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

ANNUAL REPORT 2006

Project Period: 1 February 2006 to 31 January 2007

Prepared by:

Erick S. Van Dyke
Jeffrey A. Yanke
Jesse W. Steele
Brian C. Jonasson
Richard W. Carmichael

Oregon Department of Fish and Wildlife
La Grande, OR

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

March 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 2006 from 1 July 2005 through 30 June 2006. 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, streamflow, and macroinvertebrate assemblages in four study streams in the subbasin.

CONTENTS

CONTENTS (continued)

TABLES

Number | Page

TABLES (continued)

FIGURES

Number Page

FIGURES (continued)

APPENDIX TABLES

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. Determine egg-to-parr survival for spring Chinook salmon in two local, natural populations in the Grande Ronde River Subbasin: Catherine Creek and Lostine River.

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

7. 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.

8. 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.

9. 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.

10. Describe the population characteristics of the juvenile steelhead population in Catherine Creek.

11. Document stream conditions in spring Chinook salmon rearing areas in the Grande Ronde River Subbasin.

Accomplishments

We accomplished all of our objectives in 2006.

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 6 September 2005 through 26 May 2006. 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 6 September 2005 to 28 January 2006 with a peak in the fall. 'Late' migrants left upper rearing areas from 29 January 2006 to 26 May 2006 with a peak in the spring. At the upper Grande Ronde River trap, we estimated 34,672 juvenile spring Chinook salmon migrated out of upper rearing areas with approximately 23% leaving as early migrants. At the Catherine Creek trap, we estimated 27,218 juvenile spring Chinook salmon migrated out of upper rearing areas with 84% leaving as early migrants. At the Lostine River trap, we estimated 54,268 juvenile spring Chinook salmon migrated out of upper rearing areas with 78% leaving as early migrants. At the Minam River trap, we estimated 50,959 juvenile spring Chinook salmon migrated out of the river with 58% 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 2005 were detected at Lower Granite Dam between 3 April and 9 June 2006. Although the time of arrival to Lower Granite Dam was significantly different among the four study streams ($P < 0.001$), significant differences in timing were confirmed for two of six (Catherine Creek later than Imnaha River and Minam River later than Imnaha River) pairwise comparisons ($P < 0.05$). Median arrival dates at Lower Granite Dam ranged from 28 April to 16 May. Survival probabilities were significantly lower for Chinook salmon tagged as parr in Catherine Creek (0.057) than those tagged as parr in the Lostine River (0.113). Survival probabilities for both Catherine Creek and Lostine River parr were significantly lower than those tagged as parr in the Minam and Imnaha rivers (0.145 and 0.144, respectively), which were not significantly different from each other.

Chinook salmon tagged at the traps were detected at Lower Granite Dam between 30 March and 22 June 2006. Although there was overlap in arrival dates, the median arrival date for early migrants was before that of late migrants for all four streams. Survival probabilities to Lower Granite Dam for early migrants ranged from 0.074 to 0.269, and survival probabilities for late migrants ranged from 0.367 to 0.619. Among the four migrant populations, the upper Grande Ronde River and Catherine Creek population consistently had lower rates of survival than the Lostine River and Minam River populations.

The winter rearing area of juvenile spring Chinook salmon with the higher rate of survival concurred among the upper Grande Ronde River, Catherine Creek and Lostine River populations during migration year (MY) 2006. In all three streams, survival did not differ significantly between fish that overwintered upstream or downstream of the trap.

We estimated that 80% of the total mortality of late migrating spring Chinook salmon from Catherine Creek to Lower Granite Dam occurred between the upper trap site on Catherine Creek and the downstream trap located in the Grande Ronde Valley. We determined that 88% of the total travel time of late migrants from Catherine Creek to Lower Granite Dam occurred between these trap sites, even though this reach accounts for only 26% of the distance to Lower Granite Dam. We estimated that 77% of the total mortality of upper Grande Ronde River late migrants occurred before fish reached the Grande Ronde Valley. These migrants spent 88% of the total travel time from rearing areas to Lower Granite Dam in the Grande Ronde Valley, even though this reach accounts for only 24% of the distance to Lower Granite Dam.

We estimated egg-to-parr survival for spring Chinook salmon from brood year (BY) 2005 to be approximately 11% for Catherine Creek and 14% for the Lostine River. We estimated that 29,352 immature age-0 parr inhabited the upstream rearing areas on Catherine Creek during the summer of 2006. We also estimated that 103,896 immature parr that were predominantly age-0 inhabited the upstream rearing areas on the Lostine River during the summer of 2006.

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 2006. Based on migration timing and abundance, we distinguished early and late migration patterns, similar to those of spring Chinook salmon. For MY 2006, we estimated 13,188 steelhead migrants left upper rearing areas of the upper Grande Ronde River with 14% of these fish leaving as early migrants. We estimated 23,243 steelhead migrants left upper rearing areas in Catherine Creek with 38% of these fish leaving as early migrants. We estimated 28,710 steelhead migrated out of the Lostine River, with approximately 89% of these fish leaving as early migrants. We estimated 103,141 steelhead migrated from the Minam River with 22% of these fish leaving as early migrants.

During the summer of 2006, we estimated that 7,441 steelhead inhabited the main stem Catherine Creek and 10,542 inhabited Little Catherine Creek. These fish ranged from age-1 to age-4 in main stem Catherine Creek, and age-0 to age-3 in Little Catherine Creek.

The steelhead collected at trap sites during MY 2006 were comprised of four age groups. Early migrants ranged from 0 to 3 years of age, whereas late migrants ranged from 1 to 4 years of age. Smolts detected at Snake River and lower Columbia River dams ranged from 0 to 4 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 8 June 2006. Median arrival dates for early migrants ranged from 28 April to 19 May. Median arrival dates for late migrants ranged from 1 May to 10 May.

The survival probability for steelhead tagged in the Catherine Creek drainage during the summer of 2005 was 0.138 for fish tagged in the main stem and a probability of survival was not achievable in Middle Fork Catherine Creek because no fish were detected at Lower Granite

Dam. Survival probabilities to Lower Granite Dam for early migrating steelhead ranged from 0.077 to 0.094. Survival probabilities to Lower Granite Dam for late migrants ranged from 0.522 to 0.665. The upper Grande Ronde River population had the highest survival of the four early migrant populations and the lowest survival of the four late migrant populations while fish from Catherine Creek had consistently lower rates of survival than fish from the Lostine and Minam rivers.

Stream Condition

Daily mean water temperature typically fell within DEQ standards in all four study streams while the 2004 BY of spring Chinook salmon were in the Grande Ronde River Subbasin (1 August 2004–30 June 2006). The 2004 BY encountered daily mean water temperature in excess of the DEQ standard of 17.8°C for 28 of 257 days in the upper Grande Ronde River, 28 of 480 days Catherine Creek, 0 of 661 days in the Lostine River, and 54 of 664 days Minam River. Daily mean temperatures in excess of 17.8°C occurred intermittently during the period that we expected eggs were being deposited in to redds (August and September 2004) or intermittently during parr rearing stages (July–August 2005) 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 23% of the hours logged in the upper Grande Ronde River, 18% of the hours logged in Catherine Creek, 20% of the hours logged in the Lostine River and 17% 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 in the upper Grande Ronde and Minam rivers (1 of 257 and 10 of 664 days, respectively). 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 runoff typically occurred March/April through June/July with peak flows occurring mid-May in all four study streams.

Based on aquatic macroinvertebrate collections, only the lower reach in Catherine Creek and upper Reach in the Lostine River had a metric score that indicated that relative stream condition was severely impaired during summer 2006. In the upper Grande Ronde River and Catherine Creek, combined metric scores were greater than 23 in the upper reaches (natal rearing area) from summer to late fall, while metric scores increased in the lower reach (early migrant overwintering area) from 20 or less in summer to over 23 in late fall. Additional collections in these areas may provide more information about survival relationships between these two rearing populations.

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.

Our research has shown that a disproportional amount of mortality occurs through the Grande Ronde Valley for spring Chinook salmon migrants leaving the upper Grande Ronde River and Catherine Creek. Additional research may be needed to identify factors associated with differences in timing and survival exhibited by fish within and downstream of the Grande Ronde Valley.

The information gathered thus far on the occurrence of age-2 smolts indicates this life history is rare among northeast Oregon spring Chinook salmon, and can probably be discounted for life cycle modeling. The mature parr life history is more prevalent and should be considered from both life cycle modeling and biological perspectives. Based on the mature parr per redd ratios observed in the Grande Ronde River Subbasin, it is evident that mature parr have the potential to make significant gametic contributions to northeast Oregon spring Chinook salmon populations. Given the fluctuating abundance of adult spawners, mature parr may be an important means of sustaining the breeding population especially in years with low spawner escapement.

Current methods used to determine stream condition are confined to using data collected during summer, which may act to conceal the ecological significance of stream health during cold periods. Because conditions in the four study streams endure winter-like conditions for a longer duration than summer-like conditions, we incorporated metrics for cold periods. Initial findings have shown that metric scores change from summer to late fall in natal rearing areas above the screw trap, and increase from summer to late fall in lower reaches below the screw trap where early migrants are known to overwinter. Conditions like these may help explain the level of equivalence in survival between migrant groups in each study stream. Additional research is needed to verify this hypothesis.

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 are 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.

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

We used mark–recapture and scale-aging techniques to estimate the abundance of immature and mature parr in Catherine Creek and the Lostine River in July and August 2006. We used these abundance estimates, in addition to redd survey and fecundity data collected for related projects, to estimate egg-to-parr survival. Our goal for each stream was to mark at least 1,000 immature parr and as many mature parr as we could capture in 4 days. During subsequent sampling, our goal was to capture at least 1,000 immature parr and as many mature parr as possible in 4 days. We collected scales for age determination from parr captured in each stream.

Site Description: Parr were collected, marked, and released upstream of rotary screw traps in the majority of the spawning and rearing habitat on Catherine Creek and the Lostine River (Figure 1). Sampling on Catherine Creek occurred from river kilometer (rkm) 37 upstream to the confluence of the North and South forks of Catherine Creek (rkm 52) and included the lower 1 km of North Fork Catherine Creek. Sampling on the Lostine River occurred from the rotary screw trap (rkm 3) up to 1 km upstream of the Lostine guard station (rkm 32). Collection activities were not conducted in a 9-km long canyon within the Lostine River study area because it was unsuitable rearing habitat for juvenile spring Chinook salmon.

Marking Phase: Parr were collected for marking in Catherine Creek above the screw trap during 24–27 July. On the Lostine River, parr were collected in 5 sections of stream (~ 16 km total) throughout the 27 km of spawning and rearing area during 7–10 August (Table 1). In most cases, 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. Prior to being marked, fish were anesthetized in an aerated bath containing 40–50 mg/L of tricaine methanesulfonate (MS-222). All mature parr, and any immature parr less than 55 mm in fork length (FL), were marked with a caudal fin clip. Immature parr that exceeded 54 mm in FL were either caudal fin-clipped or PIT tagged. PIT tags were injected manually with a modified hypodermic syringe as described by Prentice et al. (1986, 1990) and Matthews et al. (1990, 1992). Syringes were disinfected for 10 min in 70% isopropyl alcohol and allowed to dry 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. The fork length and weight of mature parr, and the fork length of caudal clipped immature parr were also recorded. All fish were handled and marked at stream temperatures of 16°C or less and released in the area of capture within 24 hours of being tagged.

Recapture Phase: Parr were captured and examined for marks the week following the marking phase (31 July–3 August on Catherine Creek and 14–17 August on the Lostine River). Using identical seining techniques as described for the marking phase we captured parr throughout the same sections of stream on both Catherine Creek and the Lostine River. Each fish was inspected for marks and maturity status. The numbers of immature and mature parr that were unmarked, caudal clipped, PIT tagged, or that had lost their PIT tag (i.e., no tag could be detected, but a recent PIT tag scar was evident) were recorded.

Age Determination: Age composition estimates for both immature and mature parr from each stream were based on results from scale analyses. Scales were collected from most of the mature parr captured during the marking phase. We identified mature parr based on body morphology, coloration, and the presence/absence of milt. Mature parr tended to be longer, deeper-bodied, and more yellowish in color (laterally) than immature parr. Precocious maturation of Chinook salmon parr has only been reported for males. Therefore we assumed that all mature parr were male, unless there were unmistakable indications to the contrary. All parr that did not exhibit signs of early maturity were assumed to be age-0 based on data from previous years (Appendix Table A-1). To verify this assumption, we collected scales from a random subsample of immature parr for age analysis. Scales were glued between two glass cover slips and inspected on a microfiche reader at 42x magnification following scale aging conventions described in DeVries and Frie (1996).

Calculations: The abundance of immature and mature parr in Catherine Creek and the Lostine River was determined using Chapman's modification of the Petersen estimate (Ricker 1975). The 95% confidence interval (CI) was obtained for each abundance estimate using equation (3.7) and values from Appendix II in Ricker (1975). The proportion of mature parr was calculated by age for each stream using the results of scale analyses. We used parr abundance and age composition estimates in July–August 2005 and 2006 (Van Dyke et al. 2008), and redd count data from 2004 and 2005 spawning ground surveys (ODFW, unpublished data) to determine the following about spring Chinook salmon populations in Catherine Creek and the Lostine River: 1) the abundance of immature and mature parr, by age class, in July–August 2006; 2) the percentages of immature age-0 parr present in each stream in July–August 2005 that were present in July–August 2006 as mature or immature age-1 parr; 3) the average number of mature and immature age-0 parr (in 2006) produced per redd constructed in 2005; and 4) the average number of mature and immature age-1 parr (in 2006) produced per redd constructed in 2004. Estimated rates of egg-to-parr survival were based on fecundity of wild fish collected at weir sites in Catherine Creek and the Lostine River and spawned at Lookingglass Hatchery (ODFW, unpublished data). These estimates were adjusted for age composition of female spawners, and the number of redds counted above the trap sites on Catherine Creek and the Lostine River.

The abundance of parr ($\hat{N}_{i,j,k}$) by maturity i, age-class j, and summer k, where k = 2006 was calculated as

$$\hat{N}_{i,j,k} = \hat{N}_{i,k} \times \frac{C_{i,j,k}}{C_{i,k}}, \tag{1}$$

where $\hat{N}_{i,k}$ is the population estimate for parr of maturity *i* during the summer *k,* as determined from separate mark–recapture estimates for mature and immature parr, $C_{i,j,k}$ is the number of fish of maturity *i,* sampled during summer *k,* that were determined by scale analysis to be age *j*, and $C_{i,k}$ is the number of fish of maturity *i* that were aged from scale samples collected during the summer *k.*

The number of mature age-1 parr present in the stream a particular summer (*k*) compared to the number of immature age-0 parr present the previous summer (*k-1*), expressed as a percentage was calculated as

$$\frac{\hat{N}_{mature,age-1,k}}{\hat{N}_{immature,age-0,k-1}} \times 100. \tag{2}$$

This represents the rate of precocious maturation of parr for a particular stream.

The average number of mature and immature age-0 parr (estimated for summer *k* using values calculated in equation 1) produced per redd built the previous fall (*k-1*) was calculated as

$$\frac{\hat{N}_{immature,age-0,k} + \hat{N}_{mature,age-0,k}}{R_{k-1}}, \tag{3}$$

where R_{k-1} is the number of redds counted above the trap site on a particular stream in year *k-1*.

The average number of mature and immature age-1 parr present in summer *k* per redd built two falls previous (*k-2*) was calculated as

$$\frac{\hat{N}_{immature,age-1,k} + \hat{N}_{mature,age-1,k}}{R_{k-2}}, \tag{4}$$

where R_{k-2} is the number of redds counted above the trap site on a particular stream in year *k-2*.

The egg-to-parr survival, calculated using the estimated number of age-0 parr produced per redd (from equation 3), an assumed 1:1 ratio of spawning females to redds, and an estimated fecundity ($\hat{E}_{k-1}$) for females returning to the stream to spawn in year *k-1* was calculated as

$$\frac{\hat{N}_{immature,age-0,k} + \hat{N}_{mature,age-0,k}}{R_{k-1} \times \hat{E}_{k-1}}, \tag{5}$$

where $\hat{E}_{k-1}$ is the estimated fecundities for BY 2005 (3,852 eggs/female from Catherine Creek and 4,936 eggs/female from the Lostine River; ODFW, unpublished data).

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 2006. Spring Chinook salmon in each study stream exhibit two migrational 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 five 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. A third rotary screw trap was operated only during spring at the lower end of the Grande Ronde Valley near the town of Elgin at rkm 164. 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 low flow 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.

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. Fry captured in the trap were able to escape without detection, so they were not included in migrant abundance estimates. Sexually mature parr were not included in migrant abundance estimates. Fork lengths (mm) and weights (g) were measured from at least 100 juvenile spring Chinook salmon each week when possible. Prior to sampling, juvenile spring Chinook salmon were anesthetized with MS-222 (40–60 mg/L). Fish were allowed to recover fully from anesthesia before release into the river. River height was recorded daily from permanent staff gauges. Water temperatures were recorded daily at each trap location using thermographs or hand held thermometers.

Migrant abundance was estimated by conducting weekly trap efficiency tests throughout the migratory year at each trap site. Trap efficiency was determined by releasing a known number of fin clipped or PIT tagged (marked) fish above each trap and enumerating recaptures. 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

$$\hat{E}_j = R_j / M_j \, , \tag{6}$$

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

$$\hat{N}_j = U_j \big/ \hat{E}_j \,, \tag{7}$$

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 (6 and 7) 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

$$95\%\, CI = 1.96\sqrt{V} \,, \tag{8}$$

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

$$\hat{P}_i = S_i / C \,, \tag{9}$$

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

$$\hat{N}_s = \left(U_i / \hat{P}_i\right) / \hat{E}\ , \tag{10}$$

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 River, 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 (6, 9, and 10) 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 each of the summer, fall, winter, and spring tag groups.

The summer tag groups consisted of age-0 parr tagged during July and August 2005 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 the snorkel–seine method described in **Egg-to-Parr Survival, Parr Abundance, and Age Composition in Summer.** 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 2005 and 28 January 2006 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 difference between the two groups was that the winter group was tagged earlier in the upper rearing areas (December 2005) than the spring group which were tagged at the screw trap as migrants (29 January–30

June 2006) and therefore experienced overwinter mortality after tagging. 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.

The spring tag groups represented late migrants that left the upstream rearing areas between 29 January 2006 and 30 June 2006. 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 2006, 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 six 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 2006, 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 daily numbers of PIT tag detections according to the proportion of river flow spilled each day. This procedure was necessary because some fish may have passed undetected over the spillway and the amount of spill varies throughout the migration season. The proportion of fish that passed over the spillway (spill effectiveness) 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 (fish guidance efficiency) 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):

$$\hat{N}_d = D_d \times \frac{O_d + L_d}{O_d}, \qquad (11)$$

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*. Daily migration estimates were added for each week to obtain weekly migration 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 migration 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 2.1 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:

$$\hat{S}_{s,overwinter} = \frac{\hat{S}_{s,winter}}{\hat{S}_{s,spring}} \tag{12}$$

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 that population and provided information about the population's overall survival and timing of the smolt migration past the dams. In summer of 2004 and 2005, 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. The collection and PIT tagging methods were previously described for the mark–recapture studies (*see* **Methods; Egg-to-Parr Survival, Parr Abundance, and Age Composition in Summer**).

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 fish numbers (see expansion explanation in **Comparison of Early Life History Strategies within Populations: *Migration Timing***). When significant differences were found, the Dunn's pairwise multiple comparison procedure was used (α = 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 2.1 (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 by rounding the expanded fish numbers to the nearest integer. 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.

Survival and Migration Timing through the Grande Ronde Valley: During the spring of 2006, juvenile spring Chinook salmon were collected for PIT-tagging at the rotary screw trap located in the Grande Ronde River (rkm 164) at the lower end of the Grande Ronde Valley. This trap was approximately 93 km downstream of the Catherine Creek trap (rkm 32) and 135 km downstream from the upper Grande Ronde River trap (rkm 299, Figure 1). However, a migrating juvenile salmon from the upper Grande Ronde River actually travels only 93 km between trap sites because a 8.3 km flood control ditch constructed in the valley bypasses 50 km of natural river channel between these trap sites. The stream reach comprising the migration corridor through the Grande Ronde Valley is highly meandering and low gradient relative to other reaches of the corridor to Lower Granite Dam.

A survival probability to Lower Granite Dam calculated for fish tagged at the Grande Ronde Valley trap was compared to the survival probabilities of the spring tag groups from the upper Grande Ronde River and Catherine Creek to indirectly estimate survival of late migrants from each of these populations as they migrated through the Grande Ronde Valley using the equation

$$S_{bj} = S_{uj} / S_l \,, \tag{13}$$

where S_{bj} is the indirect survival probability for fish migrating between upper trap site j and the Grande Ronde Valley trap site, S_{uj} is the survival probability calculated for the spring tag group from upper trap site j to Lower Granite Dam, and S_l is the survival probability for the fish tagged at the Grande Ronde Valley trap to Lower Granite Dam. In the previous years of this study, the majority (97–99%) of juvenile spring Chinook salmon did not emigrate past the Grande Ronde Valley trap until spring. Because fish tagged at the Grande Ronde Valley trap were a combination of early and late migrants from both the upper Grande Ronde River and Catherine Creek, it was not possible to directly compare the survival probabilities of late migrants as they traveled from the Grande Ronde Valley to Lower Granite Dam. We assumed that the three tag groups had a common survival probability from the Grande Ronde Valley trap to Lower Granite Dam.

The percentage of total mortality to Lower Granite Dam that occurred between trap sites was estimated using the equation

$$M_{bj} = ((1 - S_{bj}) / (1 - S_{uj}))100 \,, \tag{14}$$

where M_{bj} is the percentage of the total mortality to Lower Granite Dam occurring between trap site j and the Grande Ronde Valley trap site, S_{bj} is the indirect survival probability calculated from equation (13), and S_{uj} is the survival probability estimate to Lower Granite Dam for PIT tagged fish from upper trap site j.

Travel times through the migration corridor were based on PIT tagged fish released at a trap site and subsequently detected at Lower Granite Dam. The number of days between the release date and detection date was determined for each fish and median travel time to Lower Granite Dam was calculated for spring tag groups tagged at each trap site. Travel time to Lower Granite Dam for wild fish tagged at the Grande Ronde Valley trap was assumed to be representative of the travel time of late migrants originating from Catherine Creek and the upper Grande Ronde River. Therefore, we assumed that the three tag groups exhibited a common travel time from the Grande Ronde Valley trap to Lower Granite Dam. Based on this assumption, travel time between the upper trap sites and the Grande Ronde Valley trap was estimated by subtracting the median travel time from the Grande Ronde Valley trap to Lower Granite Dam from the median travel time from each of the upper trap sites to Lower Granite Dam.

Results and Discussion

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

Catherine Creek: We estimated that 29,352 (95% CI, 22,794–37,758) immature spring Chinook salmon parr inhabited Catherine Creek in the last week of July 2006 (Table 2). For the first time in 9 years census data was inadequate to calculate an unbiased population estimate for mature, wild parr (Appendix Table A-2). We marked three mature, hatchery parr but census data was inadequate to calculate an unbiased population estimate. Results of scale analysis indicated that all of the mature parr sampled were age-1 (Appendix Table A-1). No scales were collected from immature parr, so based on past data all were assumed to be age-0.

There were 94 and 72 redds counted in the Catherine Creek study area in 2004 and 2005, respectively. Based on our assumption that all immature parr were age-0, we estimated that 408 parr were produced per redd constructed in 2005 (Appendix Table A-3). This was equivalent to an egg-to-parr survival of 10.58%, which falls within the range of estimates calculated for brood years 1997–2005 (Table 3). Census data was inadequate to calculate an unbiased population estimate for mature, wild parr present in the late summer of 2006 for each redd counted a month or two later (Appendix Table A-4).

Lostine River: We estimated that 103,896 (95% CI, 87,319–123,594) immature parr inhabited the Lostine River in August 2006 (Table 2). Census data was inadequate to calculate an unbiased population estimate for mature parr, but estimates from previous years are shown in Appendix Table A-2. We did not observe any mature, hatchery parr in the Lostine River during the summer of 2006. Results of scale analysis indicated that 11 of the 12 mature parr sampled were age-1 (Appendix Table A-1). Of the 46 immature parr sampled, 39 were age-0 and 7 were age-1.

There were 144 and 125 redds counted in the Lostine River study area in 2004 and 2005, respectively. We estimated that 15,792 immature age-1 parr were present in the Lostine River during August 2006. This was equivalent to an estimate of 110 immature age-1 parr produced per redd constructed in 2004. We estimated that 705 immature age-0 parr were produced per redd constructed in the Lostine River in 2005 (Appendix Table A-3). This was equivalent to an egg-to-parr survival of 14.28%, which falls within the range of estimates calculated for brood years 1997–2005 (Table 3). Census data was inadequate to calculate an unbiased population estimate for mature, wild parr present in the late summer of 2006 for each redd counted a month or two later (Appendix Table A-4).

In-Basin Migration Timing and Abundance

Upper Grande Ronde River: The upper Grande Ronde River trap fished for 119 d between 13 September 2005 and 26 May 2006 (Table 4). There was a distinct early and late migration exhibited by juvenile spring Chinook salmon at this trap site (Figure 2). Systematic subsampling comprised 13 of the 62 d the trap was fished during late migration period, and a total of 1,523 juvenile Chinook salmon were caught during this period. The median emigration date for early migrants passing the trap was 2 October 2005, and the median emigration date for late migrants passing the trap was 29 March 2006 (Appendix Table A-5). 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 34,672 (95% CI, ± 5,319) juvenile spring Chinook salmon migrated out of the upper Grande Ronde River rearing areas during MY 2006 (Appendix Table A-5). This migrant estimate was the second-largest population estimate reported during this study. Based on the total minimum estimate, 23% (7,846 ± 1,248) of the juvenile spring Chinook salmon were early migrants and 77% (26,826 ± 5,170) were late migrants. A dominant late migration in the upper Grande Ronde River is consistent with most migratory years studied (Appendix Table A-5).

Catherine Creek: The Catherine Creek trap fished for 176 d between 7 September 2005 and 16 May 2006 (Table 4). 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 2006 (Figure 2), which was similar to the patterns observed since MY 2000. Systematic subsampling comprised 16 of the 70 d the trap was fished during late migration period, and a total of 111 juvenile Chinook salmon were caught during this period. The median emigration date for early migrants passing the trap was 31 October 2005, and the median emigration date for late migrants was 22 March 2006. Both early and late median emigration dates were within the range of median dates reported from previous years of this study (Appendix Table A-5).

We estimated a minimum of 27,218 ± 2,368 juvenile spring Chinook salmon migrated out of the upper Catherine Creek rearing areas during MY 2006. This migrant estimate was within the range of population estimates previously reported for this study (Appendix Table A-5). Based on the total minimum estimate, 84% (22,823 ± 2,176) migrated early and 16% (4,395 ± 934) 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 213 d between 7 September 2005 and 15 May 2006 (Table 4). Distinct early and late migrations were evident at this trap site, with an additional increase of migrants occurring in late winter (Figure 2). The winter increase overlapped the early and late migration periods, and migrants observed during this period were distributed into both early and late migrant periods based in the date of capture. Systematic subsampling comprised 38 of the 101 d the trap was fished during the late migration period, and a total of 1,141 juvenile Chinook salmon were caught during this period. The median emigration date for early migrants was 4 November 2005, and the median date for late migrants was 11 April 2006. Both dates were within the range reported in previous years of this study (Appendix Table A-5).

We estimated a minimum of 54,268 ± 8,812 juvenile spring Chinook salmon migrated out of the Lostine River during MY 2006. This migrant estimate was the second largest estimate to date of this study (Appendix Table A-5). Based on the minimum estimate, 78% (42,563 ± 8,705) of the juvenile spring Chinook salmon migrated early and 22% (11,705 ± 1,372) migrated late. The percentage of late migrants is within the range reported from previous years of this study (Appendix Table A-5). 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-5).

Minam River: The Minam River trap fished for 147 d between 6 September 2005 and 15 May 2006 (Table 4). Distinct early and late migrations were evident (Figure 2). The median emigration date of early migrants was 14 October 2005, and the median date for late migrants was 1 April 2006.

We estimated a minimum of 50,959 ± 8,262 juvenile spring Chinook salmon migrated out of the Minam River during MY 2006. Based on the minimum estimate, 58% (29,492 ± 6,275) of the juvenile spring Chinook salmon migrated early and 42% (21,467 ± 5,374) migrated late. The percentage of late migrants is within the range reported from previous years of this study (Appendix Table A-5).

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 5 and 6. 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, with the exception of the Lostine River trap (Figure 4). As in previous years, late migrants captured at the Grande Ronde Valley trap were larger than fish captured at the upper Grande Ronde River and Catherine Creek traps in MY 2006.

Migration Timing and Survival to Lower Granite Dam

Population Comparisons: During July–August 2005, spring 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 2006 will be reported in the 2007 annual report.

Migration Timing: Spring Chinook salmon parr that were captured with seines and PIT-tagged on Catherine Creek and the Imnaha, Lostine, and Minam rivers in summer 2005 were detected at Lower Granite Dam from 3 April to 9 June 2006 (Appendix Table A-6). The period of detection at Lower Granite Dam among the four populations ranged from 22 d (Catherine Creek) to 66 d (Lostine River) in length. Median dates of arrival ranged from 28 April to 16 May (Figure 5). Both Catherine Creek and Minam River fish had later median arrival dates (May) than Imnaha River and Lostine River populations (April). Although the median dates of arrival in 2006 at Lower Granite Dam were significantly different among the four populations (Kruskal–Wallis; $P < 0.001$) two of six pairwise multiple comparisons were significantly different between the Catherine Creek and Imnaha populations, and the Minam and Imnaha populations (Dunn's, $P < 0.05$). All four populations fell within the range of median dates reported in previous years of this study (Appendix Table A-6).

Survival Probabilities: Survival probabilities to Lower Granite Dam for parr tagged in the summer of 2005 were 0.057 for Catherine Creek, 0.113 for the Lostine River, 0.145 for the Minam River, and 0.144 for the Imnaha River population. Hypothesis testing indicated that the model Catherine ≠ Lostine ≠ Minam = Imnaha had the best fit ($P = 0.02$). Survival probabilities did not differ significantly between the Minam and Imnaha populations, but these populations had significantly higher survival probabilities than the Lostine and Catherine population (Table 7). Survival probabilities for the Catherine population for MY 2006 tied with MY 2005 for the lowest observed for this study while survival probabilities for the Lostine, Minam and Imnaha populations were at the lower end of the range reported in previous years (Appendix Table A-7).

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. The total number of fish tagged in each tag group for each study stream is provided in Table 8.

Migration Timing: Median arrival dates at Lower Granite Dam for the fall, winter and spring tag groups on the upper Grande Ronde River were 18 May, 3 June, and 20 May 2006, respectively (Figure 6). Median arrival dates at Lower Granite Dam for the fall, winter, and spring tag groups tagged on Catherine Creek were 4 May, 15 May, and 4 June 2006, respectively (Figure 7). Median arrival dates at Lower Granite Dam for the fall, winter, and spring tag groups from the Lostine River were 22 April, 12 May, and 11 May 2006, respectively (Figure 8). Median arrival dates at Lower Granite Dam for the fall and spring tag groups on the Minam River were 19 April and 17 May 2006, respectively (Figure 9). Median arrival dates were within the range observed during past migratory years for all the trap sites (Appendix Table A-6).

As in past years, early migrants (fall tag group) reached Lower Granite Dam earlier than late migrants (winter tag group) from upper Grande Ronde River and Lostine River (Mann–Whitney rank-sum test, $P < 0.001$). Although early migrants from Catherine Creek had a median arrival date that was 12 days earlier than late migrants from Catherine Creek the difference was not significant ($P = 0.261$). There was no winter tag group to compare with early migrants for the Minam River.

Travel times from the screw trap to Lower Granite Dam for late migrants from the upper Grande Ronde River ranged from 21 to 77 d with a median of 50 d ($n = 49$). Travel times for late migrants from Catherine Creek ranged from 12 to 86 d with a median of 50 d ($n = 34$). Travel times for late migrants from the Lostine River ranged from 5 to 53 d with a median of 32 ($n = 112$). Travel times for late migrants from the Minam River ranged from 6 to 58 d with a median of 33 ($n = 74$). Median travel time during MY 2006 was faster in Catherine Creek and Minam River than previous years for each of these populations while in the upper Grande Ronde River and the Lostine River travel times fell within the range observed during previous years (Appendix Table A-8).

Survival Probabilities: Survival probabilities to Lower Granite Dam for the fall, winter, and spring tag groups from the upper Grande Ronde River were 0.171, 0.080, and 0.398, respectively. Survival probabilities to Lower Granite Dam for the fall, winter and spring tag groups from Catherine Creek were 0.074, 0.125, and 0.367, respectively. Survival probabilities for the fall, winter and spring tag groups from the Lostine River were 0.269, 0.177, and 0.619, respectively. Survival probabilities for the fall and spring tag groups from the Minam River were 0.245 and 0.543, respectively. As expected, survival probabilities were highest for the spring tag groups which were not subject to overwinter mortality after tagging (Table 8), as was the case for the summer, fall and winter tag groups.

Overwinter survival of BY 2004 (MY 2006) fish in the upper rearing areas on the upper Grande Ronde River was 20%. This was at the lowest percentage observed during the previous eight years that overwinter survival has been measured (Appendix Table A-9). During MY

2006, fish that overwintered upstream of the upper Grande Ronde River trap survived at an equivalent rate as those that overwintered downstream of the trap (Maximum Likelihood Ratio test; $P = 0.070$). This was the second time that there was no significant difference in survival between fish that overwintered upstream as opposed to downstream in the upper Grande Ronde River (Appendix Table A-10). In previous years survival rates were either equivalent between upstream and downstream rearing fish, were higher for fish that overwintered downstream, or were higher for fish that overwintered upstream.

Overwinter survival of BY 2004 fish in the upper rearing areas on Catherine Creek was 34%. This was in the middle of the range observed during the previous twelve years that overwinter survival has been measured (Appendix Table A-9). However, there was no significant difference in survival between fish that overwintered upstream as opposed to downstream in Catherine Creek (Maximum Likelihood Ratio test; $P = 0.061$) during MY 2006. As with the upper Grande Ronde River population, comparisons of overwinter survival have either been equivalent between upstream and downstream rearing fish, higher for downstream rearing fish, or higher for upstream rearing fish (Appendix Table A-10).

Overwinter survival of BY 2004 fish in the upper rearing areas on the Lostine River was 29%, and was lowest percentage observed over the previous ten years that overwinter survival has been measured (Appendix Table A-9). During MY 2006, there was no significant difference in survival between fish that overwintered upstream as opposed to downstream in the Lostine River (Maximum Likelihood Ratio test; $P = 0.144$). This is the sixth of nine comparisons that survival was found to be equivalent for fish that overwintered in both rearing areas (Appendix Table A-10). The remaining three comparisons indicated higher survival rates for downstream rearing fish.

Survival and Migration Timing through the Grande Ronde Valley: We PIT-tagged 400 wild spring Chinook salmon migrants at the Grande Ronde Valley trap from 16 March through 24 May 2006. The median date of tagging was 9 May 2006, which was well over one month later than the median date the year before (1 April 2005). The survival probability to Lower Granite Dam for wild Chinook salmon migrants tagged at the Grande Ronde Valley trap was 0.745 (Appendix Table A-7). Based on this survival probability, and the survival probability of late migrants tagged at the Catherine Creek trap (S_u= 0.367), the survival rate was estimated to be 0.493 for fish as they moved from the Catherine Creek trap to the Grande Ronde Valley trap. Based on these survival rates, 80% of the total late migrant mortality from the Catherine Creek trap to Lower Granite Dam occurred between the Catherine Creek trap and the Grande Ronde Valley trap. This mortality is at the higher end of the range since we began calculating survival between these sites in MY 2002 (range; 65–87%). The distance traveled between trap sites was 26% (94 km) of the total distance of 356 km from the Catherine Creek trap to Lower Granite Dam. The median travel time to Lower Granite Dam for late migrants tagged at the Catherine Creek trap was 50.1 d but was 5.8 d for Chinook salmon migrants tagged at the Grande Ronde Valley trap. Assuming travel times of the combined migrants tagged at the Grande Ronde Valley trap were representative of travel times for Catherine Creek late migrants once they passed the lower valley trap, 88% (44.3 d) of the total travel time to Lower Granite Dam occurred in the first 94 km between trap sites. These results suggest fish migrated through the Grande Ronde Valley faster than in past years (range; 49.7–54.8 d), and faster from the

Grande Ronde Valley trap to Lower Granite Dam than in previous years (range; 7.4–20.3 d) when over 59–87% of the total travel time to Lower Granite Dam occurred between trap sites.

Similarly, based on a survival probability to Lower Granite Dam for the upper Grande Ronde River spring tag group of 0.398 (S_u) and a survival probability of 0.745 for wild fish tagged at the Grande Ronde Valley trap, the late migrant survival rate was estimated to be 0.534 for fish moving between these trap sites. Based on these survival rates, 77% of the total mortality to Lower Granite Dam occurred while fish migrated between trap sites. The total mortality to Lower Granite Dam was comparable to estimates of survival calculated between these trap sites beginning in MY 2002 (range; 71–80%). The distance between trap sites was 24% (85 km) of the total distance of 347 km from the upper Grande Ronde River trap to Lower Granite Dam. The median travel time to Lower Granite Dam for late migrants tagged at the upper Grande Ronde River trap was 49.9 d but was 5.8 d for Chinook salmon migrants tagged at the Grande Ronde Valley trap. The median travel time between traps accounted for 88% of the time traveled from the upper Grande Ronde River trap site to Lower Granite Dam. This percentage was higher than any measured since we began estimating travel time between these trap sites in MY 2002 (range; 45–88%).

Alternate Life History Strategy: During MY 2006, there were no detections of age-2 smolts. Although rare, some spring Chinook salmon parr from the Grande Ronde River Subbasin smolt as two year olds (Burck, 1967; Keefe et al. 1998; Jonasson et al. 2006). Of the 39,235 parr tagged on Catherine Creek and the Grande Ronde, Imnaha, Lostine, Minam, and Wenaha rivers from 1992 to 2001, 11 (0.03%) were detected in the hydrosystem as age-2 smolts. Since MY 2001, only one age-2 smolt has been detected emigrating seaward, which supports our earlier conclusion that this group can probably be discounted for life cycle modeling.

We have been estimating the abundance of precociously mature age-1 parr in study streams of the Grande Ronde River Subbasin since summer 1998. To date, the median mature male parr per anadromous female spawner (i.e. redd) was 8.4 (range 1.9–27.0) in Catherine Creek and 3.8 (range 3.6–5.6) in the Lostine River (Appendix Table A-4). These ratios have generally exceeded adult male to female ratios in most years since weirs have been operated. Precocious male Chinook salmon parr are capable of fertilizing eggs and producing viable offspring in a hatchery environment (Robertson 1957, Unwin et al. 1999) and may play an important role in the fertilization of eggs in the wild (Gebhards 1960). However, it is still unclear how much, if any, this life history strategy contributes to the wild population. Given the continual low abundance of anadromous spawners in northeast Oregon streams, mature male parr (wild and hatchery) may be an important component of the breeding population.

SUMMER STEELHEAD INVESTIGATIONS

Methods

In the Grande Ronde River 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 to learn more about the abundance, migration characteristics, growth rates, and size and age structure of the population. 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.

Characterization of Steelhead in Catherine Creek and Tributaries During Summer

We estimated abundance, age composition, and size structure of the main stem Catherine Creek and Little Catherine Creek steelhead populations in the summer of 2006. We used recaptures and detections of steelhead PIT tagged during previous summers to learn more about migration patterns, anadromy, and growth rates of this population.

Summer Abundance Estimates: *Main stem Catherine Creek:* We used mark–recapture methods to estimate the abundance of steelhead in main stem Catherine Creek during July 2006. Steelhead were collected in Catherine Creek from the screw trap site (rkm 32) upstream 20 km to the confluence of the north and south forks of Catherine Creek. Fish were captured, marked, and released in Catherine Creek 10–13 July 2006. Subsequent sampling was conducted 17–20 July 2006 throughout the same 20 km section of main stem Catherine Creek. The collection and handling of steelhead used the same procedure described for spring Chinook salmon parr (*see* **SPRING CHINOOK SALMON INVESTIGATIONS; Methods; Egg-to-Parr Survival, Parr Abundance, and Age Composition in Summer**). Generally, fish less than 50 mm in FL were not marked. Given that ontogenetic factors influence where fish rear in a stream (Everest and Chapman 1972), we considered our abundance estimate to be a minimum estimate because sampling was not conducted in every habitat type found in the stream (e.g. snorkel seining was impractical in shallow areas or in faster and deeper habitats). An overall minimum abundance estimate with 95% confidence interval was calculated using methods described in Ricker (1975).

Little Catherine Creek: Little Catherine Creek is a tributary that enters main stem Catherine Creek at rkm 44. We used mark–recapture methods to estimate the abundance of steelhead from the mouth of Little Catherine Creek upstream 8 km. Steelhead were collected and handled for marking 22–27 June 2006, and for examination of marks 5–7 July 2006. Steelhead were captured using backpack electrofishing and then PIT-tagged or caudal fin-clipped as described above. During the recapture effort fish were collected from the same 8 km section, and the data collected was summarized and analyzed as described above for the main stem of Catherine Creek.

In addition to mark–recapture, we used the removal method described in Zippin (1958) to estimate abundance in the upper 5 km of Little Catherine Creek (rkm 8-13). Backpack electrofishing was used to collect steelhead on 7 July 2006. We blocked off two 100 m sections of stream with seine nets to prevent immigration and emigration of fish during sampling. Our goal was to sample each section successively until the number of steelhead captured decreased by two-thirds between consecutive passes. Once a 100 m section was sufficiently depleted an abundance estimation was calculated and then extrapolated to include a 2.5 km segment. A total population abundance in Little Catherine Creek was obtained by summing mark–recapture and removal method estimates. Variance was combined using the variance sum law.

Lengths and Age-Composition in Summer Rearing Areas: In addition to collecting fork length and weight from each fish, scales were taken from a subsample of steelhead (10 fish/10 mm FL group) captured and handled during the marking phase on Catherine and Little Catherine creeks. Scales were aged as described for juvenile spring Chinook salmon (*see* **SPRING CHINOOK SALMON INVESTIGATIONS**; **Methods; Egg-to-Parr Survival, Parr Abundance, and Age Composition in Summer**). An age–length key was created and used to characterize the age composition of each population (DeVries and Frie 1996). Each age–length key was summarized using 10 mm FL intervals.

Growth Rates: Daily growth rates (mm/d) of steelhead PIT tagged during summer 2005 and recaptured during summer 2006 were calculated by dividing the difference in fork lengths between captures by the days between captures. Only fish recaptured 365 ± 14 d after their initial measurement and marking were used for this calculation. A mean growth rate for each population was calculated from individual growth rates.

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 (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 measure and handle steelhead (*see* **SPRING CHINOOK SALMON INVESTIGATIONS; Methods; In-Basin Migration Timing and Abundance**). In addition, scale samples were taken during both migration periods using the methods described above for steelhead collected in summer. 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 (usually July) and was only conducted in Catherine Creek drainage. 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, the goal was to PIT-tag 500 steelhead in the main stem of Catherine Creek, and 500 fish in Middle Fork Catherine Creek. At each trap site the goal was to PIT-tag 1,000 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. The same procedures described for spring Chinook salmon handling and marking were used for steelhead (*see* **SPRING CHINOOK SALMON INVESTIGATIONS; Methods; In-Basin Migration Timing and Abundance**). Steelhead exceeding 54 mm in FL were PIT-tagged for both fall and spring tag groups. 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 this 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.

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 SURPH2.1 program (Lady et al. 2001). Survival probabilities for steelhead tagged during the summer of 2006 will be reported in the 2007 annual report.

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 2005 were compared to the fork lengths of those subsequently detected at the dams in the spring of 2006 using Mann–Whitney rank-sum test. The fork lengths of all steelhead tagged in the fall of 2004 were compared to the lengths of those detected in 2005 and 2006 using a Kruskal–Wallis one-way ANOVA on ranks. In addition, the fork lengths of steelhead tagged in the spring of 2006 were compared to the fork lengths of those subsequently detected at the dams in the spring of 2006 using 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 2006 were characterized. Only those 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

Characterization of Steelhead in Catherine Creek and Tributaries During Summer

Summer Abundance Estimates: We estimated 7,441 (95% CI, 4,809–12,083) steelhead were present above the screw trap in the main stem of Catherine Creek during July 2006 (Table 9). We estimated 10,542 (95% CI, 8,890–12,194) steelhead were present in Little Catherine Creek in late June–July of 2006 (Table 9). This is the first year during this study that the abundance estimate for a tributary of Catherine Creek has exceeded the estimate for the main stem (Appendix Table B-1). The estimate for main stem Catherine Creek is the lowest abundance reported during this study.

Length and Age Composition in Summer Rearing Areas: The median length of steelhead sampled in Catherine Creek was 127 mm FL (range 61–331), and in Little Catherine Creek the median length was 90 mm FL (range 48–200). By using different collection methods in Little Catherine Creek (electrofishing) than were used in the main stem of Catherine Creek (snorkel–seining and angling) measures of central tendency may not be comparable between these two populations. Reynolds (1996) identified a number of biological, environmental, or technical factors that influenced the efficiency of electrofishing. Similar considerations would be expected for fish collected by snorkel–seining. Everest and Chapman (1972) identified that ontogenetic factors influenced where fish reared in a stream. Since snorkeling and seining was impractical in shallower habitats on the stream margins and in faster and deeper habitats, the chance of fully representing fish of smaller and larger sizes could have been biased. For this reason, we did not compare the lengths of steelhead in Catherine Creek with those in Little Catherine Creek.

Analysis of scales taken from steelhead in the main stem Catherine Creek indicated the presence of age 1–4 fish, while age 0–3 were found in Little Catherine Creek (Table 10). The age-frequency distribution computed using the age–length key indicated that greater than 70% of the steelhead population in both main stem and Little Catherine Creek were age-1 (Figure 10). The high percentage of age-1 fish in the main stem of Catherine Creek is similar to analyses completed for this population in previous years (Appendix Table B-2). As with median lengths, comparisons of age composition between the two populations may be confounded by the different collection methods used in each stream, so direct comparisons between the two populations were not made.

Growth Rates: One steelhead tagged during the summer of 2005 was recaptured during the summer of 2006 in the main stem of Catherine Creek. The growth rate of this fish was 0.165

mm/d. However, this small sample size precluded using it to estimate mean daily growth rate for the population.

In-Basin Migration Timing and Abundance

Upper Grande Ronde River: The upper Grande Ronde River trap fished for 119 d between 13 September 2005 and 26 May 2006 (Table 11). Systematic subsampling comprised 13 of the 62 d the trap was fished during late migration period. A distinct early migration was not as evident at this trap site as it was at the Catherine Creek and Lostine River trap sites (Figure 11). Most juvenile steelhead moved as late migrants during spring months as has been the case during previous years of this study. The median emigration date for early migrants passing the trap was 2 October 2005 and the median emigration date for late migrants was 12 April 2006. Both median migration dates were within the range previously reported for this study (Appendix Table B-3).

We estimated a minimum of 13,188 (95% CI, ± 2,819) juvenile steelhead migrated out of upper rearing areas of the upper Grande Ronde River during MY 2006. This estimate is within estimates from the previous migratory years (Appendix Table B-3). Based on the total minimum estimate, 14% (1,841 ± 2,136) were early migrants and 86% (11,347 ± 1,839) 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-3).

Catherine Creek: The Catherine Creek trap fished for 176 d between 7 September 2005 and 16 May 2006 (Table 11). Systematic subsampling comprised 16 of the 70 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 11). The median emigration date for early migrants was 13 October 2005, and the median date for late migrants was 13 April 2006. Both median migration dates were within the range previously reported for this study (Appendix Table B-3).

We estimated a minimum of 23,243 ± 8,142 juvenile steelhead migrated out of the upper rearing areas of Catherine Creek during MY 2006. Based on the total minimum estimate, 38% (8,910 ± 1,743) migrated early and 62% (14,333 ± 7,954) 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-3). 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 before the onset of winter.

Lostine River: The Lostine River trap fished for 213 d between 7 September 2005 and 15 May 2006 (Table 11). Systematic subsampling comprised 38 of the 101 d the trap was fished during late migration period. Distinct early and late migrations were evident at this trap site (Figure 11). Most early migrants left upper rearing areas in early October, but there was a smaller peak in January. The median emigration date of early migrants was 3 October 2005 which was the third-earliest median emigration date reported since this investigation began (Appendix Table B-3). The median emigration date for late migrants was 18 April 2006, and was within the range of emigration dates reported in previous years of this study (Appendix Table B-3).

We estimated a minimum of 28,710 ± 7,068 steelhead migrated out of the Lostine River during MY 2006. This is the third-largest estimate reported for this river since this study began (Appendix Table B-3). Based on the total minimum estimate, 89% (25,531 ± 7,049) of the juvenile steelhead migrated early and 11% (3,179 ± 515) migrated late. The percentage of late migrants was the lowest reported in previous years of this study (Appendix Table B-3).

Minam River: The Minam River trap fished for 147 d between 6 September 2005 and 15 May 2006 (Table 11). Distinct early and late migrations were evident at this trap site (Figure 11). The median emigration date for early migrants was 2 October 2005, and was the second-earliest emigration date reported in previous years of this study. The median emigration date for late migrants was 22 April 2006, and was within the range previously reported for this study (Appendix Table B-3).

We estimated a minimum of 103,141 ± 62,607 juvenile steelhead migrated out of the Minam River during MY 2006. Based on the total minimum estimate, 22% (22,576 ± 6,523) migrated early and 78% (80,565 ± 62,266) migrated late.

Age of Migrants at Traps: The steelhead collected at trap sites during MY 2006 were comprised of four age-groups. Early migrants ranged from 0 to 3 years of age while late migrants ranged in age from 1 (equivalent to age-0 early migrants) to 4 (equivalent to age-3 early migrants) years of age. The age structure varied between migrant periods within and among trap sites (Table 12). 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-4. Detections of the summer tag group from Catherine Creek and tributaries represented an undetermined combination of the two migrant groups that originated from this drainage.

Migration Timing: The median arrival dates at Lower Granite Dam for both the fall and spring tag groups on the upper Grande Ronde River were 10 May (Figure 12). The median arrival dates for the summer, fall and spring tag groups on Catherine Creek were 2 May, 30 April, and 7 May respectively (Figures 13). The median arrival dates for the fall and spring tag groups on Lostine River were 19 May and 1 May, respectively (Figure 14). The median arrival dates for the fall and spring tag groups on Minam River were 28 April and 2 May, respectively (Figure 15).

Travel times from the screw trap to Lower Granite Dam for the spring tag group from the four study streams are presented in Table 13. Travel time to Lower Granite Dam for the spring tag group from the upper Grande Ronde River ranged from 7 to 57 d with a median of 35 d. Travel times to Lower Granite Dam for the spring tag group from Catherine Creek ranged from 7 to 59 d with a median of 20 d. Travel times to Lower Granite Dam for the spring tag group from Lostine River ranged from 5 to 62 d with a median of 9 d. Travel times to Lower Granite Dam for the spring tag group from Minam River ranged from 4 to 66 d with a median of 11 d.

Survival Probabilities: The survival probabilities of wild steelhead PIT-tagged during the summer of 2005 and detected at the dam during MY 2006 was 0.138 for Catherine Creek and we could not calculate a survival probability for Middle Fork Catherine Creek because no fish were detected at Lower Granite Dam (Table 14). Survival probabilities of steelhead tagged in fall 2005 ranged from 0.077 to 0.094 among the four trap sites (Table 14). Survival probabilities of steelhead tagged in the spring 2006 (FL ≥ 115 mm) ranged from 0.522 to 0.665 among the four trap sites (Table 14). Some steelhead from all three tag groups do not migrate past the dams until the following migratory year (Appendix Table B-5). 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 North and South forks 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-5). To date none of the 214 fish tagged in Middle Fork Catherine Creek have been detected at any of the dams, so we can not confirm that the anadromous life history is present in this tributary population.

Length and Age Characterization of Smolt Detections: Of all the early migrating steelhead tagged at all four traps in the fall of 2005, the larger individuals from each trap tended to be the ones detected at the dams in 2006 (Mann–Whitney rank sum test $P < 0.05$; Figure 16). This pattern was also observed the previous migratory year for early migrants tagged in fall 2004 (Kruskal–Wallis one-way ANOVA on ranks $P < 0.05$; Figure 17). The spring tag group of 2006 also showed this pattern (Mann–Whitney rank sum test; $P < 0.05$; Figure 18). 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-6, B-7, and B-8. 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-6, B-7, and B-8).

Of the 136 early migrating age-0 fish tagged in the four study streams two were observed at the dams the following spring while 24 of the 194 age-1, 12 of the 78 age-2, and none of the five age-3 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 2006 (Table 15). Late migrant smolts consisted primarily of age 1 to 3 years, with one age-4 smolt from the Lostine River being observed at the dams in 2006. Overall, these results indicate that steelhead smolts from the Grande Ronde River Subbasin range in age from 1 to 4 years with the highest composition being age-2 fish. 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 ≥ 115 mm) were more likely to migrate out of the upstream rearing areas by spring while smaller fish (median FL ≤ 101 mm) were more likely to migrate out more than one year after tagging (Appendix Table B-8).

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 United States Geologic Survey (USGS) and La Grande District Water Master. Stream temperature and stream flow was characterized in all four study streams using the entire in-basin life history of juvenile spring Chinook salmon from BY 2004 which extended from 1 August 2004 (spawning) to 1 July 2006 (the end of MY 2006). 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 USGS 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).

Aquatic Macroinvertebrate Structure

Aquatic macroinvertebrates were collected from juvenile spring Chinook salmon rearing areas located upstream and downstream of the four rotary screw traps 21 August through 19 September 2006 to assess overall stream condition (OPSW 1999). In addition, aquatic macroinvertebrates were collected from rearing areas upstream and downstream of the rotary screw traps on the upper Grande Ronde River, Catherine Creek, and Lostine River during overwintering periods (late fall) 17 November 2006 through 1 December 2006 to characterize differences between the two reaches, and to identify trends between periods. Stream segments upstream of rotary screw traps were used to characterize conditions in the natal rearing area. The stream segments downstream of screw traps represented conditions where early migrants have been observed overwintering, and were based on past early migrant behavior, PIT tag detections, and winter rearing collections conducted throughout the Grande Ronde River Subbasin. Overwinter rearing areas used by early migrants from the upper Grande Ronde River and Catherine Creek occur in the Grande Ronde Valley just upstream of the town of Elgin (rkm 164) up to the town of La Grande (rkm 257) for the upper Grande Ronde River population and the town of Union (rkm 26) for the Catherine Creek population. Early migrants from the Lostine and Minam populations migrate through the Wallowa River and overwinter around its confluence with the Lower Grande Ronde River. For this reason lower reach samples for these two populations were based on samples collected in the Lower Grande Ronde River between rkm 0–140. Each stream segment was partitioned into a single continuous reach that was 40 times the length of the mean wetted channel width. The starting point of each reach was randomly selected using the unit number of pools with depths ≥ 0.8 m, and was based primarily on aquatic habitat inventories from each study stream. Identifying the location of each sample site was determined using a random number generator to select a number of meters from the reach starting point and a percentage of the wetted channel before the day of collection. The combined contents of eight D-frame net samples (composite) were collected from eight unique 30 cm by 60 cm sites within a stream reach, and two composites were collected from each reach. Composites were preserved in the field using 80% ethyl alcohol solution. In the lab, a minimum of 500 individuals were sorted from each composite using a Caton sorting tray (Caton 1991). Each individual was identified to a family level (Merritt and Cummins 1996), and the total number of individuals in a family was recorded. A general characterization of the macroinvertebrate assemblage was described for each reach. The mean of the two composite counts of unique taxonomic families in a reach was used to assess stream condition using a level-2 assessment which utilized scoring criteria of four common taxa richness measurements and two percentages of taxa to generate an overall metric score for each reach (Appendix Table C-1). Scoring criteria was calibrated using reference data collected from northeastern Oregon index streams (Ecoregion 3) by Oregon Department of Environmental Quality. Final metric scores were used to rate relative stream condition in each reach as either being not impaired, moderately impaired, or severely impaired. Metrics were calculated using samples collected during summer, and may not fully represent stream conditions across every season of the year. We assumed that applying the DEQ reference information to both summer and late fall collections would effectively measure relative richness and percentage of taxa within a season, but avoided applying an impairment rating to late fall stream conditions because a reference collection was not available for that period.

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 2004 upper Grande Ronde River Chinook salmon ranged from a low of 0.0°C to a high of 20.3°C. Unfortunately we were only able to characterize an 84 day period during the summer of 2005 (6 July-27 September 2005), and a 173 day period from the end of winter through emigration in spring (9 January-30 June 2006). No data was available during the period of spawning through a large portion of upper rearing (1 August 2004–5 July 2005) or during early dispersal and winter rearing (28 September 2005–8 January 2006). Daily mean water temperature exceeded the DEQ standard of 17.8°C 28 of 257 days in the upper Grande Ronde River. Water temperature was within the range preferred by juvenile Chinook salmon (10–15.6°C; OPSW 1999) 1,415 of 6,124 hours logged in the upper Grande Ronde River. The DEQ lethal limit of 25°C was exceeded for one hour during one of the 257 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 19). Moving mean temperatures exceeded 18.9°C 49 days (9 July–26 August 2005) during the period when the majority of young of the year parr were rearing in habitats within the spawning grounds, and 6 days (22–27 June 2006) during the last few days of spring emigration of this cohort. Moving mean temperatures were less than 4.4°C 71 days (12 January–23 March 2005) while the 2004 cohort was overwintering in upper rearing areas through the beginning of spring emigration. Average daily discharge (station located at the upper end of summer rearing distribution) during the entire in-basin life history of the 2004 cohort ranged from a low of 0.176 to a high of 8.893 m^3/s (Figure 20). Discharge was typically less than 0.75 m^3/s July through March–April. Discharge generally was 1.5 m^3/s or greater from late April through June, with annual peak flow occurring 14 May 2005 and 21 May 2006. In addition to the usual spring increase, stream discharge exceeded 1.5 m^3/s for 23 days during the winter (28 December 2005–6 February 2006) peaking out at 7.363 m^3/s 4 January 2006.

Catherine Creek: Water temperatures during the majority of the in-basin life history of BY 2004 Catherine Creek Chinook salmon ranged from a low of 0.0°C to a high of 20.1°C. Unfortunately we were not able to characterize the initial 219 days of the BY 2004 (spawning through emergence) because data were not available 1 August 2004–7 March 2005. Daily mean water temperature exceeded the DEQ standard of 17.8°C 28 of 480 days in Catherine Creek. Water temperature was within the range preferred by juvenile Chinook salmon (10–15.6°C; OPSW 1999) 2,022 of 11,473 hours logged in Catherine Creek. The DEQ lethal limit of 25°C was not exceeded on any of the 480 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 19). Moving mean temperatures exceeded 18.9°C 62 days (1 July–31 August 2005) 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 121 days (11 November 2005–13 March 2006) during parr dispersal, winter rearing, and early in spring when this cohort began emigrating seaward. Average daily discharge (station located in the lower end of summer rearing distribution) during the entire in-basin life history of the 2004 cohort ranged from a low of 0.283 to a high of 29.736 m^3/s (Figure 20). Discharge was typically less than 3.75 m^3/s June into April. Discharge generally was 3.75 m^3/s or greater from mid-March into June, with annual peak flow occurring 16 May 2005 and 20 May 2006.

Lostine River: Water temperatures during the in-basin life history of BY 2004 Lostine River Chinook salmon ranged from a low of 0.0°C to a high of 16.8°C. Daily mean water temperature did not exceed the DEQ standard of 17.8°C during any of the 661 days logged in the Lostine River. Water temperature was within the range preferred by juvenile Chinook salmon (10–15.6°C; OPSW 1999) 3,201 of 15,775 hours logged in the Lostine River. The DEQ lethal limit of 25°C was not exceeded on any 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 19). Moving mean temperatures exceeded 18.9°C 20 day during the period (21 July–9 August 2005) 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 156 days (11 November 2004–21 February 2005) while the 2004 cohort was in redds or emerging, and 65 days (18 November 2005–24 February 2006) 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 2004 cohort ranged from a low of 0.263 to a high of 45.595

m^3/s (Figure 20). Discharge was typically less than 7.5 m^3/s late July into May. Discharge generally was 7.5 m^3/s or greater from late-April through June, with annual peak flow occurring 16 May 2005 and 20 May 2006.

Minam River: Water temperatures during the in-basin life history of BY 2004 Minam River Chinook salmon ranged from a low of 0.0°C to a high of 21.5°C. Daily mean water temperature exceeded the DEQ standard of 17.8°C 54 of 664 days in the Minam River. Water temperature was within the range preferred by juvenile Chinook salmon (10–15.6°C; OPSW 1999) 2,707 of 15,874 hours logged in the Minam River. The DEQ lethal limit of 25°C was exceeded 10 out of the 664 days (10 hours, 11–15 August 2004, and 18 hours, 31 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 19). Moving mean temperatures exceeded 18.9°C 24 days (4 August–4 September 2004) during the period adults were spawning, and 57 days (13 July–7 September 2005) 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 66 days (6 November 2004–25 February 2005) while the 2004 cohort was in redds or emerging, and 111 days (8 November 2005–11 March 2005) during parr dispersal, winter rearing, and the initial period of emigration in spring. Average daily discharge (station located at the lower end of summer rearing distribution) during the entire in-basin life history of the 2004 cohort ranged from a low of 1.558 to a high of 112.714 m^3/s (Figure 20). Discharge was typically less than 9.0 m^3/s mid-July through March. Discharge generally was 9.0 m^3/s or greater from late-March into July, with annual peak flow occurring 16 May 2005 and 20 May 2006. In addition to the usual spring increase, stream discharge exceeded 9.0 m^3/s for 13 days during the winter (22 December 2005–19 January 2006) peaking out at 14.160 m^3/s 29 December 2005.

Aquatic Macroinvertebrate Structure

Upper Grande Ronde River: Summer macroinvertebrate assemblages in the upper Grande Ronde River consisted of the orders Coleoptera (beetles), Diptera (true flies), Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) occurring in both the upper and lower reaches; while Hemiptera (true bugs), Lepidoptera (butterflies–moths), Megaloptera (alderflies), and Odonata (dragonflies and damselflies) were only observed in the lower reach (Appendix Table C-2). In terms of relative abundance, mayflies were the dominant order in the upper reach (38%), while beetles (33%) dominated in the lower reach. Of the five orders found in both the upper and lower reaches, stoneflies had the lowest relative abundance (range: 3–13%). Families considered to be sensitive to poor water quality (tolerance values ≤ 2) were present in both reaches. Gatherers were the dominant functional feeding group in both the upper and lower reaches (53 and 59%, respectively) while clingers were the dominant functional habit of existence (54 and 72%, respectively) in both reaches.

There was no indication that relative stream condition was severely impaired in the upper or lower rearing areas during summer 2006 (Table 16). The upper reach was found to be within the range of no impairment while the lower reach fell within the range of moderate impairment. Different impairment ratings were primarily associated with stonefly and Caddisfly richness scoring higher in the upper reach than the lower reach.

Late fall macroinvertebrate assemblages consisted of the orders Coleoptera (beetles), Diptera (true flies), Ephemeroptera (mayflies), Lepidoptera (butterflies–moths), Plecoptera (stoneflies), Odonata (dragonflies and damselflies), and Trichoptera (caddisflies) which occurred in both the upper and lower reaches; while Hemiptera (true bugs) and Megaloptera (alderflies) were only observed in the lower reach (Appendix Table C-2). In terms of relative abundance, true flies were the dominant order in the upper reach (49%), while mayflies (49%) were the dominant order in the lower reach. Of the six orders found in both the upper and lower reaches, dragonflies (<1–2%) and stoneflies had the lowest relative abundance (range: 1–8%). Families considered to be sensitive to poor water quality (tolerance values ≤ 2) were present in both reaches. Gatherers were the dominant functional feeding group in both the upper and lower reaches (69 and 62%, respectively). Burrowers were the dominant functional habit of existence (46%) in the upper reach while clingers dominated (70%) in the lower reach.

Family level metric scores decreased from summer to late fall in the upper reach, and increased from summer to late fall in the lower reach of the upper Grande Ronde River during 2006 (Figure 21). Although there has been documentation of young of the year spring Chinook salmon moving from natal rearing areas into the lower rearing areas in summer months, few fish are expected to be rearing in the lower rearing areas prior to early migration in the fall. Therefore, conditions in this rearing area would have little influence on overall survival of this population in summer. However, equivalent metric scores in the upper and lower rearing areas during late fall may in part explain equivalent overwinter survival among the two migrant groups, as was estimated during MY 2006 (Appendix Table A-10). Additional research will be necessary to test this hypothesis and to verify this trend.

Catherine Creek: Summer macroinvertebrate assemblages in Catherine Creek consisted of the orders Coleoptera (beetles), Diptera (true flies), Ephemeroptera (mayflies), Hemiptera (true bugs), Odonata (dragonflies and damselflies), and Trichoptera (caddisflies) occurring in both the upper and lower reaches; while Plecoptera (stoneflies) were only observed in the upper reach (Appendix Table C-2). In terms of relative abundance, mayflies were the dominant order in the upper reach (35%), while true flies (54%) dominated in the lower reach. Of the six orders found in both the upper and lower reaches, true bugs had the lowest relative abundance (range: <0.1–1%). Families considered to be sensitive to poor water quality (tolerance values ≤ 2) were present in both reaches. Gatherers were the dominant functional feeding group in both the upper and lower reaches (56 and 68%, respectively). Clingers were the dominant functional habit of existence (63%) in the upper reach, and burrowers (51%) were dominant in the lower reach.

Relative stream condition was shown to be severely impaired in the lower reach of Catherine Creek during summer 2006 while the upper reach fell within the range of no impairment (Table 16). All but mayfly richness scored the lowest possible metric score (1) during summer in the lower reach. In contrast all but mayfly and stonefly richness achieved the highest possible score (5) in the upper reach.

Late fall macroinvertebrate assemblages consisted of the orders Coleoptera (beetles), Diptera (true flies), Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) which occurred in both the upper and lower reaches; while Hemiptera (true bugs) , Lepidoptera (butterflies–moths), and Odonata (dragonflies and damselflies) were only observed in the lower reach (Appendix Table C-2). In terms of relative abundance, caddisflies were the dominant order in the upper reach (35%), while mayflies (42%) were the dominant order in the lower reach. Of the five orders found in both the upper and lower reaches, stoneflies had the lowest relative abundance in the upper reach (range: 3–6%) and beetles had the lowest relative abundance in the lower reach (range: 3–6%). Families considered to be sensitive to poor water quality (tolerance values ≤ 2) were present in both reaches. Gatherers were the dominant functional feeding group in both the upper and lower reaches (39 and 41%, respectively). Clingers were the dominant functional habit of existence in both the upper and lower reaches (50 and 59%, respectively).

Family level metric scores were equivalent from summer to late fall in the upper reach, and increased from summer to late fall in the lower reach during 2006 (Figure 21). Although there has been documentation of young of the year spring Chinook salmon moving from natal rearing into the lower rearing area in summer months, few fish are expected to be rearing in the lower rearing areas prior to early migration in the fall. Therefore, conditions in this rearing area would have little influence on overall survival of this population in summer. However, metric scores > 25 in the upper and lower rearing areas during late fall may in part explain equivalent overwinter survival among the two migrant groups during MY 2006 (Appendix Table A-10). Additional research will be necessary to test this hypothesis and to verify this trend.

Lostine River: Summer macroinvertebrate assemblages in the Lostine River (lower Grande Ronde River for lower reach) consisted of the orders Coleoptera (beetles), Diptera (true flies), Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) in both the upper and lower reaches; while Lepidoptera (butterflies–moths) were only observed in the lower reach (Appendix Table C-2). In terms of relative abundance, true flies were the dominant order in the upper reach (39%), while mayflies (37%) dominated in the lower reach. Of the five orders found in both the upper and lower reaches, stoneflies had the lowest relative abundance (range: 2–3%). Families considered to be sensitive to poor water quality (tolerance values ≤ 2) were present in both reaches. Gatherers were the dominant functional feeding group in both the upper and lower reaches (66 and 39%, respectively). Clingers were the dominant functional habit of existence (57 and 63%, respectively) in both reaches.

Relative stream condition was shown to be severely impaired in the upper reach of the Lostine River during summer 2006 while the lower reach fell within the range of moderate impairment (Table 16). Every metric category but stonefly richness (equivalent scores) scored lower in the upper reach than was scored in the lower reach.

Late fall macroinvertebrate assemblages consisted of the orders Coleoptera (beetles), Diptera (true flies), Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) which occurred in the upper reach, and we were not able to collect late fall composites in the lower reach during 2006 (Appendix Table C-2). In terms of relative abundance, mayflies were the dominant order in the upper reach (66%). Of the five orders found in the upper reach, stoneflies had the lowest relative abundance (range: 4–6%). Families considered to be sensitive to poor water quality (tolerance values ≤ 2) were present in the upper reach. Gatherers and scrapers were the dominant functional feeding groups in the upper reach

(38 and 37%, respectively). Clingers were the dominant functional habit of existence (82%) in the upper reach.

Family level metric scores increased from summer to late fall in the upper reach of the Lostine River during 2006 (Figure 21). We were not able to characterize the trend in the lower reach.

Minam River: Summer macroinvertebrate assemblages in the Minam River (lower Grande Ronde River for lower reach) consisted of the orders Coleoptera (beetles), Diptera (true flies), Ephemeroptera (mayflies), Lepidoptera (butterflies–moths), Plecoptera (stoneflies), and Trichoptera (caddisflies) during summer in both the upper and lower reaches (Appendix Table C-2); while Odonata (dragonflies and damselflies) were only observed in the lower reach. In terms of relative abundance, caddisflies were the dominant order in both the upper and lower reaches (33 and 45%, respectively). Of the six orders in both the upper and lower reaches, moths/butterflies and stoneflies were found in low relative abundance in the upper reach (range: <0.1–1% and 0–6% respectively). Families considered to be sensitive to poor water quality (tolerance values ≤ 2) were present in both reaches. Gatherers were the dominant functional feeding group in both the upper and lower reaches (34 and 48%, respectively). Clingers were the dominant functional habit of existence (73 and 79%, respectively).

Relative stream condition was shown to be within the range of no impairment during summer 2006 in both the upper and lower rearing areas of the Minam River population (Table 16). All metric scores were ≥ 3 in the upper reach while only stonefly richness scored < 3 in the lower reach.

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.

REFERENCES

Burck, W. A. 1967. Mature stream-reared spring Chinook salmon. Oregon Fish Commission Research Briefs 13(1): 128.

Burck, W. A. 1993. Life history of spring Chinook salmon in Lookingglass Creek, Oregon. Oregon Department of Fish and Wildlife, Information Reports 94-1, Portland.

Caton, L. W. 1991. Improved sampling methods for the EPA "Rapid Bioassessment" benthic protocols. Bulletin of the North American Benthological Society 8:817–319.

DeVries, D. R., and R. V. Frie. 1996. Determination of age and growth. Pages 483–512 *in* B. R. Murphy and D. W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, MD.

Efron, B., and R. Tibshirani. 1986. Bootstrap methods for standard errors, confidence intervals, and other measures of statistical accuracy. Statistical Science 1: 54–77.

Everest, F. H., and D. W. Chapman. 1972. Habitat selection and spatial interaction by juvenile Chinook salmon and steelhead trout in two Idaho streams. Journal of the Fisheries Research Board of Canada 29: 91–100.

Gebhards, S. V. 1960. Biological notes on precocious male Chinook salmon in Salmon River drainage. Progressive Fish-Culturist 22(3): 121–123.

Giorgi, A. E., G. A. Swan, W. S. Zaugg, T. C. Corley and T. Y. Barila. 1988. The susceptibility of Chinook salmon smolts to bypass systems at hydroelectric dams. North American Journal of Fisheries Management 8:25–29.

Hankin, D. G., and G. H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian Journal of Fisheries and Aquatic Science 45:834–844.

Johnson, G. E., R. L. Johnson, E. Kucera, and C. Sullivan. 1997. Fixed-location hydroacoustic evaluation of the prototype surface bypass and collector at Lower Granite Dam in 1996. Final Report. U.S. Army Corps of Engineers, Walla Walla, WA.

Jonasson, B. C., J. V. Tranquilli, M. Keefe, and R. W. Carmichael. 1997. Investigations into the early life history of naturally produced spring Chinook salmon in the Grande Ronde River basin. Annual Progress Report 1997. Bonneville Power Administration, Portland, OR.

Jonasson, B. C., A. G. Reischauer, F. R. Monzyk, E. S. Van Dyke, and R. W. Carmichael. 2006. Investigations into the early life history of naturally produced spring Chinook salmon in the Grande Ronde River basin. Annual Progress Report 2002. Bonneville Power Administration, Portland, OR.

Keefe, M., R. W. Carmichael, B. C. Jonasson, R. T. Messmer, and T. A. Whitesel. 1994. Investigations into the life history of spring Chinook salmon in the Grande Ronde River basin. Annual Progress Report 1994. Bonneville Power Administration, Portland, OR.

Keefe, M., D. J. Anderson, R. W. Carmichael, and B. C. Jonasson. 1995. Early life history study of Grande Ronde River basin Chinook salmon. Annual Progress Report 1995. Bonneville Power Administration, Portland, OR.

Keefe M., J. V. Tranquilli, P. Sankovich, E. S. Van Dyke, B. C. Jonasson, and R. W. Carmichael. 1998. Investigations into the early life history of naturally produced spring Chinook salmon in the Grande Ronde River basin. Annual Progress Report 1998. Bonneville Power Administration, Portland, OR.

Kuehl, S. 1986. Hydroacoustic evaluation of fish collection efficiency at Lower Granite Dam in spring 1985. Final Report to U.S. Army Corps of Engineers, Walla Walla, WA.

Lady, J., P. Westhagen, and J. R. Skalski. 2001. SURPH.2 User Manual, SURPH 2.1, SURvival under Proportional Hazards. School of Aquatic and Fisheries Sciences, University of Washington, Seattle, WA. Available: http://www.cbr.washington.edu/paramEst/SURPH (January 2008).

Matthews, G. M., J. R. Harmon, S. Achord, O. W. Johnson, and L. A. Kubin. 1990. Evaluation of transportation of juvenile salmonids and related research on the Columbia and Snake rivers, 1989. Report of the U.S. Army Corps of Engineers, Contract DACW68-84-H0034. National Marine Fisheries Service, Seattle.

Matthews, G. M., and eight coauthors. 1992. Evaluation of transportation of juvenile salmonids and related research on the Columbia and Snake rivers, 1990. Report of the U.S. Army Corps of Engineers, Contract DACW68-84-H0034. National Marine Fisheries Service, Seattle.

Merritt, R. W., and K. W. Cummins, editors. 1996. An Introduction to the Aquatic Insects of North America, 3rd addition. Kendall/Hunt Publishing, Dubuque, Iowa.

Nowak, M. C., lead writer. 2004. Grande Ronde Subbasin Plan. Northwest Power and Conservation Council, Portland. Available: http://www.nwcouncil.org/fw/subbasinplanning/granderonde/plan/ (January 2008).

NWPPC (Northwest Power Planning Council). 1992. Strategy for salmon, Volume VII.

ODFW (Oregon Department of Fish and Wildlife). 1990. Grande Ronde River Subbasin Salmon and Steelhead Production Plan. Oregon Department of Fish and Wildlife, Portland, OR.

OPSW (The Oregon Plan for Salmon and Watersheds). 1999. Water Quality Monitoring Technical Guide Book: version 2.0. Available: http://www.oregon.gov/OWEB/docs/pubs/wq_mon_guide.pdf (January 2008).

Prentice, E. F., T. A. Flagg, C. S. McCutcheon, D. F. Brastow, and D. C. Cross. 1990. Equipment, methods, and an automated data-entry station for PIT tagging. American Fisheries Society Symposium 7: 335–340.

Prentice, E. F., D. L. Park, T. A. Flagg, and S. McCutcheon. 1986. A study to determine the biological feasibility of a new fish tagging system, 1985–1986. Annual Progress Report. Bonneville Power Administration, Portland OR.

Peven, C. M., R. R. Whitney, and K. R. Williams. 1994. Age and length of steelhead smolts from the mid-Columbia river basin, Washington. North American Journal of Fisheries Management 14:77–86

Reischauer, A. G., F. R. Monzyk, E. S. Van Dyke, B. C. Jonasson, and R. W. Carmichael. 2003. Investigations into the early life history of naturally produced spring Chinook salmon in the Grande Ronde River basin. Annual Progress Report 2001. Bonneville Power Administration, Portland, OR.

Reynolds, J. B. 1996. Electrofishing. Pages 221–253 *in* B. R. Murphy and D. W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, MD.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada Bulletin 191.

Robertson, O. H. 1957. Survival of precociously mature king salmon male parr (*Oncorhynchus tshawytscha*, juv.) after spawning. California Fish and Game 43 (2): 119–130.

Snake River Recovery Team. 1993. Draft Snake River salmon recovery plan recommendations. National Marine Fisheries Service, Portland, OR.

Swan, G. A., R. F. Krcma, and F. J. Ossiander. 1986. Continuing studies to improve and evaluate juvenile collection at Lower Granite Dam, 1985. Report to U.S. Army Corps of Engineers, Portland, OR.

Thedinga, J. F., M. L. Murphy, S. W. Johnson, J. M. Lorenz, and K. V. Koski. 1994. Determination of salmonid smolt yield with rotary-screw traps in the Situk River, Alaska, to predict effects of glacial flooding. North American Journal of Fisheries Management 14: 837–851.

TRT (Interior Columbia Basin Technical Recovery Team). 2003. Independent Populations of Chinook, Steelhead, and Sockeye for Listed Evolutionarily Significant Units within the Interior Columbia River Domain.

Unwin, M. J., M. T. Kinnison, and T. P. Quinn. 1999. Exceptions to semelparity: postmaturation survival, morphology, and energetics of male Chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fish and Aquatic Science 56: 1172–1181.

Van Dyke, E. S., M. Keefe, B. C. Jonasson, and R. W. Carmichael. 2001. Aspects of life history and production of juvenile *Oncorhynchus mykiss* in the Grande Ronde River Basin, northeast Oregon. Summary Report. Bonneville Power Administration, Portland, OR.

Van Dyke, E. S., J. A. Yanke, B. C. Jonasson, and R. W. Carmichael. 2008. Investigations into the early life history of naturally produced spring Chinook salmon in the Grande Ronde River basin. Annual Progress Report 2005. Bonneville Power Administration, Portland, OR.

Ward, B. R., and P. A. Slaney. 1988. Life history and smolt-to-adult survival of Keogh River steelhead trout (*Salmo gairdneri*) and the relationship to smolt size. Canadian Journal of Fish and Aquatic Science 45: 1110–1122.

Zippin, C. 1958. The removal method of population estimation. Journal of Wildlife Management 22: 82–90.

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)
2005			
Catherine Creek	26–29 Jul	523	363–383
Lostine River	8–12 Aug	1,105	271–308
Minam River	22–25 Aug	1,007	276–290
Imnaha River	30 Aug–1 Sep	1,011	221–233
2006			
Catherine Creek	24–27 Jul	501	368–383
Lostine River	7–10 Aug	500	273–304
Minam River	28–31 Aug	1,000	279–292
Imnaha River	5–6 Sep	1,000	209–226

Table 2. Census data used to estimate the number of spring Chinook salmon parr by maturity in Catherine Creek and the Lostine River in summer 2006.

Stream, Group	Number marked (M)	Number sampled (C)	Number recaptured (R)	Population estimate (95% CI)
Catherine Creek				
immature	1,253	1,380	58	29,352 (22,794–37,758)
mature	27	18	0	(a)
Lostine River				
immature	2,335	5,603	125	103,896 (87,319–123,594)
mature	25	43	0	(a)

[a] Census data was inadequate to calculate an unbiased population estimate.

Table 3. Estimated abundance of age-0 spring Chinook salmon parr during the summer, and the corresponding egg-to-parr survival of spring Chinook salmon in Catherine Creek and the Lostine River for the 1997–2005 brood years.

Stream, BY	Redds[a]	Fecundity[b]	Total eggs	Age-0 parr abundance	Rate (%)
Catherine Creek					
1997	45	3,782	170,190	13,222	7.77
1998	34	4,066	138,244	22,509	16.28
1999	38	3,742	142,196	25,698	18.07
2000	26	3,872	100,672	15,032	14.93
2001	131	3,801	497,931	37,337	7.50
2002	156	3,754	585,624	114,326	19.52
2003	165	3,868	638,220	81,145	12.71
2004	94	3,742	351,748	33,983	9.66
2005	72	3,852	277,344	29,352	10.58
Lostine River					
1997	47	4,925	231,475	40,748	17.60
1998	28	5,393	151,004	28,084	18.60
1999	45	4,963	223,335	12,372	5.54
2000	53	4,925	261,025	33,086	12.68
2001	98	4,950	485,100	41,209	8.49
2002	182	4,957	902,174	98,538	10.92
2003	127	5,235	664,845	66,794	10.05
2004	144	4,912	707,328	111,093	15.71
2005	125	4,936	617,000	88,104	14.28

[a] Redds counted above screw traps on Catherine Creek (rkm 32) and Lostine River (rkm 3).
[b] Average number of eggs per female wild spring Chinook salmon spawned at Lookingglass Hatchery (ODFW, unpublished data) adjusted for age composition of females on the spawning grounds.

Table 4. Catch of juvenile spring Chinook salmon at five trap locations in the Grande Ronde River Subbasin during MY 2006. The early migration period began 1 July 2005 and ended 28 January 2006. The late migration period began 29 January and ended 30 June 2006. Numbers in parentheses are percentage of days fished out of total possible for that trapping period.

Trap site	Migration period	Period trap operated	Days fished	Trap catch
Upper Grande Ronde River	Early	13 Sep 05–17 Nov 05	57 (86)	3,962
	Late	6 Mar 06–26 May 06	49 (60)	3,397[a]
		27 Mar 06–14 Apr 06	13 (68)	1,523[b]
Catherine Creek	Early	7 Sep 05–28 Jan 06	106 (73)	12,902
	Late	29 Jan 06–16 May 06	54 (68)	608[a]
		27 Mar 06–15 Apr 06	16 (80)	111[b]
Grande Ronde Valley	Late	16 Mar 06–24 May 06	46 (66)	414
Lostine River	Early	7 Sep 05–28 Jan 06	112 (78)	6,264
	Late	29 Jan 06–15 May 06	63 (59)	1,021[a]
		11 Mar 06–17 Apr 06	38 (100)	1,141[b]
Minam River	Early	6 Sep 05–20 Nov 05	73 (96)	5,094
	Late	28 Feb 06–15 May 06	74 (96)	1,384

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

Table 5. Fork lengths of juvenile spring Chinook salmon collected from the study streams during MY 2006. 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	587	69.4	0.35	50	93	519	70.3	0.35	53	93
Winter group	463	65.6	0.35	51	90	463	65.6	0.35	51	90
Late migrants	717	79.9	0.31	59	112	505	79.2	0.36	59	110
Catherine Creek										
Early migrants	688	79.8	0.33	56	117	500	79.8	0.39	56	117
Winter group	500	83.1	0.33	59	114	500	83.1	0.33	59	114
Late migrants	361	88.6	0.43	67	127	360	88.6	0.43	67	127
Grande Ronde Valley										
Late migrants	401	102.6	0.51	79	130	400	102.7	0.51	79	130
Lostine River										
Early migrants	1,390	85.3	0.26	59	120	495	86.2	0.49	59	120
Winter group	501	73.4	0.32	54	107	501	73.4	0.32	54	107
Late migrants	1,158	88.4	0.29	63	137	517	89.5	0.40	65	127
Minam River										
Early migrants	904	78.5	0.34	50	118	499	78.6	0.43	58	110
Late migrants	733	84.9	0.27	65	121	401	84.3	0.37	65	115

Table 6. Weights of juvenile spring Chinook salmon collected from the study streams during MY 2006. 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	555	3.67	0.06	1.1	8.5	489	3.79	0.06	1.5	8.5
Winter group	351	2.98	0.06	1.5	7.3	351	2.98	0.06	1.5	7.3
Late migrants	562	5.07	0.07	1.9	10.7	377	4.82	0.08	2.0	10.1
Catherine Creek										
Early migrants	660	5.60	0.07	2.1	12.3	473	5.67	0.09	2.2	12.3
Winter group	496	6.06	0.07	2.1	13.1	496	6.06	0.07	2.1	13.1
Late migrants	332	7.44	0.13	2.6	21.4	331	7.45	0.13	2.6	21.4
Grande Ronde Valley										
Late migrants	389	11.79	0.19	5.1	25.3	388	11.80	0.19	5.1	25.3
Lostine River										
Early migrants	1,375	7.40	0.07	2.4	20.7	490	7.86	0.13	2.4	20.7
Winter group	489	4.56	0.07	1.5	14.2	489	4.56	0.07	1.5	14.2
Late migrants	1,140	7.67	0.08	3.0	34.6	512	7.98	0.11	3.1	22.6
Minam River										
Early migrants	889	5.77	0.08	1.4	17.7	497	5.71	0.10	2.2	14.4
Late migrants	716	6.82	0.07	2.8	23.2	391	6.87	0.09	3.2	14.8

Table 7. Survival probability to Lower Granite Dam for spring Chinook salmon parr tagged in summer 2005 and detected at Columbia and Snake River dams in 2006. 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	523	0.057^{a} (0.033–0.128)
Lostine River	1,105	0.113^{b} (0.091–0.143)
Minam River	1,007	0.145^{c} (0.119–0.178)
Imnaha River	1,011	0.144^{c} (0.117–0.180)

Table 8. 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 2005 to spring 2006 and detected at the dams during 2006.

Stream, Tag group	Number PIT-tagged and released	Survival probability (95% CI)
Upper Grande Ronde River		
Fall (trap)	521	0.171 (0.136–0.232)
Winter (above trap)	464	0.080 (0.052–0.183)
Spring (trap)	505	0.398 (0.318–0.561)
Catherine Creek		
Fall (trap)	500	0.074 (SE = 0.012)
Winter (above trap)	500	0.125 (0.080–0.312)
Spring (trap)	360	0.367 (0.290–0.526)
Lostine River		
Fall (trap)	495	0.269 (0.207–0.406)
Winter (above trap)	501	0.177 (0.127–0.304)
Spring (trap)	517	0.619 (0.551–0.722)
Minam River		
Fall (trap)	499	0.245 (0.205–0.304)
Spring (trap)	401	0.543 (0.482–0.630)

Table 9. Census data used to estimate the number of wild steelhead present in Catherine Creek and Little Catherine Creek during summer 2006.

Stream, Section (rkm)	Number marked (M)	Number recaptured (R)	Number sampled (C)	Population Estimate (95% CI)
Catherine Creek				
32–52	334	18	421	7,441 (4,809–12,083)
Little Catherine Creek				
0–8	738	106	1,301	8,992 (7,341–10,643)
8–10.5[a]	—	—	—	1,100 (1,048–1,152)[b]
10.5–13[a]	—	—	—	450 (420–480)[c]

[a] Estimate was generated using removal methods described in Zippin (1958).
[b] Three passes were made (20, 14, 4, respectively) which yielded an estimate of 44 fish/100m.
[c] Two passes were made (12, 4, respectively) which yielded an estimate of 18 fish/100m.

Table 10. Length and scale sample information with frequency distribution by age determined from an age–length key for steelhead collected from main stem Catherine Creek and Little Catherine Creek during the summer 2006.

Stream, Length group (mm)	Number sampled	Number scales aged	Age 0[a]	Age 1	Age 2	Age 3	Age 4
Catherine Creek							
< 50	0	—	—	—	—	—	—
50–59	0	—	—	—	—	—	—
60–69	0	—	—	—	—	—	—
70–79	5	5	0	5	0	0	0
80–89	30	11	0	30	0	0	0
90–99	90	12	0	90	0	0	0
100–109	108	12	0	108	0	0	0
110–119	120	11	0	120	0	0	0
120–129	104	10	0	104	0	0	0
130–139	79	10	0	55	24	0	0
140–149	44	9	0	39	5	0	0
150–159	47	10	0	19	28	0	0
160–169	35	11	0	3	32	0	0
170–179	36	11	0	7	29	0	0
180–189	14	6	0	2	10	2	0
190–199	12	11	0	0	9	3	0
200–209	4	3	0	1	0	3	0
210–219	2	0	(b)	(b)	(b)	(b)	(b)
220–229	2	0	(b)	(b)	(b)	(b)	(b)
230–239	4	4	0	0	0	4	0
240–249	0	—	—	—	—	—	—
≥ 250	4	3	0	0	0	3	1
Total	**740**	**139**	**0**	**583**	**137**	**15**	**1**
Little Catherine Creek							
< 50	1	0	(b)	(b)	(b)	(b)	(b)
50–59	44	4	22	22	0	0	0
60–69	225	16	14	211	0	0	0
70–79	401	19	0	401	0	0	0
80–89	321	15	0	321	0	0	0
90–99	187	16	0	187	0	0	0
100–109	216	17	0	152	64	0	0
110–119	204	17	0	132	72	0	0
120–129	149	19	0	24	125	0	0
130–139	92	14	0	7	85	0	0
140–149	69	16	0	0	69	0	0

[a] Age 0 fish were not fully represented in the sample because smaller fish (FL < 70 mm) were not targeted for scale samples or collection during mark–recapture sampling.
[b] Number sampled was not allocated to an age because no scales were aged in this interval.

Table 10. Continued

Stream, Length group (mm)	Number sampled	Number scales aged	Age 0[a]	Age 1	Age 2	Age 3	Age 4
Little Catherine Creek (cont.)							
150–159	29	16	0	0	24	5	0
160–169	25	13	0	0	13	12	0
170–179	14	9	0	0	6	8	0
180–189	8	5	0	0	0	8	0
190–199	3	1	0	0	0	3	0
200–209	1	0	(b)	(b)	(b)	(b)	(b)
210–219	0	—	—	—	—	—	—
220–229	0	—	—	—	—	—	—
230–239	0	—	—	—	—	—	—
240–249	0	—	—	—	—	—	—
≥ 250	0	—	—	—	—	—	—
Total	**1,989**	**197**	**36**	**1,457**	**458**	**36**	**0**

Table 11. Catch of juvenile steelhead at five trap locations in the Grande Ronde River Subbasin during MY 2006. The early migration period starts 1 July 2005 and ends 28 January 2006. The late migration period starts 29 January and ends 30 June 2006. 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	Trap catch
Upper Grande Ronde River	Early	13 Sep 05–17 Nov 05	57 (86)	283
	Late	6 Mar 06–26 May 06	49 (60)	1,516[a]
		27 Mar 06–14 Apr 06	13 (68)	265[b]
Catherine Creek	Early	7 Sep 05–28 Jan 06	106 (73)	2,285
	Late	29 Jan 06–16 May 06	54 (68)	626[a]
		27 Mar 06–15 Apr 06	16 (80)	225[b]
Grande Ronde Valley	Late	16 Mar 06–24 May 06	46 (66)	358
Lostine River	Early	7 Sep 05–28 Jan 06	112 (78)	2,725
	Late	29 Jan 06–15 May 06	63 (59)	320[a]
		11 Mar 06–17 Apr 06	38 (100)	137[b]
Minam River	Early	6 Sep 05–20 Nov 05	73 (96)	316
	Late	28 Feb 06–15 May 06	74 (96)	699

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

Table 12. Age structure of early and late steelhead migrants collected at trap sites during MY 2006. 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	36.7	35.0	26.7	1.7	0.0
Catherine Creek	53.4	36.1	10.0	0.4	0.0
Lostine River	68.6	27.2	4.1	0.2	0.0
Minam River	54.3	30.9	12.8	2.1	0.0
Mean	**60.2**	**31.7**	**7.7**	**0.4**	**0.0**
Late					
Upper Grande Ronde River	—	22.9	49.7	27.5	0.0
Catherine Creek	—	47.9	37.5	14.6	0.0
Lostine River	—	72.8	26.6	0.3	0.3
Minam River	—	38.0	45.9	15.8	0.2
Mean	—	**42.0**	**41.4**	**16.4**	**0.1**

Table 13. Travel time to Lower Granite Dam (LGD) of wild steelhead PIT-tagged at screw traps in spring of 2006 and arriving at Lower Granite Dam in 2006.

	Distance to	Number	Travel time (d)		
Stream	LGD (km)	detected	Median	Min.	Max.
Upper Grande Ronde River	397	62	34.6	7	57
Catherine Creek	362	32	20.4	7	59
Lostine River	274	23	8.6	5	62
Minam River	245	64	10.9	4	66

Table 14. Survival probability to Lower Granite Dam of steelhead PIT-tagged on Catherine Creek during summer 2005 and at screw traps on Catherine Creek and the upper Grande Ronde, Lostine, and Minam rivers during the fall of 2005 and spring of 2006 (MY 2006).

Season, Location tagged	Number tagged	Number detected	Survival probability (95% CI)
Summer			
Catherine Creek	418	19	0.138 (0.090–0.252)
Middle Fork Catherine Creek	214	0	—
Fall			
Upper Grande Ronde River	53	4	0.094 (SE= 0.040)
Catherine Creek	934	23	0.077 (0.058–0.110)
Lostine River	827	21	0.085 (0.063–0.125)
Minam River	81	5	0.086 (SE= 0.031)
Spring (FL ≥ 115 mm)			
Upper Grande Ronde River	500	60	0.522 (0.454–0.629)
Catherine Creek	500	31	0.540 (0.421–0.790)
Lostine River	270	22	0.629 (SE= 0.051)
Minam River	437	64	0.665 (0.584–0.809)

Table 15. 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			
		Age-0	Age-1	Age-2	Age-3
Trap Site	*n*	*Age-1 smolt*	*Age-2 smolt*	*Age-3 smolt*	*Age-4 smolt*
Early/Fall Migrants		**PIT tagged fish with known age**			
Upper Grande Ronde River	50	36	36	28	0
Catherine Creek	168	34	44	21	1
Lostine River	147	31	55	14	1
Minam River	48	33	44	19	4
Mean		**32.9**	**47.0**	**18.9**	**1.2**
		PIT tagged fish detected at dams			
Upper Grande Ronde River	5	0	40	60	0
Catherine Creek	13	15	46	38	0
Lostine River	13	0	85	15	0
Minam River	7	0	71	29	0
Mean		**5.3**	**63.1**	**31.6**	**0.0**

Table 16. Family level metric scores for benthic macroinvertebrate kick samples collected from a reach located upstream and downstream of each rotary screw trap on the four study streams during summer and late fall 2006. The upper reach represent conditions in natal rearing areas of juvenile spring Chinook salmon, and the lower reach represents conditions in areas where early migrants overwinter. Stream condition was rated as either not impaired (NI), moderately impaired (MI), or severely impaired (SI).

	Summer 2006				Late fall 2006			
Stream,	Upper Reach		Lower Reach		Upper Reach		Lower Reach	
Metric	Value	Score	Value	Score	Value	Score	Value	Score
Upper Grande Ronde River								
Taxa Richness	23	5	23	5	27	5	24	5
Mayfly Richness	5	5	6	5	6	5	6	5
Stonefly Richness	6	5	3	1	6	5	3	1
Caddisfly Richness	6	5	4	1	7	5	6	5
Chironomidae (%)	16	5	17	5	44	1	20	5
Dominance (%)	46	5	60	3	65	3	64	3
Combined score		**30**		**20**		**24**		**24**
Impairment rating		**NI**		**MI**				
Catherine Creek								
Taxa Richness	24	5	13	1	24	5	25	5
Mayfly Richness	4	3	5	5	6	5	7	5
Stonefly Richness	4	3	0	1	6	5	5	5
Caddisfly Richness	6	5	2	1	5	3	5	3
Chironomidae (%)	10	5	50	1	16	5	11	5
Dominance (%)	46	5	87	1	60	3	52	5
Combined score		**26**		**10**		**26**		**28**
Impairment rating		**NI**		**SI**				
Lostine River								
Taxa Richness	17	1	21	3	15	1	—	—
Mayfly Richness	4	3	5	5	3	1	—	—
Stonefly Richness	3	1	3	1	3	1	—	—
Caddisfly Richness	3	1	5	3	5	3	—	—
Chironomidae (%)	29	3	21	5	2	5	—	—
Dominance (%)	61	3	65	3	68	3	—	—
Combined score		**12**		**20**		**14**		—
Impairment rating		**SI**		**MI**				
Minam River								
Taxa Richness	25	5	18	3				
Mayfly Richness	6	5	5	5				
Stonefly Richness	4	3	2	1				
Caddisfly Richness	6	5	6	5				
Chironomidae (%)	9	5	12	5				
Dominance (%)	41	5	55	5				
Combined score		**28**		**24**				
Impairment rating		**NI**		**NI**				

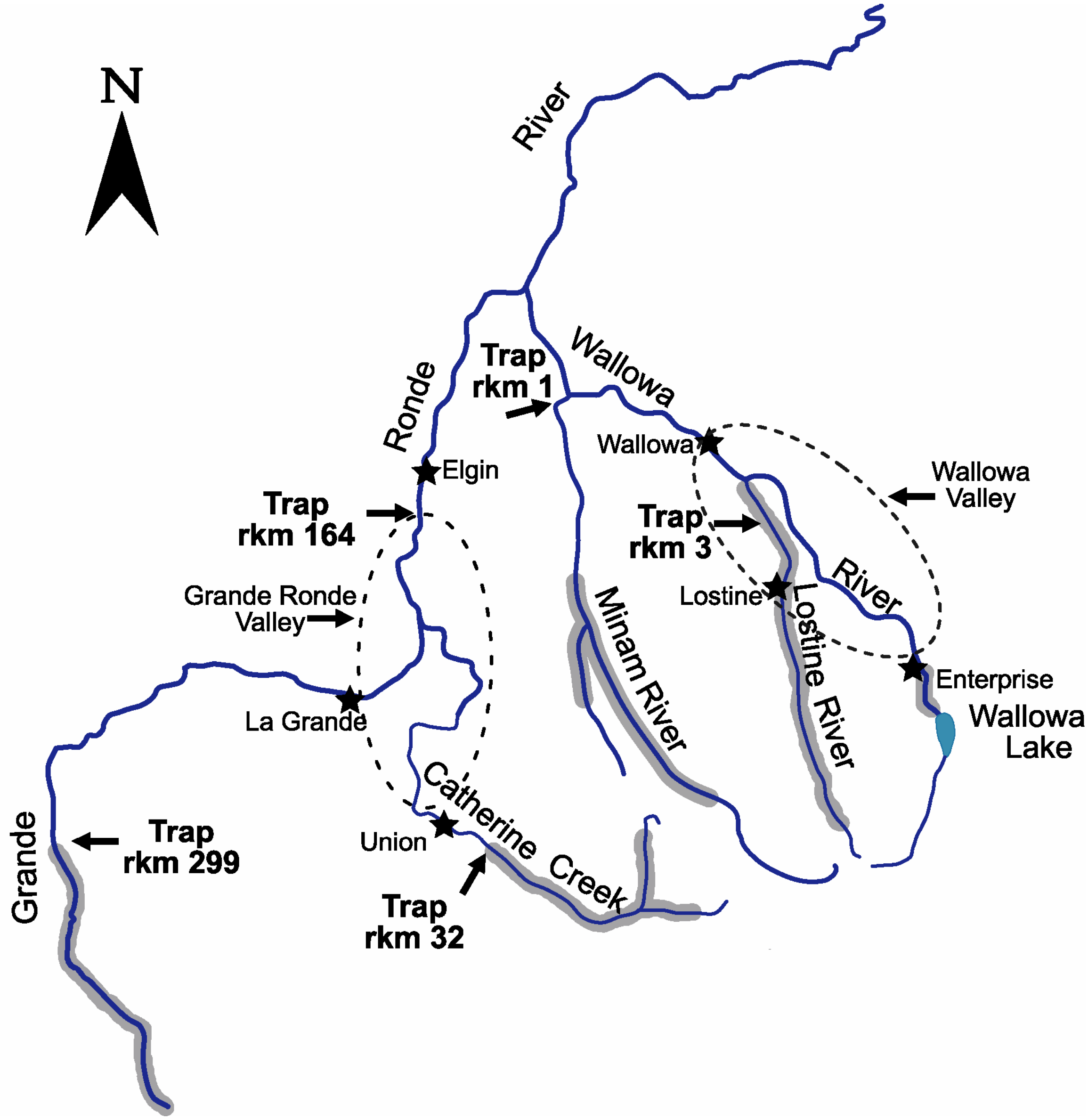

Figure 1. Locations of fish traps in the Grande Ronde River Subbasin during the study period. Shaded areas delineate spring Chinook salmon spawning and upper rearing areas in each study stream. Dashed lines indicate the Grande Ronde River and Wallowa River valleys.

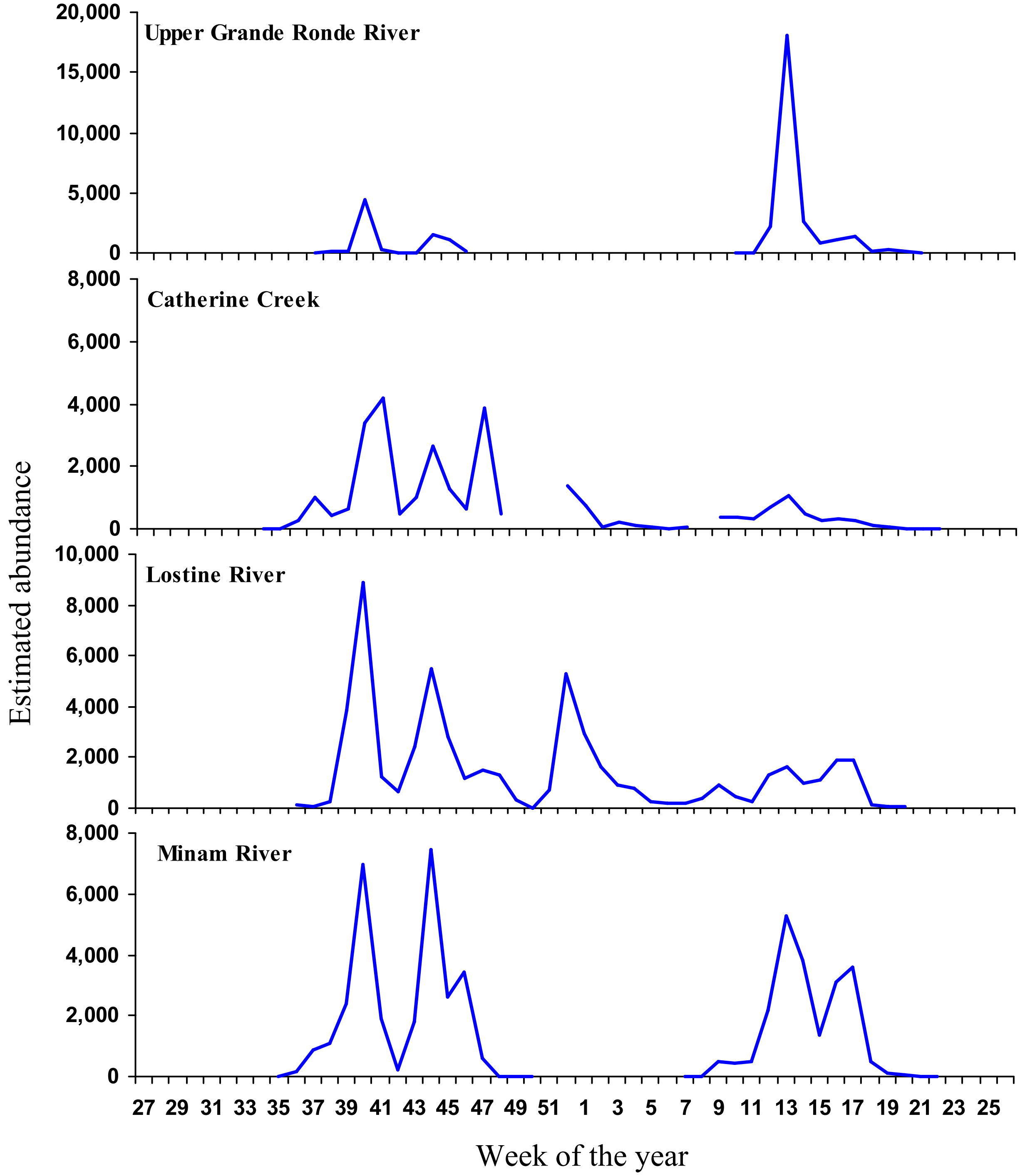

Figure 2. Estimated migration timing and abundance of juvenile spring Chinook salmon migrants captured by rotary screw traps during MY 2006. Traps were located at rkm 299 of the Grande Ronde River, rkm 32 of Catherine Creek, rkm 3 of the Lostine River, and rkm 0 of the Minam River.

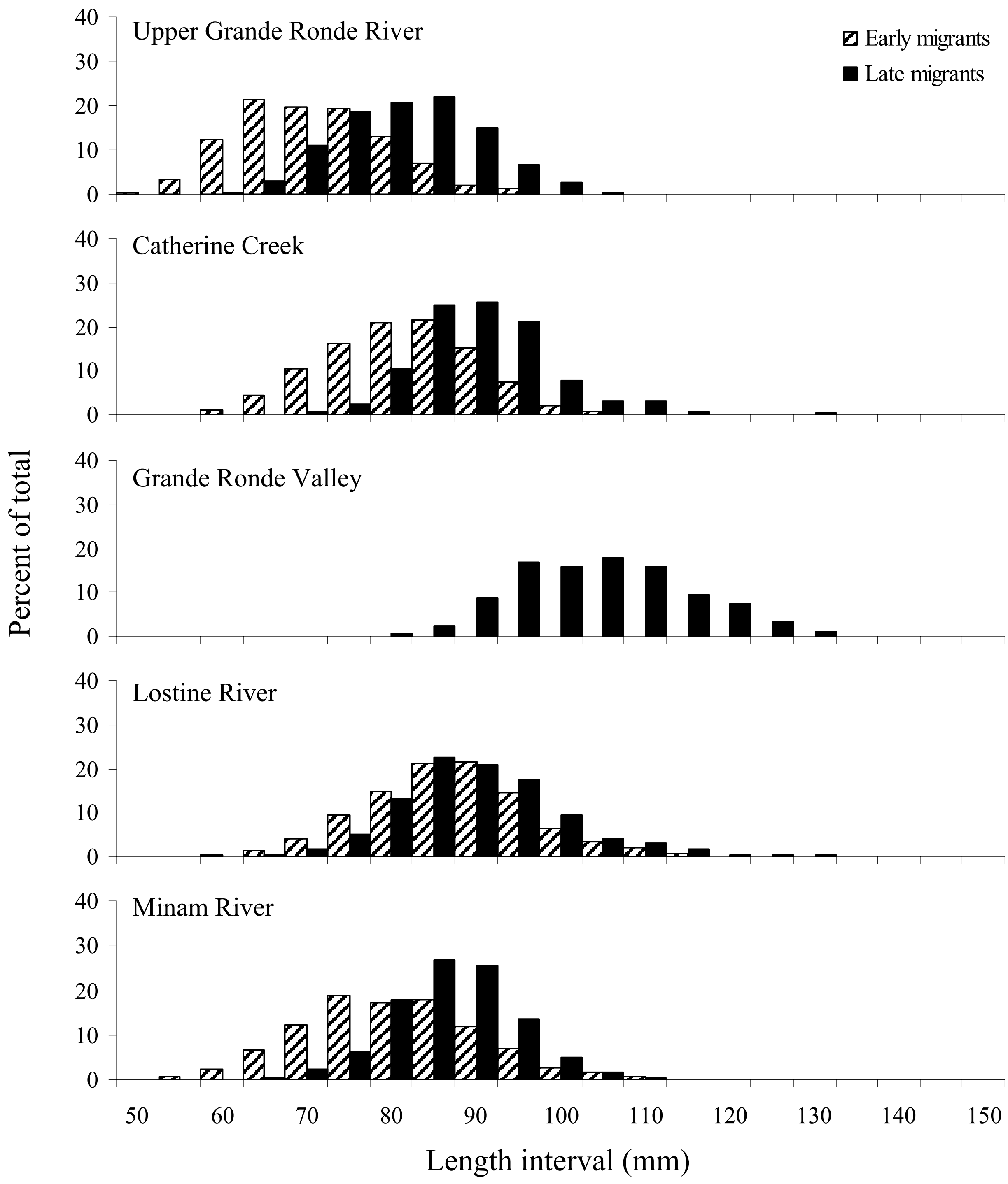

Figure 3. Length frequency distribution (fork length) of early and late migrating juvenile spring Chinook salmon captured at the upper Grande Ronde River (rkm 299), Catherine Creek (rkm 32), Grande Ronde Valley (rkm 164), Lostine River (rkm 3), and Minam River (rkm 0) traps during the 2006 migratory year. The Grande Ronde Valley trap was operated only during the late migrant period.

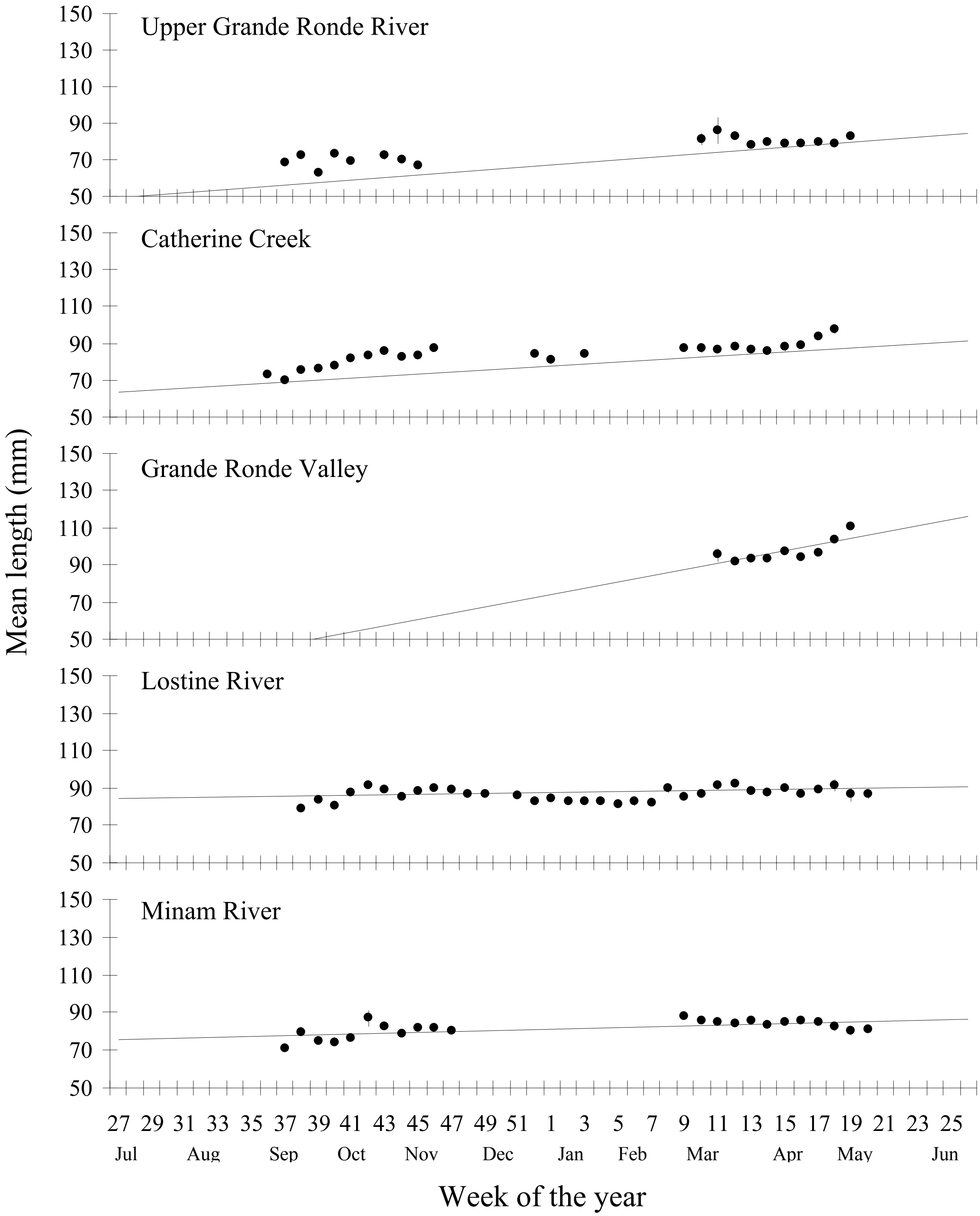

Figure 4. Weekly mean fork lengths (mm) with standard error for spring Chinook salmon captured in rotary screw traps in the Grande Ronde River Subbasin during MY 2006.

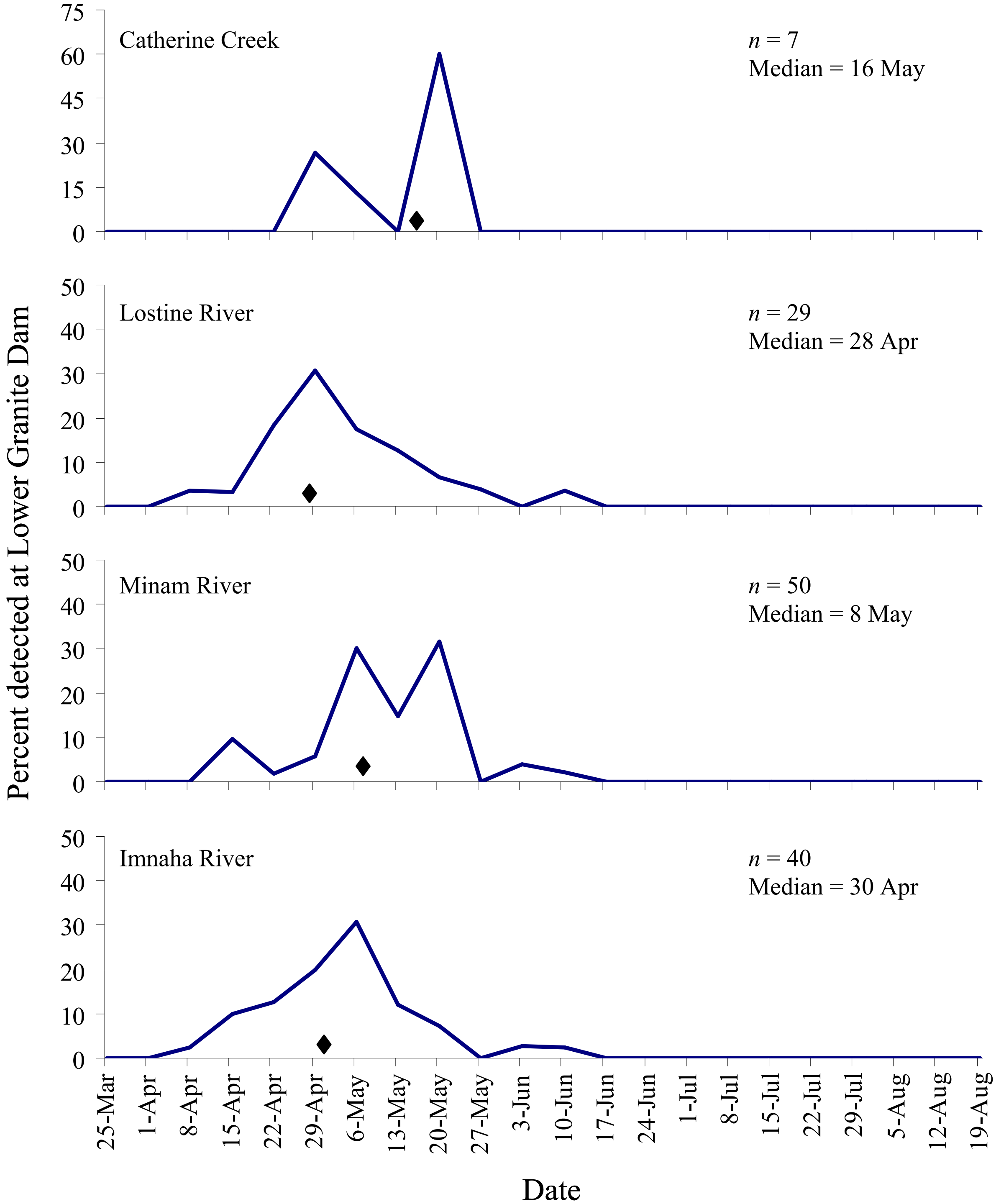

Figure 5. Dates of arrival in 2006 at Lower Granite Dam of spring Chinook salmon PIT-tagged as parr on Catherine Creek and the Imnaha, Lostine, and Minam rivers during the summer of 2005 summarized by week and expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

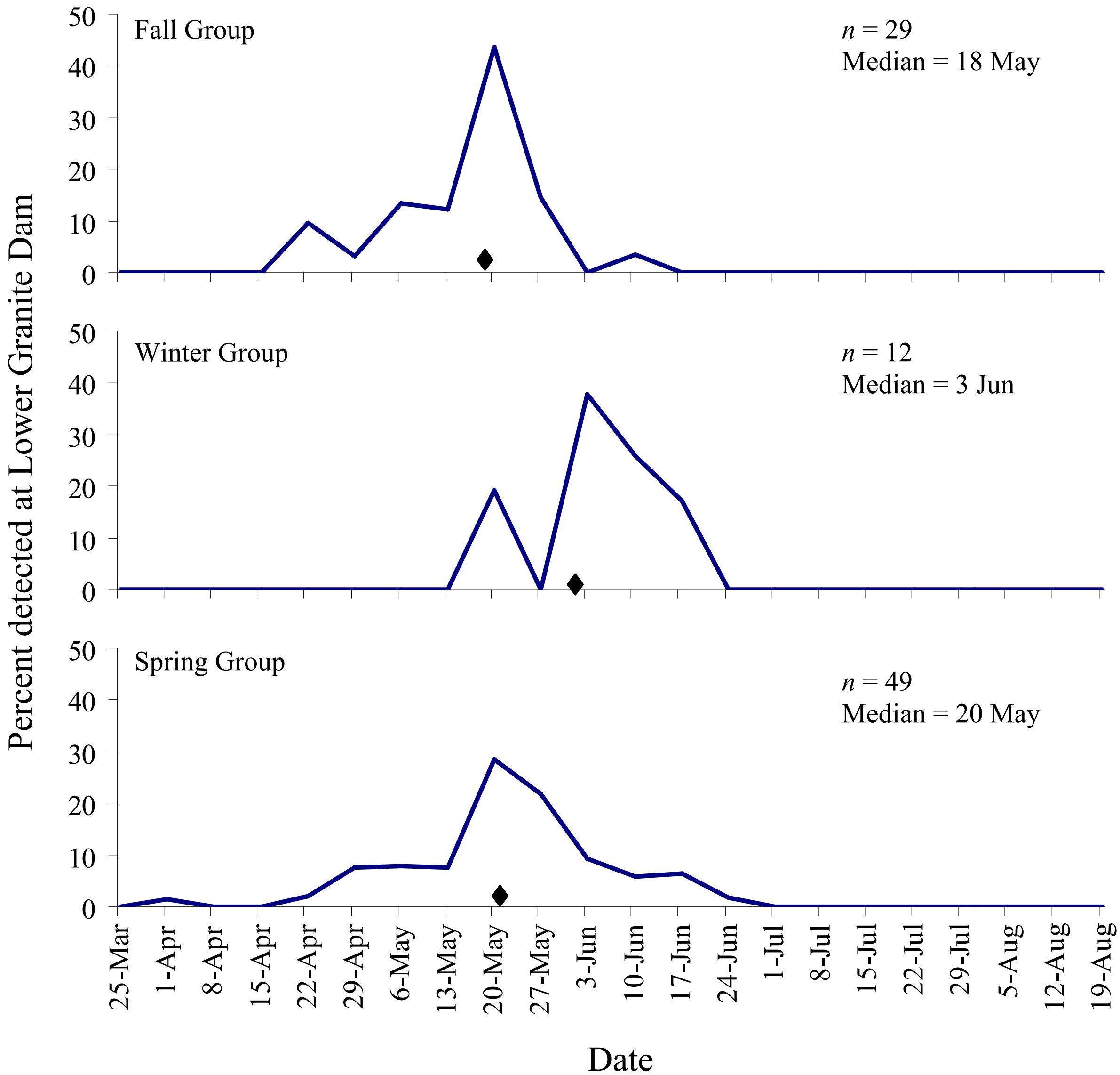

Figure 6. Dates of arrival in 2006 at Lower Granite Dam for the fall, winter, and spring tag groups of juvenile spring Chinook salmon PIT-tagged on the upper Grande Ronde River, expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

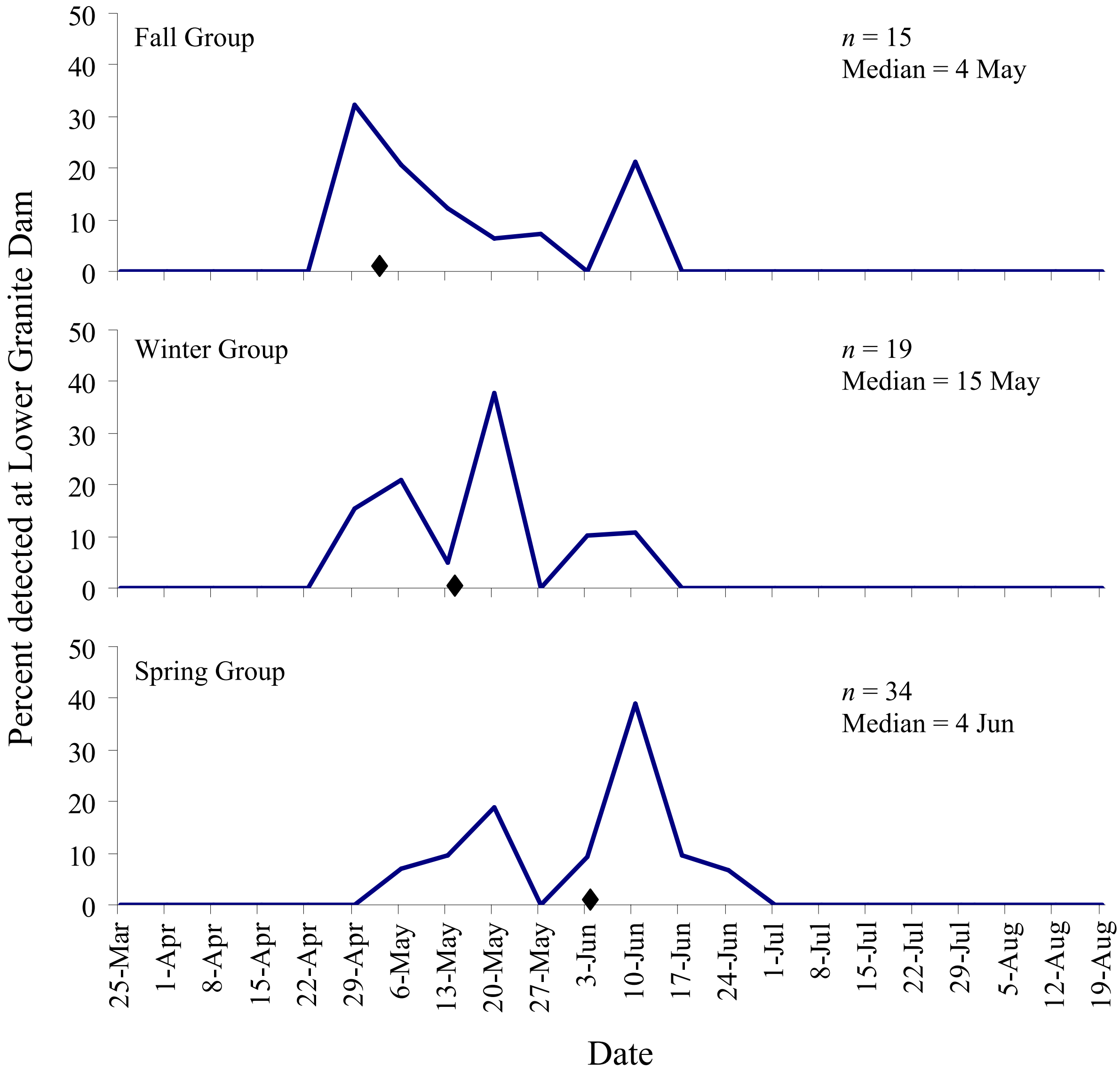

Figure 7. Dates of arrival in 2006 at Lower Granite Dam for the fall, winter, and spring tag groups of juvenile spring Chinook salmon PIT-tagged on Catherine Creek, expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

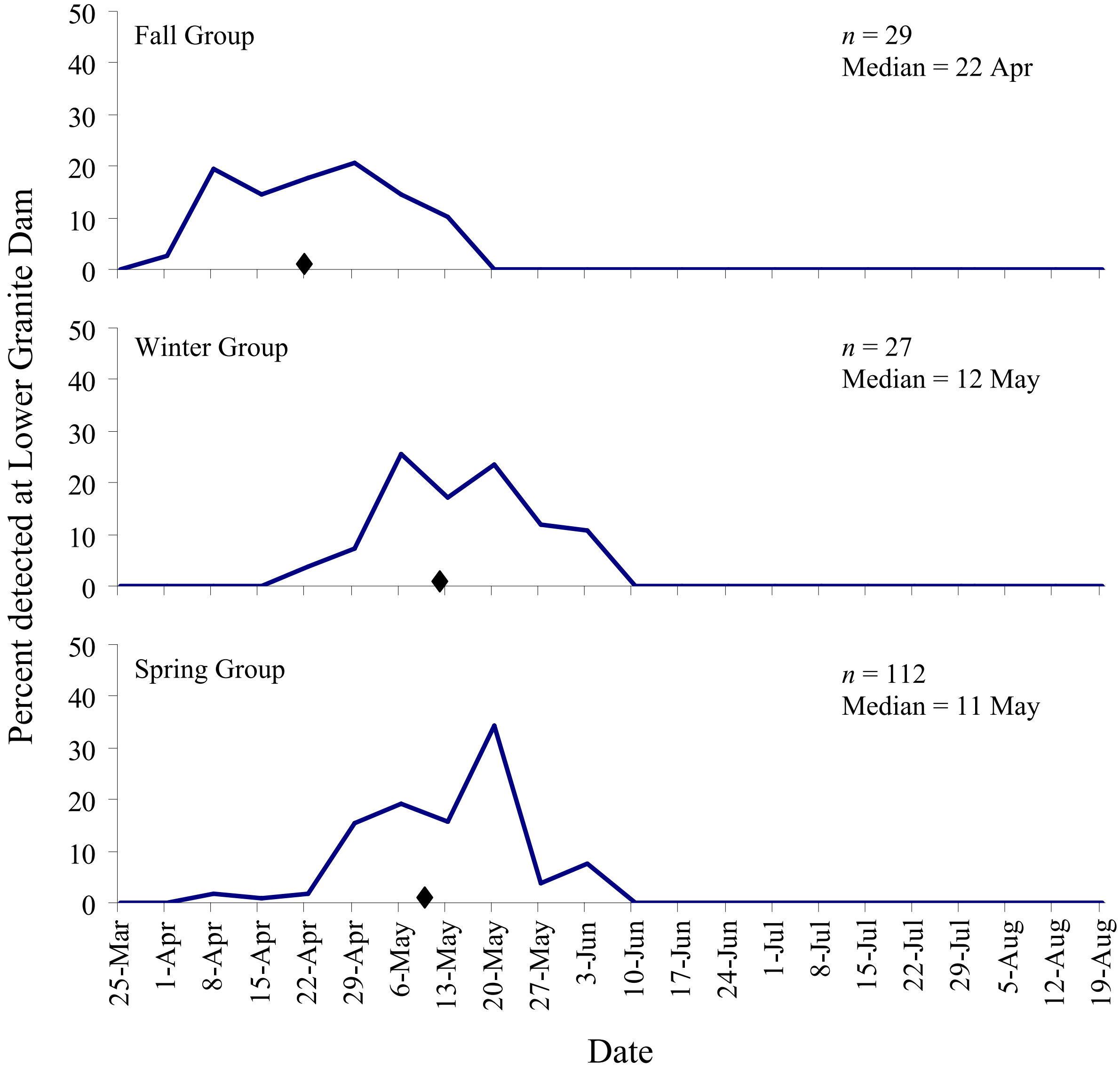

Figure 8. Dates of arrival in 2006 at Lower Granite Dam for the fall, winter, and spring tag groups of juvenile spring Chinook salmon PIT-tagged on the Lostine River, expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

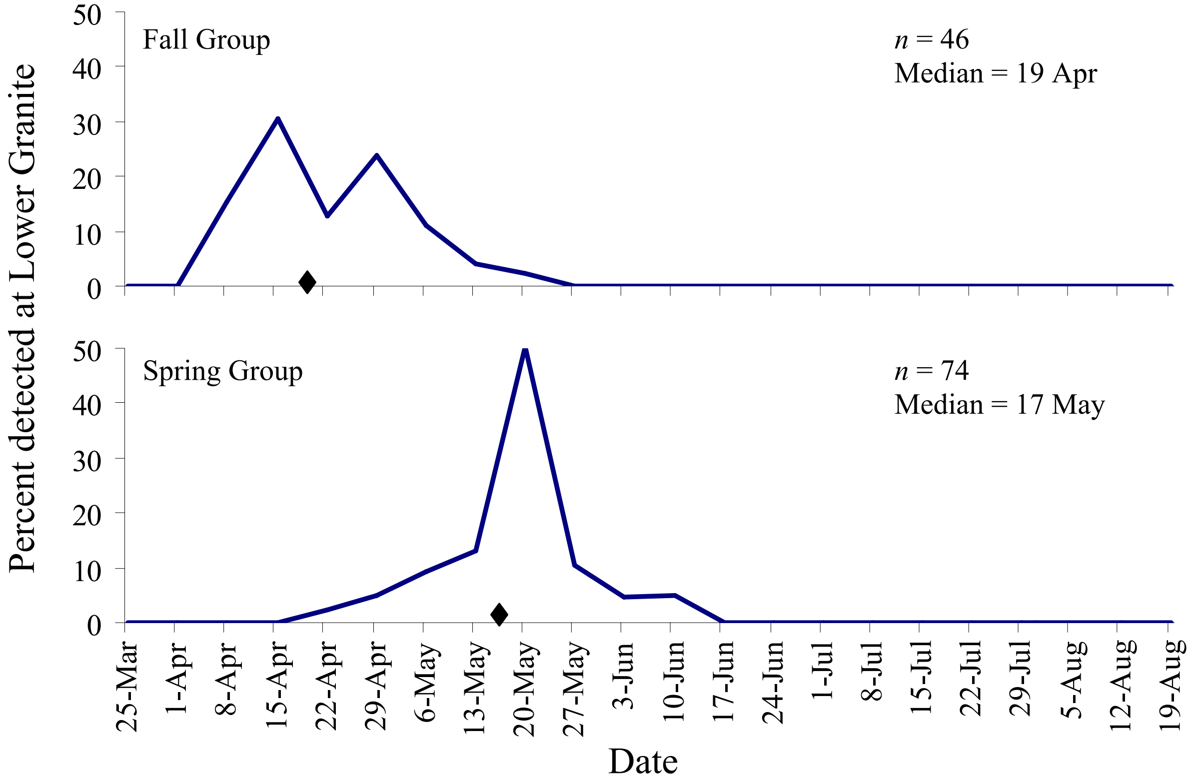

Figure 9. Dates of arrival in 2006 at Lower Granite Dam for the fall and spring tag groups of juvenile spring Chinook salmon PIT-tagged on the Minam River, expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

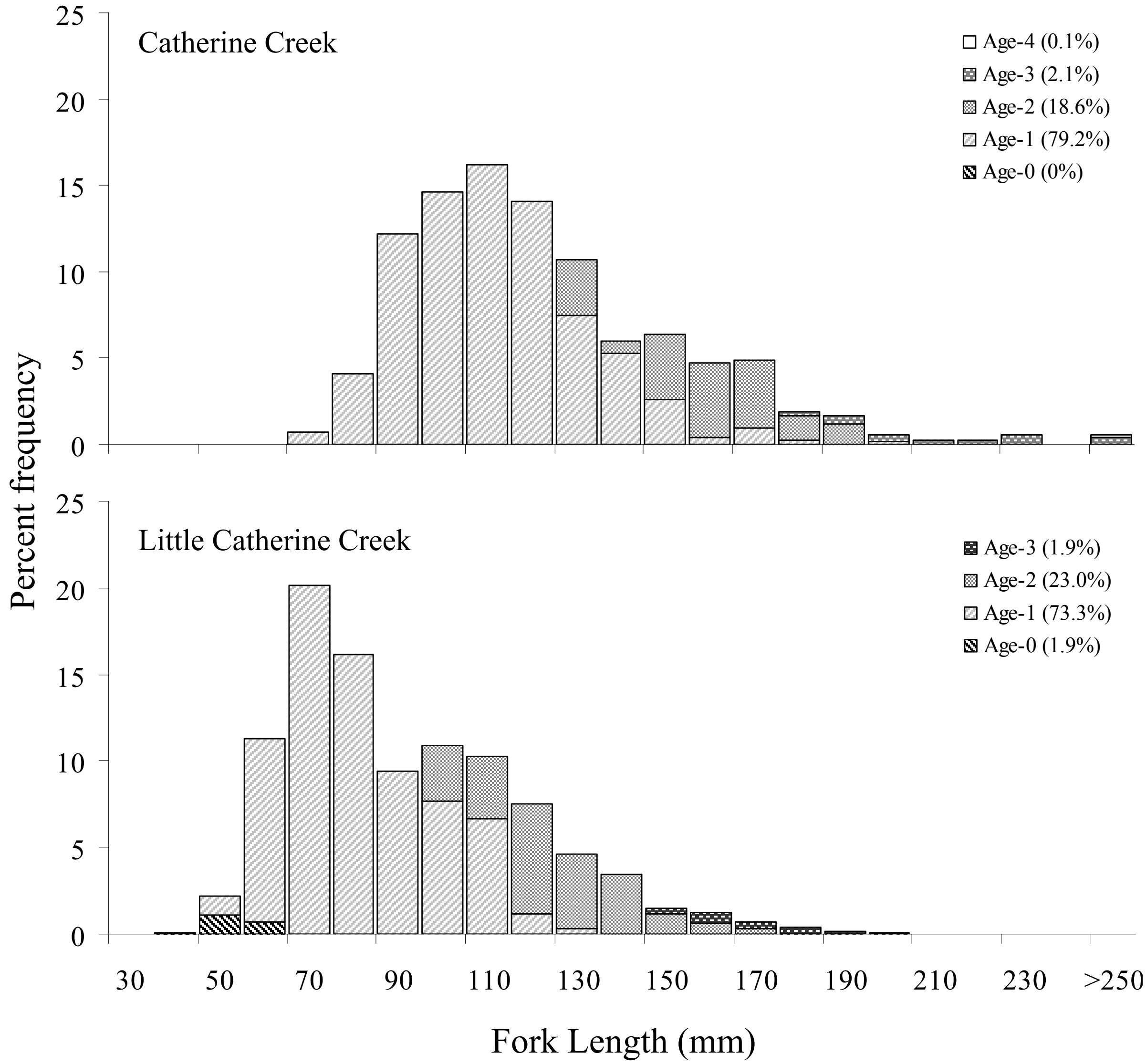

Figure 10. Fork lengths of steelhead in Catherine Creek and Little Catherine Creek measured during the summer of 2006. Percentage by age information was calculated and distributed across each length category using an age–length key.

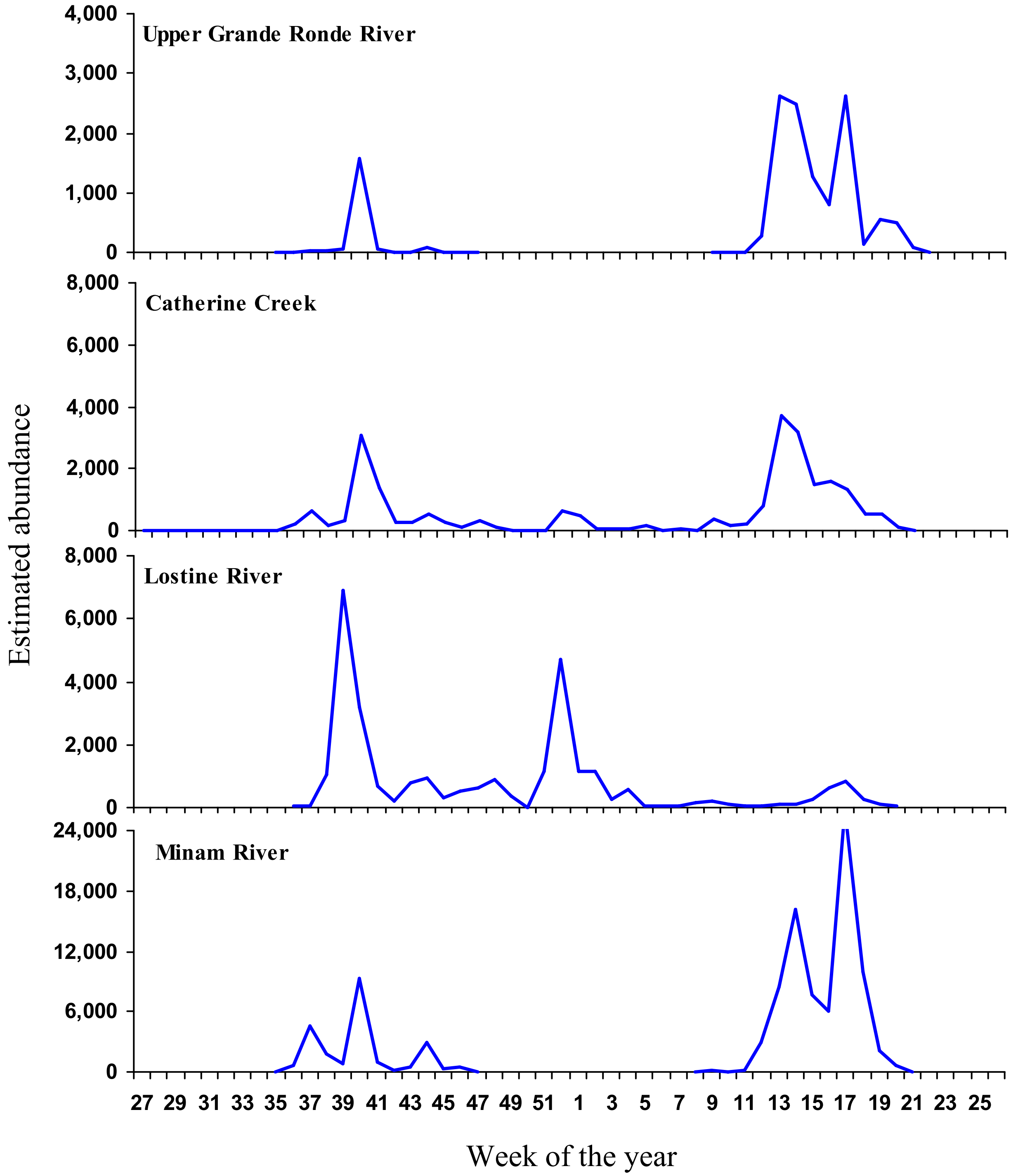

Figure 11. Estimated abundance and migration timing of steelhead migrants captured by rotary screw traps, during MY 2006. Traps were located at rkm 299 of the Grande Ronde River, rkm 32 of Catherine Creek, rkm 3 of the Lostine River, and rkm 0 of the Minam River.

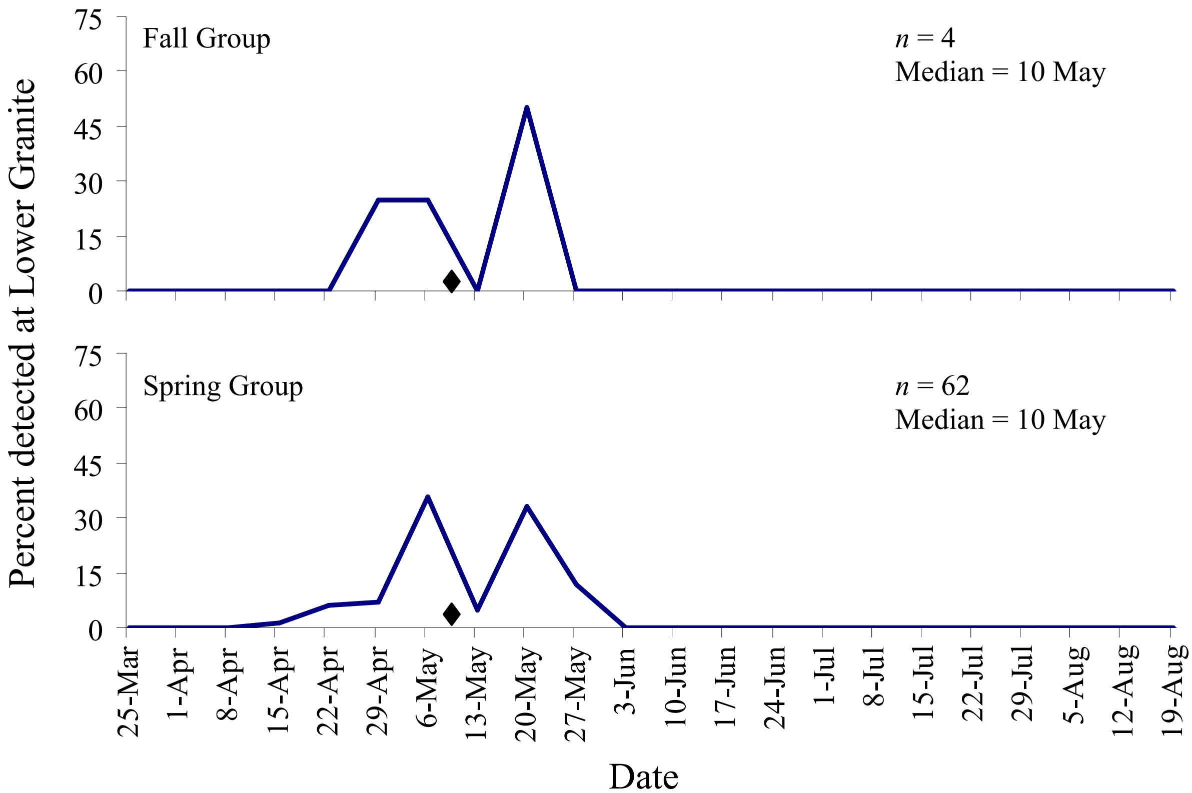

Figure 12. Dates of arrival in 2006 at Lower Granite Dam for the fall and spring tag groups of steelhead PIT-tagged on the upper Grande Ronde River, expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

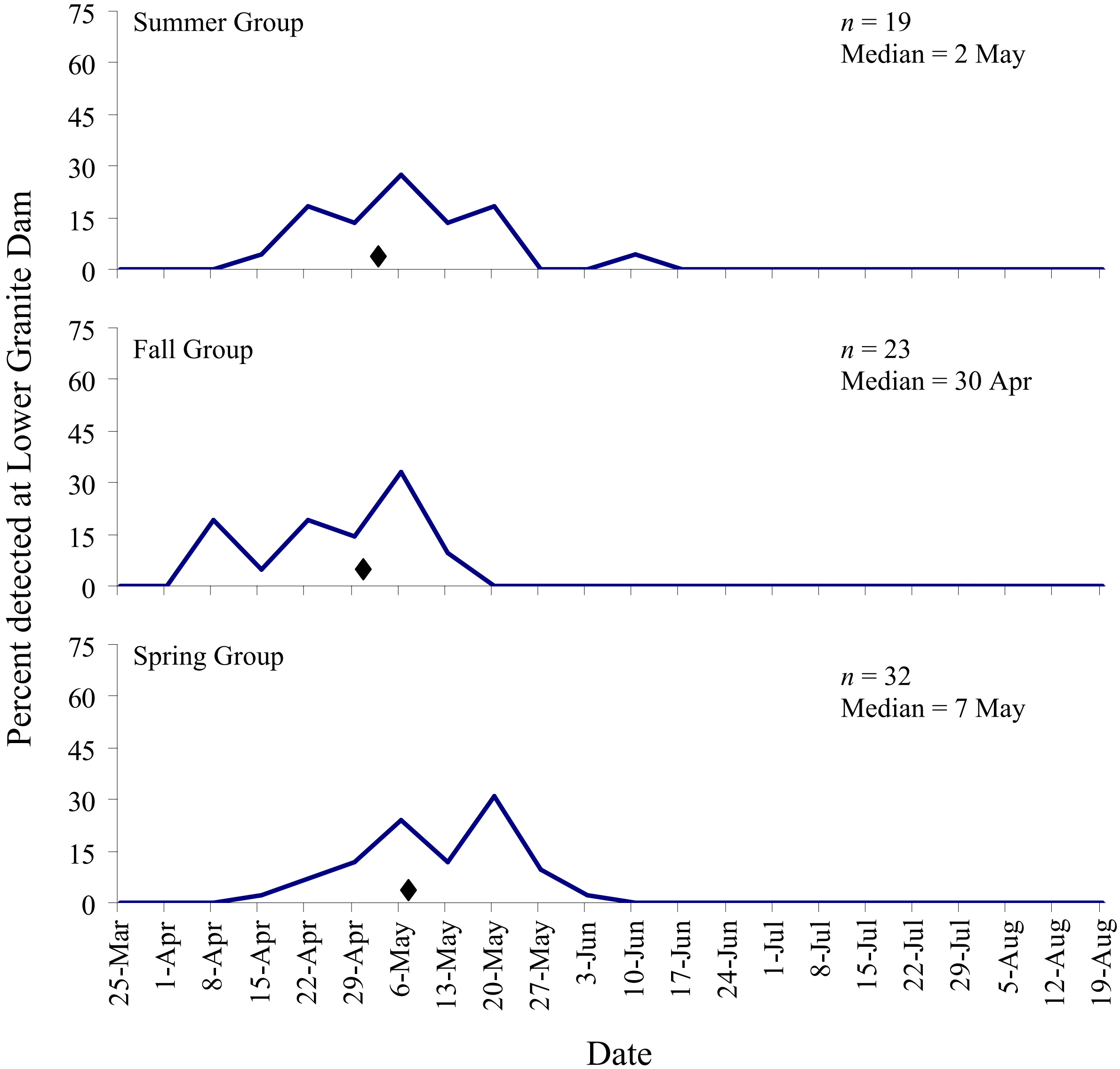

Figure 13. Dates of arrival in 2006 at Lower Granite Dam for the summer, fall, and spring tag groups of steelhead PIT-tagged on Catherine Creek, expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

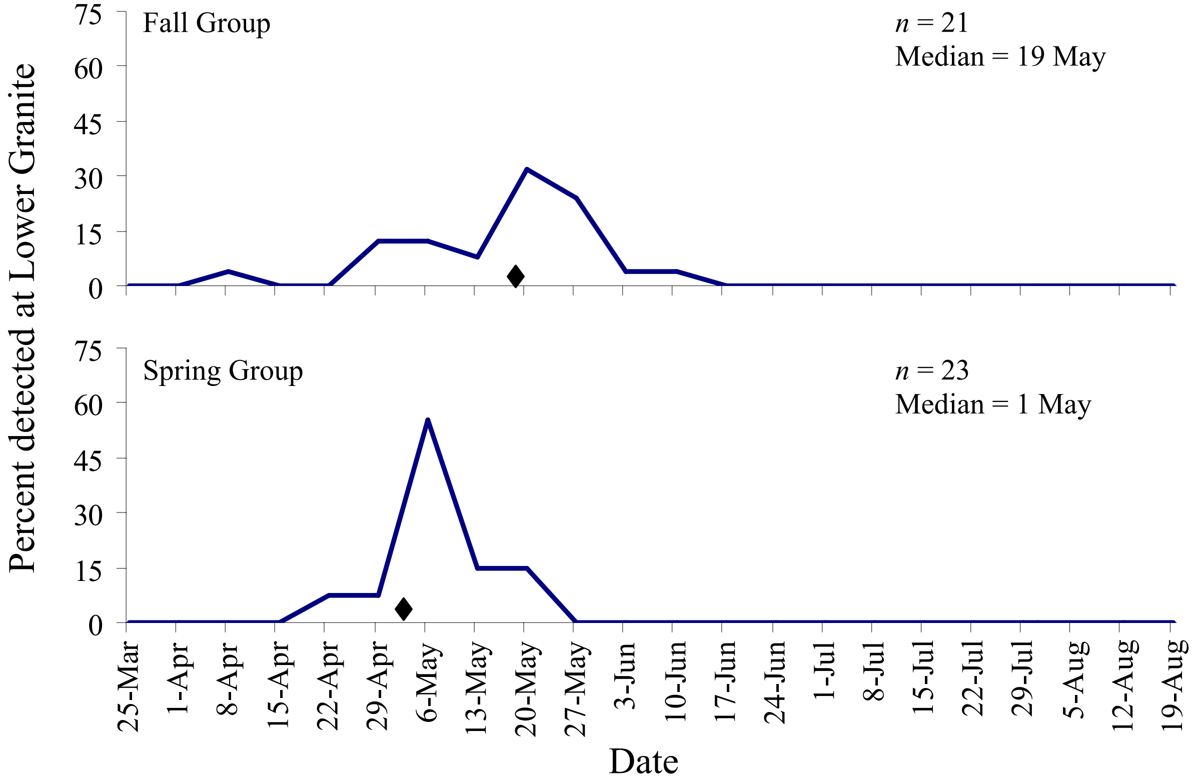

Figure 14. Dates of arrival in 2006 at Lower Granite Dam for the fall and spring tag groups of steelhead PIT-tagged on the Lostine River, expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

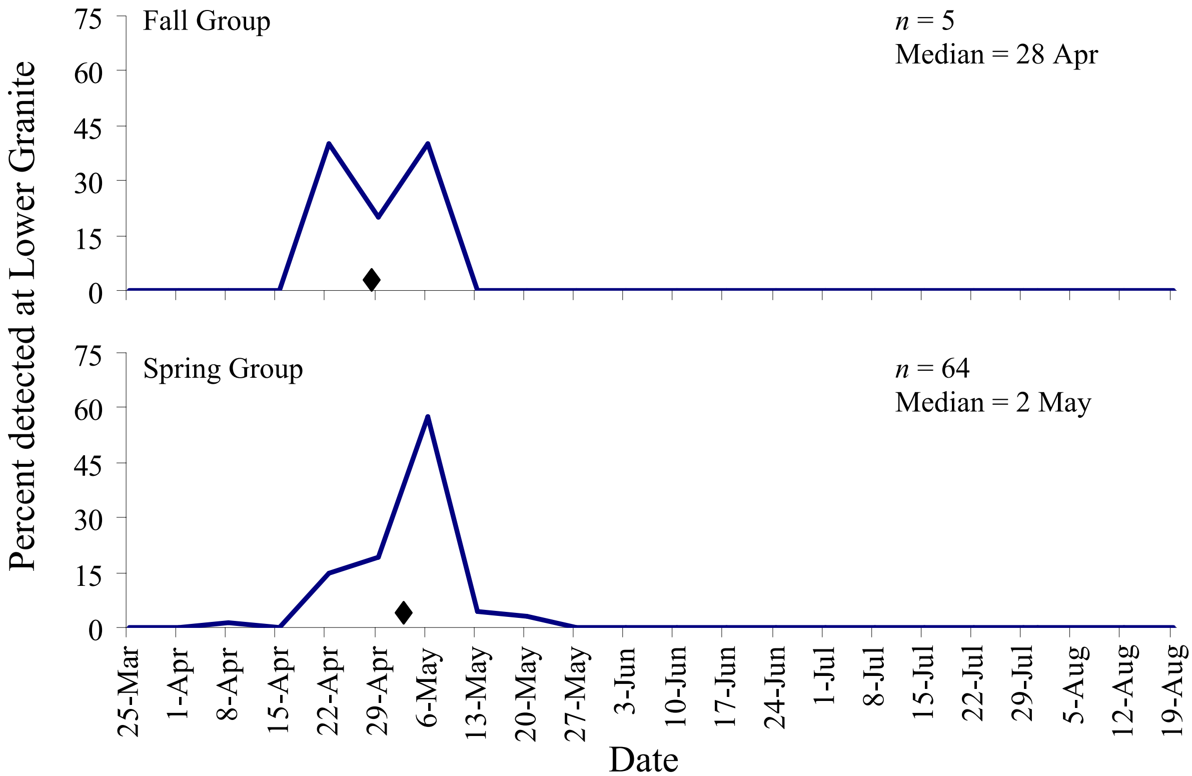

Figure 15. Dates of arrival in 2006 at Lower Granite Dam for the fall and spring tag groups of steelhead PIT-tagged on the Minam River, expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

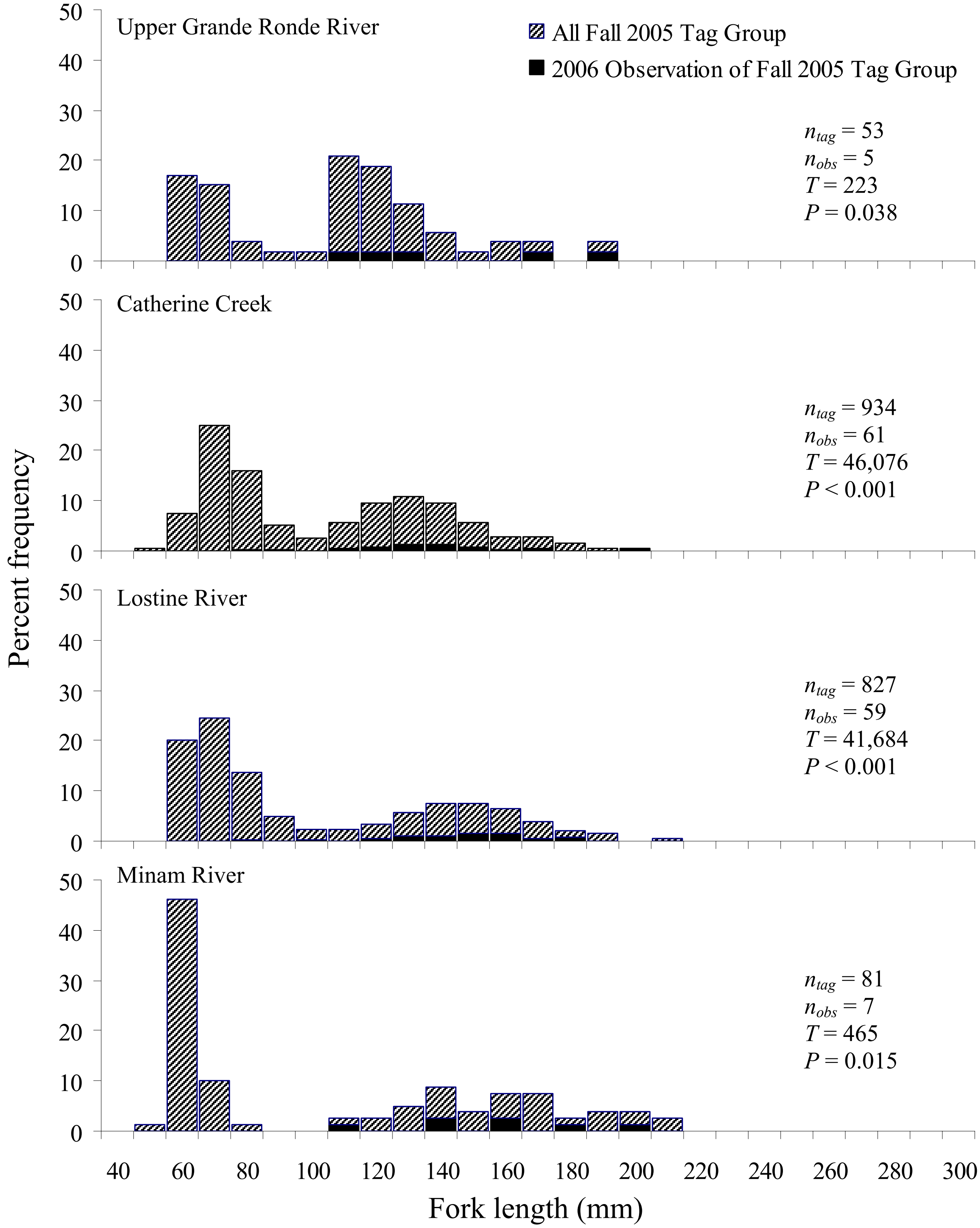

Figure 16. Length frequency distributions for all steelhead PIT-tagged at screw traps in the fall of 2005 and those subsequently observed at Snake River or Columbia River dams in 2006. Fork lengths are based on measurements taken at the time of tagging. Frequency is expressed as the percent of the total number tagged (n_{tag}). 'n_{obs}' is the number detected.

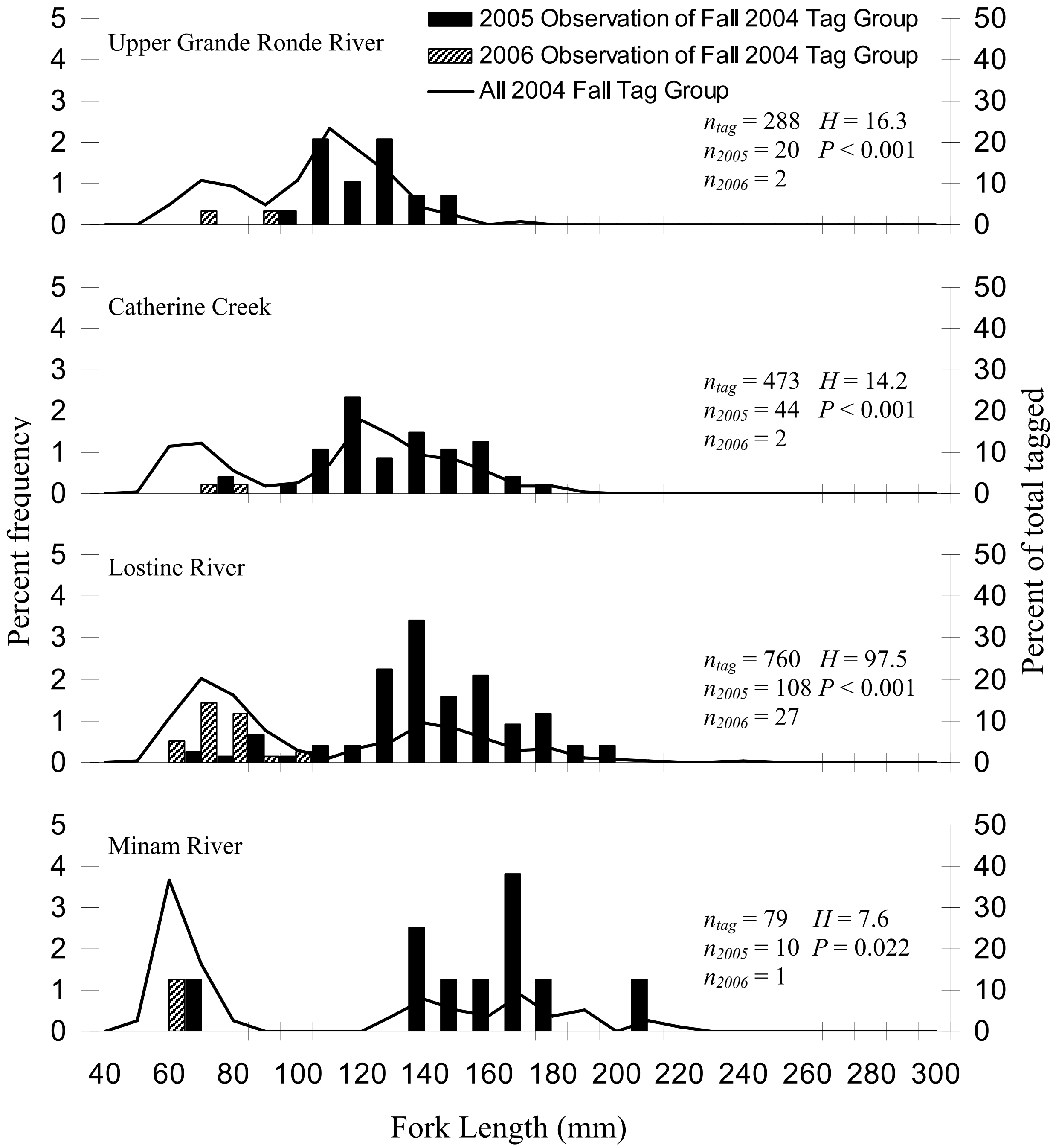

Figure 17. Length frequency distributions for all steelhead PIT-tagged at screw traps in the fall of 2004, and those subsequently observed at Snake River or Columbia River dams in 2005 and 2006. Fork lengths are based on measurements taken at the time of tagging. Frequency is expressed as the percent 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).

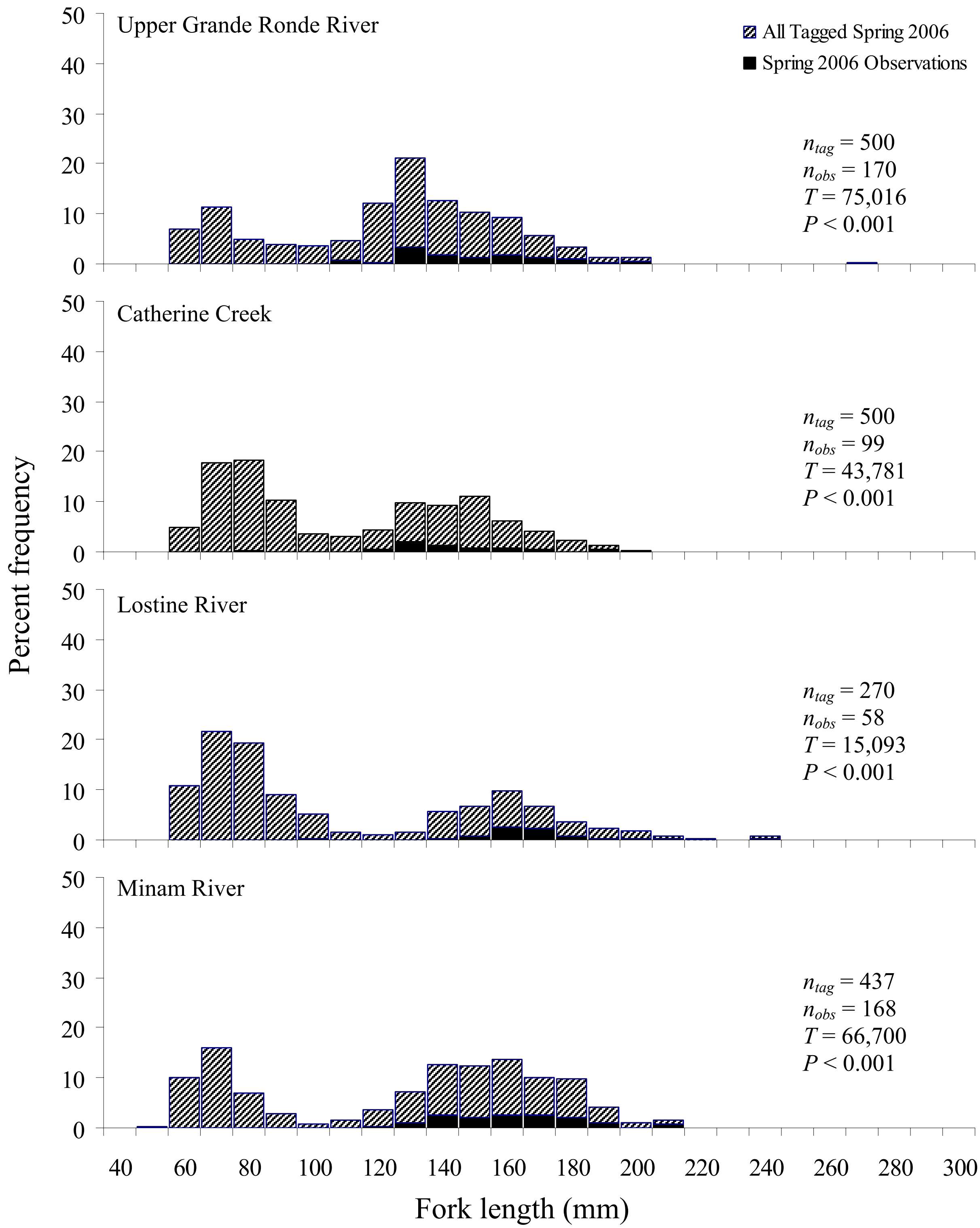

Figure 18. Length frequency distributions for all steelhead PIT-tagged at screw traps in the spring of 2006 and those subsequently observed at Snake River or Columbia River dams in 2006. Fork lengths are based on measurements taken at the time of tagging. Frequency is expressed as the percent of the total number tagged (n_{tag}), and 'n_{obs}' is the number detected.

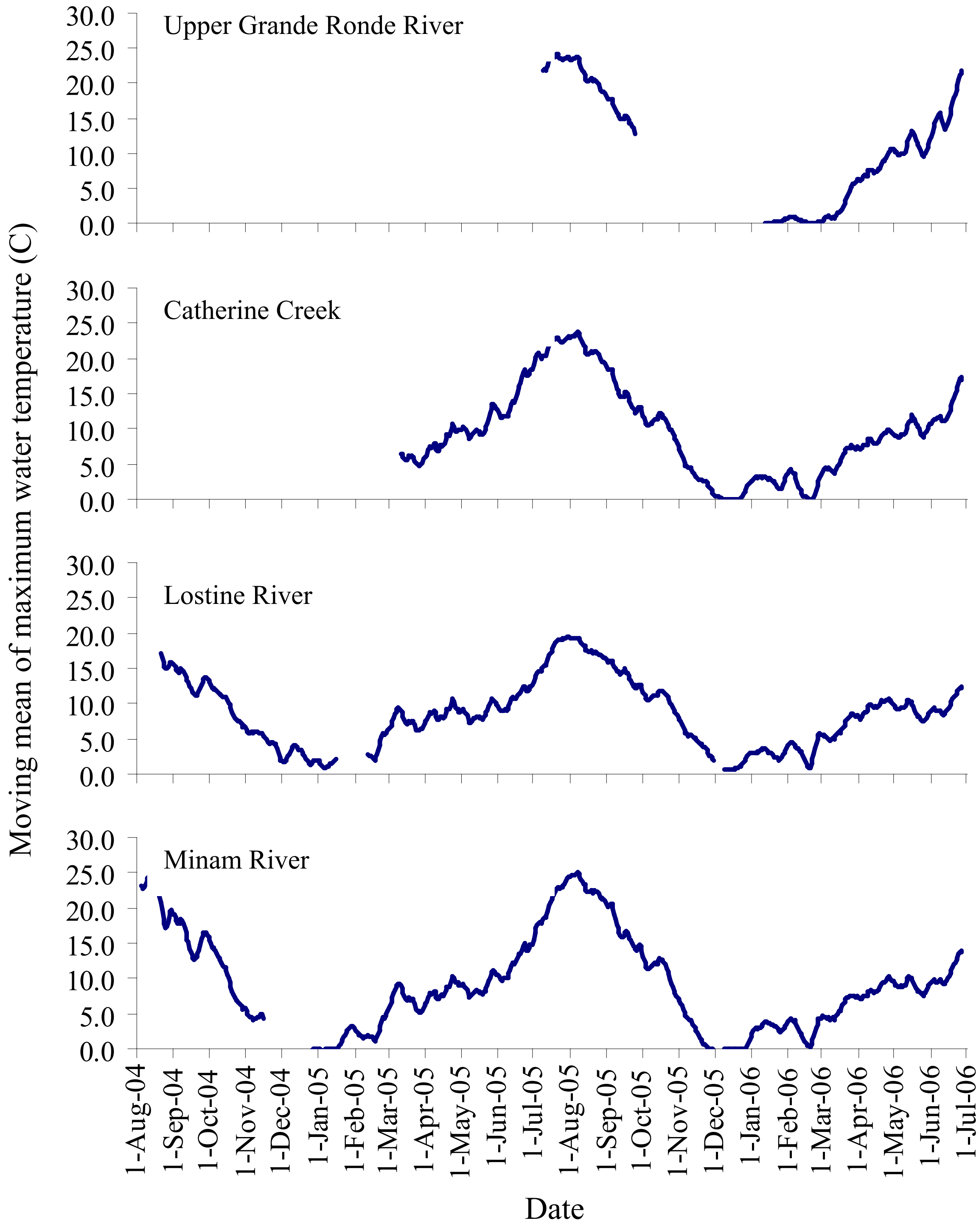

Figure 19. Moving mean of maximum water temperature during the in-basin life stages of egg-to-emigrant for juvenile spring Chinook salmon that migrated from four study streams in the Grande Ronde River basin during migration year 2006. Missing portions of a trend line represent periods where data were not available.

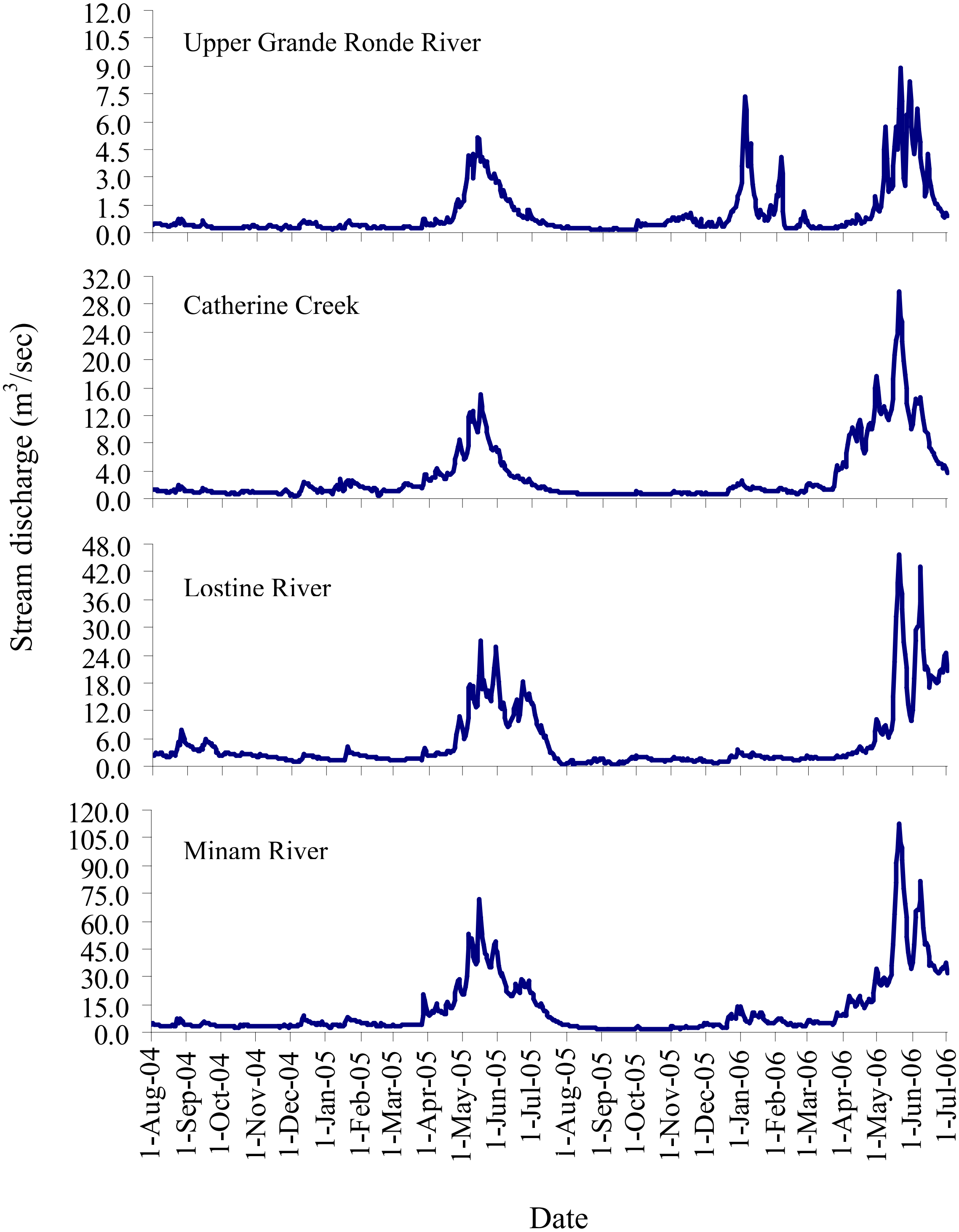

Figure 20. Average daily discharge during the in-basin life stages of egg-to-emigrant for juvenile spring Chinook salmon that migrated from four study streams in the Grande Ronde River basin during migration year 2006.

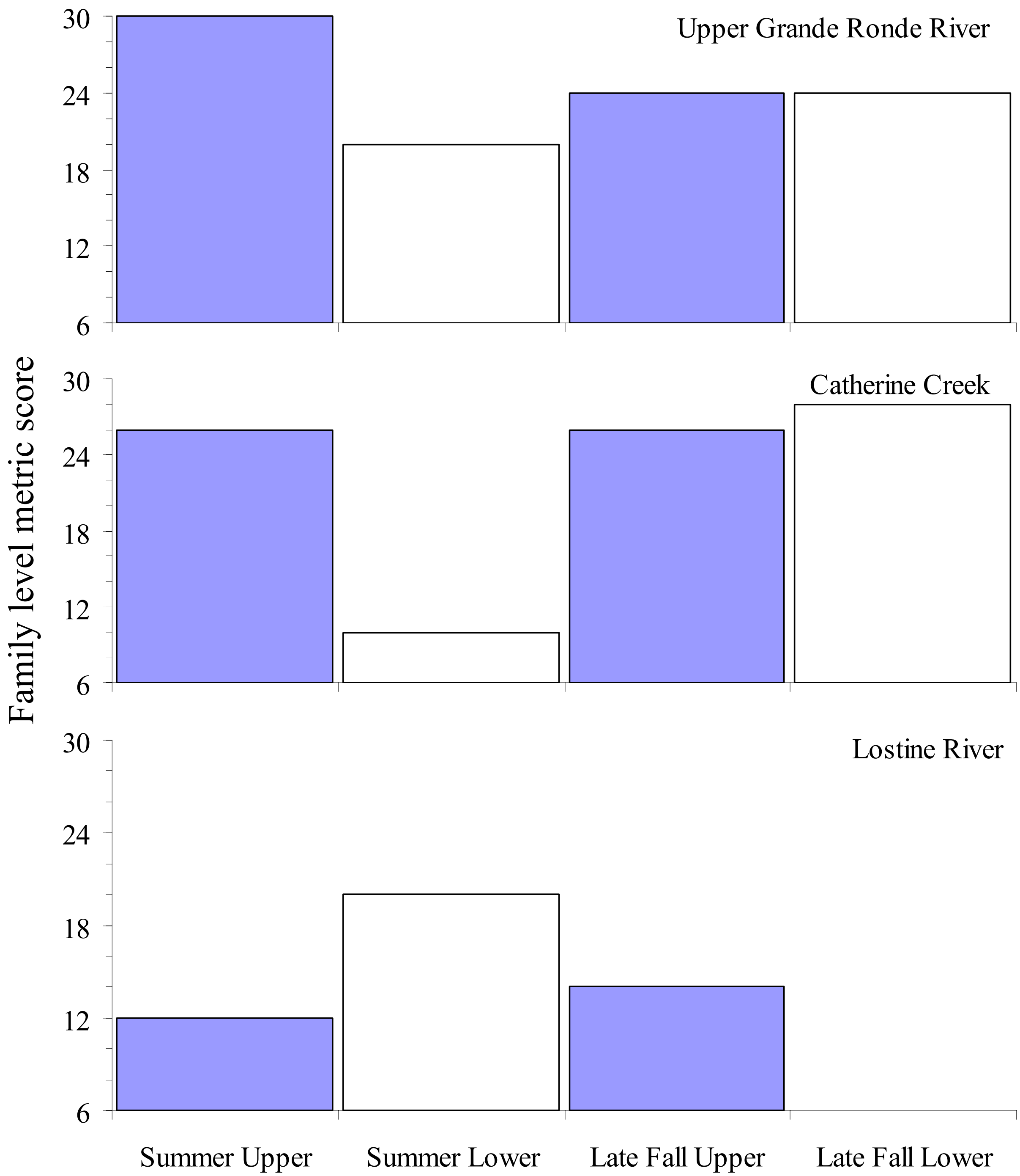

Figure 21. Family level metric scores collected during summer 2006 and late fall 2006 in both upper and lower reaches used by upper Grande Ronde River, Catherine Creek and Lostine River populations. The upper reach represents conditions in natal rearing areas of juvenile spring Chinook salmon, and the lower reach represents conditions in areas where early migrants overwinter. Fish from these populations were not expected to be rearing in lower reaches during summer.

APPENDIX A

A Compilation of Spring Chinook Salmon Data

Appendix Table A-1. Number of scales sampled from immature and mature, wild spring Chinook salmon parr and the percentage of the labeled age-group in summer rearing areas of Catherine Creek, and the Lostine, Minam, and Imnaha rivers, 1998–2006. Ages were determined by analysis of scales collected from a random sub sample of fish caught for PIT tagging, unless otherwise noted.

Stream,	Immature parr		Mature parr	
Year	*n*	Percent Age-0	*n*	Percent Age-1
Catherine Creek				
1998	208	100.0	113	100.0
1999	204	100.0	210	99.5
2000	261	98.9	106	100.0
2001	—	—	103	100.0
2002	1	100.0[a]	52	100.0
2003	—	—	121	100.0
2004	7	71.4[a]	98	100.0
2005	—	—	87	95.4
2006	—	—	28	100.0
Lostine River				
1998	231	100.0	20	100.0
1999	201	100.0	23	100.0
2000	110	100.0	31	100.0
2001	—	—	4	75.0
2002	15	100.0[a]	2	100.0
2003	9	88.9[a]	32	100.0
2004	34	67.6[a]	54	94.4
2005	101	11.9[a]	22	100.0
2006	46	84.8	12	91.7
Minam River				
1998	—	—	1	100.0
1999	—	—	—	—
2000	70	100.0	—	—
2001	212	100.0	4	100.0
2002	4	100.0[a]	5	100.0
2003	3	100.0[a]	—	—
2004	6	0.0[a]	1	100.0
2005	—	—	11	100.0
2006	9	88.9	8	100.0

[a] Scales were only taken from the larger immature parr captured (2002 fork length ≥ 85 mm; 2003–2005 fork length ≥ 90 mm).

Appendix Table A-1. Continued.

Stream, Year	Immature Parr		Mature Parr	
	n	Percent Age-0	*n*	Percent Age-1
Imnaha River				
1998	—	—	3	100.0
1999	—	—	—	—
2000	—	—	—	—
2001	67	100.0	—	—
2002	3	100.0[a]	—	—
2003	6	100.0[a]	—	—
2004	—	—	1	100.0
2005	11	36.4[a]	1	100.0
2006	4	75.0[a]	3	100.0

Appendix Table A-2. Census data used to estimate the number of spring Chinook salmon parr by maturity and origin in Catherine Creek and the Lostine River during summer, 1998–2006.

Stream, parr maturity, origin	Year	Census data: Marked	Recaptured	Captured	Population estimate (95% CI)
Catherine Creek					
Immature, wild	1998	1,050	49	628	13,222 (10,047–17,819)
	1999	1,003	52	1,187	22,505 (17,239–29,341)
	2000	1,262	47	987	25,997 (19,651–35,151)
	2001	1,325	121	1,382	15,032 (12,598–17,931)
	2002	1,315	120	3,432	37,337 (31,270–44,572)
	2003	1,203	44	4,272	114,326 (85,745–155,900)
	2004	2,264	112	4,167	83,544 (69,541–100,340)
	2005	2,875	314	3,718	33,955 (30,411–37,911)
	2006	1,253	58	1,380	29,352 (22,794–37,758)
Mature, wild	1998	73	9	57	429 (237–858)
	1999	117	21	136	735 (490–1,155)
	2000	123	14	87	727 (445–1,254)
	2001	111	9	87	986 (545–1,971)
	2002	57	10	56	301 (170–580)
	2003	152	10	81	1,141 (647–2,201)
	2004	135	10	62	779 (442–1,503)
	2005	90	18	125	603 (390–980)
	2006	27	0	18	(a)
Mature, hatchery	2000	18	5	11	38 (18–88)
	2002	28	4	14	87 (39–218)
	2004	15	1	6	(a)
	2005	5	0	11	(a)
	2006	3	0	0	(a)

[a] Census data was inadequate to calculate an unbiased population estimate.

Appendix Table A-2. Continued.

Stream, parr maturity, origin	Year	Census data			Population estimate (95% CI)
		Marked	Recaptured	Captured	
Lostine River					
Immature, wild	1998	1,010	22	926	40,748 (27,403–63,324)
	1999	1,000	17	504	28,084 (17,926–46,377)
	2000	974	89	1,141	12,372 (10,075–15,185)
	2001	1,074	62	1,938	33,086 (25,901–42,226)
	2002	1,227	51	1,744	41,209 (31,488–53,859)
	2003	1,043	31	3,037	99,115 (70,482–144,167)
	2004	2,618	137	3,564	67,658 (57,300–79,873)
	2005	3,078	95	3,704	118,830 (97,398–144,922)
	2006	2,335	125	5,603	103,896 (87,319–123,594)
Mature, wild	1998	14	1	9	(a)
	1999	10	0	15	(a)
	2000	35	3	32	297 (121–743)
	2001	5	0	1	(a)
	2002	2	0	2	(a)
	2003	31	2	10	(a)
	2004	60	10	98	549 (311–1,1059)
	2005	60	6	51	453 (225–991)
	2006	25	0	43	(a)

Appendix Table A-3. Redd counts with estimated numbers of spring Chinook salmon parr in summer by age and maturity, the number of parr produced per redd, and the percentage of parr from each BY that matured in Catherine Creek and the Lostine River for BY 1996–2005. Age was based on ratios determined from scale analysis while maturity was based on external characteristics. The number of age-0 parr represents population estimates calculated one year after BY date, and the number of age-1 parr represents estimates calculated two years after BY date.

		Age-0 parr			Age-1 parr			
Stream, BY	Redds[a]	Immature	Mature	Parr produced /redd	Immature	Mature	Parr produced /redd	Percentage of parr that matured
Catherine Creek								
1996	15	—	—	—	0	429	29	—
1997	45	13,222	0	294	0	731	16	5.5
1998	34	22,505	4	662	299	703	29	3.1
1999	38	25,698	0	676	0	986	26	3.8
2000	26	15,032	0	578	0	301	12	2.0
2001	131	37,337	0	285	0	1,141	9	3.1
2002	156	114,326	0	733	2,399	779	20	0.7
2003	165	81,145	0	492	0	575	3	0.7
2004	94	33,955	28	362	0	(b)	(b)	<0.1
2005	72	29,352	(b)	408	—	—	—	(b)
Lostine River								
1996	27	—	—	—	0	(b)	(b)	—
1997	47	40,748	(b)	867	0	(b)	(b)	(b)
1998	28	28,084	(b)	1,003	0	297	11	1.1
1999	45	12,372	0	275	0	(b)	(b)	(b)
2000	53	33,086	(b)	624	0	(b)	(b)	(b)
2001	98	41,209	(b)	420	577	(b)	6[b]	(b)
2002	182	98,538	(b)	541	895	518	8	0.5
2003	127	66,763	31	526	7,737	453	64	0.7
2004	144	111,093	0	771	15,792	(b)	110[b]	(b)
2005	125	88,104	(b)	705	—	—	—	—

[a] Redd information from unpublished ODFW spawning ground survey data.
[b] Census data was inadequate to calculate an unbiased population estimate.

Appendix Table A-4. Redd counts and estimated number of mature spring Chinook salmon parr with the number of mature parr per redd counted during the same year in Catherine Creek and the Lostine River, 1998–2006.

Stream, Year	Redds[a]	Mature parr	Mature parr /redd
Catherine Creek			
1998	34	429	12.6
1999	38	735	19.3
2000	26	703	27.0
2001	131	986	7.5
2002	156	301	1.9
2003	165	1,141	6.9
2004	94	779	8.3
2005	72	603	8.4
2006	115	(b)	(b)
Lostine River			
1998	28	(b)	(b)
1999	45	(b)	(b)
2000	53	297	5.6
2001	98	(b)	(b)
2002	182	(b)	(b)
2003	127	(b)	(b)
2004	144	549	3.8
2005	125	453	3.6
2006	96	(b)	(b)

[a] Redd information is from unpublished ODFW spawning ground survey data.
[b] Census data was inadequate to calculate an unbiased population estimate.

Appendix Table A-5. Population estimates, median migration dates, and percentage of juvenile spring Chinook salmon population moving as late migrants past traps sites, 1994–2006. 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		Percentage migrating late
			Early migrants	Late migrants	
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
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

[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*=1; MY 2001, *n*=6.

Appendix Table A-5. 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
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

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

Appendix Table A-6. 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 1993–2006. 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	6 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-6. 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
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
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

Appendix Table A-6. Continued.

Stream, MY	Tag group	Migration period	Number tagged	Number detected at LGD	Arrival dates		
					Median	First	Last
Catherine Creek (cont.)							
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
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
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

Appendix Table A-6. Continued.

Stream, MY	Tag group	Migration period	Number tagged	Number detected at LGD	Arrival dates Median	First	Last
Lostine River (cont.)							
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[a]	77	18 Apr	25 Mar	27 May
	Winter	Late	491	42	15 May	13 Apr	8 Jun
	Spring	Late	527[a]	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
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

Appendix Table A-6. Continued.

Stream, MY	Tag group	Migration period	Number tagged	Number detected at LGD	Arrival dates		
					Median	First	Last
Minam River (cont.)							
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
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
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
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-7. The number of PIT tagged spring Chinook salmon released by tag group and stream, and survival probability to Lower Granite Dam during migratory years 1993–2006. 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)
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)
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)
	1998	992	0.228 (0.199–0.259)
	1999	1,006	0.181 (0.155–0.210)

Appendix Table A-7. Continued.

Tag group, Stream	MY	Number released	Survival probability (95% CI)
Summer (cont.)			
Minam River (cont.)	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)
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)
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)
	2004	180	0.164 (0.114–0.225)
	2005	368	0.138 (0.105–0.177)
	2006	521	0.171 (0.136–0.232)

Appendix Table A-7. Continued.

Tag group, Stream	MY	Number released	Survival probability (95% CI)
Fall trap (cont.)			
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)
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)
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)
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)
	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)

Appendix Table A-7. Continued.

Tag group, Stream	MY	Number released	Survival probability (95% CI)
Winter (cont.)			
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)
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)
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)
	2005	615	0.374 (0.335–0.418)
	2006	505	0.398 (0.318–0.561)
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)

Appendix Table A-7. Continued.

Tag group, Stream	MY	Number released	Survival probability (95% CI)
Spring (cont.)			
Catherine Creek (cont.)	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)
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)
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)

Appendix Table A-8. 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
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
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-8. 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
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

[b] Limited trapping operations

Appendix Table A-9. 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

Appendix Table A-10. Comparisons of overwinter survival of spring Chinook salmon parr in rearing areas upstream (above screw trap) and downstream (below screw trap) on 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

APPENDIX B

A Compilation of Steelhead Data

Appendix Table B-1. Census data used to estimate the number of wild steelhead in Catherine Creek and its tributaries above the screw trap (rkm 32) during summer 2000–2006. Collection methods differed among years and streams, and mark–recapture followed those methods described in Ricker (1975) unless otherwise noted.

Stream, Year	Collection methods	Census data Marked	Recaptured	Captured	Population estimate (95% CI)
Catherine Creek					
2000	Snorkel seine; hook and line	1,062	60	1,284	22,393 (17,461–28,689)
2001	Snorkel seine	1,321	91	1,790	25,736 (21,005–31,519)
2002	Snorkel seine; hook and line	822	46	1,162	20,365 (15,364–27,633)
2003	Snorkel seine; hook and line	907	41	1,574	34,050 (25,267–47,043)
2004	Snorkel seine; hook and line	735	47	837	12,849 (9,713–17,374)
2005	Snorkel seine; hook and line	431	31	691	9,342 (6,643–13,588)
2006	Snorkel seine; hook and line	334	18	421	7,441 (4,809–12,083)
Little Catherine Creek					
2006	Electrofishing	(a)	(a)	(a)	10,542 (8,890–12,194)
Middle Fork Catherine Creek					
2005	Electrofishing; hook and line	283	92	343	1,050 (858–1,285)
Milk Creek					
2002	Electrofishing	532	194	660	1,825 (1,600–2,050)
North Fork Catherine Creek					
2001	Snorkel observation; electrofishing; snorkel seine	(b)	(b)	(b)	10,338 (5,137–15,539)
2004	Electrofishing; hook and line	426	27	500	7,640 (5,322–11,379)
South Fork Catherine Creek					
2000	Electrofishing	226	12	570	9,971 (5,892–18,002)
2003	Electrofishing; hook and line	605	32	670	12,322 (8,821–17,834)

[a] Estimate was generated using a combination of mark–recapture and removal methods described in Zippin (1958).
[b] Estimate was generated using a combination of mark–recapture and observation techniques described in Hankin and Reeves (1988).

Appendix Table B-2. Age composition of steelhead sampled in Catherine Creek and its tributaries during summer, 2000–2006. Age was determined by scale analysis, and the percent of all lengths sampled was allocated using an age–length key.

Stream, Year sampled	Age	Total aged	Length range (mm FL)	Percent of all lengths sampled
Catherine Creek				
2000	0	0		(a)
	1	83	65–151	64.0
	2	60	113–200	31.0
	3	17	173–263	5.0
2001	0	0		(a)
	1	196	72–163	88.3
	2	29	114–200	11.5
	3	1	221	0.2
2002	0	0		(a)
	1	88	71–183	84.9
	2	25	119–202	14.3
	3	2	169–184	0.8
2003	0	3	72–79	1.8[a]
	1	68	77–162	89.8
	2	31	131–172	8.0
	3	3	178–230	0.4
2004	0	1	54	0.4[a]
	1	87	85–176	74.7
	2	49	91–235	23.2
	3	9	162–280	1.7
2005	0	0		(a)
	1	89	75–176	74.5
	2	53	99–200	22.4
	3	8	183–240	2.1
	4	1	232	0.2
	5	1	279	0.7
2006	0	0		(a)
	1	85	73–206	79.2
	2	41	132–198	18.6
	3	12	182–268	2.1
	4	1	266	0.1
Little Catherine Creek				
2006	0	3	58–66	1.9[a]
	1	94	58–131	73.3
	2	80	103–174	23.0
	3	20	151–197	1.9

[a] Fry (age-0) were not targeted for this study.

Appendix Table B-2. Continued.

Stream, Year sampled	Age	Total aged	Length range (mm FL)	Percent of all lengths sampled
Milk Creek				
2002	0	0		(a)
	1	80	74–175	72.2
	2	42	108–212	25.3
	3	6	151–230	2.5
North Fork Catherine Creek				
2001	0	6	52–62	15.9[a]
	1	108	70–159	57.3
	2	52	118–213	24.3
	3	6	178–215	2.5
2004	0	12	47–94	6.6[a]
	1	87	53–191	52.3
	2	69	113–213	28.5
	3	35	131–239	10.9
	4	8	180–217	1.7
South Fork Catherine Creek				
2000	0	2	59	0.9[a]
	1	23	69–136	53.8
	2	21	123–177	40.0
	3	4	159–198	5.3
2003	0	12	57–74	14.7[a]
	1	36	61–109	39.1
	2	72	91–201	38.7
	3	12	139–191	7.5

Appendix Table B-3. Population estimates, median migration dates, and percentage of steelhead population moving as late migrants past trap sites, 1997–2006 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
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
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

[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-3. Continued.

Stream, MY	Population estimate	95% CI	Median migration date		Percentage migrating late
			Early migrants	Late migrants	
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

Appendix Table B-4. 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, 2000–2006. 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
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-4. Continued.

Stream, MY	Tag group	Number tagged	Number detected	Arrival dates Median	First	Last
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
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

[a] Limited trapping operations during MY 2004.

Appendix Table B-5. 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	6	0	0.061 (0.042–0.086)
	2004	527	37	16	0	0.117 (0.090–0.148)
	2005	704	47	1	—	0.084 (0.065–0.106)
	2006	418	19	—	—	0.138 (0.090–0.252)
Little Catherine Creek						
	2001	415	0	3	0	0.010 (0.002–0.097)
Middle Fork Catherine Creek						
	2006	214	0	—	—	(a)
Milk Creek						
	2003	532	27	1	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	9	2	—	0.068 (0.041–0.115)
South Fork Catherine Creek						
	2001	225	5	4	0	0.041 (0.020–0.074)
	2004	519	17	9	0	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	7	0	0.063 (0.048–0.082)
	2004	1,046	54	25	0	0.087 (0.071–0.106)
	2005	1,024	56	3	—	0.078 (0.062–0.097)
	2006	632	19	—	—	0.094 (0.061–0.173)
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)
	2004	108	1	0	0	0.019 (SE = 0.013)
	2005	288	16	0	—	0.079 (0.051–0.117)
	2006	53	4	—	—	0.094 (SE = 0.040)

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

Appendix Table B-5. Continued.

Tag group, Stream	MY tagged	Number tagged	Number detected MY	MY + 1	MY + 2	Cumulative survival probability Probability (95% CI)
Fall cont.						
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	10	0	0.086 (0.064–0.118)
	2004	512	38	4	0	0.139 (0.105–0.189)
	2005	473	31	2	—	0.095 (0.070–0.127)
	2006	934	23	—	—	0.077 (0.058–0.110)
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	98	23	0	0.141 (0.118–0.167)
	2005	760	73	12	—	0.189 (0.159–0.223)
	2006	827	21	—	—	0.085 (0.063–0.125)
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	0	0	0.238 (0.105–1.663)
	2004	60	2	0	0	(a)
	2005	79	7	1	—	0.139 (SE = 0.039)
	2006	81	5	—	—	0.086 (SE = 0.031)
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	204	3	0	0.455 (0.391–0.540)
	2004	853	186	2	0	0.496 (0.447–0.546)
	2005	371	130	2	—	0.554 (0.492–0.627)
	2006	342	60	—	—	0.522 (0.454–0.629)
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	107	1	0	0.365 (0.295–0.479)
	2004	411	146	1	0	0.476 (0.425–0.528)
	2005	181	42	1	—	0.460 (0.362–0.617)

Appendix Table B-5. 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.						
Catherine Creek cont.						
	2006	222	31	—	—	0.540 (0.421–0.790)
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	267	3	0	0.719 (0.646–0.811)
	2005	90	37	0	—	0.654 (0.544–0.780)
	2006	89	22	—	—	0.629 (SE= 0.051)
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	271	0	0	0.664 (0.591–0.756)
	2004	120	52	1	0	0.607 (0.508–0.712)
	2005	161	60	1	—	0.585 (0.505–0.666)
	2006	274	64	—	—	0.665 (0.584–0.809)
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	4	18	1	0.097 (0.069–0.136)
	2005	272	0	2	—	0.033 (SE= 0.011)
	2006	157	2	—	—	(a)
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	4	12	0	0.124 (0.080–0.187)
	2005	442	0	8	—	0.063 (SE= 0.016)
	2006	278	1	—	—	(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	9	—	0.169 (SE= 0.031)

Appendix Table B-5. 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.						
Lostine River cont.						
	2006	89	1	—	—	(a)
Minam River						
	2001	9	0	0	0	(a)
	2002	1	0	0	0	(a)
	2003	0	0	0	0	(a)
	2004	97	0	6	1	0.094 (SE= 0.030)
	2005	172	0	2	—	0.058 (SE= 0.018)
	2006	274	0	—	—	(a)

Appendix Table B-6. 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 1999–2005, 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							
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
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-6. Continued.

Stream, Year tagged	Year detected	*N*	Length at tagging (mm) Median	Min	Percentile 25th	Percentile 75th	Max
Catherine Creek (cont.)							
2005	(a)	934	91	55	77	134	246
	2006	61	140	82	127	154	208
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
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
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

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

Appendix Table B-7. 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 2000–2006, 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							
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
2006	(a)	500	132	62	94	150	276
	2006	170	150	111	135	166	203
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
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

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

Appendix Table B-7. Continued.

Stream, Year tagged	Year detected	*N*	Length at tagging (mm) Median	Min	Percentile 25th	75th	Max
Catherine Creek cont.							
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
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
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

Appendix Table B-7. Continued.

Stream, Year tagged	Year detected	*N*	Length at tagging (mm)				
					Percentile		
			Median	Min	25th	75th	Max
Minam River cont.							
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

Appendix Table B-8. 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 2000–2005, 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
Detected at dams during 2005	0	—	—	—	—	—

Appendix Table B-8. 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
Still upstream after spring 2005	1	179	—	—	—	—
Still upstream after spring 2006	1	107	—	—	—	—
Detected at dams during 2005	72	141	105	127	156	185
Detected at dams during 2006	9	103	80	99	108	120
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
Still upstream after spring 2006	1	101	—	—	—	—
Detected at dams during 2006	41	126	96	116	149	186

APPENDIX C

A Compilation of Stream Condition Data

Appendix Table C-1. Criteria used to score six macroinvertebrate metrics to family level. Each metric scoring criteria was generated using data provided by the Department of Environmental Quality for index streams of northeastern Oregon (Ecoregion 3). Combined metric scores were used to rate relative stream condition and are based on impairment score range.

Family level scoring criteria

	SCORE		
Metric	5	3	1
Taxa Richness [a]	>22	18–22	<18
Mayfly Richness [b]	>4	4	<4
Stonefly Richness [c]	>4	4	<4
Caddisfly Richness [d]	>5	5	<5
Percent common midges [e]	<22	22–32	>32
Percent Dominance (top three taxa) [f]	<58	58–69	>69

Score Range	Stream Condition
>23	No impairment: indicates good diversity of invertebrates and stream conditions with little disturbance.
17–23	Moderate impairment: evidence that some impairment exists.
<17	Severe impairment: evidence that stream disturbance exists.

[a] Taxa richness represents the total number of families identified in the sample (≥ 500 individuals).

[b] Mayfly richness represents the total number of families from the Order Ephemeroptera that was identified in the sample.

[c] Stonefly richness represents the total number of families from the Order Plecoptera that was identified in the sample.

[d] Caddisfly richness represents the total number of families from the Order Trichoptera that was identified in the sample.

[e] Percent common midges represent the total number of individuals from the family Chironomidae divided by the total number of individuals identified in the sample (≥ 500 individuals).

[f] Percent dominance represents the total number of individuals from the three most abundant families in the sample divided by the total number of individuals identified in the sample (≥ 500 individuals).

Appendix Table C-2. Summary of aquatic macroinvertebrate taxa collected from four study streams and Lower Grande Ronde River during 2006. Each collection period with reach location relative to the screw trap and reach starting river kilometer (rkm) is in brackets next to each stream label. The period and reach location were abbreviated using SU = Summer Upper; SL = Summer Lower; FU = Late fall Upper; FL = Late fall Lower. Summer sampling occurred 21 August–19 September 2006, and late fall sampling occurred 17 November 2006–1 December 2006. Family level information on the total number of genera (*species*) in North America, and four common trophic descriptions were derived from Merritt and Cummins (1996).

Stream (period–reach, rkm), **Order** (common name), *Family*	Period and reach location	Documented genera (*species*) in North America	Tolerance value NW Idaho/ HBI[a]	Primary functional feeding mechanism	Primary functional habit of existence	Primary habitat
Upper Grande Ronde River (Summer Upper, 322; Summer Lower, 254; Late Fall Upper, 322; Late Fall Lower, 268)						
Coleoptera (Beetles)						
Dytiscidae	SU,SL	44 (*552*)	5 / 5	Predator	Climber	Lentic vascular hydrophytes
Elmidae	ALL	7 (*101*)	4 / 4	Gatherer	Clinger	Lotic and lentic erosional
Psephenidae	SL,FU,FL	5 (*14*)	4 / 4	Scraper	Clinger	Lotic and lentic erosional
Diptera (True flies)						
Athericidae	SU,FL	2 (*4*)	2 / 4	Predator	Sprawler	Lotic erosional and depositional
Ceratopogonidae	FL	20 (*501*)	6 / 6	Predator	Sprawler	Lentic littoral
Chironomidae	ALL	208[b] (*932*[b])	6 / 6	Gatherer	Burrower	All
Empididae	SL,FU,FL	16 (*265*)	6 / 6	Predator	Sprawler	Lotic erosional and depositional
Ephydridae	SL	69 (*445*)	6 / 6	Gatherer	Burrower	Vascular hydrophytes
Pelecorhynchidae	SU,FU	6 (*67*)	10 / 10	Gatherer	Burrower	Lotic depositional
Psychodidae	SU,SL,FU	6 (*67*)	10 / 10	Gatherer	Burrower	Lotic depositional
Simuliidae	SU,SL,FU	11 (*143*)	6 / 6	Filterer	Clinger	Lotic erosional
Tipulidae	ALL	34 (*573*)	3 / 3	Shredder	Burrower	All erosional and depositional

[a] Hilsenhof Biotic Index (HBI).

[b] North American *chironomid* fauna includes many undescribed genera and species, so each total represents a minimum estimate for this family.

Appendix Table C-2. Continued.

Stream (period–reach, rkm), **Order** (common name), *Family*	Period and reach location	Documented genera (*species*) in North America	Tolerance value NW Idaho/ HBI[a]	Primary functional feeding mechanism	Primary functional habit of existence	Primary habitat
Upper Grande Ronde River cont.						
Ephemeroptera (Mayflies)						
Ameletidae	ALL	1 (*33*)	0 / 0	Scraper	Swimmer	Lotic erosional and depositional
Baetidae	ALL	18 (*121*)	4 / 4	Gatherer	Swimmer	Lotic erosional
Ephemerellidae	ALL	8 (*90*)	1 / 1	Gatherer	Clinger	Lotic erosional
Heptageniidae	ALL	14 (*128*)	4 / 4	Scraper	Clinger	Lotic and lentic erosional
Leptophlebiidae	ALL	9 (*72*)	2 / 2	Gatherer	Swimmer	Lotic erosional
Tricorythidae	SL,FU,FL	2 (*24*)	4 / 4	Gatherer	Clinger	Lotic erosional
Hemiptera (True bugs)						
Corixidae	SL,FL	18 (*129*)	10 / 8	Piercer	Swimmer	Lentic vascular hydrophytes
Lepidoptera (Butterflies/Moths)						
Pyralidae	SL,FL	21 (*148*)	5 / 5	Shredder	Climber	Lentic vascular hydrophytes
Megaloptera (Alderflies)						
Sialidae	SL	1 (24)	4 / 4	Predator	Burrower	Lotic erosional and depositional
Odonata (dragonflies and damselflies)						
Coenagrionidae	SL,FU,FL	13 (96)	9 / 9	Predator	Climber	Lentic and lotic
Plecoptera (Stoneflies)						
Capniidae	SU,FU	10 (151)	1 / 1	Shredder	Sprawler	Lotic erosional
Chloroperlidae	ALL	13 (*77*)	1 / 1	Predator	Clinger	Lotic erosional
Nemouridae	SU,SL,FU	12 (*65*)	2 / 2	Shredder	Sprawler	Lotic erosional and depositional
Peltoperlidae	SU,FU,FL	6 (*18*)	2 / 1	Shredder	Clinger	Lotic erosional and depositional
Perlidae	ALL	15 (*55*)	2 / 1	Predator	Clinger	Lotic and lentic erosional
Perlodidae	ALL	30 (*103*)	1 / 2	Predator	Clinger	Lotic and lentic erosional
Pteronarcyidae	SL	2 (*10*)	0 / 0	Shredder	Clinger	Lotic erosional and depositional
Taeniopterygidae	FU,FL	6 (*35*)	2 / 2	Shredder	Clinger	Lotic erosional

Appendix Table C-2. Continued.

Stream (period–reach, rkm), **Order** (common name), *Family*	Period and reach location	Documented genera (*species*) in North America	Tolerance value NW Idaho/ HBI[a]	Primary functional feeding mechanism	Primary functional habit of existence	Primary habitat
Upper Grande Ronde River cont.						
Trichoptera (Caddisflies)						
Brachycentridae	SU,SL	5 (*36*)	1 / 1	Filterer	Clinger	Lotic erosional
Glossosomatidae	SU,SL	6 (*76*)	0 / 0	Scraper	Clinger	Lotic erosional
Helicopsychidae	SL	1 (*4*)	3 / 3	Scraper	Clinger	Lotic and Lentic
Hydropsychidae	SU,SL	12 (*144*)	4 / 4	Filterer	Clinger	Lotic erosional
Hydroptilidae	FU,FL	15 (*230*)	4 / 4	Piercer	Climber	Lotic and lentic erosional
Lepidostomatidae	SU	2 (*80*)	3 / 1	Shredder	Climber	Lotic erosional and depositional
Leptoceridae	SL,FU,FL	8 (*17*)	4 / 4	Shredder	Climber	Lotic and Lentic
Limnephilidae	SU,SL	50 (*300*)	4 / 4	Shredder	Climber	Lotic and Lentic
Polycentropodidae	SL	7 (*76*)	— / 6	Filterer	Clinger	Lotic erosional
Rhyacophilidae	SU	2 (*127*)	0 / 1	Predator	Clinger	Lotic erosional
Catherine Creek (Summer Upper, 43; Summer Lower, 18; Late Fall Upper, 43; Late Fall Lower, 23)						
Coleoptera (Beetles)						
Dytiscidae	SU	44 (*552*)	5 / 5	Predator	Climber	Lentic vascular hydrophytes
Elmidae	ALL	27 (*101*)	4 / 4	Gatherer	Clinger	Lotic and lentic erosional
Psephenidae	FL	5 (*14*)	4 / 4	Scraper	Clinger	Lotic and lentic erosional
Diptera (True flies)						
Athericidae	SU,FU	2 (*4*)	2 / 4	Predator	Sprawler	Lotic erosional and depositional
Blephariceridae	SU,FU	4 (*28*)	0 / 0	Scraper	Clinger	Lotic erosional
Ceratopogonidae	ALL	20 (*501*)	6 / 6	Predator	Sprawler	Lentic littoral
Chironomidae	ALL	208[b] (*932*[b])	6 / 6	Gatherer	Burrower	All
Culicidae	SL	12 (*172*)	8 / 8	Filterer	Swimmer	Lentic littoral lentic depositional
Empididae	FL	16 (*265*)	6 / 6	Predator	Sprawler	Lotic erosional and depositional
Ephydridae	SL	69 (*445*)	6 / 6	Gatherer	Burrower	Lotic erosional and depositional

Appendix Table C-2. Continued.

Stream (period–reach, rkm), **Order** (common name), *Family*	Period and reach location	Documented genera (*species*) in North America	Tolerance value NW Idaho/ HBI[a]	Primary functional feeding mechanism	Primary functional habit of existence	Primary habitat
Catherine Creek cont.						
Diptera cont.						
Pelecorhynchidae	FU	1 (*7*)	3 / 3	Predator	Sprawler	Lotic depositional
Psychodidae	SU,SL,FU	6 (*67*)	10 / 10	Gatherer	Burrower	Lotic depositional
Simuliidae	SU,FU	11 (*143*)	6 / 6	Filterer	Clinger	Lotic erosional
Tabanidae	SL,FL	14 (*332*)	8 / 8	Predator	Sprawler	Lotic depositional
Tipulidae	SU,FU,FL	34 (*573*)	3 / 3	Shredder	Burrower	All erosional and depositional
Ephemeroptera (Mayflies)						
Ameletidae	SU,FU,FL	1 (*33*)	0 / 0	Scraper	Swimmer	Lotic erosional and depositional
Baetidae	ALL	18 (*121*)	4 / 4	Gatherer	Swimmer	Lotic erosional
Caenidae	SL,FL	4 (*26*)	7 / 7	Gatherer	Sprawler	Lotic depositional
Ephemerellidae	ALL	8 (*90*)	1 / 1	Gatherer	Clinger	Lotic erosional
Heptageniidae	ALL	14 (*128*)	4 / 4	Scraper	Clinger	Lotic and lentic erosional
Leptophlebiidae	SL,FU,FL	9 (*72*)	2 / 2	Gatherer	Swimmer	Lotic erosional
Tricorythidae	SL,FU,FL	2 (*24*)	4 / 4	Gatherer	Clinger	Lotic erosional
Hemiptera (True bugs)						
Corixidae	SU,SL,FL	18 (*129*)	10 / 8	Piercer	Swimmer	Lentic vascular hydrophytes
Lepidoptera (Butterflies/Moths)						
Nepticulidae	SL,FL	1 (*70*)	— / —	Shredder	Burrower	Lentic vascular hydrophytes
Pyralidae	SL,FL	21 (*148*)	5 / 5	Shredder	Climber	Lentic vascular hydrophytes
Odonata (dragonflies and damselflies)						
Coenagrionidae	SU,SL	13 (96)	9 / 9	Predator	Climber	Lentic and lotic
Gomphidae	FL	13 (97)	1 / 4	Predator	Burrower	Lotic depositional
Plecoptera (Stoneflies)						
Capniidae	FU,FL	10 (151)	1 / 1	Shredder	Sprawler	Lotic erosional
Chloroperlidae	SU,FU,FL	13 (*77*)	1 / 1	Predator	Clinger	Lotic erosional

Appendix Table C-2. Continued.

Stream (period–reach, rkm), **Order** (common name), *Family*	Period and reach location	Documented genera (*species*) in North America	Tolerance value NW Idaho/ HBI[a]	Primary functional feeding mechanism	Primary functional habit of existence	Primary habitat
Catherine Creek cont.						
Plecoptera cont.						
Nemouridae	FU	12 (*65*)	2 / 2	Shredder	Sprawler	Lotic erosional and depositional
Perlidae	SU,FU,FL	6 (*18*)	2 / 1	Shredder	Clinger	Lotic erosional and depositional
Perlodidae	SU,FU,FL	15 (*55*)	2 / 1	Predator	Clinger	Lotic and lentic erosional
Pteronarcyidae	SU,FU,FL	30 (*103*)	1 / 2	Predator	Clinger	Lotic and lentic erosional
Taeniopterygidae	FU,FL	6 (*35*)	2 / 2	Shredder	Clinger	Lotic erosional
Trichoptera (Caddisflies)						
Brachycentridae	SU,FU,FL	5 (*36*)	1 / 1	Filterer	Clinger	Lotic erosional
Glossosomatidae	SU,FU,FL	6 (*76*)	0 / 0	Scraper	Clinger	Lotic erosional
Helicopsychidae	FL	1 (*4*)	3 / 3	Scraper	Clinger	Lotic and Lentic
Hydropsychidae	SU,FU,FL	12 (*144*)	4 / 4	Filterer	Clinger	Lotic erosional
Lepidostomatidae	SU,FU,FL	2 (*80*)	3 / 1	Shredder	Climber	Lotic erosional and depositional
Leptoceridae	SL	8 (*17*)	4 / 4	Shredder	Climber	Lotic and Lentic
Limnephilidae	SU,FU,FL	50 (*300*)	4 / 4	Shredder	Climber	Lotic and Lentic
Polycentropodidae	SL	7 (*76*)	— / 6	Filterer	Clinger	Lotic erosional
Rhyacophilidae	SU,FU	2 (*127*)	0 / 1	Predator	Clinger	Lotic erosional
Lostine River (Summer Upper, 17; Late Fall Upper, 12)						
Coleoptera (Beetles)						
Chrysomelidae	SU	8 (*98*)	— / 6	Shredder	Clinger	Lentic vascular hydrophytes
Elmidae	SU,FU	27 (*101*)	4 / 4	Gatherer	Clinger	Lotic and lentic erosional
Haliplidae	SU	4 (*70*)	7 / 5	Shredder	Climber	Lentic littoral
Psephenidae	SU	5 (*14*)	4 / 4	Scraper	Clinger	Lotic and lentic erosional
Diptera (True flies)						
Athericidae	SU,FU	2 (*4*)0	2 / 4	Predator	Sprawler	Lotic erosional and depositional

Appendix Table C-2. Continued.

Stream (period–reach, rkm), **Order** (common name), *Family*	Period and reach location	Documented genera (*species*) in North America	Tolerance value NW Idaho/ HBI[a]	Primary functional feeding mechanism	Primary functional habit of existence	Primary habitat
Lostine River cont.						
Diptera cont.						
Ceratopogonidae	SU	20 (*501*)	6 / 6	Predator	Sprawler	Lentic littoral
Chironomidae	SU,FU	208[b] (*932*[b])	6 / 6	Gatherer	Burrower	All
Psychodidae	SU,FU	6 (*67*)	10 / 10	Gatherer	Burrower	Lotic depositional
Simuliidae	SU,FU	11 (*143*)	6 / 6	Filterer	Clinger	Lotic erosional
Stratiomyidae	SU,FU	11 (*178*)	8 / 8	Gatherer	Sprawler	Lentic littoral
Thaumaleidae	SL	2 (*7*)	— / 8	Scraper	Clinger	Lotic madicolous
Tipulidae	SU,FU	34 (*573*)	3 / 3	Shredder	Burrower	All erosional and depositional
Ephemeroptera (Mayflies)						
Baetidae	SU,FU	18 (*121*)	4 / 4	Gatherer	Swimmer	Lotic erosional
Ephemerellidae	SU,FU	8 (*90*)	1 / 1	Gatherer	Clinger	Lotic erosional
Heptageniidae	SU,FU	14 (*128*)	4 / 4	Scraper	Clinger	Lotic and lentic erosional
Leptophlebiidae	SU	9 (*72*)	2 / 2	Gatherer	Swimmer	Lotic erosional
Plecoptera (Stoneflies)						
Chloroperlidae	SU,FU	13 (*77*)	1 / 1	Predator	Clinger	Lotic erosional
Perlidae	SU	6 (*18*)	2 / 1	Shredder	Clinger	Lotic erosional and depositional
Perlodidae	SU,FU	15 (*55*)	2 / 1	Predator	Clinger	Lotic and lentic erosional
Pteronarcyidae	SU,FU	30 (*103*)	1 / 2	Predator	Clinger	Lotic and lentic erosional
Trichoptera (Caddisflies)						
Brachycentridae	SU,FU	5 (*36*)	1 / 1	Filterer	Clinger	Lotic erosional
Glossosomatidae	FU	6 (*76*)	0 / 0	Scraper	Clinger	Lotic erosional
Helicopsychidae	FU	1 (*4*)	3 / 3	Scraper	Clinger	Lotic and Lentic
Hydropsychidae	SU,FU	12 (*144*)	4 / 4	Filterer	Clinger	Lotic erosional
Hydroptilidae	FU	15 (*230*)	4 / 4	Piercer	Climber	Lotic and lentic erosional

Appendix Table C-2. Continued.

Stream (period–reach, rkm), **Order** (common name), *Family*	Period and reach location	Documented genera (*species*) in North America	Tolerance value NW Idaho/ HBI[a]	Primary functional feeding mechanism	Primary functional habit of existence	Primary habitat
Minam River (Summer Upper, 38)						
Coleoptera (Beetles)						
Dytiscidae	SU	44 (*552*)	5 / 5	Predator	Climber	Lentic vascular hydrophytes
Elmidae	SU	27 (*101*)	4 / 4	Gatherer	Clinger	Lotic and lentic erosional
Psephenidae	SU	5 (*14*)	4 / 4	Scraper	Clinger	Lotic and lentic erosional
Diptera (True flies)						
Athericidae	SU	2 (*4*)	2 / 4	Predator	Sprawler	Lotic erosional and depositional
Blephariceridae	SU	4 (*28*)	0 / 0	Scraper	Clinger	Lotic erosional
Ceratopogonidae	SU	20 (*501*)	6 / 6	Predator	Sprawler	Lentic littoral
Chironomidae	SU	208[b] (*932*[b])	6 / 6	Gatherer	Burrower	All
Empididae	SU	16 (*265*)	6 / 6	Predator	Sprawler	Lotic erosional and depositional
Ephydridae	SU	69 (*445*)	6 / 6	Gatherer	Burrower	Lotic erosional and depositional
Simuliidae	SU	11 (*143*)	6 / 6	Filterer	Clinger	Lotic erosional
Tipulidae	SU	34 (*573*)	3 / 3	Shredder	Burrower	All erosional and depositional
Ephemeroptera (Mayflies)						
Ameletidae	SU	1 (*33*)	0 / 0	Scraper	Swimmer	Lotic erosional and depositional
Baetidae	SU	18 (*121*)	4 / 4	Gatherer	Swimmer	Lotic erosional
Ephemerellidae	SU	8 (*90*)	1 / 1	Gatherer	Clinger	Lotic erosional
Heptageniidae	SU	14 (*128*)	4 / 4	Scraper	Clinger	Lotic and lentic erosional
Leptophlebiidae	SU	9 (*72*)	2 / 2	Gatherer	Swimmer	Lotic erosional
Tricorythidae	SU	2 (*24*)	4 / 4	Gatherer	Clinger	Lotic depositional
Lepidoptera (Butterflies/Moths)						
Pyralidae	SU	21 (*148*)	5 / 5	Shredder	Climber	Lentic vascular hydrophytes
Plecoptera (Stoneflies)						
Chloroperlidae	SU	13 (*77*)	1 / 1	Predator	Clinger	Lotic erosional
Perlidae	SU	6 (*18*)	2 / 1	Shredder	Clinger	Lotic erosional and depositional

Appendix Table C-2. Continued.

Stream (period–reach, rkm), **Order** (common name), *Family*	Period and reach location	Documented genera (*species*) in North America	Tolerance value NW Idaho/ HBI[a]	Primary functional feeding mechanism	Primary functional habit of existence	Primary habitat
Minam River cont.						
Plecoptera cont.						
Perlodidae	SU	15 (*55*)	2 / 1	Predator	Clinger	Lotic and lentic erosional
Pteronarcyidae	SU	30 (*103*)	1 / 2	Predator	Clinger	Lotic and lentic erosional
Trichoptera (Caddisflies)						
Brachycentridae	SU	5 (*36*)	1 / 1	Filterer	Clinger	Lotic erosional
Glossosomatidae	SU	6 (*76*)	0 / 0	Scraper	Clinger	Lotic erosional
Hydropsychidae	SU	12 (*144*)	4 / 4	Filterer	Clinger	Lotic erosional
Lepidostomatidae	SU	2 (*80*)	3 / 1	Shredder	Climber	Lotic erosional and depositional
Limnephilidae	SU	50 (*300*)	4 / 4	Shredder	Climber	Lotic and Lentic
Polycentropodidae	SU	7 (*76*)	— / 6	Filterer	Clinger	Lotic erosional
Lower Grande Ronde River (Summer Lower, 137 and 73)						
Coleoptera (Beetles)						
Elmidae	SL	27 (*101*)	4 / 4	Gatherer	Clinger	Lotic and lentic erosional
Psephenidae	SL	5 (*14*)	4 / 4	Scraper	Clinger	Lotic and lentic erosional
Diptera (True flies)						
Ceratopogonidae	SL	20 (*501*)	6 / 6	Predator	Sprawler	Lentic littoral
Chironomidae	SL	208[b] (*932*[b])	6 / 6	Gatherer	Burrower	All
Culicidae	SL	12 (*172*)	8 / 8	Filterer	Swimmer	Lentic littoral lentic depositional
Simuliidae	SL	11 (*143*)	6 / 6	Filterer	Clinger	Lotic erosional
Stratiomyidae	SL	11 (*178*)	8 / 8	Gatherer	Sprawler	Lentic littoral
Tabanidae	SL	14 (*332*)	8 / 8	Predator	Sprawler	Lotic depositional
Thaumaleidae	SL	2 (*7*)	— / 8	Scraper	Clinger	Lotic madicolous
Tipulidae	SL	34 (*573*)	3 / 3	Shredder	Burrower	All erosional and depositional

Appendix Table C-2. Continued.

Stream (period–reach, rkm), **Order** (common name), *Family*	Period and reach location	Documented genera (*species*) in North America	Tolerance value NW Idaho/ HBI[a]	Primary functional feeding mechanism	Primary functional habit of existence	Primary habitat
Lower Grande Ronde River cont.						
Ephemeroptera (Mayflies)						
Baetidae	SL	18 (*121*)	4 / 4	Gatherer	Swimmer	Lotic erosional
Ephemerellidae	SL	8 (*90*)	1 / 1	Gatherer	Clinger	Lotic erosional
Ephemeridae	SL	3 (*13*)	4 / 4	Gatherer	Burrower	Lotic and lentic depositional
Heptageniidae	SL	14 (*128*)	4 / 4	Scraper	Clinger	Lotic and lentic erosional
Leptophlebiidae	SL	9 (*72*)	2 / 2	Gatherer	Swimmer	Lotic erosional
Tricorythidae	SL	2 (*24*)	4 / 4	Gatherer	Clinger	Lotic depositional
Lepidoptera (Butterflies/Moths)						
Pyralidae	SL	21 (*148*)	5 / 5	Shredder	Climber	Lentic vascular hydrophytes
Odonata (dragonflies and damselflies)						
Coenagrionidae	SL	13 (96)	9 / 9	Predator	Climber	Lentic and lotic
Plecoptera (Stoneflies)						
Chloroperlidae	SL	13 (*77*)	1 / 1	Predator	Clinger	Lotic erosional
Perlidae	SL	6 (*18*)	2 / 1	Shredder	Clinger	Lotic erosional and depositional
Perlodidae	SL	15 (*55*)	2 / 1	Predator	Clinger	Lotic and lentic erosional
Trichoptera (Caddisflies)						
Brachycentridae	SL	5 (*36*)	1 / 1	Filterer	Clinger	Lotic erosional
Glossosomatidae	SL	6 (*76*)	0 / 0	Scraper	Clinger	Lotic erosional
Helicopsychidae	SL	1 (*4*)	3 / 3	Scraper	Clinger	Lotic and Lentic
Hydropsychidae	SL	12 (*144*)	4 / 4	Filterer	Clinger	Lotic erosional
Hydroptilidae	SL	15 (*230*)	4 / 4	Piercer	Climber	Lotic and lentic erosional
Lepidostomatidae	SL	2 (*80*)	3 / 1	Shredder	Climber	Lotic erosional and depositional
Leptoceridae	SL	8 (*17*)	4 / 4	Shredder	Climber	Lotic and Lentic
Limnephilidae	SL	50 (*300*)	4 / 4	Shredder	Climber	Lotic and Lentic

Appendix Table C-2. Continued.

Stream (period–reach, rkm), **Order** (common name), *Family*	Period and reach location	Documented genera (*species*) in North America	Tolerance value NW Idaho/ HBI[a]	Primary functional feeding mechanism	Primary functional habit of existence	Primary habitat
Lower Grande Ronde River cont.						
Trichoptera cont.						
Philopotamidae	SL	3 (*42*)	3 / 3	Filterer	Clinger	Lotic erosional
Rhyacophilidae	SL	2 (*127*)	0 / 1	Predator	Clinger	Lotic erosional