83)	4076
	Late	6 Mar 07–13 Jun 07	77/100 (77)	3811[a]
		19 Mar 07–14 Apr 07	17/27 (63)	261[b]
Catherine Creek	Early	18 Sept 06–27 Nov 06	60/71 (84)	7563
	Late	14 Feb 07–11 Jun 07	98/118 (83)	350[a]
		26 Mar 07–14 Apr 07	6/20 (30)	46[b]
Lostine River	Early	12 Sept 06–11 Jan 07	112/122 (92)	11166
	Late	16 Feb 07–15 Jun 07	103/120 (86)	2579[a]
		17 Mar 07–20 Apr 07	15/35 (43)	1056[b]
Minam River	Early	11 Sept 06–27 Nov 06	70/78 (90)	3931
	Late	13 Feb 07–15 Jun 07	111/123(90)	779

[a] Continuous 24 h trapping
[b] Sub-sampling with 2 or 4 h trapping.

Table 3. Fork lengths of juvenile spring Chinook salmon collected from the study streams during MY 2007. Early and late migrants were captured with a rotary screw trap on each study stream. Winter group fish were captured with dipnets upstream of the rotary screw traps. Min. = minimum, Max. = maximum.

	Lengths (mm) of fish collected					Lengths (mm) of fish tagged and released				
Stream, group	*n*	Mean	SE	Min.	Max.	*n*	Mean	SE	Min.	Max.
Upper Grande Ronde River										
Early migrants	698	73.3	0.24	56	97	534	72.1	0.26	56	94
Winter group	482	75.6	0.37	56	103	482	75.6	0.37	56	103
Late migrants	661	86.5	0.39	38	140	501	85.5	0.41	64	130
Catherine Creek										
Early migrants	551	83.9	0.36	61	129	500	83.7	0.37	61	107
Winter group	500	80.7	0.32	55	100	500	80.7	0.32	55	100
Late migrants	433	83.7	0.94	33	141	361	91.2	0.46	70	141
Lostine River										
Early migrants	1,340	83.4	0.29	54	180	500	84.2	0.48	56	126
Winter group	500	75.7	0.34	56	97	500	75.7	0.34	56	97
Late migrants	515	92.4	0.45	70	132	505	92.1	0.43	70	130
Minam River										
Early migrants	776	77.4	0.36	50	114	500	78.3	0.41	55	102
Late migrants	247	91.6	0.78	68	223	217	92.1	0.87	68	223

Table 4. Weights of juvenile spring Chinook salmon collected from the study streams during MY 2007. Early and late migrants were captured with a rotary screw trap on each study stream. Winter group fish were captured with dip nets upstream of the rotary screw traps. Min. = minimum, Max. = maximum.

	Weights (g) of fish collected					Weights (g) of fish tagged and released				
Stream, group	*n*	Mean	SE	Min.	Max.	*n*	Mean	SE	Min.	Max.
Upper Grande Ronde River										
Early migrants	674	4.14	0.04	1.9	9.5	518	4.00	0.04	1.9	9.5
Winter group	481	4.78	0.07	1.9	11.4	481	4.78	0.07	1.9	11.4
Late migrants	603	6.82	0.20	2.3	31.6	444	6.30	0.12	2.4	24.4
Catherine Creek										
Early migrants	538	6.45	0.08	2.4	14.4	493	6.48	0.08	2.4	14.4
Winter group	498	5.67	0.06	1.9	10.7	498	5.67	0.06	1.9	10.7
Late migrants	341	8.20	0.15	3.7	28.4	340	8.12	0.15	3.7	28.4
Lostine River										
Early migrants	1,334	7.10	0.09	1.3	73.3	496	7.50	0.13	2.0	23.0
Winter group	499	5.13	0.07	2.0	10.9	499	5.13	0.07	2.0	10.9
Late migrants	512	8.78	0.13	3.5	24.5	502	8.65	0.13	3.5	23.7
Minam River										
Early migrants	769	5.59	0.08	1.5	15.5	499	5.75	0.09	2.2	12.1
Late migrants	247	8.91	0.46	3.1	111.8	217	9.16	0.52	3.1	111.8

Table 5. Survival probability to Lower Granite Dam for spring Chinook salmon parr tagged in summer 2006 and detected at Columbia and Snake River dams in 2007. Survival probabilities that have a letter in common are not significantly different ($P \leq 0.05$).

Stream	Number PIT-tagged and released	Survival probability (95% CI)
Catherine Creek	501	0.042[a] (SE = 0.009)
Lostine River	500	0.159[b] (0.112–0.245)
Minam River	1,000	0.175[b] (0.147–0.211)
Imnaha River	1,000	0.178[b] (0.147–0.218)

Table 6. Juvenile spring Chinook salmon survival probability by location and tag group from time of tagging to Lower Granite Dam. Chinook salmon were tagged from fall 2006 to spring 2007 and detected at the dams during 2007.

Stream, Tag group	Number PIT-tagged and released	Survival probability (95% CI)
Upper Grande Ronde River		
Fall (trap)	534	0.242 (0.199–0.301)
Winter (above trap)	383	0.138 (0.102–0.187)
Spring (trap)	501	0.373 (0.307–0.469)
Catherine Creek		
Fall (trap)	500	0.203 (0.143–0.340)
Winter (above trap)	500	0.088 (0.047–0.343)
Spring (trap)	363	0.310 (0.250–0.402)
Lostine River		
Fall (trap)	500	0.223 (0.172–0.301)
Winter (above trap)	500	0.135 (0.101–0.186)
Spring (trap)	505	0.589 (0.508–0.706)
Minam River		
Fall (trap)	500	0.250 (0.186–0.368)
Spring (trap)	217	0.602 (0.519–0.725)

Table 7. Catch of juvenile steelhead at four trap locations in the Grande Ronde River Subbasin during MY 2007. The early migration period starts 1 July 2006 and ends 28 January 2007. The late migration period starts 29 January and ends 30 June 2007. The period a trap operated was used to identify the total number of days fished with percentage in parentheses during each migration period.

Trap site	Migration period	Period trap operated	Days fished / days operated	Trap catch
Upper Grande Ronde River	Early	19 Sept 06–27 Nov 06	58/70 (83)	820
	Late	6 Mar 07–13 Jun 07	77/100 (77)	2,526[a]
		19 Mar 07–14 Apr 07	17/27 (63)	116[b]
Catherine Creek	Early	18 Sept 06–27 Nov 07	60/71 (84)	1,575
	Late	14 Feb 07–11 Jun 07	98/118 (83)	356[a]
		26 Mar 07–14 Apr 07	6/20 (30)	24[b]
Lostine River	Early	12 Sept 06–11 Jan 07	112/122 (92)	2120
	Late	16 Feb 07–15 Jun 07	103/120 (86)	375[a]
		17 Mar 07–20 Apr 07	15/35 (43)	47[b]
Minam River	Early	11 Sept 06–27 Nov 07	70/78 (90)	170
	Late	13 Feb 07–15 Jun 07	111/123(90)	434

[a] Continuous 24 h trapping
[b] Sub-sampling with 2 or 4 h trapping.

Table 8. Age structure of early and late steelhead migrants collected at trap sites during MY 2007. The same four cohorts were represented in each migration period but ages increased by one year from early migrants to late migrants (e.g. age-0 early migrants were same cohort as age-1 late migrants). Age structure was based on the frequency distribution of sampled lengths and allocated using an age–length key. Means were weighted by migrant abundance at trap sites.

Migration period,	Percentage by age				
Trap Site	Age-0	Age-1	Age-2	Age-3	Age-4
Early					
Upper Grande Ronde River	28.0	63.0	9.0	0.0	0.0
Catherine Creek	44.7	29.5	25.5	0.3	0.0
Lostine River	59.9	33.9	6.2	0.0	0.0
Minam River	62.1	25.3	12.6	0.0	0.0
Mean	**49.8**	**35.8**	**14.3**	**0.1**	**0.0**
Late					
Upper Grande Ronde River	—	31.4	44.9	23.7	0.0
Catherine Creek	—	71.8	21.9	6.3	0.0
Lostine River	—	73.0	23.2	3.8	0.0
Minam River	—	57.9	36.0	6.1	0.0
Mean	—	**54.7**	**32.5**	**12.8**	**0.0**

Table 9. Travel time to Lower Granite Dam (LGD) of wild steelhead PIT tagged at screw traps in spring of 2007 and arriving at Lower Granite Dam in 2007.

	Distance to	Number	Travel time (d)		
Stream	LGD (km)	detected	Median	Min.	Max.
Upper Grande Ronde River	397	51	24.3	9	83
Catherine Creek	362	13	28.3	8	59
Lostine River	274	9	8.8	7	48
Minam River	245	25	11.7	5	63

Table 10. Survival probability to Lower Granite Dam of steelhead PIT tagged on Catherine Creek during summer 2006 and at screw traps on Catherine Creek and the upper Grande Ronde, Lostine, and Minam rivers during the fall of 2006 and spring of 2007 (MY 2007).

Season, location tagged	Number tagged	Number detected	Survival probability (95% CI)
Summer			
Catherine Creek	334	3	0.072 (0.024–0.992)
Little Catherine Creek	275	0	—
Fall			
Upper Grande Ronde River	859	16	0.121 (0.065–0.488)
Catherine Creek	485	19	0.084 (0.059–0.155)
Lostine River	1,000	41	0.160 (0.110–0.279)
Minam River	107	2	—
Spring (FL ≥ 115 mm)			
Upper Grande Ronde River	600	52	0.315 (0.246–0.453)
Catherine Creek	370	13	0.179 (0.108–0.546)
Lostine River	273	9	—
Minam River	293	25	0.684 (0.432–1.638)

Table 11. Age structure of PIT tagged early migrating steelhead with known age information, and the subset subsequently detected at downstream dams the following spring. Italicized ages reflect the expected age of smolts when detected at dams. Means were weighted by sample size (*n*).

		Percentage by age			
Trap site	*n*	Age-0 *Age-1 smolt*	Age-1 *Age-2 smolt*	Age-2 *Age-3 smolt*	Age-3 *Age-4 smolt*
		PIT tagged fish with known age			
Upper Grande Ronde River	130	35	55	10	0
Catherine Creek	224	21	71	8	0
Lostine River	152	30	54	16	0
Minam River	68	38	49	13	0
Mean		**28.6**	**60.5**	**10.9**	**0.0**
		PIT tagged fish detected at dams			
Upper Grande Ronde River	10	0	70	30	0
Catherine Creek	0	0	0	0	0
Lostine River	20	0	70	30	0
Minam River	6	0	83	17	0
Mean		**0**	**72.2**	**27.8**	**0.0**

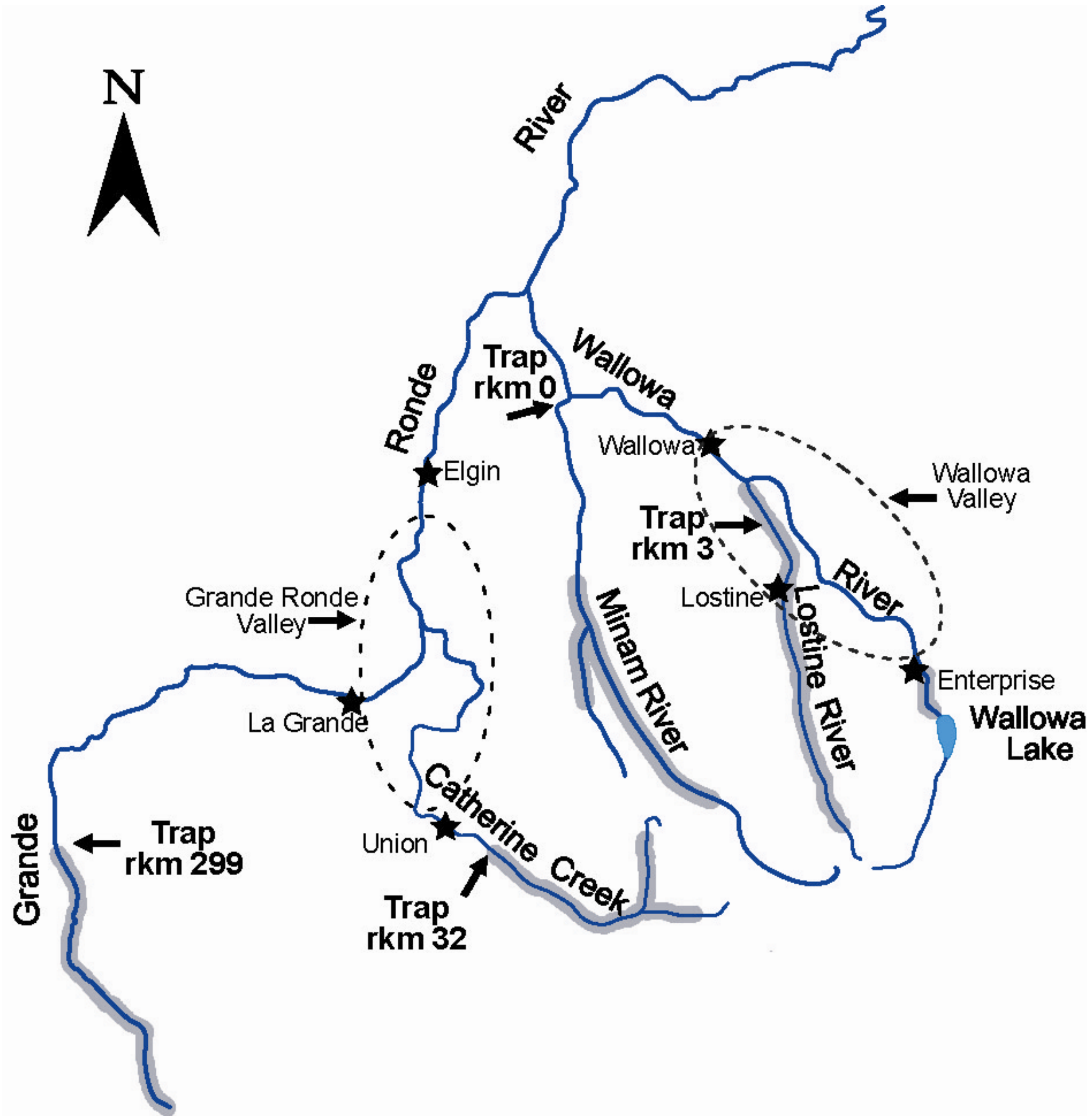

Figure 1. Locations of fish traps in the Grande Ronde River Subbasin during the study period. Shaded areas delineate spring Chinook salmon spawning and upper rearing areas in each study stream. Dashed lines indicate the Grande Ronde River and Wallowa River valleys.

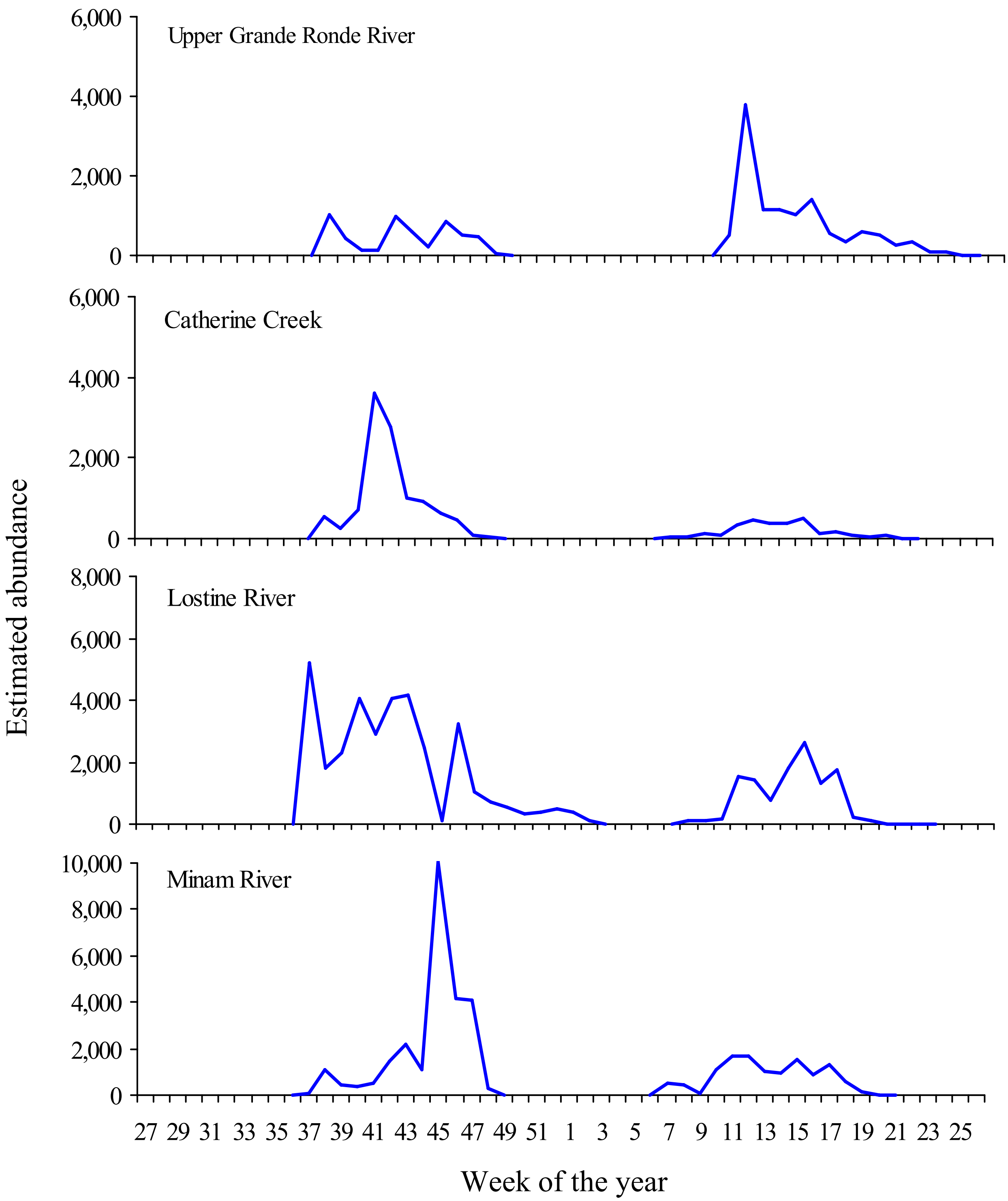

Figure 2. Estimated migration timing and abundance of juvenile spring Chinook salmon migrants captured by rotary screw traps during MY 2007. Traps were located at rkm 299 of the Grande Ronde River, rkm 32 of Catherine Creek, rkm 3 of the Lostine River, and rkm 0 of the Minam River.

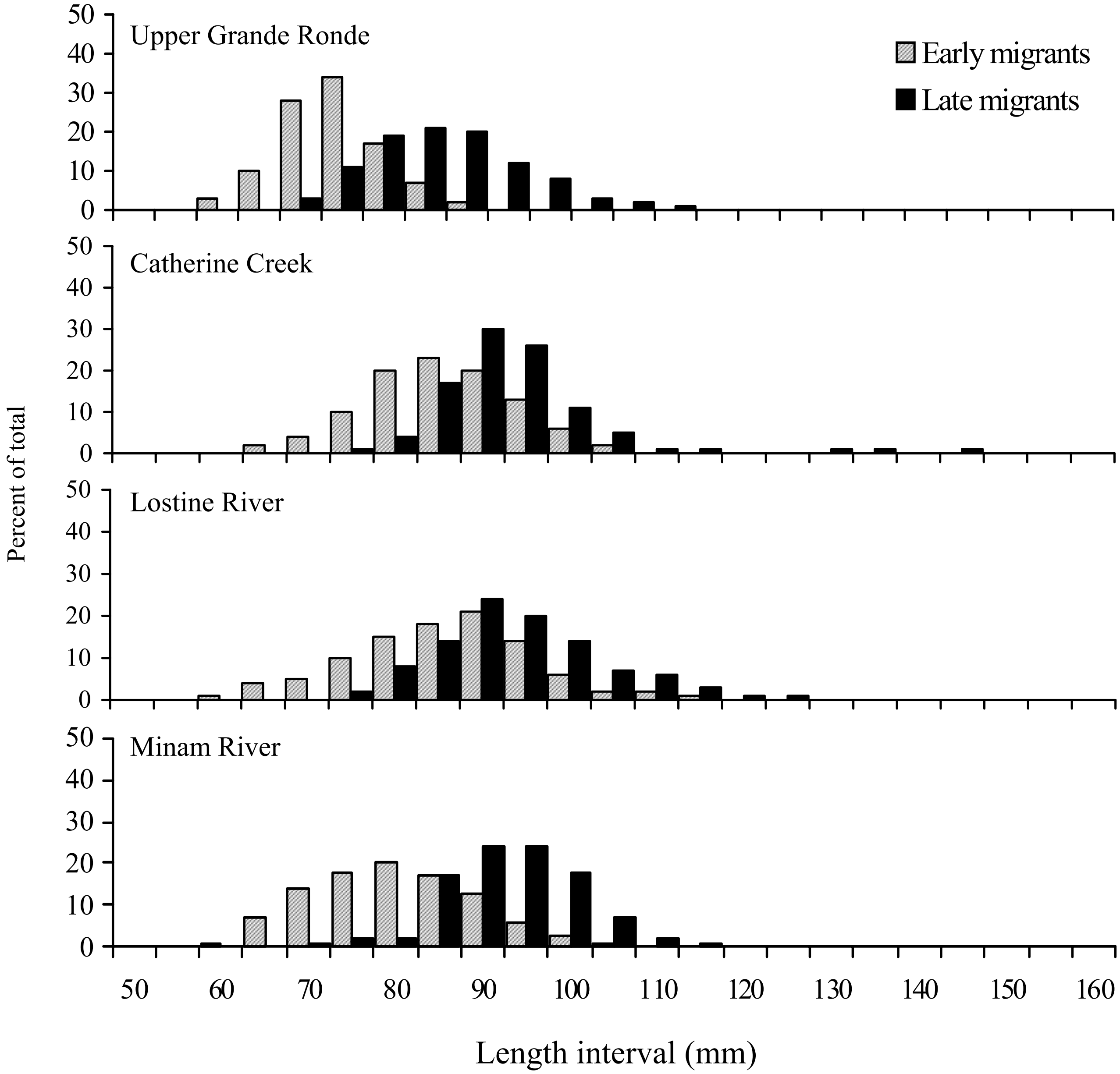

Figure 3. Length frequency distribution (fork length) of early and late migrating juvenile spring Chinook salmon captured at the Catherine Creek (rkm 32), Grande Ronde Valley (rkm 164), Lostine River (rkm 3), and Minam River (rkm 0) traps during the 2007 migratory year.

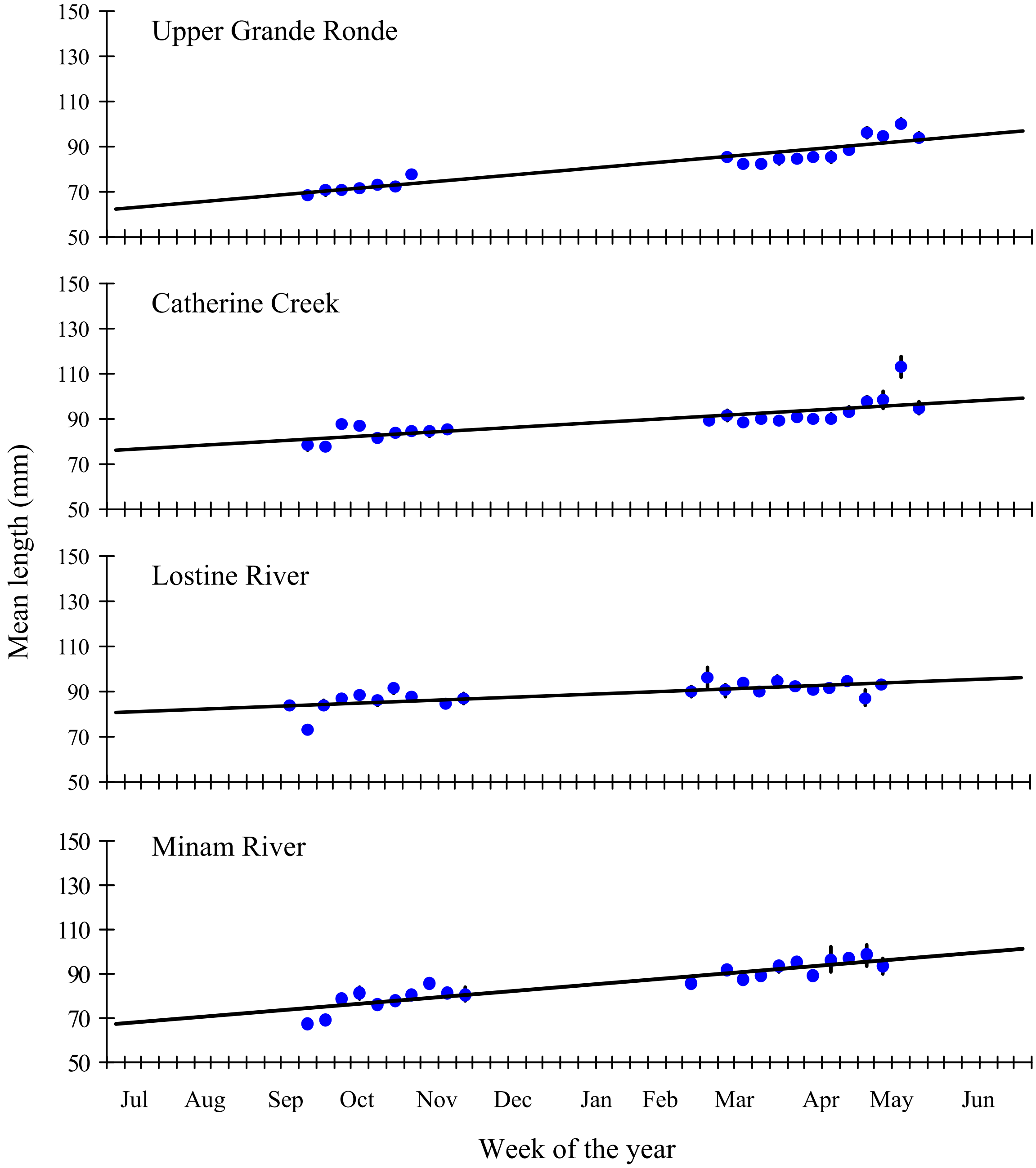

Figure 4. Weekly mean fork lengths (mm) with standard error for spring Chinook salmon captured in rotary screw traps in the Grande Ronde River Subbasin during MY 2007.

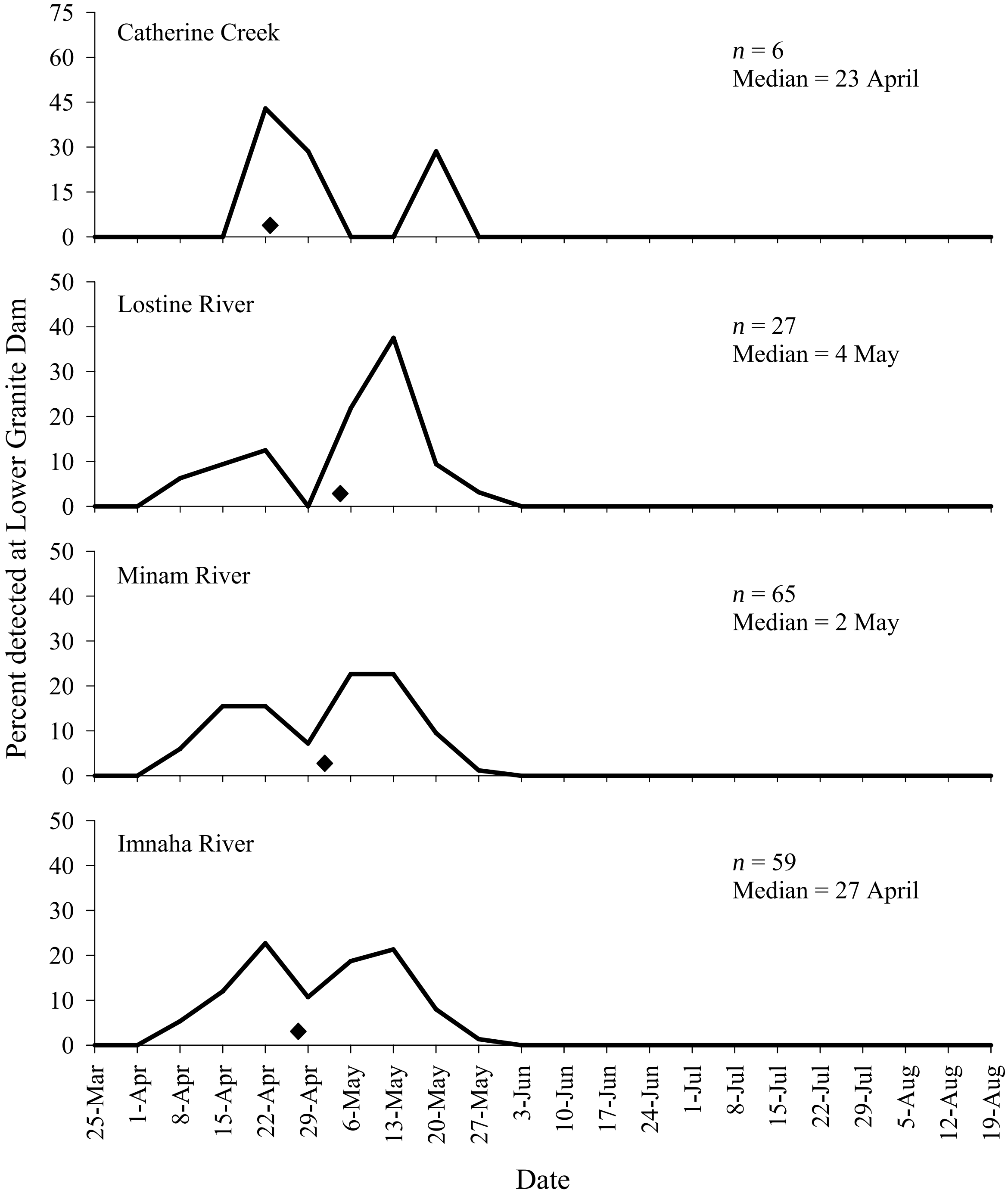

Figure 5. Dates of arrival in 2007 at Lower Granite Dam of spring Chinook salmon PIT-tagged as parr on Catherine Creek and the Imnaha, Lostine, and Minam rivers during the summer of 2006 summarized by week and expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

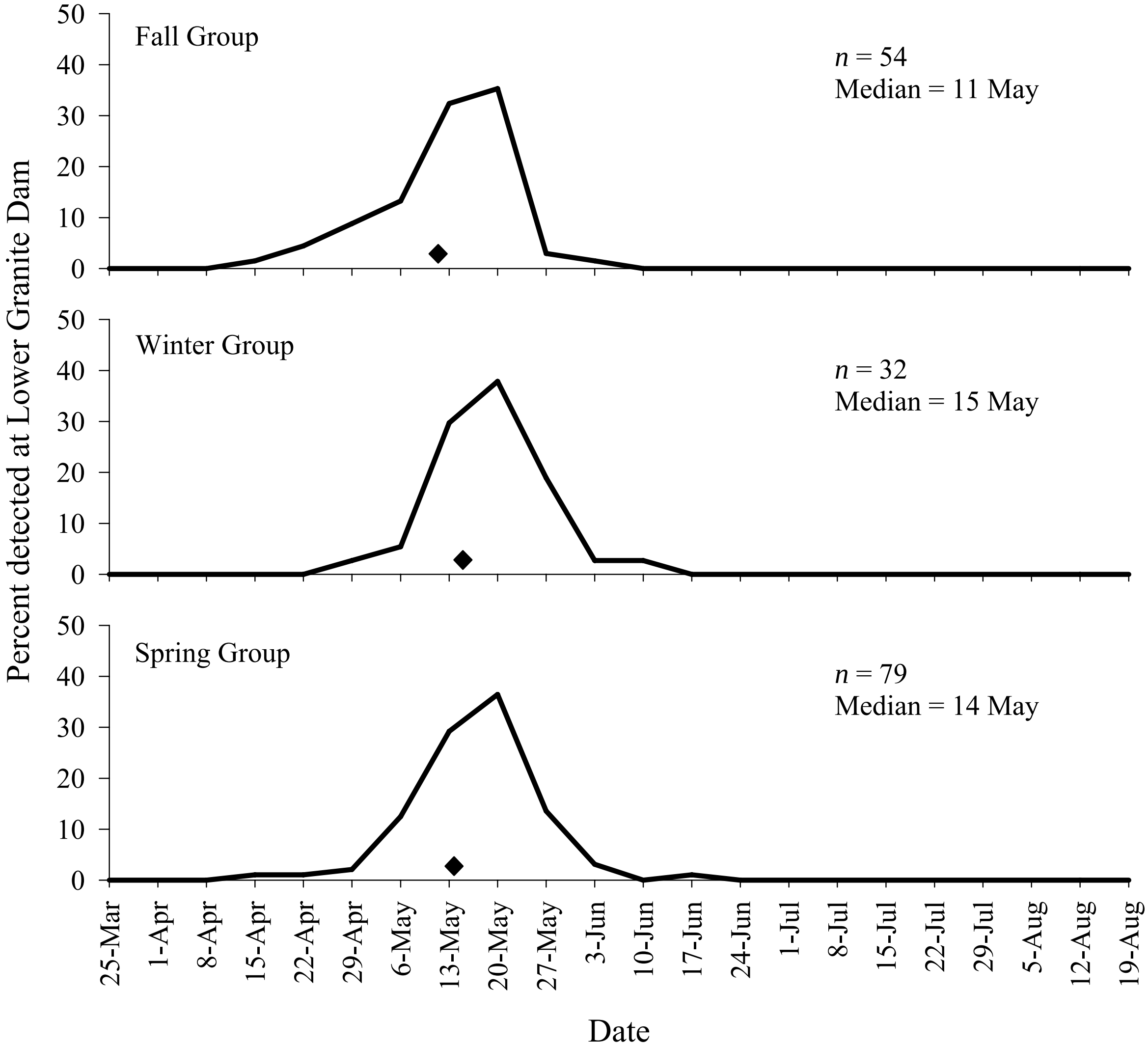

Figure 6. Dates of arrival in 2007 at Lower Granite Dam for the fall, winter, and spring tag groups of juvenile spring Chinook salmon PIT-tagged on the upper Grande Ronde River, expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

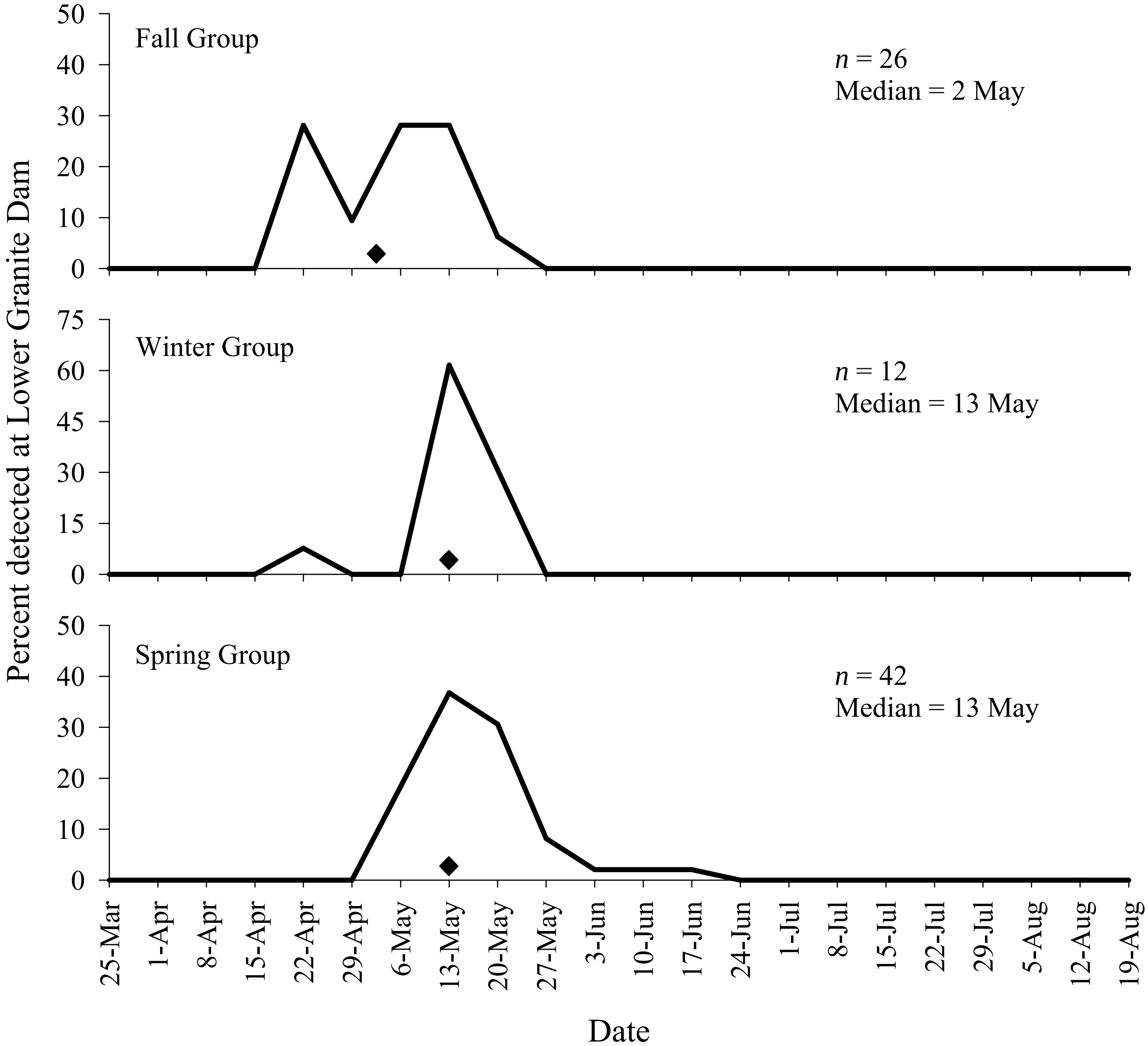

Figure 7. Dates of arrival in 2007 at Lower Granite Dam for the fall, winter, and spring tag groups of juvenile spring Chinook salmon PIT-tagged on Catherine Creek, expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

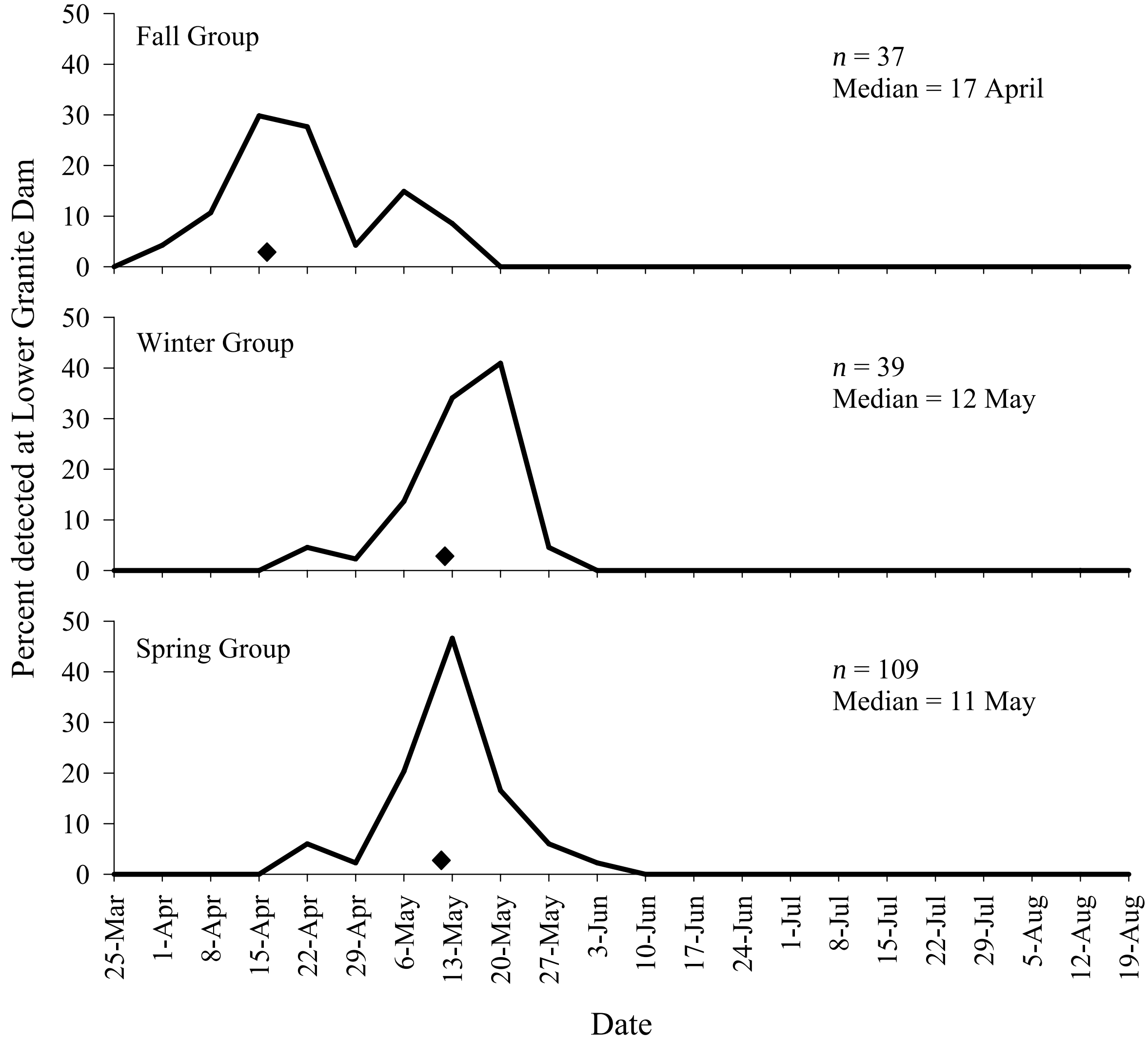

Figure 8. Dates of arrival in 2007 at Lower Granite Dam for the fall, winter, and spring tag groups of juvenile spring Chinook salmon PIT-tagged on the Lostine River, expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

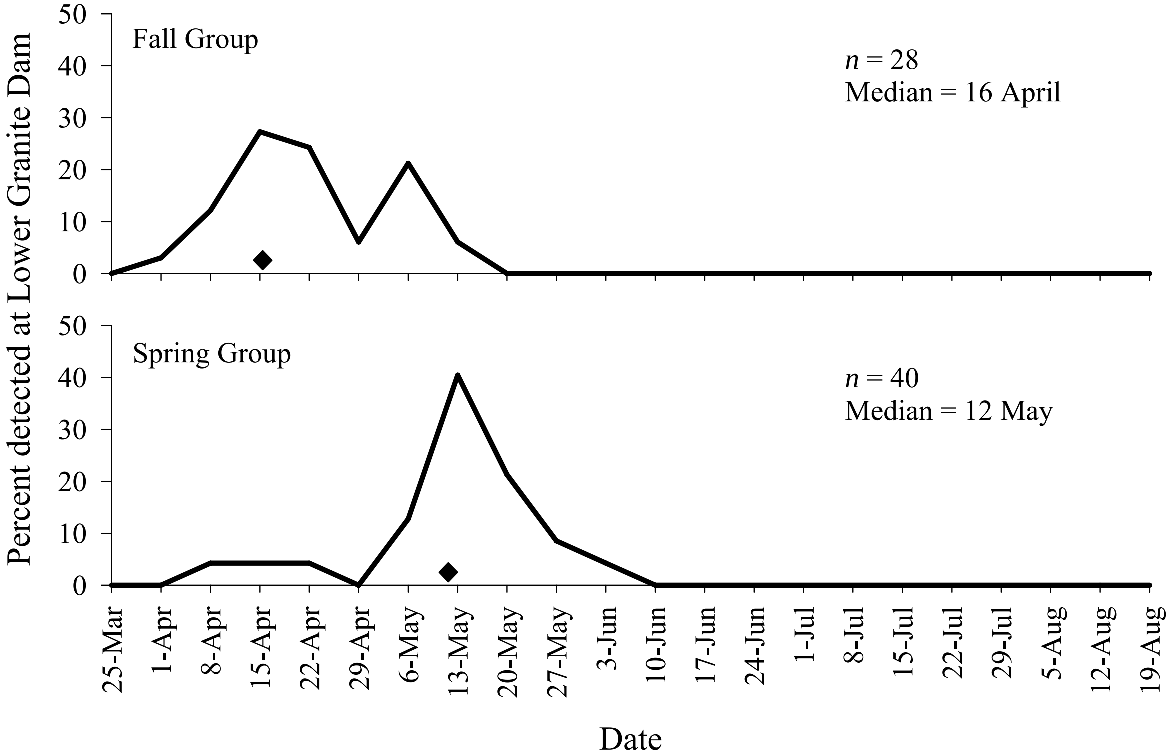

Figure 9. Dates of arrival in 2007 at Lower Granite Dam for the fall, winter, and spring tag groups of juvenile spring Chinook salmon PIT-tagged on the Minam River, expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

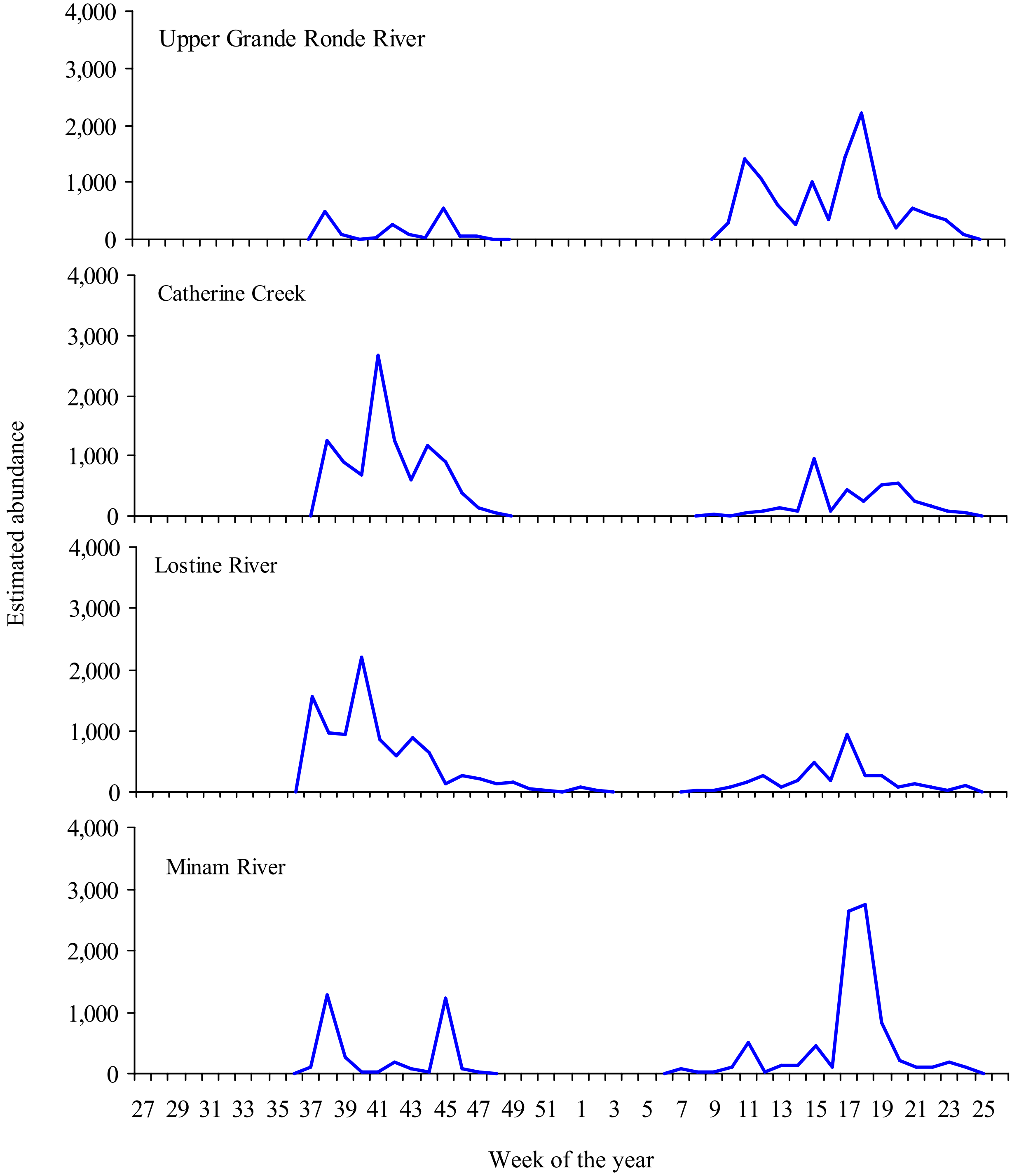

Figure 10. Estimated abundance and migration timing of steelhead migrants captured by rotary screw traps, during MY 2007. Traps were located at rkm 299 of the Grande Ronde River, rkm 32 of Catherine Creek, rkm 3 of the Lostine River, and rkm 0 of the Minam River.

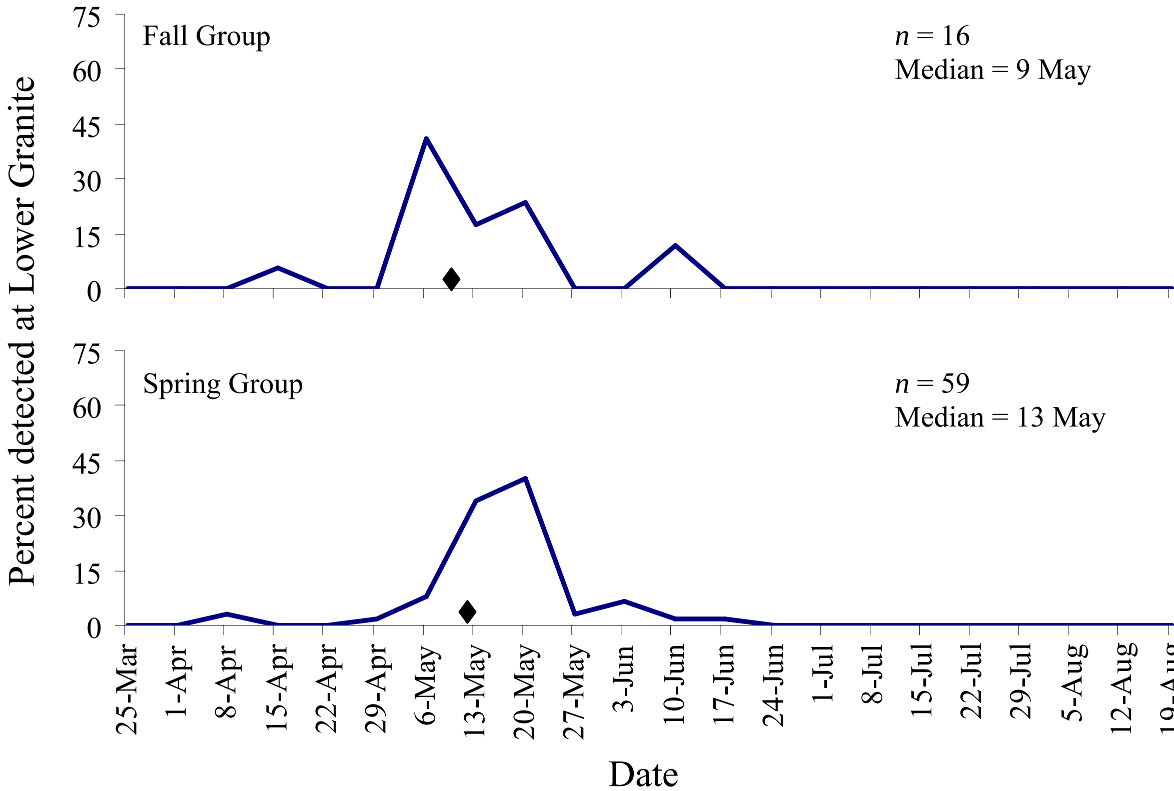

Figure 11. Dates of arrival in 2007 at Lower Granite Dam for the fall and spring tag groups of steelhead PIT-tagged on the upper Grande Ronde River, expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

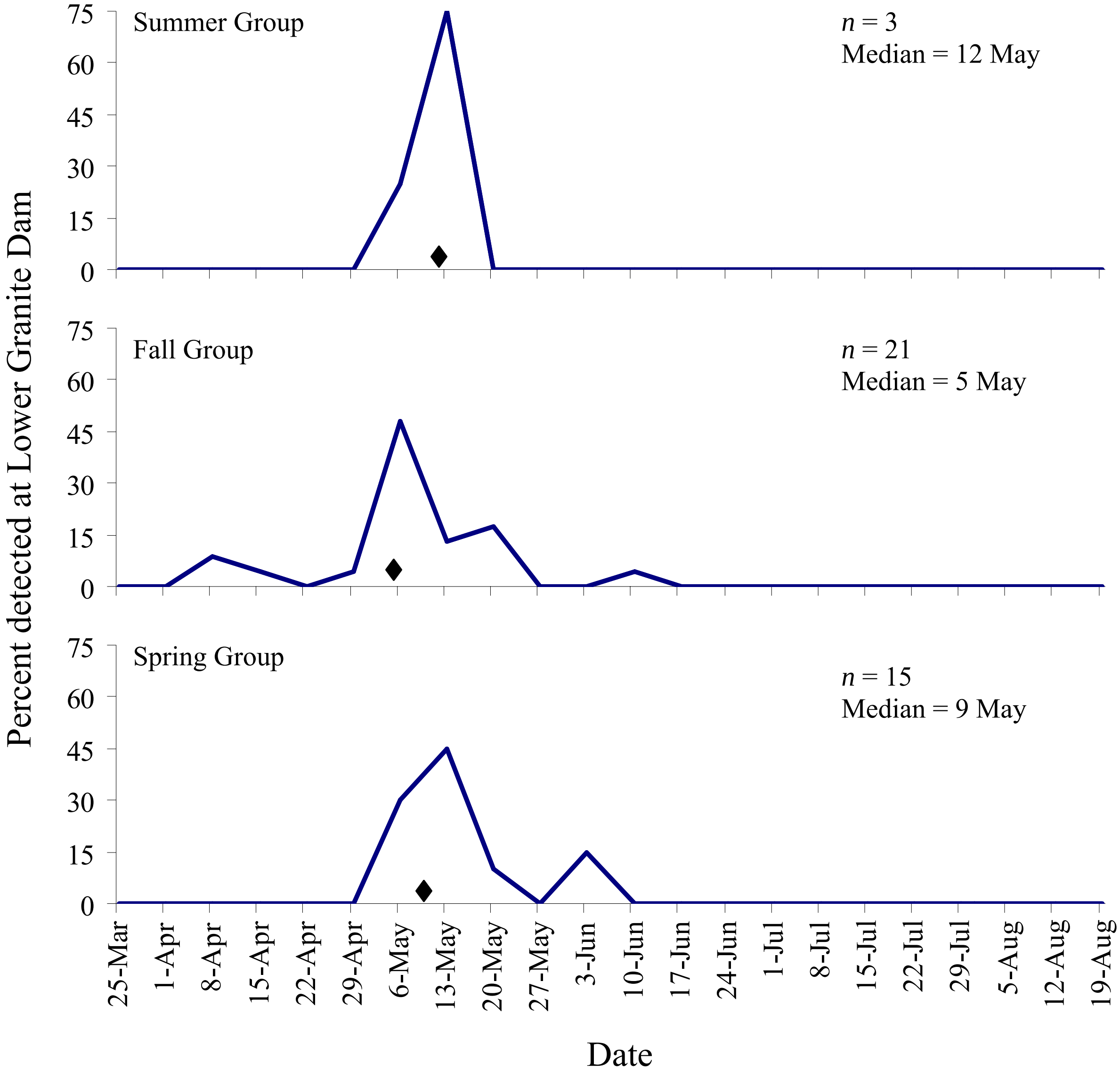

Figure 12. Dates of arrival in 2007 at Lower Granite Dam for the summer, fall, and spring tag groups of steelhead PIT-tagged on Catherine Creek, expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

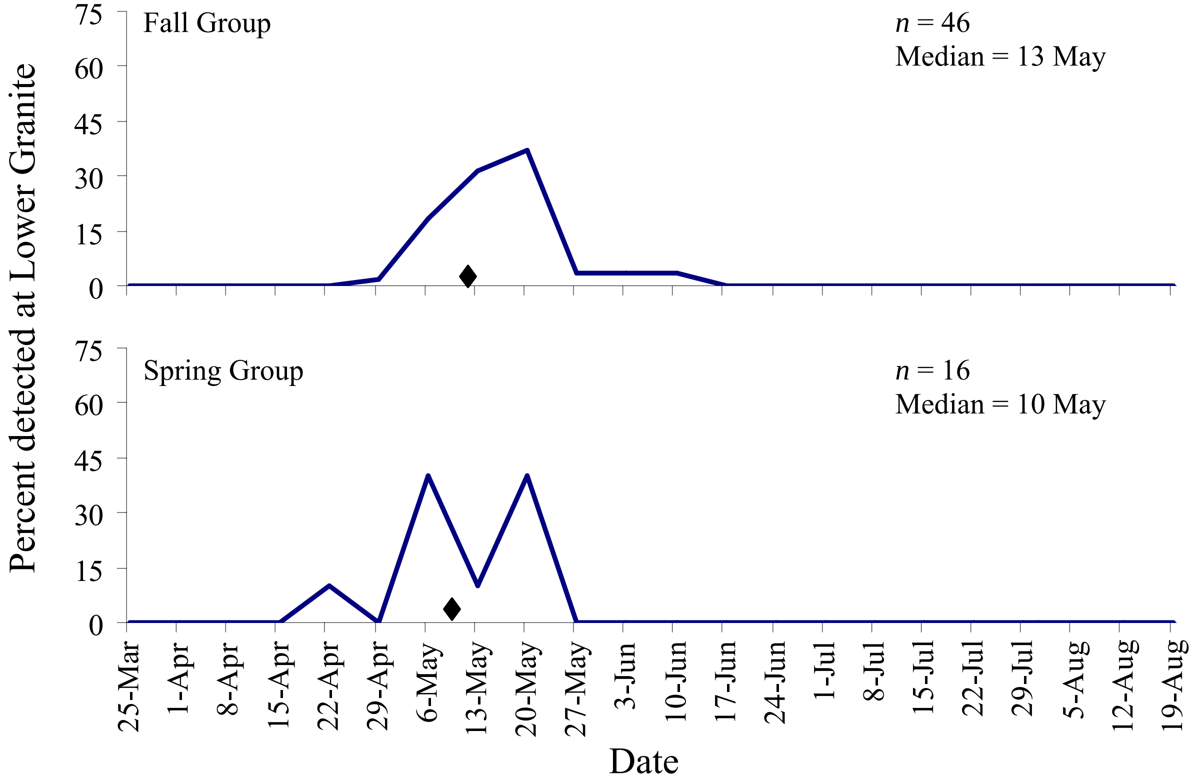

Figure 13. Dates of arrival in 2007 at Lower Granite Dam for the fall and spring tag groups of steelhead PIT-tagged on the Lostine River, expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

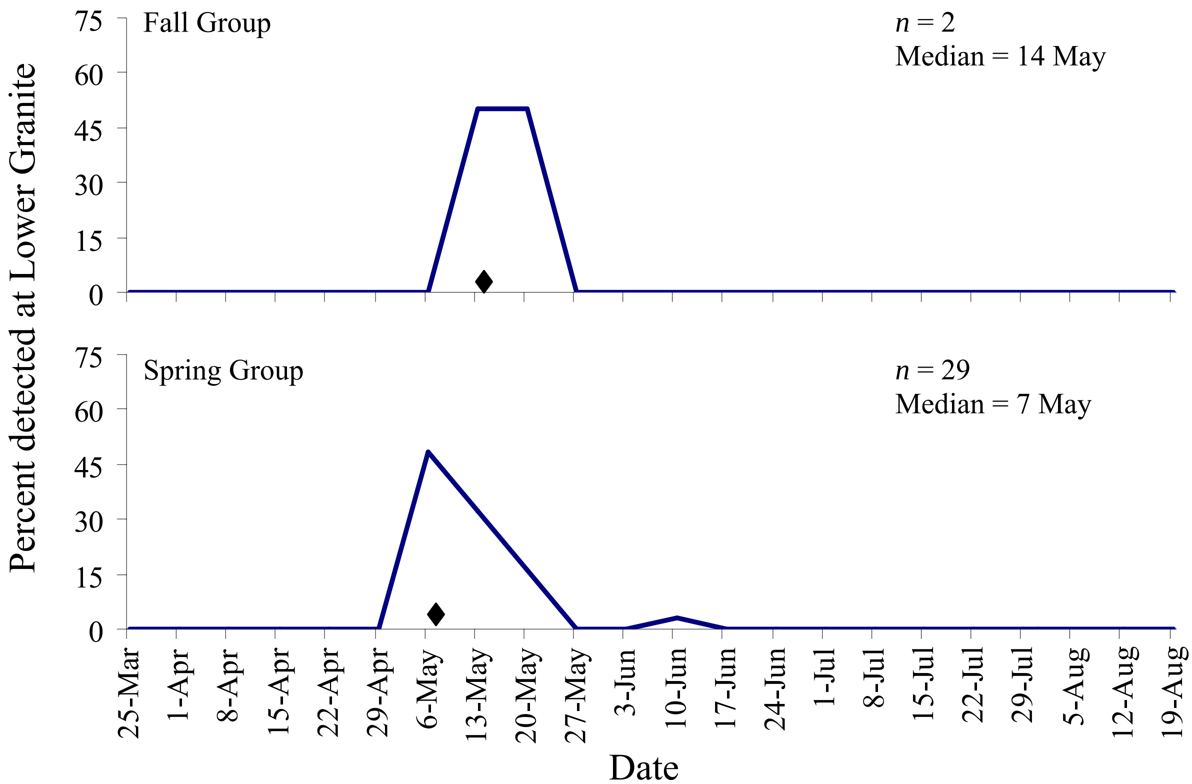

Figure 14. Dates of arrival in 2007 at Lower Granite Dam for the fall and spring tag groups of steelhead PIT-tagged on the Minam River, expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

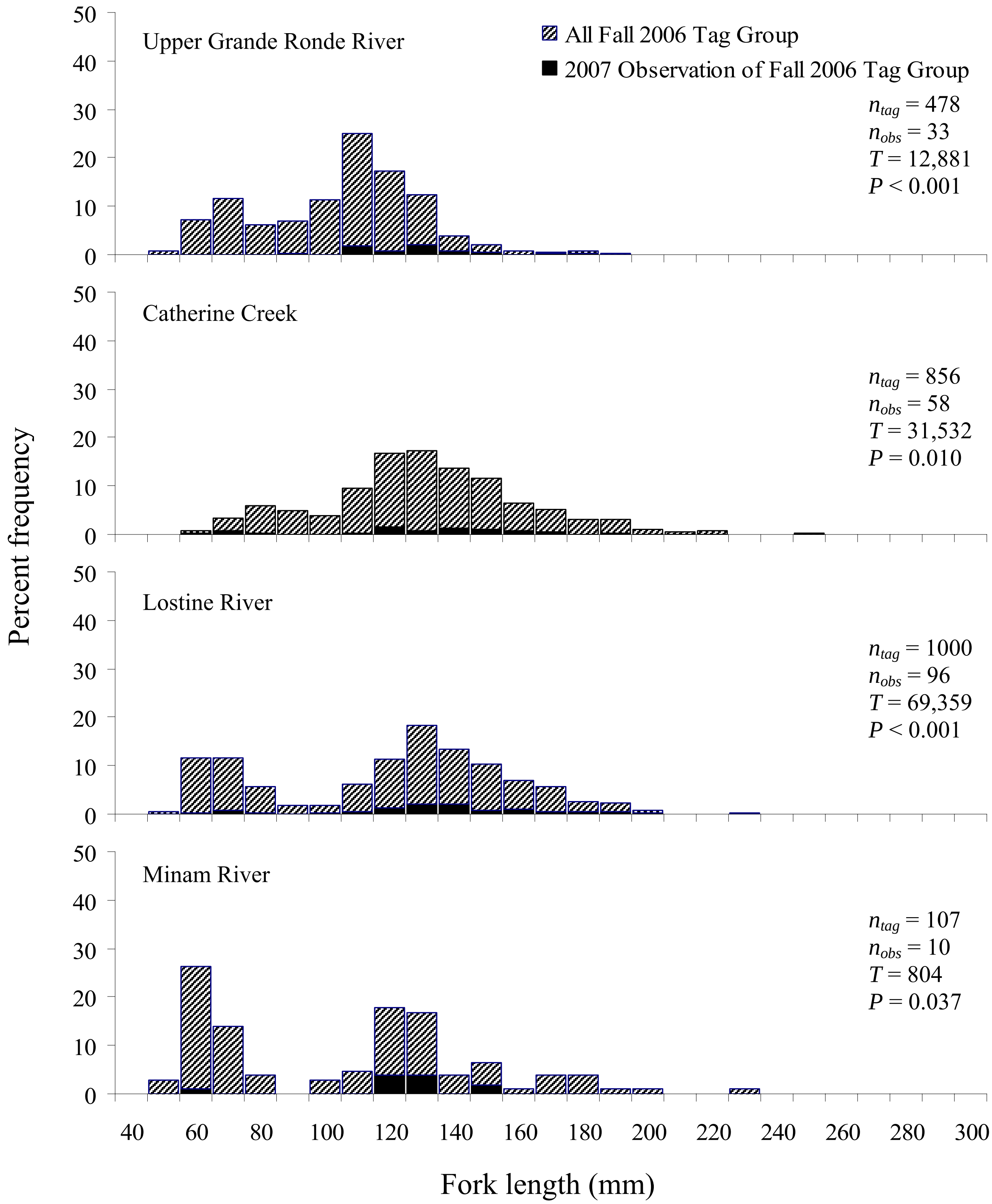

Figure 15. Length frequency distributions for all steelhead PIT-tagged at screw traps in the fall of 2006 and those subsequently observed at Snake River or Columbia River dams in 2007. Fork lengths are based on measurements taken at the time of tagging. Frequency is expressed as the percent of the total number tagged (n_{tag}). 'n_{obs}' is the number detected.

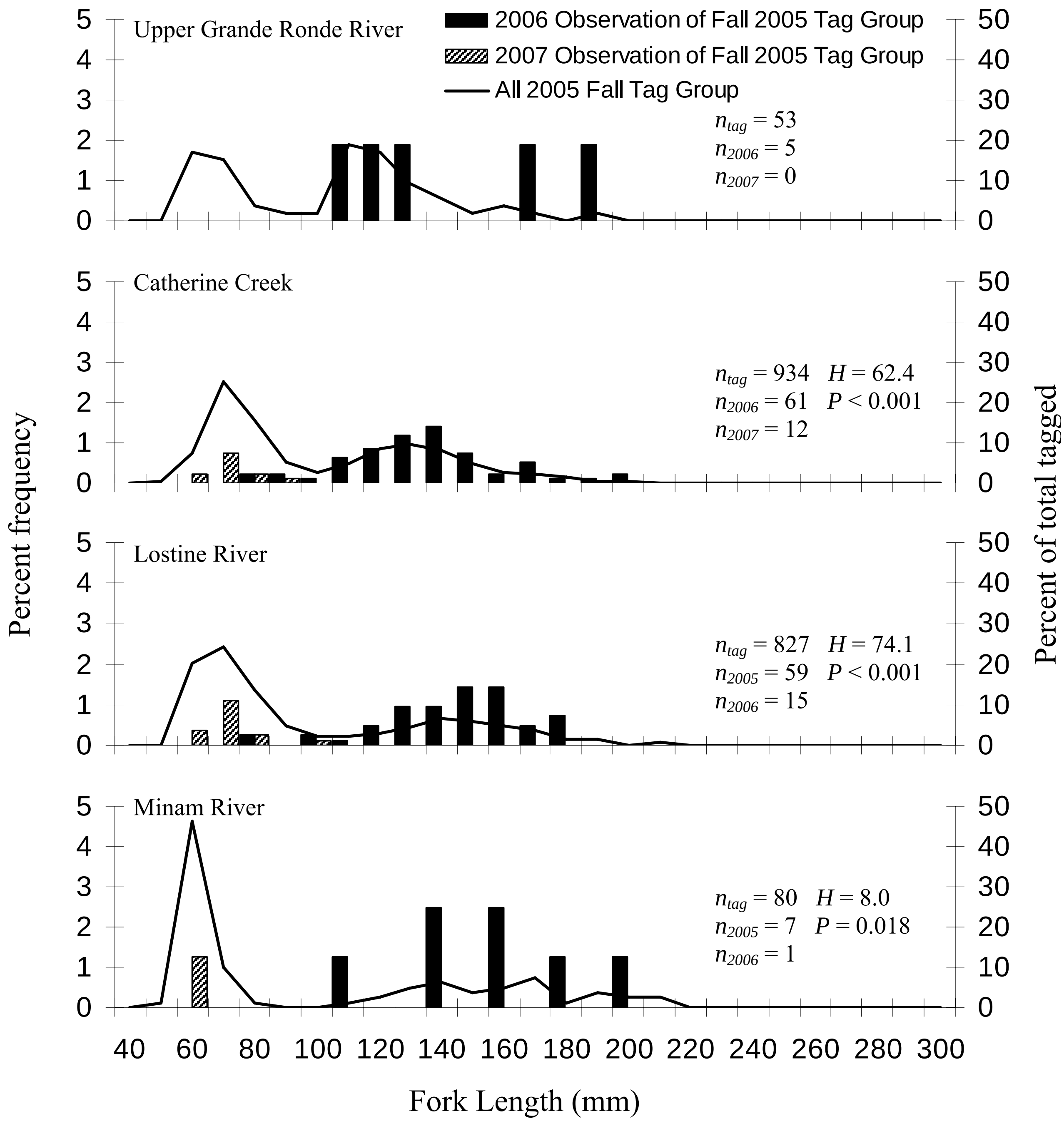

Figure 16. Length frequency distributions for all steelhead PIT-tagged at screw traps in the fall of 2005, and those subsequently observed at Snake River or Columbia River dams in 2006 and 2007. Fork lengths are based on measurements taken at the time of tagging. Frequency is expressed as the percent of the total number tagged. ‘H’ is the test statistic for the Kruskal–Wallis one-way ANOVA on ranks of the lengths. * Median length of the group was significantly different (α = 0.05, Dunn’s all pair-wise multiple comparison procedure).

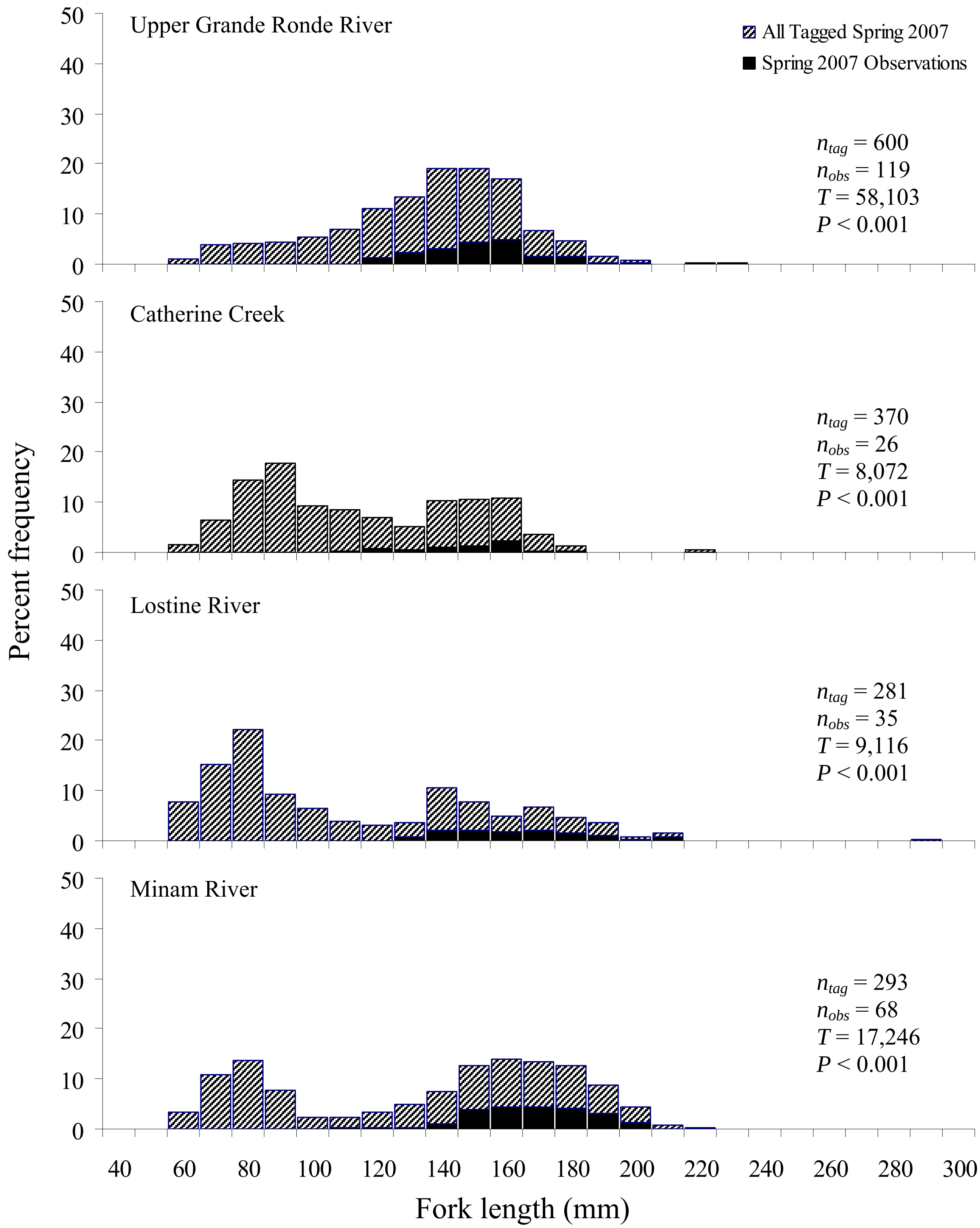

Figure 17. Length frequency distributions for all steelhead PIT-tagged at screw traps in the spring of 2007 and those subsequently observed at Snake River or Columbia River dams in 2007. Fork lengths are based on measurements taken at the time of tagging. Frequency is expressed as the percent of the total number tagged (n_{tag}), and 'n_{obs}' is the number detected.

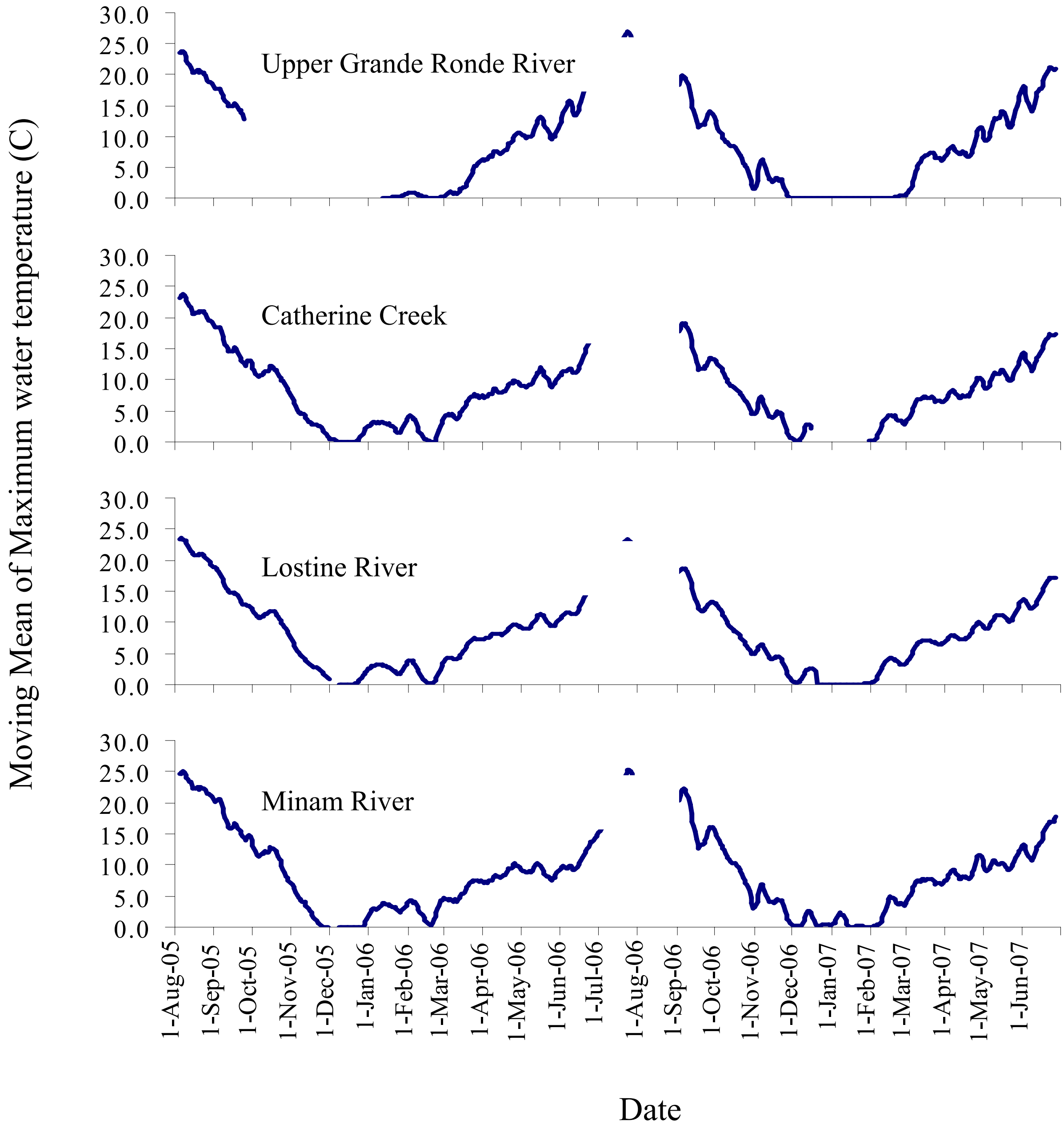

Figure 18. Moving mean of maximum water temperature during the in-basin life stages of egg-to-emigrant for juvenile spring Chinook salmon that migrated from four study streams in the Grande Ronde River basin during migratory year 2007. Missing portions of a trend line represent periods where data were not available.

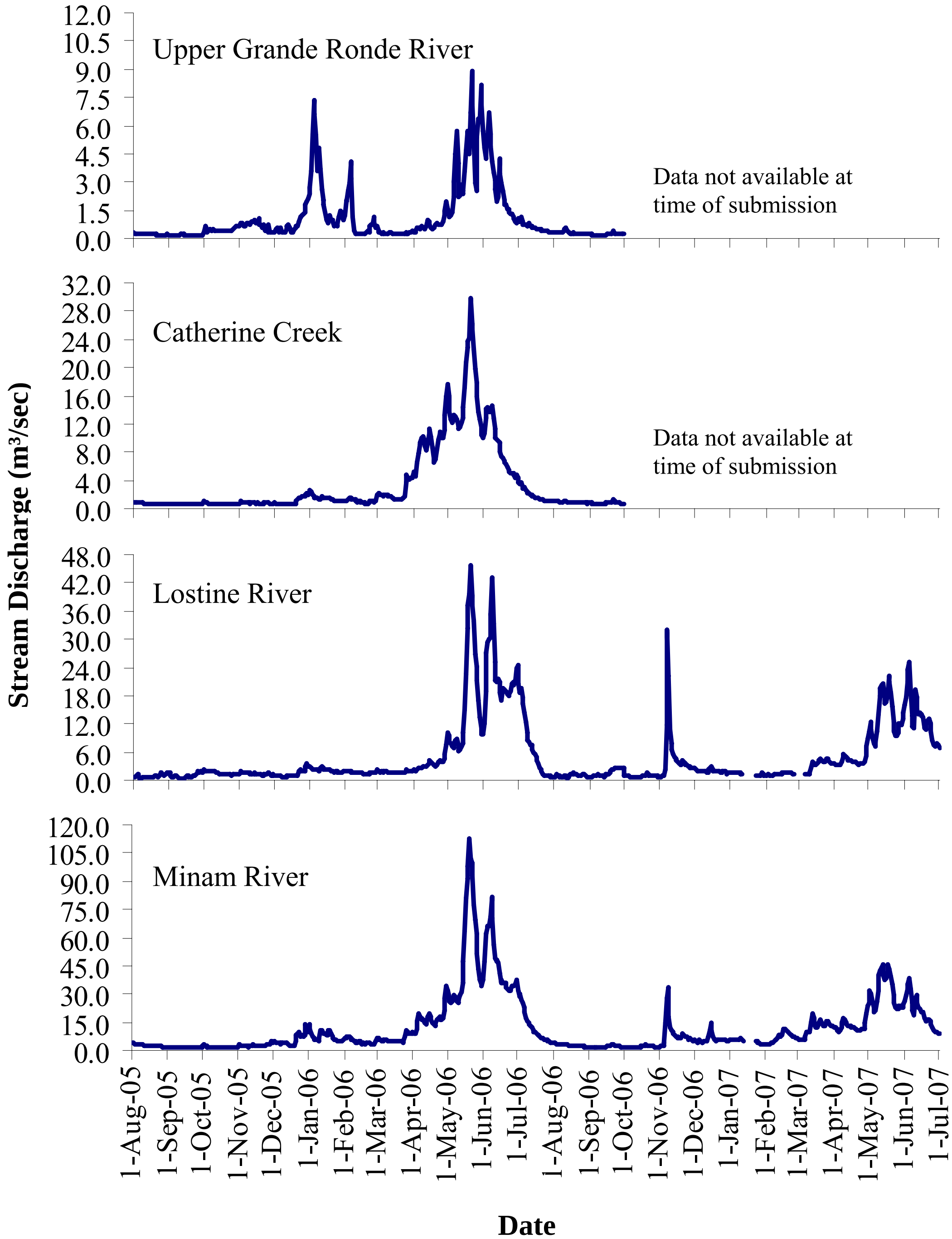

Figure 19. Average daily discharge during the in-basin life stages of egg-to-emigrant for juvenile spring Chinook salmon that migrated from the Lostine and Minam rivers during migratory year 2007. Discharge data was not available for the upper Grande Ronde River and Catherine Creek.

APPENDIX A

A Compilation of Spring Chinook Salmon Data

Appendix Table A-1. Population estimates, median migration dates, and percentage of juvenile spring Chinook salmon population moving as late migrants past traps sites, 1994–2007. The early migratory period begins 1 July of the preceding year and ends 28 January of the migratory year. The late migratory period begins 29 January and ends 30 June.

Stream, MY	Population estimate	95% CI	Median migration date: Early migrants	Median migration date: Late migrants	Percentage migrating late
Upper Grande Ronde River					
1994	24,791	3,193	14 Oct[a]	1 Apr	89[a]
1995	38,725	12,690	30 Oct[b]	31 Mar[b]	87[b]
1996	1,118	192	10 Oct[c]	16 Mar	99[c]
1997	82	30	12 Nov	26 Apr[c]	17[c]
1998	6,922	622	31 Oct	23 Mar	66
1999	14,858	3,122	16 Nov	31 Mar	84
2000	14,780	2,070	30 Oct	3 Apr	74
2001	51	31	1 Sep[c]	10 Apr	88[c]
2002	9,133	1,545	24 Oct	1 Apr	82
2003	4,922	470	12 Oct	19 Mar	73
2004	4,854	642	17 Oct	22 Mar	90
2005	6,257	834	25 Oct	13 Apr	83
2006	34,672	5,319	2 Oct	29 Mar	77
2007	17,109	1,708	20 Oct	13 Mar	69
Catherine Creek					
1995	17,633	2,067	1 Nov[a]	21 Mar	49[a]
1996	6,857	688	20 Oct	11 Mar	27
1997	4,442	1,123	1 Nov[a]	13 Mar	10[a]
1998	9,881	1,209	30 Oct	19 Mar	29
1999	20,311	2,299	14 Nov	23 Mar	38
2000	23,991	2,342	31 Oct	23 Mar	18
2001	21,936	2,282	8 Oct	24 Mar	13
2002	23,362	2,870	12 Oct	2 Apr	9
2003	34,623	2,615	28 Oct	20 Mar	14
2004	64,012	4,203	1 Nov	18 Mar	16
2005	56,097	6,713	11 Oct	26 Mar	10
2006	27,218	2,368	31 Oct	22 Mar	16
2007	13,831	1,032	14 Oct	29 Mar	21

[a] Trap was started late, thereby potentially missing some early migrants.
[b] Trap was located at rkm 257.
[c] Median date based on small sample size: MY 1996, *n*=4; MY 1997, *n*=6; MY 2001,*n*=2.
[d] Limited trapping operations prevented complete population estimates and migration timing

Appendix Table A-1. Continued.

Stream, MY	Population estimate	95% CI	Median migration date: Early migrants	Median migration date: Late migrants	Percentage migrating late
Lostine River					
1997	4,496	606	26 Nov[a]	30 Mar	52[a]
1998	17,539	2,610	26 Oct	26 Mar	35
1999	34,267	2,632	12 Nov	18 Apr	41
2000	12,250	887	2 Nov	9 Apr	32
2001	13,610	1,362	29 Sep	20 Apr	23
2002	18,140	2,428	24 Oct	1 Apr	15
2003	28,939	1,865	22 Oct	1 Apr	34
2004	—[d]	—	—	—	—
2005	54,602	6,734	22 Sep	31 Mar	25
2006	54,268	8,812	4 Nov	11 Apr	22
2007	46,183	4,827	14 Oct	7 Apr	26
Minam River					
2001	28,209	4,643	8 Oct[a]	27 Mar	64[a]
2002	79,000	10,836	24 Oct[a]	8 Apr	21[a]
2003	63,147	10,659	30 Oct[a]	5 Apr	69[a]
2004	65,185	9,049	13 Nov	29 Mar	34
2005	111,390	26,553	21 Oct	28 Mar	57
2006	50,959	8,262	14 Oct	1 Apr	42
2007	37,719	5,767	5 Nov	22 Mar	31

[a] Trap was started late, thereby potentially missing some early migrants.
[b] Trap was located at rkm 257.
[c] Median date based on small sample size: MY 1996, *n*=4; MY 1997, *n*=6; MY 2001, *n*=2.
[d] Limited trapping operations prevented complete population estimates and migration timing

Appendix Table A-2. Dates of arrival at Lower Granite Dam (LGD) of spring Chinook salmon smolts PIT-tagged in upper rearing areas during the summer and winter, and at screw traps as early and late migrants during migratory years 1993–2007. Italics indicate that the median may be biased due to when fish were tagged. Numbers of fish detected at Lower Granite Dam were expanded for spillway flow to calculate the median arrival date.

Stream, MY	Tag group	Migration period	Number tagged	Number detected at LGD	Arrival dates: Median	First	Last
Upper Grande Ronde River (rkm 299)							
1993	Summer	All	918	117	17 May	23 Apr	20 Jun
1994	Summer	All	1,001	57	29 May	23 Apr	29 Aug
	Fall	Early	405	65	30 Apr	21 Apr	23 Jun
	Winter	Late	505	27	29 May	28 Apr	16 Jul
	Spring	Late	573	93	*15 May*	20 Apr	06 Aug
1995[a]	Summer	All	1,000	89	29 May	12 Apr	1 Jul
	Fall	Early	424	57	5 May	11 Apr	2 Jun
	Winter	Late	433	30	28 May	17 Apr	4 Jul
	Spring	Late	368	109	*2 Jun*	15 Apr	12 Jul
1996	Fall	Early	4	0	—	—	—
	Spring	Late	327	47	*16 May*	19 Apr	6 Jun
1997	Fall	Early	27	2	23 Apr	22 Apr	24 Apr
	Spring	Late	1	1	14 May	—	—
1998	Fall	Early	592	81	27 Apr	4 Apr	25 May
	Winter	Late	124	5	5 Jun	11 May	26 Jun
	Spring	Late	513	116	*5 May*	8 Apr	5 Jun
1999	Fall	Early	500	42	29 Apr	31 Mar	1 Jun
	Winter	Late	420	13	27 May	12 May	20 Jun
	Spring	Late	535	83	*4 May*	18 Apr	20 Jun
2000	Fall	Early	493	45	8 May	12 Apr	6 Jun
	Winter	Late	500	22	26 May	9 May	16 Jul
	Spring	Late	495	91	*11 May*	15 Apr	20 Jul
2001	Spring	Late	6	4	*17 May*	4 May	20 May
2002	Fall	Early	344	20	20 May	17 Apr	2 Jun
	Spring	Late	538	71	*31 May*	14 Apr	28 Jun
2003	Fall	Early	584	46	1 May	3 Apr	26 May
	Spring	Late	571	95	*17 May*	31 Mar	2 Jun
2004	Fall	Early	180	24	5 May	15 Apr	3 Jun
	Winter	Late	301	68	21 May	26 Apr	17 Jun
	Spring	Late	525	173	*21 May*	17 Apr	3 Jun
2005	Fall	Early	368	39	7 May	20 Apr	1 Jun
	Winter	Late	449	46	30 May	3 May	19 Jun
	Spring	Late	615	131	19 May	19 Apr	13 Jun

[a] Trap was located at rkm 257.

Appendix Table A-2. Continued.

Stream, MY	Tag group	Migration period	Number tagged	Number detected at LGD	Arrival dates		
					Median	First	Last
Upper Grande Ronde River (cont.)							
2006	Fall	Early	521	29	18 May	16 Apr	6 Jun
	Winter	Late	464	12	3 Jun	20 May	14 Jun
	Spring	Late	505	49	20 May	30 Mar	20 Jun
2007	Fall	Early	534	54	11 May	14 Apr	3 Jun
	Winter	Late	383	32	15 May	27 Apr	6 Jun
	Spring	Late	501	79	14 May	13 Apr	11 Jun
Catherine Creek							
1993	Summer	All	1,094	125	18 May	29 Apr	26 Jun
1994	Summer	All	1,000	91	11 May	13 Apr	26 Jul
1995	Summer	All	999	88	25 May	26 Apr	2 Jul
	Fall	Early	502	65	7 May	22 Apr	19 Jun
	Winter	Late	483	57	13 May	27 Apr	4 Jul
	Spring	Late	348	88	5 Jun	1 May	8 Jul
1996	Summer	All	499	60	1 May	17 Apr	29 May
	Fall	Early	566	76	29 Apr	14 Apr	4 Jun
	Winter	Late	295	14	18 May	19 Apr	14 Jun
	Spring	Late	277	70	17 May	17 Apr	13 Jun
1997	Summer	All	583	51	14 May	24 Apr	10 Jun
	Fall	Early	403	40	12 May	17 Apr	1 Jun
	Winter	Late	102	5	17 May	27 Apr	15 Jun
	Spring	Late	78	22	26 May	28 Apr	1 Jun
1998	Summer	All	499	43	17 May	24 Apr	4 Jun
	Fall	Early	598	66	1 May	3 Apr	3 Jun
	Winter	Late	438	57	11 May	15 Apr	15 Jun
	Spring	Late	453	109	21 May	26 Apr	26 Jun
1999	Summer	All	502	20	26 May	26 Apr	26 Jun
	Fall	Early	656	41	23 May	19 Apr	28 Jun
	Winter	Late	494	35	29 May	23 Apr	9 Jul
	Spring	Late	502	54	21 May	20 Apr	20 Jun
2000	Summer	All	497	30	7 May	12 Apr	7 Jun
	Fall	Early	677	56	3 May	12 Apr	29 May
	Winter	Late	500	22	9 May	25 Apr	1 May
	Spring	Late	431	52	12 May	21 Apr	2 Jul
2001	Summer	All	498	33	17 May	28 Apr	3 Jul
	Fall	Early	494	57	10 May	27 Apr	18 Jun
	Winter	Late	538	27	1 Jun	4 May	6 Jul
	Spring	Late	329	100	30 May	29 Apr	13 Jul

Appendix Table A-2. Continued.

Stream, MY	Tag group	Migration period	Number tagged	Number detected at LGD	Arrival dates		
					Median	First	Last
Catherine Creek (cont.)							
2002	Summer	All	502	17	6 May	15 Apr	22 May
	Fall	Early	515	20	6 May	16 Apr	20 Jun
	Winter	Late	449	15	14 May	24 Apr	26 Jun
	Spring	Late	217	27	*26 May*	17 Apr	1 Jul
2003	Summer	All	501	17	16 May	14 Apr	9 Jun
	Fall	Early	1,196	59	18 May	14 Apr	31 May
	Winter	Late	531	25	22 May	18 Apr	6 Jun
	Spring	Late	576	95	*25 May*	13 Apr	23 Jun
2004	Summer	All	467	30	15 May	22 Apr	25 Jun
	Fall	Early	524	45	21 May	15 Apr	15 Jun
	Winter	Late	502	66	21 May	23 Apr	8 Jul
	Spring	Late	525	172	*29 May*	22 Apr	14 Jul
2005	Summer	All	495	21	8 May	20 Apr	2 Jun
	Fall	Early	544	43	7 May	14 Apr	2 Jun
	Winter	Late	529	28	21 May	18 Apr	20 Jun
	Spring	Late	410	82	31 May	26 Apr	20 Jun
2006	Summer	All	523	7	16 May	28 Apr	19 May
	Fall	Early	500	15	4 May	23 Apr	10 Jun
	Winter	Late	500	19	15 May	26 Apr	9 Jun
	Spring	Late	360	34	4 Jun	2 May	22 Jun
2007	Summer	All	501	6	23 Apr	19 Apr	19 May
	Fall	Early	500	26	2 May	16 Apr	15 May
	Winter	Late	500	12	13 May	21 Apr	20 May
	Spring	Late	363	42	13 May	1 May	13 Jun
Grande Ronde River (rkm 164)							
2002	Spring	NA	167	21	*23 May*	17 May	18 Jun
2003	Spring	NA	250	90	*16 May*	22 Apr	18 Jun
2004	Spring	NA	488	286	*5 May*	21 Apr	5 Jun
2005	Spring	NA	236	118	3 May	6 Apr	29 May
2006	Spring	NA	400	107	16-May	8-Apr	30-May
Lostine River							
1993	Summer	All	997	136	4 May	17 Apr	1 Jun
1994	Summer	All	725	77	2 May	19 Apr	7 Jun
1995	Summer	All	1,002	115	2 May	8 Apr	19 Jun
1996	Summer	All	977	129	15 May	17 Apr	19 Jun
1997	Summer	All	527	43	25 Apr	9 Apr	21 May
	Fall	Early	519	53	22 Apr	2 Apr	13 May
	Winter	Late	390	60	2 May	15 Apr	27 May
	Spring	Late	476	109	*25 Apr*	10 Apr	22 May

Appendix Table A-2. Continued.

Stream, MY	Tag group	Migration period	Number tagged	Number detected at LGD	Arrival dates Median	First	Last
Lostine River (cont.)							
1998	Summer	All	506	19	15 May	29 Mar	29 May
	Fall	Early	500	109	21 Apr	31 Mar	13 May
	Winter	Late	504	96	29 Apr	4 Apr	24 May
	Spring	Late	466	185	*28 Apr*	4 Apr	1 Jul
1999	Summer	All	509	36	8 May	13 Apr	3 Jun
	Fall	Early	501	40	26 Apr	31 Mar	18 May
	Winter	Late	491	39	10 May	6 Apr	7 Jun
	Spring	Late	600	88	*12 May*	9 Apr	8 Jul
2000	Summer	All	489	87	9 May	10 Apr	12 Jun
	Fall	Early	514	59	18 Apr	3 Apr	13 May
	Winter	Late	511	51	9 May	20 Apr	2 Jul
	Spring	Late	355	65	*22 May*	14 Apr	16 Jul
2001	Summer	All	501	23	20 Apr	28 Mar	29 May
	Fall	Early	500	139	27 Apr	12 Apr	18 May
	Winter	Late	500	113	14 May	16 Apr	19 Jun
	Spring	Late	445	246	*12 May*	21 Apr	4 Jul
2002	Summer	All	509	21	8 May	11 Apr	3 Jun
	Fall	Early	501	37	17 Apr	30 Mar	5 May
	Winter	Late	564	22	7 May	11 Apr	23 Jun
	Spring	Late	406	61	*7 May*	15 Apr	11 Jun
2003	Summer	All	997	136	4 May	17 Apr	1 Jun
	Fall	Early	900	77	18 Apr	25 Mar	27 May
	Winter	Late	491	42	15 May	13 Apr	8 Jun
	Spring	Late	527	107	*4 May*	3 Apr	4 Jul
2004	Summer	All	525	26	7 May	14 Apr	15 Jun
	Winter	Late	500	70	11 May	23 Apr	27 May
2005	Summer	All	500	49	28 Apr	5 Apr	18 Jun
	Fall	Early	500	103	20 Apr	5 Apr	9 May
	Winter	Late	500	72	9 May	12 Apr	13 Jun
	Spring	Late	464	174	8 May	13 Apr	19 Jun
2006	Summer	All	1,105	29	28 Apr	5 Apr	9 Jun
	Fall	Early	495	29	22 Apr	2 Apr	10 May
	Winter	Late	501	27	12 May	20 Apr	31 May
	Spring	Late	517	112	11 May	6 Apr	3 Jun
2007	Summer	All	500	27	4 May	5 Apr	21 May
	Fall	Early	500	37	17 Apr	27 Mar	12 May
	Winter	Late	500	39	12 May	17 Apr	25 May
	Spring	Late	505	109	11 May	18 Apr	1 Jun

Appendix Table A-2. Continued.

Stream, MY	Tag group	Migration period	Number tagged	Number detected at LGD	Arrival dates		
					Median	First	Last
Minam River							
1993	Summer	All	994	113	4 May	18 Apr	3 Jun
1994	Summer	All	997	120	29 Apr	18 Apr	13 Aug
1995	Summer	All	996	71	2 May	8 Apr	7 Jun
1996	Summer	All	998	117	24 Apr	10 Apr	7 Jun
1997	Summer	All	589	49	16 Apr	3 Apr	13 May
1998	Summer	All	992	123	29 Apr	3 Apr	30 May
1999	Summer	All	1,006	50	29 Apr	31 Mar	2 Jun
2000	Summer	All	998	74	3 May	10 Apr	29 May
2001	Summer	All	1,000	178	8 May	8 Apr	12 Jun
	Fall	Early	300	107	28 Apr	12 Apr	26 May
	Spring	Late	539	274	*14 May*	16 Apr	18 Aug
2002	Summer	All	994	30	3 May	16 Apr	31 May
	Fall	Early	537	35	18 Apr	25 Mar	9 May
	Spring	Late	382	42	*30 May*	8 Apr	23 Jun
2003	Summer	All	1,000	23	13 May	13 Apr	1 Jun
	Fall	Early	849	82	18 Apr	26 Mar	23 May
	Spring	Late	512	95	*15 May*	31 Mar	1 Jun
2004	Summer	All	996	36	1 May	7 Apr	31 May
	Fall	Early	500	58	28 Apr	2 Apr	21 May
	Spring	Late	412	164	*9 May*	4 Apr	14 Jun
2005	Summer	All	1,002	95	6 May	8 Apr	8 Jun
	Fall	Early	498	115	23 Apr	5 Apr	18 May
	Spring	Late	374	135	9 May	13 Apr	19 Jun
2006	Summer	All	1,007	50	8 May	11 Apr	6 Jun
	Fall	Early	499	45	19 Apr	4 Apr	16 May
	Spring	Late	401	74	17 May	21 Apr	7 Jun
2007	Summer	All	1,000	65	2 May	4 Apr	22 May
	Fall	Early	500	28	16 Apr	30 Mar	12 May
	Spring	Late	217	40	12 May	5 Apr	2 Jun
Imnaha River							
1993	Summer	All	1,000	74	14 May	15 Apr	23 Jun
1994	Summer	All	998	65	8 May	20 Apr	11 Aug
1995	Summer	All	996	41	2 May	10 Apr	7 Jul
1996	Summer	All	997	158	26 Apr	14 Apr	12 Jun
1997	Summer	All	1,017	98	19 Apr	31 Mar	2 Jun
1998	Summer	All	1,009	159	29 Apr	3 Apr	24 May
1999	Summer	All	1,009	41	8 May	17 Apr	3 Jun
2000	Summer	All	982	63	2 May	12 Apr	16 Jun
2001	Summer	All	1,000	159	30 Apr	8 Apr	28 May
2002	Summer	All	1,001	15	4 May	15 Apr	31 May

Appendix Table A-2. Continued.

Stream, MY	Tag group	Migration period	Number tagged	Number detected at LGD	Arrival dates		
					Median	First	Last
Imnaha River (cont.)							
2003	Summer	All	1,003	43	8 May	17 Apr	31 May
2004	Summer	All	998	81	4 May	18 Apr	8 Jun
2005	Summer	All	1,001	90	2 May	5 Apr	11 Jun
2006	Summer	All	1,011	40	30 Apr	3 Apr	4 Jun
2007	Summer	All	1,000	59	27 Apr	5 Apr	24 May
Wenaha and South Fork Wenaha rivers							
1993	Summer	All	749	84	28 Apr	14 Apr	15 May
1994	Summer	All	998	93	24 Apr	18 Apr	6 Jun
1995	Summer	All	999	76	26 Apr	9 Apr	15 May
1996	Summer	All	997	105	21 Apr	13 Apr	16 May
1997	Summer	All	62	10	16 Apr	9 Apr	23 Apr

Appendix Table A-3. The number of PIT tagged spring Chinook salmon released by tag group and stream, and survival probability to Lower Granite Dam during migratory years 1993–2007. Summer and winter tag groups were collected upstream of screw traps, while fall and spring tag groups were collected at screw traps. Asterisks indicate that low detections precluded calculation of survival probabilities.

Tag group, Stream	MY	Number released	Survival probability (95% CI)
Summer			
Upper Grande Ronde	1993	918	0.287 (0.237–0.365)
	1994	1,001	0.144 (0.110–0.197)
	1995	1,000	0.173 (0.144–0.207)
Catherine Creek	1993	1,094	0.178 (0.151–0.212)
	1994	1,000	0.226 (0.186–0.279)
	1995	999	0.154 (0.129–0.184)
	1996	499	0.277 (0.205–0.406)
	1997	583	0.176 (0.139–0.225)
	1998	499	0.211 (0.164–0.276)
	1999	502	0.157 (0.122–0.212)
	2000	497	0.151 (0.109–0.217)
	2001	498	0.087 (0.063–0.115)
	2002	502	0.109 (0.079–0.157)
	2003	501	0.075 (0.052–0.106)
	2004	467	0.072 (0.051–0.098)
	2005	495	0.057 (0.038–0.082)
	2006	523	0.057 (0.033–0.128)
	2007	501	0.042 (SE = 0.009)
Lostine River	1993	997	0.250 (0.214–0.296)
	1994	725	0.237 (0.188–0.309)
	1995	1,002	0.215 (0.183–0.255)
	1996	977	0.237 (0.191–0.306)
	1997	527	0.213 (0.160–0.310)
	1999	506	0.180 (0.145–0.234)
	2000	509	0.212 (0.159–0.294)
	2001	489	0.210 (0.175–0.248)
	2002	501	0.154 (0.117–0.209)
	2003	509	0.155 (0.109–0.238)
	2004	525	0.065 (0.046–0.089)
	2005	500	0.129 (0.101–0.163)
	2006	1,105	0.113 (0.091–0.143)
	2007	500	0.159 (0.112–0.245)
Minam River	1993	994	0.187 (0.115–0.230)
	1994	997	0.293 (0.249–0.350)
	1995	996	0.153 (0.124–0.191)
	1996	998	0.208 (0.169–0.264)
	1997	589	0.270 (0.181–0.693)

Appendix Table A-3. Continued.

Tag group, Stream	MY	Number released	Survival probability (95% CI)
Summer (cont.)			
Minam River (cont.)	1998	992	0.228 (0.199–0.259)
	1999	1,006	0.181 (0.155–0.210)
	2000	998	0.239 (0.199–0.292)
	2001	1,000	0.228 (0.202–0.256)
	2002	994	0.093 (0.074–0.119)
	2003	1,000	0.061 (0.044–0.088)
	2004	996	0.062 (0.047–0.080)
	2005	1,002	0.136 (0.114–0.160)
	2006	1,007	0.145 (0.119–0.178)
	2007	1,000	0.175 (0.147–0.211)
Imnaha River	1993	1,000	0.141 (0.115–0.180)
	1994	998	0.136 (0.109–0.173)
	1995	996	0.083 (0.064–0.108)
	1996	997	0.268 (0.222–0.330)
	1997	1,017	0.216 (0.179–0.276)
	1998	1,009	0.325 (0.290–0.366)
	1999	1,009	0.173 (0.141–0.219)
	2000	982	0.141 (0.115–0.172)
	2001	1,000	0.181 (0.158–0.206)
	2002	1,001	0.106 (0.079–0.160)
	2003	1,003	0.141 (0.110–0.185)
	2004	998	0.109 (0.090–0.131)
	2005	1,001	0.123 (0.103–0.146)
	2006	1,011	0.144 (0.117–0.180)
	2007	1,000	0.178 (0.147–0.218)
Wenaha/SF Wenaha	1993	749	0.214 (0.181–0.255)
	1994	998	0.144 (0.121–0.172)
	1995	999	0.146 (0.119–0.180)
	1996	997	0.212 (0.172–0.271)
	1997	62	*
Fall trap			
Upper Grande Ronde	1994	405	0.348 (0.284–0.432)
	1995	424	0.228 (0.184–0.281)
	1996	5	*
	1997	27	*
	1998	590	0.286 (0.244–0.334)
	1999	498	0.269 (0.229–0.315)
	2000	493	0.341 (0.260–0.476)
	2002	344	0.308 (0.198–0.653)
	2003	581	0.184 (0.143–0.247)

Appendix Table A-3. Continued.

Tag group, Stream	MY	Number released	Survival probability (95% CI)
Fall trap (cont.)			
Upper Grande Ronde	2004	180	0.164 (0.114–0.225)
	2005	368	0.138 (0.105–0.177)
	2006	521	0.171 (0.136–0.232)
	2007	534	0.242 (0.199–0.301)
Catherine Creek	1995	502	0.238 (0.193–0.297)
	1996	508	0.358 (0.296–0.446)
	1997	399	0.365 (0.256–0.588)
	1998	582	0.238 (0.194–0.293)
	1999	644	0.202 (0.166–0.250)
	2000	677	0.212 (0.170–0.269)
	2001	508	0.130 (0.103–0.162)
	2002	514	0.154 (0.114–0.245)
	2003	849	0.120 (0.093–0.160)
	2004	524	0.126 (0.099–0.158)
	2005	544	0.122 (0.093–0.161)
	2006	500	0.074 (SE = 0.012)
	2007	500	0.203 (0.143–0.340)
Lostine River	1997	519	0.312 (0.247–0.465)
	1998	500	0.448 (0.391–0.514)
	1999	501	0.422 (0.349–0.538)
	2000	514	0.317 (0.267–0.380)
	2001	498	0.335 (0.294–0.378)
	2002	500	0.326 (0.258–0.455)
	2003	854	0.287 (0.236–0.365)
	2004	0	—
	2005	500	0.267 (0.227–0.310)
	2006	495	0.269 (0.207–0.406)
	2007	500	0.223 (0.172–0.301)
Minam River	2001	300	0.427 (0.371–0.485)
	2002	537	0.249 (0.201–0.326)
	2003	849	0.238 (0.199–0.292)
	2004	500	0.183 (0.150–0.219)
	2005	498	0.293 (0.253–0.337)
	2006	499	0.245 (0.205–0.304)
	2007	500	0.250 (0.186–0.368)
Wallowa River	1999	45	*
Winter			
Upper Grande Ronde	1994	505	0.248 (0.152–0.519)
	1995	432	0.151 (0.115–0.199)
	1998	124	0.113 (SE = 0.028)

Appendix Table A-3. Continued.

Tag group, Stream	MY	Number released	Survival probability (95% CI)
Winter (cont.)			
Upper Grande Ronde	1999	420	0.118 (0.083–0.183)
	2000	500	0.133 (0.099–0.183)
	2004	301	0.296 (0.245–0.353)
	2005	449	0.207 (0.159–0.306)
	2006	464	0.080 (0.052–0.183)
	2007	383	0.138 (0.102–0.187)
Catherine Creek	1995	482	0.279 (0.230–0.343)
	1996	295	0.312 (0.163–1.008)
	1997	102	0.078 (0.033–0.222)
	1998	437	0.278 (0.226–0.345)
	1999	493	0.285 (0.230–0.367)
	2000	500	0.138 (0.102–0.191)
	2001	522	0.077 (0.054–0.106)
	2002	431	0.203 (0.129–0.476)
	2003	524	0.152 (0.109–0.231)
	2004	502	0.178 (0.145–0.215)
	2005	529	0.112 (0.079–0.178)
	2006	500	0.125 (0.080–0.312)
	2007	500	0.088 (0.047–0.343)
Lostine River	1997	388	0.445 (0.334–0.650)
	1998	504	0.349 (0.301–0.403)
	1999	491	0.305 (0.259–0.363)
	2000	511	0.397 (0.296–0.576)
	2001	499	0.284 (0.245–0.326)
	2002	564	0.246 (0.170–0.464)
	2003	501	0.226 (0.167–0.337)
	2004	500	0.189 (0.156–0.227)
	2005	500	0.201 (0.166–0.240)
	2006	501	0.177 (0.127–0.304)
	2007	500	0.135 (0.101–0.186)
Spring trap			
Upper Grande Ronde	1994	571	0.462 (0.387–0.563)
	1995	368	0.609 (0.545–0.683)
	1996	327	0.512 (0.404–0.690)
	1998	512	0.548 (0.487–0.622)
	1999	528	0.538 (0.486–0.601)
	2000	495	0.560 (0.472–0.680)
	2001	6	*
	2002	536	0.499 (0.416–0.633)
	2003	571	0.397 (0.346–0.461)
	2004	525	0.420 (0.376–0.464)

Appendix Table A-3. Continued.

Tag group, Stream	MY	Number released	Survival probability (95% CI)
Spring trap (cont.)			
Upper Grande Ronde	2005	615	0.374 (0.335–0.418)
	2006	505	0.398 (0.318–0.561)
	2007	501	0.373 (0.307–0.469)
Catherine Creek	1995	348	0.506 (0.441–0.578)
	1996	276	0.591 (0.480–0.755)
	1997	81	0.413 (0.292–0.580
	1998	453	0.517 (0.459–0.583)
	1999	502	0.448 (0.379–0.545)
	2000	431	0.452 (0.359–0.598)
	2001	328	0.376 (0.322–0.433)
	2002	217	0.527 (0.411–0.750)
	2003	535	0.365 (0.312–0.431)
	2004	525	0.413 (0.370–0.457)
	2005	410	0.445 (0.366–0.569)
	2006	360	0.367 (0.290–0.526)
	2007	363	0.310 (0.250–0.402)
Grande Ronde (Elgin)	2001	4	*
	2002	167	0.776 (0.624–1.073)
	2003	250	0.764 (0.668–0.893)
	2004	488	0.721 (0.677–0.764)
	2005	236	0.698 (0.625–0.776)
	2006	400	0.745 (0.666–0.881)
Lostine River	1997	475	0.769 (0.630–1.009)
	1998	484	0.784 (0.728–0.845)
	1999	599	0.744 (0.664–0.857)
	2000	355	0.660 (0.546–0.823)
	2001	442	0.695 (0.648–0.741)
	2002	406	0.683 (0.589–0.825)
	2003	482	0.495 (0.424–0.591)
	2004	0	—
	2005	464	0.552 (0.503–0.602)
	2006	517	0.619 (0.551–0.722)
	2007	505	0.589 (0.508–0.706)
Minam River	2001	536	0.619 (0.576–0.661)
	2002	382	0.532 (0.465–0.644)
	2003	512	0.476 (0.405–0.577)
	2004	412	0.530 (0.480–0.580)
	2005	374	0.555 (0.497–0.620)
	2006	401	0.543 (0.482–0.630)
	2007	217	0.602 (0.519–0.725)

Appendix Table A-4. Travel time to Lower Granite Dam (LGD) of juvenile spring Chinook salmon PIT-tagged at screw traps in spring and arriving at Lower Granite Dam the same year. Min. = minimum; Max. = maximum.

Stream, MY	Distance to LGD (km)	Number detected	Travel time (d)		
			Median	Min.	Max
Upper Grande Ronde River (rkm 299)	397				
1994		93	45.1	17	130
1995[a]		114	19.5	6	81
1996		47	64.7	14	88
1997		1	56.7	—	—
1998		116	48.6	25	71
1999		83	39.1	16	92
2000		91	50.5	12	98
2001		4	37.5	29	56
2002		71	46.5	12	79
2003		95	56.0	20	84
2004		173	52.5	10	95
2005		131	36.7	11	74
2006		49	49.9	21	77
2007		79	54.7	10	73
Catherine Creek	362				
1995		88	59.1	20	105
1996		70	54.2	9	91
1997		22	60.4	17	91
1998		109	56.5	12	87
1999		54	63.2	21	90
2000		52	50.5	20	95
2001		100	64.5	15	110
2002		27	52.8	13	75
2003		95	54.8	16	101
2004		172	56.8	10	109
2005		82	49.7	9	109
2006		34	50.1	12	86
2007		42	46.1	14	83
Grande Ronde River (rkm 164)	262				
2002		21	6.6	3	22
2003		90	8.6	3	35
2004		286	8.5	4	52
2005		118	20.3	4	51
2006		107	5.8	2	50

[a] Trap was located at rkm 257; distance to LGD was 355 km.

Appendix Table A-4. Continued.

Stream, MY	Distance to LGD (km)	Number detected	Travel time (d)		
			Median	Min.	Max
Lostine River	274				
1997		109	21.7	5	54
1998		183	17.8	6	59
1999		88	25.6	5	60
2000		65	32.5	5	90
2001		246	23.6	5	90
2002		61	27.5	8	57
2003		107	41.6	8	90
2004[b]		—	—	—	—
2005		174	32.8	6	75
2006		112	32.0	5	53
2007		109	34.5	6	84
Minam River	245				
2001		274	39.5	9	106
2002		42	32.4	5	52
2003		95	45.3	10	71
2004		164	38.1	6	82
2005		135	38.3	8	68
2006		74	33.4	6	58
2007		40	33.4	9	62

[b] Limited trapping operations

Appendix Table A-5. 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 MY 1995 when the upper Grande Ronde River trap was at rkm 257. Survival rates were calculated by dividing the survival probability of the winter tag group by the survival probability of the spring tag group.

		Overwinter survival in upper rearing areas		
BY	MY	Upper Grande Ronde River	Catherine Creek	Lostine River
1992	1994	0.54	—	—
1993	1995	0.25	0.55	—
1994	1996	—	0.53	—
1995	1997	—	0.19	0.58
1996	1998	0.21	0.54	0.45
1997	1999	0.22	0.64	0.41
1998	2000	0.24	0.31	0.60
1999	2001	—	0.20	0.41
2000	2002	—	0.39	0.36
2001	2003	—	0.38	0.46
2002	2004	0.70	0.43	0.30
2003	2005	0.55	0.25	0.36
2004	2006	0.20	0.34	0.29
2005	2007	0.37	0.28	0.23

Appendix Table A-6. Comparisons of overwinter survival of spring Chinook salmon parr in rearing areas upstream (above screw trap) and downstream (below screw trap) on the upper Grande Ronde River, Catherine Creek and the Lostine River. Early migrant life history corresponds to overwintering downstream; late migrant life history corresponds to overwintering upstream. Screw traps operated in the same location in each study stream with the exception of the upper Grande Ronde River trap which operated at rkm 299 in all years but MY 1995 when it was located at rkm 257. Each *P*-value was based on the maximum likelihood ratio test comparing the fit of the null model (fall tag group survival = winter tag group survival) to the fit of the full model (fall tag group survival ≠ winter tag group survival).

	Upper Grande Ronde River		Catherine Creek		Lostine River	
MY	Area/life history with higher overwinter survival	*P*-value	Area/life history with higher overwinter survival	*P*-value	Area/life history with higher overwinter survival	*P*-value
1994	Equivalent	0.331	—	—	—	—
1995	Downstream/fall migrants	0.020	Equivalent	0.278	—	—
1996	—	—	Equivalent	0.766	—	—
1997	—	—	Downstream/fall migrants	0.016	Equivalent	0.133
1998	Downstream/fall migrants	<0.001	Equivalent	0.289	Downstream/fall migrants	0.014
1999	Downstream/fall migrants	0.002	Upstream/spring migrants	0.025	Downstream/fall migrants	0.014
2000	Downstream/fall migrants	<0.001	Downstream/fall migrants	0.031	Equivalent	0.211
2001	—	—	Downstream/fall migrants	0.009	Equivalent	0.090
2002	—	—	Equivalent	0.403	Equivalent	0.350
2003	—	—	Equivalent	0.283	Equivalent	0.263
2004	Upstream/spring migrants	0.001	Upstream/spring migrants	0.026	—	—
2005	Upstream/spring migrants	0.030	Equivalent	0.733	Downstream/fall migrants	0.021
2006	Equivalent	0.070	Equivalent	0.061	Equivalent	0.144
2007	Downstream/fall migrants	0.012	Downstream/fall migrants	<0.001	Equivalent	0.115

APPENDIX B

A Compilation of Steelhead Data

Appendix Table B-1. Population estimates, median migration dates, and percentage of steelhead population moving as late migrants past trap sites, 1997–2007 migratory years. The early migratory period begins 1 July of the preceding year and ends 28 January of the migratory year. The late migratory period begins 29 January and ends 30 June.

Stream, MY	Population estimate	95% CI	Median migration date: Early migrants	Median migration date: Late migrants	Percentage migrating late
Upper Grande Ronde River					
1997	15,104	3,184	25 Oct	27 Mar	92
1998	10,133	1,612	8 Aug	27 Mar	60
1999	6,108	1,309	8 Nov	29 Apr	95
2000	17,845	3,526	30 Sep	8 Apr	94
2001	16,067	4,076	11 Oct	8 May	96
2002	17,286	1,715	24 Oct	15 Apr	94
2003	14,729	2,302	6 Oct	23 Apr	93
2004	13,126	1,487	15 Oct	11 Apr	91
2005	8,210	1,434	25 Oct	4 May	86
2006	13,188	2,819	2 Oct	12 Apr	86
2007	12,632	1,766	20 Oct	10 Apr	87
Catherine Creek					
1997	25,229	4,774	23 Nov[a]	14 Apr	42[a]
1998	20,742	2,076	22 Sep	4 Apr	58
1999	19,628	3,549	2 Nov	15 Apr	75
2000	35,699	6,024	30 Oct	16 Apr	61
2001	20,586	4,082	24 Sep	31 Mar	56
2002	45,799	6,271	12 Oct	1 May	58
2003	29,593	5,095	14 Oct	18 May	59
2004	26,642	4,324	31 Oct	23 Apr	63
2005	27,192	5,686	15 Oct	20 May	66
2006	23,243	8,142	13 Oct	13 Apr	62
2007	13,715	1,704	16 Oct	4 May	27
Lostine River					
1997	4,309	710	21 Nov[a]	1 May	63[a]
1998	10,271	2,152	4 Oct	24 Apr	46
1999	23,643	2,637	17 Oct	1 May	35
2000	11,981	1,574	19 Oct	21 Apr	44
2001	16,690	3,242	4 Oct	27 Apr	55
2002	21,019	2,958	18 Oct	17 Apr	31
2003	37,106	4,798	2 Oct	25 Apr	30
2004	—[b]	—	—	—	—
2005	31,342	8,234	23 Sep	25 Apr	26
2006	28,710	7,068	3 Oct	18 Apr	11
2007	13,162	1,867	5 Oct	28 Apr	26

[a] Trap was started late, thereby potentially missing some early migrants.

[b] Limited trapping operations prevented complete population estimates and migration timing

Appendix Table B-1. Continued.

Stream, MY	Population estimate	95% CI	Median migration date: Early migrants	Median migration date: Late migrants	Percentage migrating late
Minam River					
2001	28,113	10,537	3 Oct[a]	28 Apr	86[a]
2002	44,872	19,786	24 Oct[a]	25 Apr	82[a]
2003	43,743	20,680	10 Nov[a]	1 May	99[a]
2004	24,846	13,564	29 Oct	28 Apr	97
2005	105,853	75,607	16 Sep	18 Apr	94
2006	103,141	62,607	2 Oct	22 Apr	78
2007	11,831	3,330	1 Oct	30 Apr	72

Appendix Table B-2. Dates of arrival at Lower Granite Dam (LGD) of steelhead PIT tagged upstream of the screw trap in Catherine Creek and tributaries during summer, and at screw traps in the fall and spring during the same migratory year, 2000–2007. The numbers of fish detected were expanded for spillway flow to calculate the median arrival date.

Stream, MY	Tag group	Number tagged	Number detected	Arrival dates Median	First	Last
Upper Grande Ronde River						
2000	Fall	110	7	30 Apr	18 Apr	26 May
	Spring	462	73	7 May	31 Mar	28 Jun
2001	Fall	61	10	7 May	28 Apr	29 Jun
	Spring	475	180	5 May	26 Apr	28 Aug
2002	Fall	165	9	7 May	26 Apr	1 Jun
	Spring	543	86	22 May	14 Apr	25 Jun
2003	Fall	309	11	18 May	8 Apr	1 Jun
	Spring	583	101	25 May	4 Apr	24 Jun
2004	Fall	108	1	23 May	—	—
	Spring	853	190	17 May	15 Apr	14 Jun
2005	Fall	288	16	10 May	19 Apr	19 May
	Spring	643	150	11 May	21 Apr	27 Jun
2006	Fall	53	4	10 May	25 Apr	17 May
	Spring	500	62	10 May	15 Apr	27 May
2007	Fall	485	16	9 May	15 Apr	6 Jun
	Spring	600	59	13 May	7 Apr	12 Jun
Catherine Creek						
2000	Fall	989	43	20 Apr	2 Apr	29 Jun
	Spring	502	63	6 May	6 Apr	10 Jun
2001	Summer	1,169	26	8 May	25 Apr	25 Jun
	Fall	561	66	6 May	18 Apr	12 Jun
	Spring	266	88	14 May	22 Apr	11 Jun
2002	Summer	1,108	32	20 May	14 Apr	25 Jun
	Fall	723	10	12 May	16 Apr	17 Jun
	Spring	504	95	22 May	20 Apr	1 Jul
2003	Summer	1,043	27	26 May	26 Apr	1 Jun
	Fall	918	26	8 May	27 Mar	3 Jun
	Spring	364	52	26 May	22 Apr	3 Aug
2004	Summer	1,046	54	11 May	10 Apr	18 Aug
	Fall	512	38	7 May	3 Apr	20 Jun
	Spring	598	150	22 May	26 Apr	24 Jul
2005	Summer	1,024	81	8 May	4 Apr	3 Jun
	Fall	473	35	8 May	23 Apr	8 Jun
	Spring	623	55	10 May	18 Apr	27 Jun
2006	Summer	632	19	2 May	15 Apr	9 Jun
	Fall	934	23	30 Apr	2 Apr	22 May
	Spring	500	32	7 May	15 Apr	31 May

Appendix Table B-2. Continued.

Stream, MY	Tag group	Number tagged	Number detected	Arrival dates Median	First	Last
Catherine Creek cont.						
2007	Summer	609	3	12 May	2 May	13 May
	Fall	859	21	5 May	2 Apr	9 Jun
	Spring	370	15	9 May	4 May	3 Jun
Lostine River						
2000	Fall	777	116	10 May	26 Mar	16 Jun
	Spring	532	166	6 May	13 Apr	13 Jun
2001	Fall	421	13	12 May	16 Apr	13 Jun
	Spring	345	164	14 May	13 Apr	18 Aug
2002	Fall	837	40	8 May	10 Apr	24 Jun
	Spring	351	72	23 May	19 Apr	30 Jun
2003	Fall	999	48	26 May	25 Mar	22 Jun
	Spring	451	116	26 May	3 Apr	15 Jun
2004	Fall[a]	—	—	—	—	—
	Spring[a]	—	—	—	—	—
2005	Fall	760	73	10 May	2 Apr	18 Jun
	Spring	232	52	9 May	10 Apr	20 May
2006	Fall	827	21	19 May	6 Apr	8 Jun
	Spring	270	23	1 May	18 Apr	22 May
2007	Fall	1,000	46	13 May	27 Apr	10 Jun
	Spring	273	16	10 May	18 Apr	16 May
Minam River						
2001	Fall	32	6	9 May	2 May	17 May
	Spring	454	240	7 May	26 Apr	29 Aug
2002	Fall	262	5	11 May	17 Apr	31 May
	Spring	197	48	20 May	16 Apr	2 Jun
2003	Fall	42	6	13 Apr	2 Apr	27 May
	Spring	503	129	21 May	2 Apr	6 Jun
2004	Fall	60	2	24 May	23 May	1 Jun
	Spring	217	52	11 May	28 Apr	25 Jun
2005	Fall	79	7	8 May	1 May	10 May
	Spring	333	67	10 May	7 Apr	18 Jun
2006	Fall	81	5	28 Apr	18 Apr	6 May
	Spring	437	64	2 May	8 Apr	3 Jun
2007	Fall	107	2	14 May	12 May	16 May
	Spring	293	29	7 May	3 May	7 Jun

[a] Limited trapping operations during MY 2004.

Appendix Table B-3. Survival probabilities to Lower Granite Dam for steelhead PIT tagged in the upper rearing areas of Catherine Creek in summer and at screw traps during fall and spring.

Tag group, Stream	MY tagged	Number tagged	Number detected MY	MY + 1	MY + 2	Cumulative survival probability: Probability (95% CI)
Summer						
Catherine Creek						
	2001	410	22	7	0	0.081 (0.055–0.118)
	2002	837	65	9	0	0.119 (0.088–0.171)
	2003	510	23	7	0	0.061 (0.042–0.086)
	2004	527	42	18	0	0.117 (0.090–0.148)
	2005	704	58	3	0	0.083 (0.064–0.105)
	2006	418	40	1	—	0.142 (0.093–0.261)
	2007	334	10	—	—	0.072 (0.024–0.992)
Little Catherine Creek						
	2001	415	0	3	0	0.010 (0.002–0.097)
	2007	275	1	—	—	(a)
Middle Fork Catherine Creek						
	2006	214	1	0	—	(a)
Milk Creek						
	2003	532	27	3	0	0.068 (0.045–0.106)
North Fork Catherine Creek						
	2001	117	2	1	1	0.034 (SE = 0.017)
	2002	270	8	2	1	0.051 (0.026–0.111)
	2005	320	14	6	0	0.068 (0.041–0.115)
South Fork Catherine Creek						
	2001	225	5	4	0	0.041 (0.020–0.074)
	2004	519	20	10	1	0.057 (SE = 0.010)
Catherine Creek and tribs combined						
	2001	1,167	29	15	1	0.043 (0.032–0.058)
	2002	1,107	73	11	1	0.102 (0.078–0.140)
	2003	1,042	50	10	0	0.063 (0.048–0.082)
	2004	1,046	62	28	1	0.087 (0.071–0.106)
	2005	1,024	72	9	0	0.077 (0.062–0.096)
	2006	632	41	1	—	0.097 (0.063–0.179)
	2007	609	11	—	—	0.045 (0.015–0.062)
Fall						
Upper Grande Ronde River						
	2000	110	16	0	0	0.227 (0.118–0.650)
	2001	61	12	0	0	0.223 (0.122–0.398)
	2002	165	21	1	0	0.196 (0.115–0.411)
	2003	309	17	1	0	0.078 (0.043–0.245)

[a] Data was insufficient to calculate a survival probability.

Appendix Table B-3. Continued.

Tag group, Stream	MY tagged	Number tagged	Number detected			Cumulative survival probability
			MY	MY + 1	MY + 2	Probability (95% CI)
Fall cont.						
Upper Grande Ronde cont.						
	2004	108	1	1	0	0.019 (SE = 0.013)
	2005	288	20	2	0	0.079 (0.051–0.117)
	2006	53	5	5	—	0.094 (SE = 0.040)
	2007	485	34	—	—	0.121 (0.065–0.488)
Catherine Creek						
	2000	989	73	14	0	0.108 (0.085–0.136)
	2001	561	67	0	0	0.120 (0.095–0.149)
	2002	723	30	4	0	0.081 (0.049–0.165)
	2003	915	56	11	1	0.086 (0.064–0.118)
	2004	512	54	6	0	0.139 (0.105–0.189)
	2005	473	44	2	0	0.095 (0.070–0.127)
	2006	934	61	12	—	0.094 (0.071–0.133)
	2007	859	59	—	—	0.084 (0.059–0.155)
Lostine River						
	2000	777	157	11	0	0.271 (0.231–0.320)
	2001	421	17	18	0	0.098 (0.068–0.141)
	2002	837	106	19	0	0.178 (0.145–0.221)
	2003	998	100	31	0	0.141 (0.118–0.167)
	2005	760	108	27	0	0.189 (0.159–0.223)
	2006	827	59	15	—	0.106 (0.080–0.150)
	2007	1,000	96	—	—	0.160 (0.110–0.279)
Minam River						
	2001	32	7	2	0	0.294 (0.152–0.485)
	2002	262	11	10	0	0.172 (0.084–0.558)
	2003	42	8	1	0	0.238 (0.105–1.663)
	2004	60	3	2	0	(a)
	2005	79	10	1	0	0.139 (SE = 0.039)
	2006	81	7	1	—	0.099 (SE = 0.033)
	2007	107	10	—	—	(a)
Spring (FL ≥ 115 mm)						
Upper Grande Ronde River						
	2000	324	99	1	0	0.394 (0.329–0.487)
	2001	465	196	5	0	0.467 (0.417–0.521)
	2002	543	192	1	0	0.445 (0.383–0.523)
	2003	578	205	3	0	0.455 (0.391–0.540)
	2004	853	223	2	0	0.496 (0.447–0.546)
	2005	371	186	2	0	0.554 (0.492–0.627)

Appendix Table B-3. Continued.

Tag group, Stream	MY tagged	Number tagged	Number detected MY	MY + 1	MY + 2	Cumulative survival probability Probability (95% CI)
Spring (FL ≥ 115 mm) cont.						
Upper Grande Ronde cont.						
	2006	342	168	2	—	0.522 (0.454–0.629)
	2007	464	119	—	—	0.315 (0.246–0.453)
Catherine Creek						
	2000	305	103	2	0	0.480 (0.388–0.608)
	2001	248	96	2	0	0.404 (0.342–0.468)
	2002	504	212	2	0	0.522 (0.453–0.608)
	2003	359	108	2	0	0.365 (0.295–0.479)
	2004	411	187	1	0	0.476 (0.425–0.528)
	2005	181	69	2	0	0.457 (0.359–0.615)
	2006	222	96	0	—	0.538 (0.418–0.789)
	2007	169	26	—	—	0.179 (0.108–0.546)
Lostine River						
	2000	442	234	4	0	0.640 (0.576–0.711)
	2001	323	182	16	0	0.643 (0.585–0.700)
	2002	351	171	6	0	0.657 (0.565–0.778)
	2003	447	269	4	0	0.719 (0.646–0.811)
	2005	90	56	1	1	0.661 (0.551–0.788)
	2006	89	57	0	—	0.629 (SE= 0.051)
	2007	101	35	—	—	(a)
Minam River						
	2001	442	269	8	0	0.654 (0.605–0.702)
	2002	197	108	1	0	0.744 (0.612–0.939)
	2003	500	272	0	0	0.664 (0.591–0.756)
	2004	120	68	2	0	0.607 (0.508–0.712)
	2005	161	91	3	0	0.582 (0.501–0.663)
	2006	274	168	1	—	0.664 (0.585–0.798)
	2007	178	68	—	—	0.684 (0.432–1.638)
Spring (FL < 115 mm)						
Upper Grande Ronde River						
	2000	129	0	5	0	0.039 (0.000–0.314)
	2001	7	0	0	0	(a)
	2002	17	2	1	0	0.176 (SE= 0.092)
	2003	5	0	0	0	(a)
	2004	378	5	29	1	0.097 (0.069–0.136)
	2005	272	0	9	2	0.041 (SE= 0.012)
	2006	157	2	9	—	0.087 (0.043–0.210)
	2007	136	0	—	—	(a)

Appendix Table B-3. Continued.

Tag group, Stream	MY tagged	Number tagged	Number detected			Cumulative survival probability
			MY	MY + 1	MY + 2	Probability (95% CI)
Spring (FL < 115 mm) cont.						
Catherine Creek						
	2000	189	0	10	1	0.060 (0.032–0.103)
	2001	19	1	2	0	(a)
	2002	6	0	0	0	(a)
	2003	4	1	0	0	(a)
	2004	187	5	17	0	0.124 (0.080–0.187)
	2005	442	1	22	0	0.063 (0.039–0.114)
	2006	278	3	8	—	0.061 (0.023–0.718)
	2007	201	0	—	—	(a)
Lostine River						
	2000	84	0	9	0	0.109 (0.054–0.188)
	2001	21	1	1	0	(a)
	2002	0	0	0	0	(a)
	2003	1	0	0	0	(a)
	2005	142	0	24	1	0.170 (SE= 0.032)
	2006	89	1	16	—	0.162 (0.082–0.483)
	2007	172	0	—	—	(a)
Minam River						
	2001	9	0	0	0	(a)
	2002	1	0	0	0	(a)
	2003	0	0	0	0	(a)
	2004	97	0	9	1	0.094 (SE= 0.030)
	2005	172	0	10	0	0.053 (SE= 0.017)
	2006	274	0	7	—	0.074 (0.022–0.957)
	2007	115	0	—	—	(a)

[a] Data was insufficient to calculate a survival probability.

Appendix Table B-4. Fork lengths of steelhead at the time they were PIT-tagged at screw traps on Catherine Creek and the upper Grande Ronde, Lostine, and Minam rivers during the early migration period 1999–2006, summarized by dam detection history.

Stream, Year tagged	Year detected	*N*	Length at tagging (mm) Median	Min	Percentile 25th	Percentile 75th	Max
Upper Grande Ronde River							
1999	(a)	108	133	71	122	148	205
2000	(a)	60	124	86	101	145	180
	2001	12	152	115	134	161	180
2001	(a)	165	115	62	80	130	193
	2002	21	130	110	120	150	163
	2003	1	111	—	—	—	—
2002	(a)	309	111	63	76	131	200
	2003	17	133	120	125	140	155
	2004	1	77	—	—	—	—
2003	(a)	108	77	61	70.5	110	160
	2004	1	113	—	—	—	—
	2005	1	70	—	—	—	—
2004	(a)	288	114	62	90	125	179
	2005	20	127	101	118	137	159
	2006	2	81	72	77	86	90
2005	(a)	53	113	63	73	128	190
	2006	5	136	110	127	176	190
2006	(a)	478	112	54	87	123	190
	2007	33	131	99	119	140	180
Catherine Creek							
1999	(a)	986	101	60	76	142	200
	2000	73	148	67	133	162	195
	2001	14	77	61	73	86	118
2000	(a)	561	136	76	124	150	204
	2001	67	139	102	126	152	195
2001	(a)	723	85	62	75	124	193
	2002	30	128	78	91	136	170
	2003	4	71	62	67	75	75
2002	(a)	918	111	60	81	141	245
	2003	56	143	99	133	154	177
	2004	13	74	65	71	83	167
2003	(a)	512	117	59	85	133	240
	2004	54	131	81	118	146	185
	2005	6	77	65	71	82	118
2004	(a)	473	124	58	81	140	191
	2005	44	136	85	123	152	189
	2006	2	81	75	78	84	87

[a] Data represents all the early migrants tagged, regardless of detection history.

Appendix Table B-4. Continued.

Stream, Year tagged	Year detected	*N*	Length at tagging (mm) Median	Min	Percentile 25th	75th	Max
Catherine Creek (cont.)							
2005	(a)	934	91	55	77	134	246
	2006	61	140	82	127	154	208
	2007	12	78	69	71	79	94
2006	(a)	856	135	60	118	153	331
	2007	58	144	81	127	160	227
Lostine River							
1999	(a)	773	153	66	140	168	286
	2000	157	157	121	144	170	259
	2001	11	105	79	85	119	141
2000	(a)	421	80	61	73	91	235
	2001	17	161	95	146	178	212
	2002	18	86	65	80	89	106
2001	(a)	824	100	60	85	155	262
	2002	105	155	87	140	169	205
	2003	19	82	68	78	94	161
2002	(a)	999	93	62	73	155	348
	2003	98	152	68	136	175	263
	2004	33	75	66	70	84	263
2003	(b)	—	—	—	—	—	—
2004	(a)	758	92	57	77	148	246
	2005	108	148	73	135	166	205
	2006	27	77	62	71	85	101
2005	(a)	827	83	59	72	140	298
	2006	59	155	82	138	165	188
	2007	15	75	62	71	78	101
2006	(a)	1000	132	55	84	150	278
	2007	96	143	103	133	161	236
Minam River							
2000	(a)	32	122	58	69	153	218
	2001	7	147	114	126	155	183
	2002	2	68	63	65	70	72
2001	(a)	262	66	55	61	117	318
	2002	11	132	120	124	147	185
	2003	10	65	60	63	68	85
2002	(a)	42	104	65	72	146	199
	2003	8	161	133	135	169	185

[b] No early migrants were tagged in the Lostine River because the trap was not operated.

Appendix Table B-4. Continued.

Stream, Year tagged	Year detected	*N*	Length at tagging (mm) Median	Min	Percentile 25th	75th	Max
Minam River (cont.)							
2003	(a)	60	106	60	67	133	206
	2004	3	118	115	115	118	118
	2005	2	68	65	66	69	70
2004	(a)	79	73	59	65	161	226
	2005	10	167	73	147	173	210
	2006	1	67	—	—	—	—
2005	(a)	81	71	58	64	153	218
	2006	7	161	119	143	178	209
	2007	1	61	—	—	—	—
2006	(a)	107	112	59	67	134	230
	2007	10	131	122	128	134	153

Appendix Table B-5. Fork lengths of steelhead at the time they were PIT-tagged at screw traps on Catherine Creek and the upper Grande Ronde, Lostine, and Minam rivers during the late migration period 2000–2007, summarized by dam detection history.

			Length at tagging (mm)				
Stream,	Year				Percentile		
Year tagged	detected	*N*	Median	Min	25th	75th	Max
Upper Grande Ronde River							
2000	(a)	453	133	71	108	152	225
	2000	99	155	115	139	166	208
	2001	6	80	72	77	109	126
2001	(a)	465	147	115	135	163	219
	2001	196	156	115	145	171	207
	2002	5	143	121	127	150	152
2002	(a)	543	150	115	135	164	216
	2002	192	155	115	144	170	209
	2003	1	159	—	—	—	—
2003	(a)	578	150	115	136	164	199
	2003	204	158	115	142	169	199
	2004	4	130	117	119	168	197
2004	(a)	853	123	60	82	147	204
	2004	228	148	98	135	167	202
	2005	31	81	64	74	98	123
2005	(a)	642	130	65	91	152	208
	2005	186	150	117	141	164	197
	2006	11	89	69	81	95	140
	2007	2	82	70	76	88	94
2006	(a)	500	132	62	94	150	276
	2006	170	150	111	135	166	203
	2007	10	91	65	76	105	124
2007	(a)	600	142	65	118	157	230
	2007	119	157	121	146	168	230
Catherine Creek							
2000	(a)	494	132	61	86	150	210
	2000	103	152	120	143	167	210
	2001	12	79	70	73	104	125
	2002	1	87	—	—	—	—
2001	(a)	247	142	115	131	154	190
	2001	96	150	115	138	161	190
	2002	2	120	115	117	122	124
2002	(a)	503	152	115	139	164	260
	2002	212	156	115	144	166	208
	2003	2	126	123	124	127	128

[a] Data represents all the late migrants tagged, regardless of detection history.

Appendix Table B-5. Continued.

Stream, Year tagged	Year detected	Length at tagging (mm) *N*	Median	Min	Percentile 25th	75th	Max
Catherine Creek (cont.)							
2003	(a)	360	145	115	132	156	203
	2003	107	150	118	137	161	201
	2004	2	122	122	122	122	122
2004	(a)	598	135	62	102	152	202
	2004	192	148	94	135	160	202
	2005	18	77	63	72	82	130
2005	(a)	623	93	60	82	123	195
	2005	70	155	109	139	172	195
	2006	24	87	65	77	101	127
2006	(a)	500	98	60	81	146	203
	2006	99	151	87	138	163	199
	2007	8	83	80	82	87	105
2007	(a)	370	111	61	91	147	222
	2007	26	153	118	143	164	181
Lostine River							
2000	(a)	526	160	66	145	175	329
	2000	234	168	123	157	179	236
	2001	13	89	66	80	128	158
2001	(a)	323	163	115	148	180	292
	2001	182	172	121	157	185	292
	2002	16	141	115	121	156	160
2002	(a)	351	158	115	141	178	326
	2002	171	163	115	152	180	244
	2003	6	127	122	122	131	138
2003	(a)	447	162	115	150	174	289
	2003	267	163	132	152	175	208
	2004	4	125	115	117.5	141	152
2004	(a)	416	115	61	86	153	215
	2004	122	163	105	148	180	215
	2005	24	87	73	81	104	130
2005	(a)	232	99	64	83	156	226
	2005	56	178	141	160	188	226
	2006	25	84	69	80	97	133
2006	(a)	270	89	61	76	149	243
	2006	58	169	106	157	183	243
	2007	16	79	65	73	89	94
2007	(a)	281	94	60	81	142	292
	2007	35	167	130	154	182	210

Appendix Table B-5. Continued.

Stream, Year tagged	Year detected	N	Length at tagging (mm) Median	Min	Percentile 25th	75th	Max
Minam River							
2001	(a)	442	160	115	144	177	227
	2001	269	167	124	151	183	227
	2002	8	136	118	125	151	169
2002	(a)	197	158	115	147	179	219
	2002	108	164	119	151	185	219
	2003	1	135	—	—	—	—
2003	(a)	500	164	116	152	178	224
	2003	271	165	127	153	178	218
	2004	1	194	—	—	—	—
2004	(a)	217	133	59	86	168	239
	2004	68	169	117	154	180	239
	2005	11	102	71	82	106	122
2005	(a)	332	110	62	76	160	288
	2005	91	163	127	149	180	215
	2006	13	76	69	74	111	142
2006	(a)	437	141	58	79	165	218
	2006	168	164	115	149	180	213
	2007	8	76	67	71	87	139
2007	(a)	293	144	63	87	172	220
	2007	68	174	118	160	187	201

Appendix Table B-6. Fork lengths of steelhead at the time they were PIT-tagged in rearing areas upstream of the screw trap on Catherine Creek and its tributaries during summer 2000–2006, summarized by migration history.

Tag group,	Length at tagging (mm)					
				Percentile		
Migration history	*N*	Median	Min	25th	75th	Max
Summer 2000						
All PIT tagged	1,163	113	59	90	137	263
Captured in trap Fall 2000	22	124	83	113	135	152
Captured in trap Spring 2001	5	125	88	106	141	142
Migrated past trap during MY 2001	50	127	83	113	139	170
Migrated past trap during MY 2002	6	93	63	92	101	136
Migrated past trap during MY 2003	0	—	—	—	—	—
Still upstream after MY 2001	12	92	63	84	106	136
Still upstream after MY 2002	1	92	—	—	—	—
Still upstream after MY 2003	0	—	—	—	—	—
Detected at dams during MY 2001	29	130	85	114	143	170
Detected at dams during MY 2002	15	92	72	78	103	133
Detected at dams during MY 2003	1	83	—	—	—	—
Summer 2001						
All PIT tagged	1,108	112	63	97	130	221
Captured in trap Fall 2001	46	117	99	110	126	147
Captured in trap Spring 2002	9	129	97	122	142	168
Migrated past trap MY 2002	118	123	96	112	135	168
Migrated past trap MY 2003	8	94	68	81	108	118
Migrated past trap MY 2004	0	—	—	—	—	—
Still upstream after MY 2002	14	95	68	86	105	177
Still upstream after MY 2003	1	134	—	—	—	—
Still upstream after MY 2004	0	—	—	—	—	—
Detected at dams during MY 2002	73	128	96	112	137	161
Detected at dams during MY 2003	11	99	82	93	101	118
Detected at dams during MY 2004	1	71	—	—	—	—
Summer 2002						
All PIT tagged	1,043	115	73	103	130	230
Captured in trap Fall 2002	46	115	90	108	128	154
Captured in trap Spring 2003	10	115	88	105	128	143
Migrated past trap MY 2003	53	117	88	108	128	153
Migrated past trap MY2004	14	97	75	86	104	111
Migrated past trap MY2005	0	—	—	—	—	—
Still upstream after spring 2003	3	101	86	94	103	104
Still upstream after spring 2004	0	—	—	—	—	—
Still upstream after spring 2005	0	—	—	—	—	—
Detected at dams during 2003	50	121	86	105	134	169
Detected at dams during 2004	10	98	75	86	105	111

Appendix Table B-6. Continued.

Tag group, Migration history	Length at tagging (mm)					
				Percentile		
	N	Median	Min	25th	75th	Max
Summer 2003						
All PIT tagged	1,165	106	58	89	127	229
Captured in trap Fall 2003	16	115	92	104	124	149
Captured in trap Spring 2004	12	123	91	109	131	167
Migrated past trap MY 2004	81	121	78	110	133	171
Migrated past trap MY2005	5	91	78	85	92	96
Migrated past trap MY2006	0	—	—	—	—	—
Still upstream after spring 2004	4	107	97	101	109	110
Still upstream after spring 2005	0	—	—	—	—	—
Still upstream after spring 2006	0	—	—	—	—	—
Detected at dams during 2004	62	123	78	110	137	171
Detected at dams during 2005	28	91	65	81	99	111
Detected at dams during 2006	1	71	—	—	—	—
Summer 2004						
All PIT tagged	1,024	127	56	109	146	229
Captured in trap Fall 2004	18	130	111	122	147	172
Captured in trap Spring 2005	3	142	137	140	149	156
Migrated past trap MY 2005	90	139	105	125	155	185
Migrated past trap MY 2006	3	101	78	90	103	104
Migrated past trap MY 2007	0	—	—	—	—	—
Still upstream after spring 2005	1	179	—	—	—	—
Still upstream after spring 2006	1	107	—	—	—	—
Still upstream after spring 2007	0	—	—	—	—	—
Detected at dams during 2005	72	141	105	127	156	185
Detected at dams during 2006	9	103	80	99	108	120
Detected at dams during 2007	0	—	—	—	—	—
Summer 2005						
All PIT tagged	632	119	55	106	141	279
Captured in trap Fall 2005	10	118	89	114	123	139
Captured in trap Spring 2006	3	115	96	106	118	121
Migrated past trap MY 2006	52	122	89	115	144	186
Migrated past trap MY 2007	1	105	—	—	—	—
Still upstream after spring 2006	1	101	—	—	—	—
Still upstream after spring 2007	0	—	—	—	—	—
Detected at dams during 2006	41	126	96	116	149	186
Detected at dams during 2007	1	99	—	—	—	—

Appendix Table B-6. Continued.

Tag group, Migration history	Length at tagging (mm)					
				Percentile		
	N	Median	Min	25th	75th	Max
Summer 2006						
All PIT tagged	609	109	59	90	129	268
Captured in trap Fall 2006	18	124	95	107	131	167
Captured in trap Spring 2007	3	86	74	80	111	135
Migrated past trap MY 2007	30	124	74	107	134	177
Still upstream after spring 2007	0	—	—	—	—	—
Detected at dams during 2007	10	130	107	108	136	177