

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

ANNUAL REPORT 2007

Project Period: 1 February 2007 to 31 January 2008

Prepared by:

Jeffrey A. Yanke
Erick S. Van Dyke
Brian M. Alfonse
Jacob P. Kimbro
Jesse W. Steele
Ian P. Wilson
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

June 2008

ABSTRACT

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

CONTENTS

| | <u>Page</u> |
|--|-------------|
| ABSTRACT..... | i |
| EXECUTIVE SUMMARY | 1 |
| Objectives | 1 |
| Accomplishments..... | 1 |
| Findings..... | 2 |
| Spring Chinook Salmon..... | 2 |
| Summer Steelhead | 3 |
| Stream Condition | 3 |
| Management Implications and Recommendations | 4 |
| INTRODUCTION | 5 |
| SPRING CHINOOK SALMON INVESTIGATIONS..... | 8 |
| Methods..... | 8 |
| In-Basin Migration Timing and Abundance..... | 8 |
| Migration Timing and Survival to Lower Granite Dam | 11 |
| Results and Discussion | 15 |
| In-Basin Migration Timing and Abundance..... | 15 |
| Migration Timing and Survival to Lower Granite Dam | 16 |
| SUMMER STEELHEAD INVESTIGATIONS..... | 19 |
| Methods..... | 19 |
| In-Basin Migration Timing and Abundance..... | 19 |
| Migration Timing and Survival to Lower Granite Dam | 20 |
| Results and Discussion | 22 |
| In-Basin Migration Timing and Abundance..... | 22 |
| Migration Timing and Survival to Lower Granite Dam | 23 |

CONTENTS (continued)

| | <u>Page</u> |
|---|-------------|
| STREAM CONDITION INVESTIGATIONS | 26 |
| Methods..... | 26 |
| Stream Temperature and Flow | 26 |
| Results and Discussion | 26 |
| Stream Temperature and Flow | 26 |
| FUTURE DIRECTIONS | 29 |
| REFERENCES | 30 |
| APPENDIX A. A Compilation of Spring Chinook Salmon Data | 59 |
| APPENDIX B. A Compilation of Steelhead Data..... | 77 |

TABLES

| <u>Number</u> | <u>Page</u> |
|--|-------------|
| 1. Dates of tagging and number of spring Chinook salmon parr PIT-tagged on various northeast Oregon streams during the summers of 2006 and 2007 | 33 |
| 2. Catch of juvenile spring Chinook salmon at four trap locations in the Grande Ronde River Subbasin during MY 2007 | 33 |
| 3. Fork lengths of juvenile spring Chinook salmon collected from the study streams during MY 2007 | 34 |
| 4. Weights of juvenile spring Chinook salmon collected from the study streams during MY 2007 | 35 |
| 5. Survival probability to Lower Granite Dam for spring Chinook salmon parr tagged in summer 2006 and detected at Columbia and Snake River dams in 2007..... | 36 |
| 6. Juvenile spring Chinook salmon survival probability by location and tag group from time of tagging to Lower Granite Dam..... | 36 |
| 7. Catch of juvenile steelhead at four trap locations in the Grande Ronde River Subbasin during MY 2007 | 37 |
| 8. Age structure of early and late steelhead migrants collected at trap sites during MY 2006..... | 38 |
| 9. Travel time to Lower Granite Dam of wild steelhead PIT-tagged at screw traps in spring of 2007 and arriving at Lower Granite Dam in 2007..... | 38 |
| 10. Survival probability to Lower Granite Dam of steelhead PIT-tagged on Catherine Creek during summer 2006 and at screw traps on Catherine Creek and the upper Grande Ronde, Lostine, and Minam rivers during the fall of 2006 and spring of 2007 | 39 |
| 11. Age structure of PIT tagged early migrating steelhead with known age information, and the subset subsequently detected at downstream dams the following spring..... | 39 |

FIGURES

| <u>Number</u> | <u>Page</u> |
|---|-------------|
| 1. Locations of fish traps in the Grande Ronde River Subbasin during the study period..... | 40 |
| 2. Estimated migration timing and abundance of juvenile spring Chinook salmon migrants captured by rotary screw traps during MY 2007..... | 41 |
| 3. Length frequency distribution of early and late migrating juvenile spring Chinook salmon captured at the upper Grande Ronde River, Catherine Creek, Lostine River, and Minam River traps during MY 2007 | 42 |
| 4. Weekly mean fork lengths with standard error for spring Chinook salmon captured in rotary screw traps in the Grande Ronde River Subbasin during MY 2007. | 43 |
| 5. Dates of arrival in 2007 at Lower Granite Dam of spring Chinook salmon PIT-tagged as parr on Catherine Creek and the Imnaha, Lostine, and Minam rivers during the summer of 2006 summarized by week and expressed as a percentage of the total detected for each group | 44 |
| 6. Dates of arrival in 2007 at Lower Granite Dam for the fall, winter, and spring tag groups of juvenile spring Chinook salmon PIT-tagged on the upper Grande Ronde River, expressed as a percentage of the total detected for each group | 45 |
| 7. Dates of arrival in 2007 at Lower Granite Dam for the fall, winter, and spring tag groups of juvenile spring Chinook salmon PIT-tagged on Catherine Creek, expressed as a percentage of the total detected for each group | 46 |
| 8. Dates of arrival in 2007 at Lower Granite Dam for the fall, winter, and spring tag groups of juvenile spring Chinook salmon PIT-tagged on the Lostine River, expressed as a percentage of the total detected for each group | 47 |
| 9. Dates of arrival in 2007 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 | 48 |
| 10. Estimated abundance and migration timing of steelhead migrants captured by rotary screw traps, during MY 2007 | 49 |

FIGURES (continued)

| <u>Number</u> | | <u>Page</u> |
|---------------|--|-------------|
| 11. | Dates of arrival in 2007 at Lower Granite Dam for the fall and spring tag groups of steelhead PIT-tagged on the upper Grande Ronde River, expressed as a percentage of the total detected for each group | 50 |
| 12. | Dates of arrival in 2007 at Lower Granite Dam for the summer, fall, and spring tag groups of steelhead PIT-tagged on Catherine Creek, expressed as a percentage of the total detected for each group | 51 |
| 13. | Dates of arrival in 2007 at Lower Granite Dam for the fall and spring tag groups of steelhead PIT-tagged on the Lostine River, expressed as a percentage of the total detected for each group | 52 |
| 14. | Dates of arrival in 2007 at Lower Granite Dam for the fall and spring tag groups of steelhead PIT-tagged on the Minam River, expressed as a percentage of the total detected for each group | 53 |
| 15. | Length frequency distributions for all steelhead PIT-tagged at screw traps in the fall of 2006 and those subsequently observed at Snake River or Columbia River dams in 2007 | 54 |
| 16. | Length frequency distributions for all steelhead PIT-tagged at screw traps in the fall of 2005, and those subsequently observed at Snake River or Columbia River dams in 2006 and 2007..... | 55 |
| 17. | Length frequency distributions for all steelhead PIT-tagged at screw traps in the spring of 2007 and those subsequently observed at Snake River or Columbia River dams in 2007 | 56 |
| 18. | Moving mean of maximum water temperature during the in-basin life stages of egg-to-emigrant for juvenile spring Chinook salmon that migrated from four study streams in the Grande Ronde River basin during migratory year 2007..... | 57 |
| 19. | 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 migratory year 2007 | 58 |

APPENDIX TABLES

| <u>Number</u> | <u>Page</u> |
|--|-------------|
| A-1. Population estimates, median migration dates, and percentage of juvenile spring Chinook salmon population moving as late migrants past traps sites, 1994–2007..... | 60 |
| A-2. Dates of arrival at Lower Granite Dam of spring Chinook salmon smolts PIT-tagged in upper rearing areas during the summer and winter, and at screw traps as early and late migrants during migratory years 1993–2007 | 62 |
| A-3. The number of PIT tagged spring Chinook salmon released by tag group and stream, and survival probability to Lower Granite Dam during migratory years 1993–2007 | 68 |
| A-4. Travel time to Lower Granite Dam of juvenile spring Chinook salmon PIT-tagged at screw traps in spring and arriving at Lower Granite Dam the same year | 73 |
| A-5. Overwinter survival rates of spring Chinook salmon parr overwintering upstream of screw traps on Catherine Creek and the Lostine and Grande Ronde rivers | 75 |
| A-6. Comparisons of overwinter survival of spring Chinook salmon parr in rearing areas upstream and downstream on the upper Grande Ronde River, Catherine Creek and the Lostine River | 76 |
| B-1. Population estimates, median migration dates, and percentage of steelhead population moving as late migrants past trap sites, 1997–2007 migratory years. | 78 |
| B-2. Dates of arrival at Lower Granite Dam of steelhead PIT-tagged upstream of the screw trap in Catherine Creek and tributaries during summer, and at screw traps in the fall and spring during the same migratory year, 2000–2007..... | 80 |
| B-3. Survival probabilities to Lower Granite Dam for steelhead PIT- tagged in the upper rearing areas of Catherine Creek in summer and at screw traps during fall and spring..... | 82 |
| B-4. Fork lengths of steelhead at the time they were PIT-tagged at screw traps on Catherine Creek and the upper Grande Ronde, Lostine, and Minam rivers during the early migration period 1999–2006, summarized by dam detection history | 86 |

APPENDIX TABLES (continued)

| <u>Number</u> | | <u>Page</u> |
|---------------|--|-------------|
| B-5. | Fork lengths of steelhead at the time they were PIT-tagged at screw traps on Catherine Creek and the upper Grande Ronde, Lostine, and Minam rivers during the late migration period 2000–2007, summarized by dam detection history | 89 |
| B-6. | Fork lengths of steelhead at the time they were PIT-tagged in rearing areas upstream of the screw trap on Catherine Creek and its tributaries during summer 2000–2006, summarized by migration history | 92 |

EXECUTIVE SUMMARY

Objectives

1. Document the in-basin migration patterns and estimate egg-to-migrant survival for spring Chinook salmon juveniles in Catherine Creek and the upper Grande Ronde, Minam, and Lostine rivers.
2. Determine overwinter mortality and the relative success of fall (early) migrant and spring (late) migrant life history strategies for spring Chinook salmon from tributary populations in Catherine Creek and the upper Grande Ronde, and Lostine rivers, and the relative success of fall (early) migrant and spring (late) migrant life history strategies for spring Chinook salmon from the Minam River.
3. Estimate and compare smolt survival probabilities at main stem Columbia and Snake River dams for migrants from four local, natural populations of spring Chinook salmon in the Grande Ronde River and Imnaha River subbasins.
4. Document the annual migration patterns for spring Chinook salmon juveniles from four local, natural populations in the Grande Ronde River and Imnaha River subbasins: Catherine Creek, Lostine, Minam, and Imnaha rivers.
5. Document patterns of movement for juvenile steelhead from tributary populations in Catherine Creek, the upper Grande Ronde, Lostine and the Minam rivers including data on migration timing, duration, and smolt abundance.
6. Estimate and compare survival probabilities to main stem Columbia and Snake River dams for summer steelhead from four tributary populations: Catherine Creek and the upper Grande Ronde, Lostine, and Minam rivers.
7. Evaluate methods to estimate the proportion of steelhead captured during fall trapping that are migrating out of rearing areas and will undertake a smolt migration the following spring.

Accomplishments

We accomplished all of our objectives in 2007.

Findings

Spring Chinook Salmon

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

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

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

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

Summer Steelhead

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

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

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

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

Stream Condition

Daily mean water temperature typically fell within DEQ standards in all four study streams while the 2005 BY of spring Chinook salmon were in the Grande Ronde River Subbasin (1 August 2005–30 June 2007). The 2005 BY encountered daily mean water temperature in excess of the DEQ standard of 17.8°C for 43 of 596 days in the upper Grande Ronde River, 26 of 661 days Catherine Creek, 0 of 698 days in the Lostine River, and 59 of 698 days Minam River. Daily mean water temperatures in excess of 17.8°C occurred intermittently while eggs may have been being deposited in redds (August 2005), intermittently during parr rearing stages (June–August 2006), and during several days of early dispersal (August–September 2006) in the upper Grande Ronde River, Catherine Creek and the Minam River. Daily mean water temperature did not

exceed 17.8°C on any day in the Lostine River. Temperatures preferred by juvenile Chinook salmon (10–15.6°C) occurred for 20% of the hours logged in the upper Grande Ronde River, 18% of the hours logged in Catherine Creek, 23% of the hours logged in the Lostine River and 16% of the hours logged in the Minam River. These optimal temperatures tended to occur May–June and August–October in all four study streams. Maximum water temperature considered lethal to Chinook salmon was encountered 10 of 596 days in the upper Grande Ronde River, two of 661 days in Catherine Creek, and 11 of 698 days in the Minam River. The moving mean of maximum daily water temperature showed that temperatures below the limit for healthy growth (4.4°C) occurred more often than temperature above the limit for healthy growth (18.9°C) in all four study streams. With the exception of the upper Grande Ronde River during January of 2006, stream discharge was relatively low and stable August through March. Spring run-off typically occurred April–May through July–August with peak flows occurring mid-May in all four study streams.

Management Implications and Recommendations

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

INTRODUCTION

The Grande Ronde River originates in the Blue Mountains of northeast Oregon and flows 334 km to its confluence with the Snake River near Rogersburg, Washington. The Grande Ronde River Subbasin is divided into three watershed areas: the Upper Grande Ronde River Watershed, the Lower Grande River Watershed, and the Wallowa River Watershed. The Upper Grande Ronde River Watershed includes the Grande Ronde River and tributaries from the headwaters to the confluence with the Wallowa River. The Lower Grande Ronde River Watershed includes the Grande Ronde River and tributaries, excluding the Wallowa River, from the Wallowa River to the confluence with the Snake River. The Wallowa River Watershed includes the Wallowa River and tributaries, including the Lostine and Minam rivers, from the headwaters to its confluence with the Grande Ronde River.

Historically, the Grande Ronde River Subbasin produced an abundance of salmonids including spring, summer and fall Chinook salmon, sockeye salmon, coho salmon, and summer steelhead (ODFW 1990). During the past century, numerous factors have led to a reduction in salmonid stocks such that the only viable populations remaining are spring Chinook salmon and summer steelhead. Snake River spring/summer Chinook salmon, including Grande Ronde River spring Chinook salmon, were listed as threatened under the Endangered Species Act (ESA) in 1992. Snake River steelhead, including Grande Ronde River summer steelhead, were listed as threatened under the ESA in 1997. Six spring Chinook salmon populations have been identified in the subbasin (TRT 2003): Wenaha River; Wallowa–Lostine River (includes Wallowa River, Lostine River, Bear Creek and Hurricane Creek); Minam River; Catherine Creek (includes Catherine and Indian creeks); Upper Grande Ronde River (includes the upper Grande Ronde River and Sheep Creek); and Lookingglass Creek, of which the endemic spring Chinook salmon population is considered extinct. Four summer steelhead populations have been identified in the subbasin (TRT 2003): Lower Grande Ronde River (includes the main stem Grande Ronde River and all tributaries, except Joseph Creek, upstream to the confluence of the Wallowa River); Joseph Creek; Wallowa River (includes Minam and Lostine rivers); and Upper Grande Ronde River (includes the main stem upper Grande Ronde River, Lookingglass Creek, Catherine Creek, Indian Creek, and tributaries).

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

sensitive to fish and aquatic habitats, but the effects of past management remain (Nowak 2004).

Development of sound recovery strategies for these salmon stocks requires knowledge of stock-specific life history strategies and critical habitats for spawning, rearing, and downstream migration (Snake River Recovery Team 1993; NWPPC 1992; ODFW 1990). This project is acquiring knowledge of juvenile migration patterns, smolt production, rates of survival, and juvenile winter rearing habitat within the subbasin. This project collects data to obtain life stage specific survival estimates (egg-to-parr, parr-to-smolt, and smolt-to-adult), and includes an evaluation of the importance and frequency at which alternative life history tactics are utilized by spring Chinook salmon populations in northeast Oregon.

The spring Chinook salmon and summer steelhead smolt migration from the Grande Ronde River Subbasin occurs in spring. Data from Lookingglass Creek (Burck 1993), Catherine Creek, Grande Ronde River, and Lostine River (Keefe et al. 1994, 1995; Jonasson et al. 1997, Van Dyke et al. 2001) indicate a substantial number of juveniles move out of upper rearing areas during fall and overwinter downstream within the Grande Ronde River Subbasin. The proportion of the total migrant population these early migrants represent, and their survival to Snake and Columbia River dams varies among years and streams.

Juvenile Chinook salmon that leave upper rearing areas in Catherine Creek and the upper Grande Ronde River in fall overwinter in the Grande Ronde Valley. Much of the habitat in these mid-reaches of the Grande Ronde River is degraded. Stream conditions in the Grande Ronde River below the city of La Grande consist of both meandering and channeled sections of stream, which run through agricultural land. Riparian vegetation in this area is sparse and provides little shade or instream cover. The river is heavily silted due to extensive erosion associated with agricultural and forest management practices and mining activities. It is reasonable to suggest that salmon overwintering in degraded habitat may be subject to increased mortality due to the limited ability of the habitat to buffer against environmental extremes. The fall migration from upper rearing areas in Catherine Creek constitutes a substantial portion of the juvenile production (Jonasson et al. 2006). Therefore winter rearing habitat quantity and quality in the Grande Ronde River valley may be important factors limiting spring Chinook salmon smolt production in the Grande Ronde River.

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

Numerous enhancement activities have been undertaken in an effort to recover spring Chinook salmon populations in the Grande Ronde River Subbasin. Supplementation programs have been initiated by the Oregon Department of Fish and Wildlife, the Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce

Tribe using endemic broodstock from the upper Grande Ronde River, Catherine Creek, and Lostine River. Information collected by this project will serve as the foundation for assessing the effectiveness of programs currently underway.

SPRING CHINOOK SALMON INVESTIGATIONS

Methods

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

In-Basin Migration Timing and Abundance

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

In the Grande Ronde River Subbasin, we operated four rotary screw traps (Figure 1). In the Upper Grande Ronde River Watershed, one rotary screw trap was located below spawning and upper rearing areas in the upper Grande Ronde River near the town of Starkey at rkm 299, and a second trap was located in Catherine Creek below spawning and upper rearing areas near the town of Union at rkm 32. In the Wallowa River Watershed, one rotary screw trap was located below the majority of spawning and upper rearing areas on the Lostine River near the town of Lostine at rkm 3, and another trap was located on the Minam River below spawning and rearing areas at rkm 0. Although the intent was to operate the traps continuously through the year, there were times when a trap could not be operated due to high or low river flows or freezing conditions. There were also instances when traps were not operating due to debris blockage and mechanical breakdowns. No attempt was made to adjust population estimates for periods when traps were not operating. For this reason, estimates represent a minimum number of migrants.

Sampling and Marking: The rotary screw traps were equipped with live-boxes that safely held hundreds of juvenile spring Chinook salmon trapped over 24–72 h periods. The traps were generally checked daily, but were checked as infrequently as every third day when few fish were captured per day and environmental conditions were not severe. All juvenile spring Chinook salmon captured in traps were removed for enumeration and scanned for PIT tags. Before scanning or marking, fish were anesthetized in an aerated bath containing 40–50 mg/L of tricaine methanesulfonate (MS-222). PIT tags were injected manually with a modified hypodermic syringe as described by Prentice et al. (1986, 1990) and Matthews et al. (1990, 1992) for fish with fork length (FL) greater than 54 mm. Syringes were disinfected for 10 min in 70% isopropyl alcohol and allowed to dry between each use. A portable tagging station that consisted of a computer, PIT tag reader, measuring board, and electronic balance was used to record the tag code, fork length (± 1 mm), and weight (± 0.1 g) of tagged fish. Fork lengths (mm) and weights (g) were measured from at least 100 juvenile spring Chinook salmon each week when possible. All fish were handled and marked at stream temperatures of 16°C or less and released within 24 hours of being tagged. River height was recorded daily from permanent staff gauges and water temperatures were recorded daily at each trap location using thermographs or hand held thermometers.

Migrant abundance was estimated by conducting weekly trap efficiency tests throughout the migratory year at each trap site. Chinook salmon fry and sexually mature parr were not included in migrant abundance estimates. Trap efficiency was determined by releasing a known number of marked fish above each trap and enumerating recaptures. Immature parr that exceeded 54 mm in FL were either caudal fin-clipped or PIT-tagged, whereas fish less than 55 mm in FL were marked with a caudal fin clip only. On days when a trap stopped operating, the number of recaptured fish and the number of marked fish released the previous day were subtracted from the weekly totals. Trap efficiency was estimated by

$$\hat{E}_j = R_j / M_j, \quad (1)$$

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

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

$$\hat{N}_j = U_j / \hat{E}_j, \quad (2)$$

where \hat{N}_j is the estimated number of fish migrating past the trap for week j , U_j is the total number of unmarked fish captured that week, and \hat{E}_j is the estimated trap efficiency for week j . Total migrant abundance was estimated as the sum of weekly abundance estimates.

Variance of each weekly \hat{N} was estimated by the one-sample bootstrap method (Efron and Tibshirani 1986; Thedinga et al. 1994) with 1,000 iterations. Preliminary analysis indicated that when less than 10 fish were recaptured in a week, bootstrap variance estimates were greatly expanded. For this reason, consecutive weeks were

combined when there were fewer than 10 recaptures until total recaptures were greater or equal to 10 fish. This combined trap efficiency estimate was used in the bootstrap procedure to estimate variance of weekly population estimates. Each bootstrap iteration calculated weekly \hat{N}_j^* from equations (1 and 2) drawing R_j^* 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

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

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

The upper Grande Ronde River, Catherine Creek, and Lostine River traps were located below hatchery spring Chinook salmon release sites. The magnitude of hatchery spring Chinook salmon releases into these streams during the spring required modifications to the methods used for estimating migrant abundance of wild spring Chinook salmon at the trap sites. During low hatchery spring Chinook salmon catch periods the trap was fished continuously throughout a 24 h period as described above. During high catch periods, the trap was fished systematically (each night) for a 2 or 4 h interval using systematic two-stage sampling. Systematic sampling allowed us to reduce fish handling and overcrowding in the live-box, and avoid labor-intensive 24 h trap monitoring. Preliminary 24 h sampling indicated a strong diel pattern in spring Chinook salmon catch rates. The specific intervals were chosen because a relatively large proportion of the total daily catch was captured during these 2 and 4 h time blocks.

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

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

where \hat{P}_i is the estimated proportion of the total daily catch for sampling interval i , S_i is the total number of fish caught during sampling interval i , 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

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

where \hat{N}_s is the estimated number of fish migrating past the trap during systematic sampling, U_i is the total number of fish captured during interval i , \hat{P}_i is the proportion of daily catch from equation (9), and \hat{E} is the estimated trap efficiency. Abundance for the

total migration at the Catherine Creek, upper Grande Ronde, and Lostine river traps was determined by summing the continuous and systematic sampling estimates.

Variance for \hat{N}_s at each trap during systematic sampling was estimated by the one-sample bootstrap method (Efron and Tibshirani 1986; Thedinga et al. 1994) with 1,000 iterations. Each bootstrap iteration calculated \hat{N}_s from equations (1, 4, and 5) drawing R and S_i from the binomial distribution and U_i from the Poisson distribution. Variance of total migrant abundance was determined by summing the variance from the continuous and systematic sampling estimates.

Migration Timing and Survival to Lower Granite Dam

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

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

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

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

Both the winter and spring tag groups represented late migrants that overwintered as parr upstream of the screw traps and migrated downstream in the spring. The winter group was tagged earlier in the upper rearing areas (December 2006) than the spring group, which were tagged at the screw trap as migrants (29 January–30 June 2007). Therefore, the winter tag group experienced overwinter mortality after tagging while the

spring tag group did not. Winter tag group fish were caught, tagged, and released a minimum of 8 km above the trap sites to minimize the chance they would pass the trap sites while making localized movements during winter. Fish were caught using dip nets while snorkeling at night. The goal was to PIT-tag 500 fish in the upper Grande Ronde River, Catherine Creek, and the Lostine River for winter tag groups.

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

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

Calculations: Migration Timing: The timing of migration past Lower Granite Dam was estimated for each tag group by expanding total daily numbers of PIT tag detections relative to the proportion of river outflow and spill. This procedure was necessary because some fish may have passed undetected over the spillway and the amount of spill varies throughout the migration season. The proportion of fish that passed over the spillway was assumed to be directly related to the proportion of flow spilled. This assumption conforms fairly well to data obtained using non-species-specific hydroacoustic methods (Kuehl 1986). It was also assumed that there was no temporal variation either in the proportion of fish diverted from turbine intakes into the bypass system or in the proportion of fish that passed through the surface bypass collector. These assumptions were made in light of evidence to the contrary (Giorgi et al. 1988, Swan et al. 1986, Johnson et al. 1997) because the data required to account for such variation were unavailable. The extent to which the results may be biased would depend on the overall rates of fish passage via the bypass system and surface bypass collector, and on the degree to which daily rates of fish passage by these routes may have varied throughout the migration seasons. The number of fish in a particular tag group migrating past Lower Granite Dam by day (\hat{N}_d) was estimated by multiplying the number of fish from the tag group that were detected each day by a daily expansion factor calculated using Lower Granite Dam forebay water flow data obtained from the U.S. Army Corps of Engineers at the DART website (www.cbr.washington.edu/dart/river.html):

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

where D_d is the number of PIT tagged fish from a tag group detected at Lower Granite Dam on day d , O_d is the outflow (kcfs) measured at Lower Granite Dam forebay on day d , and L_d is the spill at Lower Granite dam spill (kcfs) on day d . Each daily estimate was rounded in the nearest integer. Daily estimates were added for each week to obtain weekly migration timing estimates for each tag group, which were reported graphically. First and last arrival dates were reported for each tag group. The median arrival date of

each tag group was determined from the daily estimates. Late migrants are tagged while fish are actively migrating seaward, whereas PIT tagged early migrants stop migrating and overwinter prior to resuming seaward migration in the spring. Simulated chi-square tests using the number of PIT tag releases and the estimated number of migrants for each week have shown that these two variables are independent when both trap efficiency estimates and annual peaks in movement vary (random). Therefore, median arrival dates may be biased on the distribution of PIT tag releases. In hopes of reducing this bias we used winter tag group to represent the late migrants when comparing migration timing differences with early migrants. The travel times for the spring tag groups to reach Lower Granite Dam from the screw traps were summarized for each location.

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

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

$$\hat{S}_{s,overwinter} = \frac{\hat{S}_{s,winter}}{\hat{S}_{s,spring}} \quad (7)$$

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

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

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

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

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

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

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

Results and Discussion

In-Basin Migration Timing and Abundance

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

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

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

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

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

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

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

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

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

Size of Migrants: A comparison of mean lengths and weights of juvenile spring Chinook salmon captured in the traps as early and late migrants and in upper rearing areas in winter and those PIT-tagged and released are given in Tables 3 and 4. Length frequency distributions of juvenile spring Chinook salmon caught in all traps by migration period are shown in Figure 3. Weekly mean lengths of migrants generally increased over time at each of the traps (Figure 4).

Migration Timing and Survival to Lower Granite Dam

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

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

median arrival dates (Appendix Table A-2).

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

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

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

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

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

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

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

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

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

SUMMER STEELHEAD INVESTIGATIONS

Methods

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

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

In-Basin Migration Timing and Abundance

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

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

of steelhead (10 fish/10 mm FL group). During the spring migration period, scales were collected from a random sample of steelhead migrants regardless of size. Descriptive statistics and an age–length key were used to describe the age structure of early and late migrants collected at each trap site.

Migration Timing and Survival to Lower Granite Dam

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

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

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

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

Results and Discussion

In-Basin Migration Timing and Abundance

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

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

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

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

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

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

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

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

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

Migration Timing and Survival to Lower Granite Dam

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

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

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

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

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

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

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

STREAM CONDITION INVESTIGATIONS

Methods

Stream Temperature and Flow

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

Stream discharge was obtained from data logged at upper Grande Ronde River (station 13317850; rkm 321.9), Catherine Creek (station 13320000; rkm 38.6), Lostine River (station 13330300; rkm 1.6) and Minam River (station 13331500; rkm 0.4) gauging stations that measured discharge (cubic foot per second, cfs) every 15 minutes. Average daily discharge was converted to the nearest 0.001 cubic meters per second (m³/s).

Results and Discussion

Stream Temperature and Flow

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

eggs were deposited into spawning gravel, upper rearing, dispersal, and emigration seaward. Moving mean temperatures were less than 4.4°C on 201 days (12 January–8 March 2005) during incubation, winter rearing, and dispersal for the first couple days of spring migration.

Due to the unavailability of discharge data collected by OWRD at the time of submission of this report, stream flow characteristics were analyzed only for the first 14 months of the in-basin life history of BY 2005 upper Grande Ronde River Chinook salmon. Average daily discharge (station located at the upper end of summer rearing distribution) during this time ranged from a low of 0.176 to a high of 8.893 m³/s (Figure 19). Discharge was less than 1.00 m³/s on 143 of 144 days from August through late December 2005. Discharge was 1.00 m³/s or greater on 63 of 65 days from late April through June 2006, with annual peak flow of 8.893 m³/s occurring 21 May 2006. In addition to the usual spring increase, stream discharge exceeded 1.00 m³/s for 23 days during the winter (23 December 2005–14 February 2006) peaking at 7.363 m³/s on 4 January 2006.

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

Due to the unavailability of discharge data collected by OWRD at the time of submission of this report, stream flow characteristics were analyzed only for the first 14 months of the in-basin life history of BY 2005 Catherine Creek Chinook salmon. Average daily discharge (station located in the lower end of summer rearing distribution) during this time ranged from a low of 0.566 to a high of 29.736 m³/s (Figure 19). Discharge was less than 2.00 m³/s on 230 of 236 days from August 2005 through late March 2006. Discharge was 2.00 m³/s or greater on 108 days from late April through mid-July, with annual peak flow of 29.736 m³/s on 20 May 2006.

Lostine River: Water temperatures during the in-basin life history of BY 2005 Lostine River Chinook salmon ranged from a low of 0.0°C to a high of 20.8°C. Daily

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

Average daily discharge (station located at the lower end of summer rearing distribution) during the entire in-basin life history of the 2005 cohort ranged from a low of 0.263 to a high of 45.595 m³/s (Figure 19). Discharge was greater than 7.5 m³/s on 69 of 75 days from late April through mid-July 2006, with annual peak flow occurring on 20 May 2006 and 5 June 2007. Discharge was less than 7.5 m³/s on 266 of 272 days from mid-July through April 2007. In addition to the usual spring increase, stream discharge exceeded 7.5 m³/s for a five day period in mid November with a peak of 32.002 m³/s on 7 November 2006. Spring flows between 1 March and 30 June were on average lower in 2007 than in 2006 (9.05 m³/s and 11.44 m³/s respectively).

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

Average daily discharge (station located at the lower end of summer rearing distribution) during the entire in-basin life history of the 2005 cohort ranged from a low of 1.558 to a high of 112.714 m³/s (Figure 19). Discharge was greater than 9.0 m³/s on 113 of 114 days from late March through mid-July 2006, with annual peak flow occurring on 20 May 2006 and 5 June 2007. Discharge was less than 9.0 m³/s on 203 of

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

FUTURE DIRECTIONS

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

REFERENCES

- 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.
- Efron, B., and R. Tibshirani. 1986. Bootstrap methods for standard errors, confidence intervals, and other measures of statistical accuracy. *Statistical Science* 1: 54–77.
- 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.
- 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.
- 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 2.2b, 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.
- 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.
- Snake River Recovery Team. 1993. Draft Snake River salmon recovery plan recommendations. National Marine Fisheries Service, Portland, OR.

- Swan, G. A., R. F. Krema, 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.
- 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, J. W. Steele, 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 2006. 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.

Table 1. Dates of tagging and number of spring Chinook salmon parr PIT-tagged on various northeast Oregon streams during the summers of 2005 and 2006.

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

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

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

^a Continuous 24 h trapping

^b Sub-sampling with 2 or 4 h trapping.

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

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

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

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

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

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

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

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

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

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

^a Continuous 24 h trapping

^b Sub-sampling with 2 or 4 h trapping.

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

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

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

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

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

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

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

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

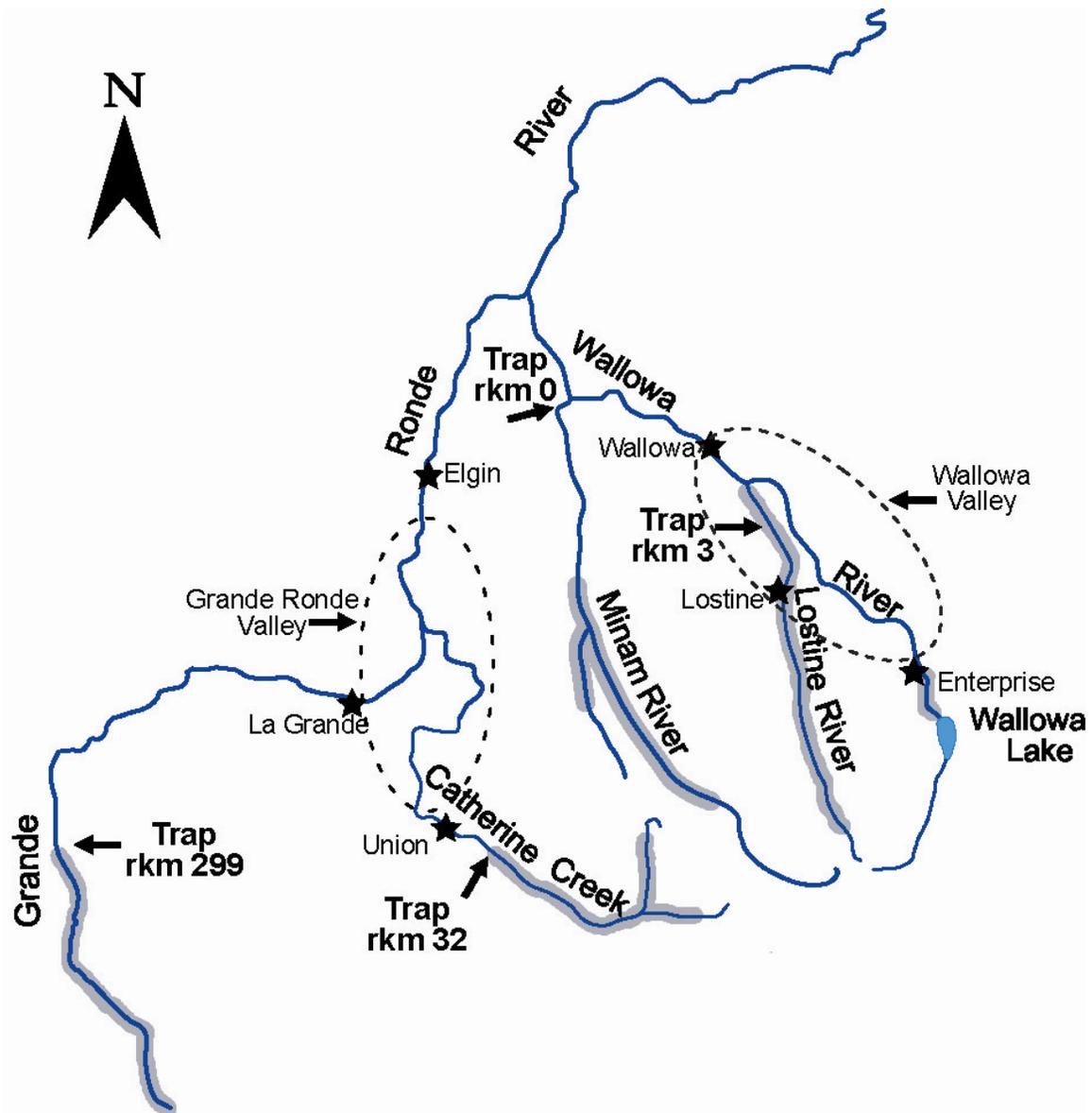


Figure 1. Locations of fish traps in the Grande Ronde River Subbasin during the study period. Shaded areas delineate spring Chinook salmon spawning and upper rearing areas in each study stream. Dashed lines indicate the Grande Ronde River and Wallowa River valleys.

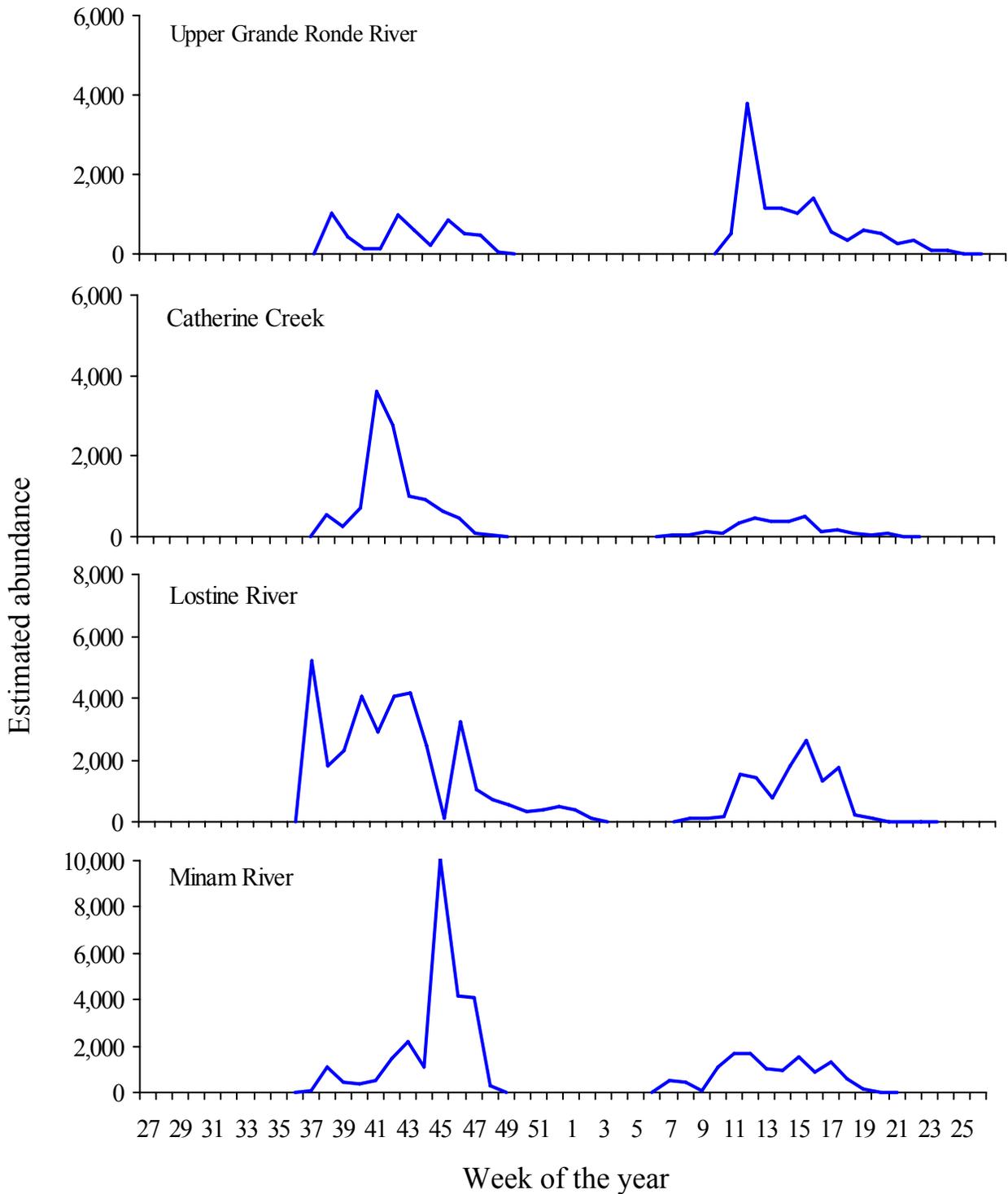


Figure 2. Estimated migration timing and abundance of juvenile spring Chinook salmon migrants captured by rotary screw traps during MY 2007. Traps were located at rkm 299 of the Grande Ronde River, rkm 32 of Catherine Creek, rkm 3 of the Lostine River, and rkm 0 of the Minam River.

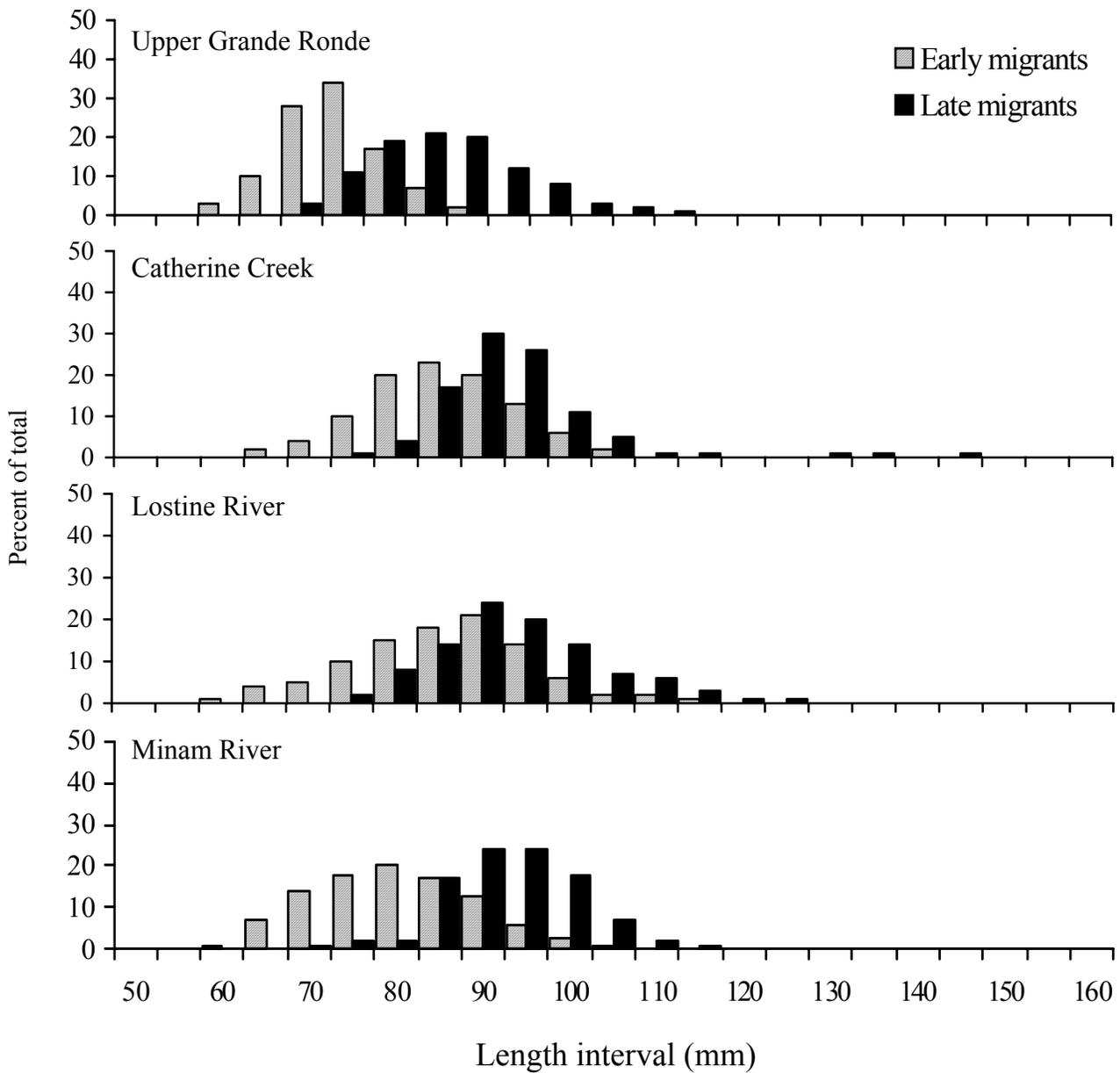


Figure 3. Length frequency distribution (fork length) of early and late migrating juvenile spring Chinook salmon captured at the Catherine Creek (rkm 32), Grande Ronde Valley (rkm 164), Lostine River (rkm 3), and Minam River (rkm 0) traps during the 2007 migratory year.

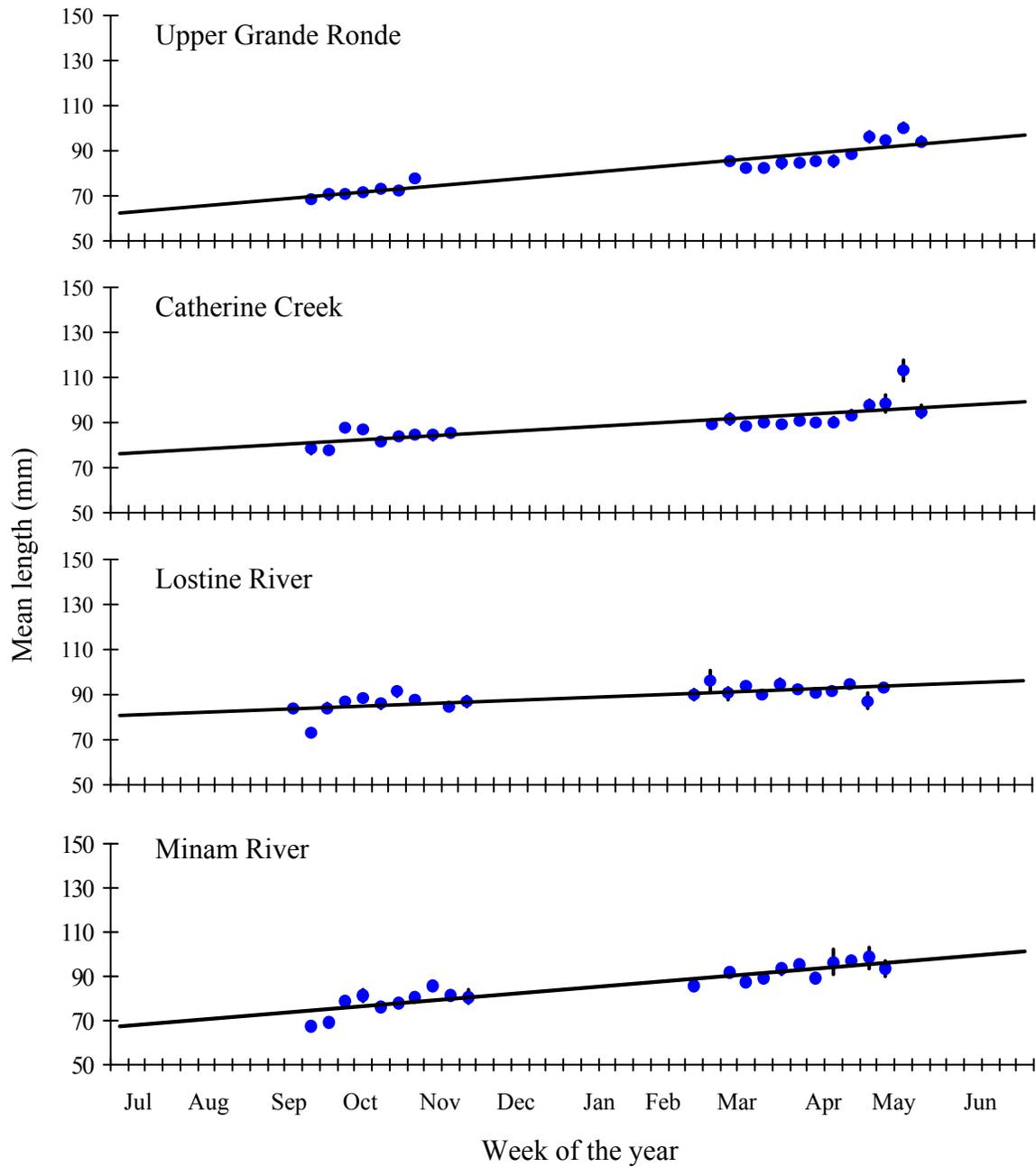


Figure 4. Weekly mean fork lengths (mm) with standard error for spring Chinook salmon captured in rotary screw traps in the Grande Ronde River Subbasin during MY 2007.

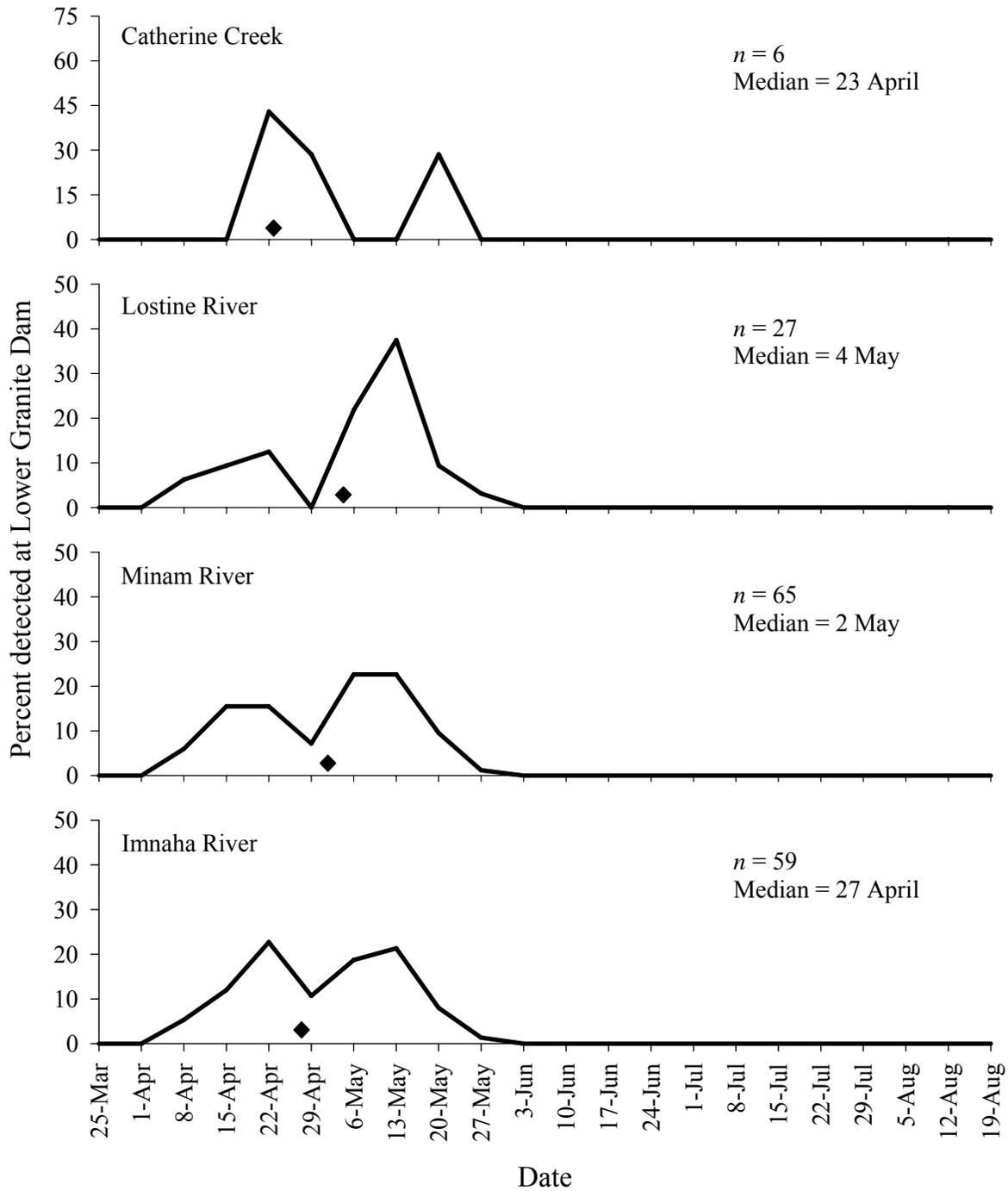


Figure 5. Dates of arrival in 2007 at Lower Granite Dam of spring Chinook salmon PIT-tagged as parr on Catherine Creek and the Imnaha, Lostine, and Minam rivers during the summer of 2006 summarized by week and expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections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

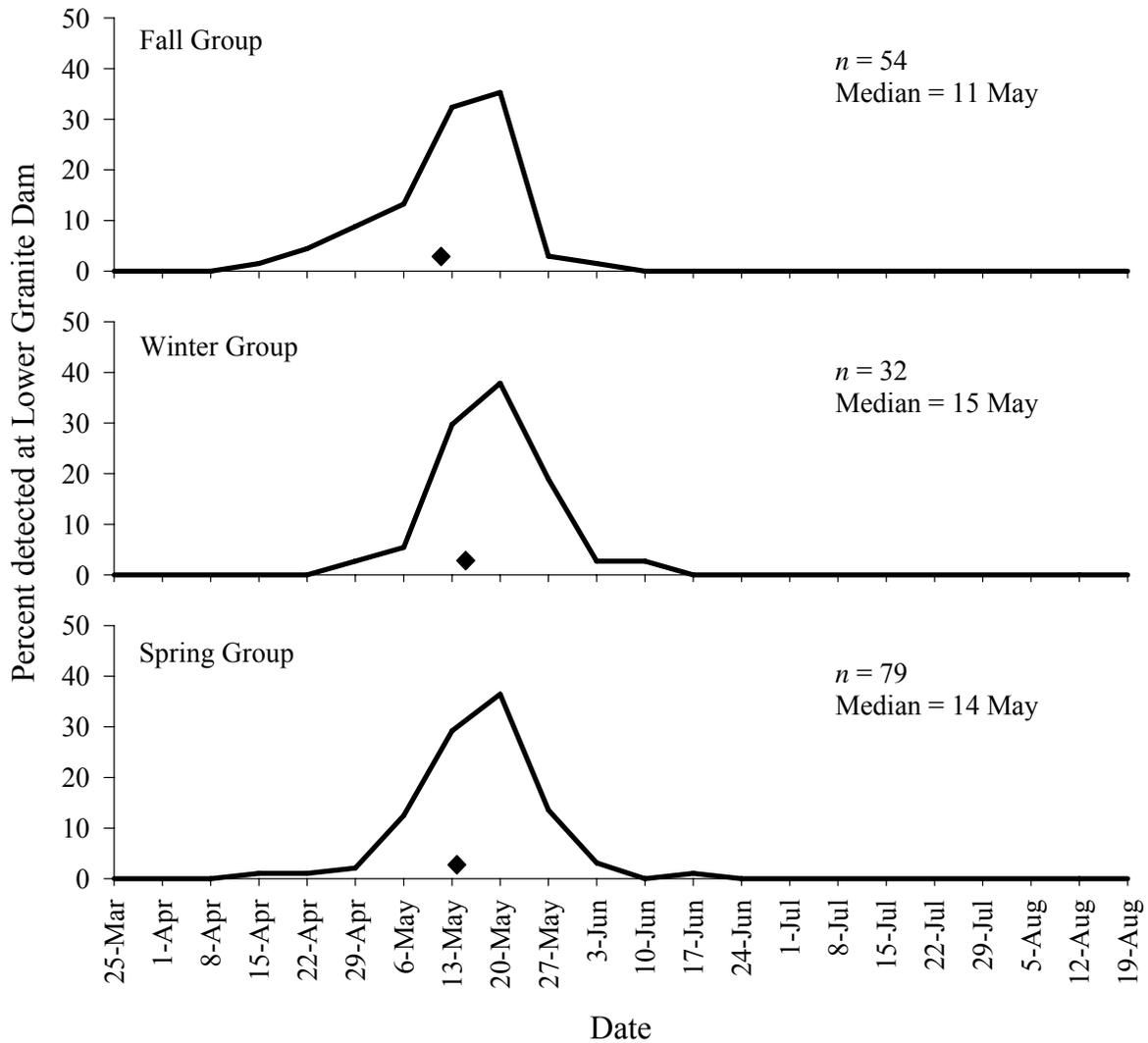


Figure 6. Dates of arrival in 2007 at Lower Granite Dam for the fall, winter, and spring tag groups of juvenile spring Chinook salmon PIT-tagged on the upper Grande Ronde River, expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway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

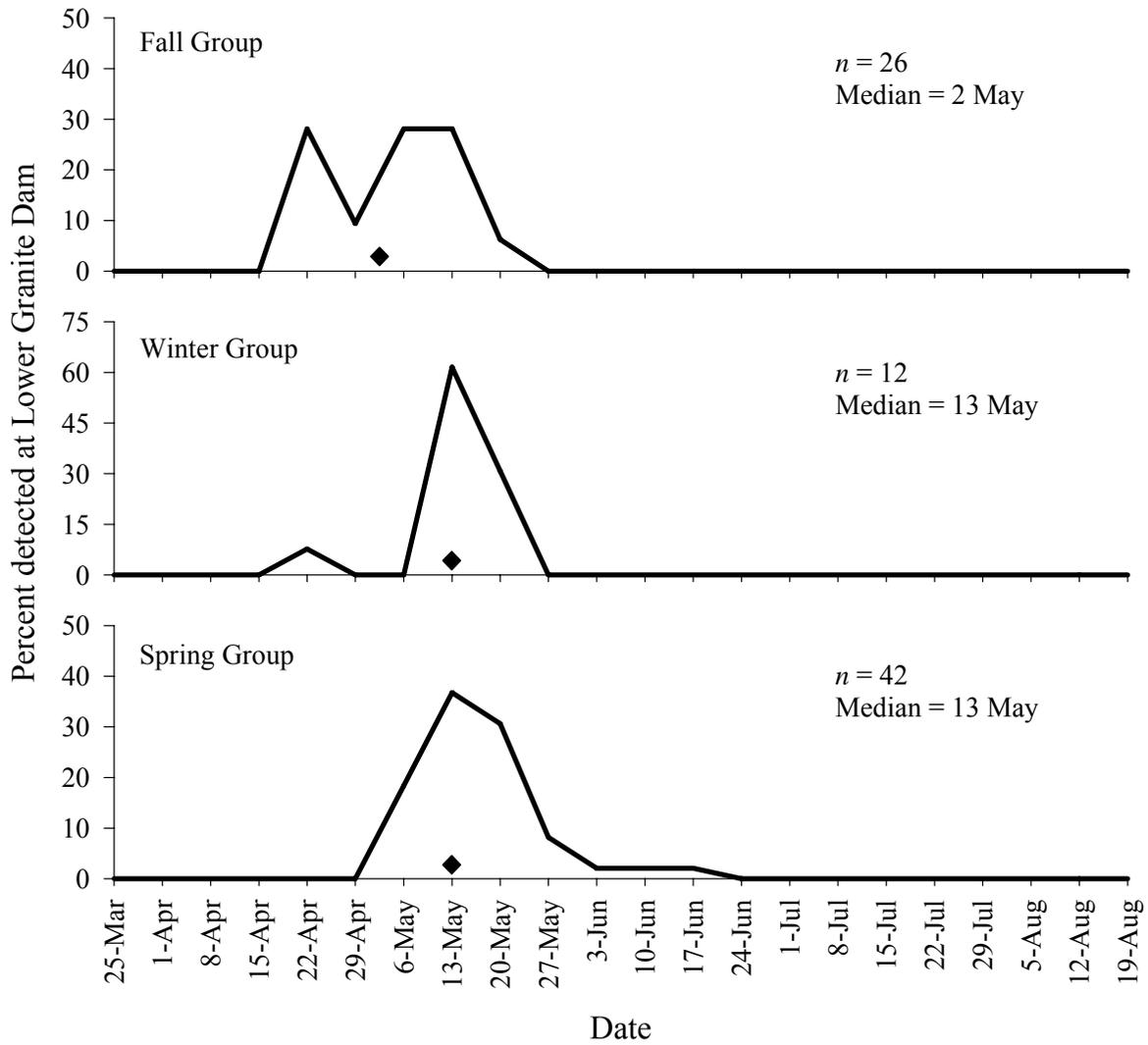


Figure 7. Dates of arrival in 2007 at Lower Granite Dam for the fall, winter, and spring tag groups of juvenile spring Chinook salmon PIT-tagged on Catherine Creek, expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

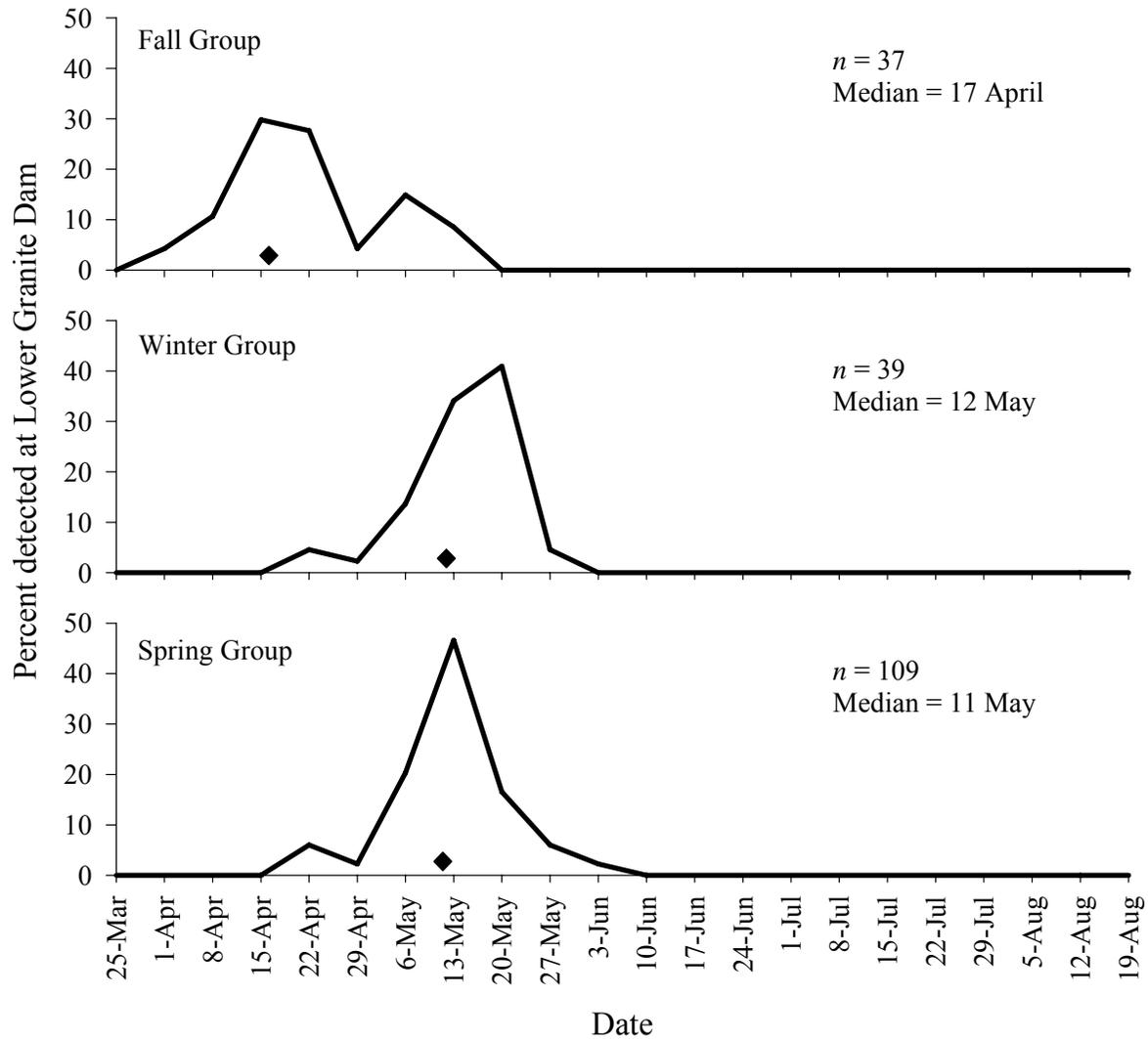


Figure 8. Dates of arrival in 2007 at Lower Granite Dam for the fall, winter, and spring tag groups of juvenile spring Chinook salmon PIT-tagged on the Lostine River, expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

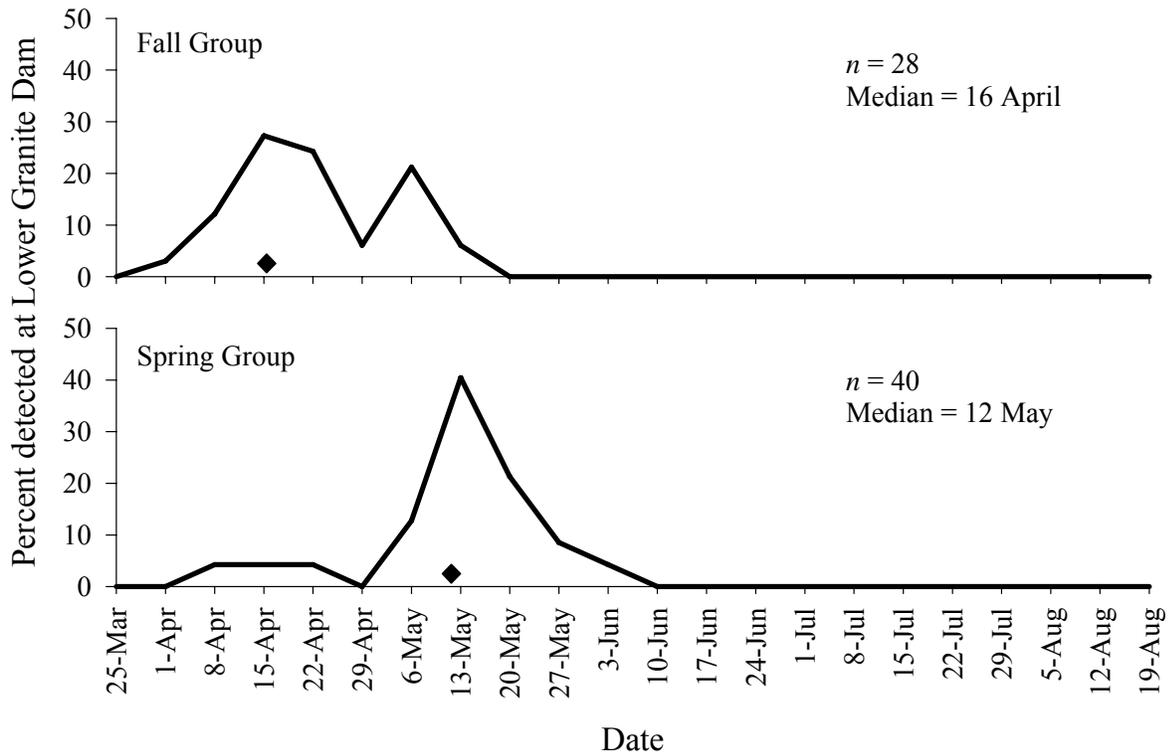


Figure 9. Dates of arrival in 2007 at Lower Granite Dam for the fall, winter, and spring tag groups of juvenile spring Chinook salmon PIT-tagged on the Minam River, expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

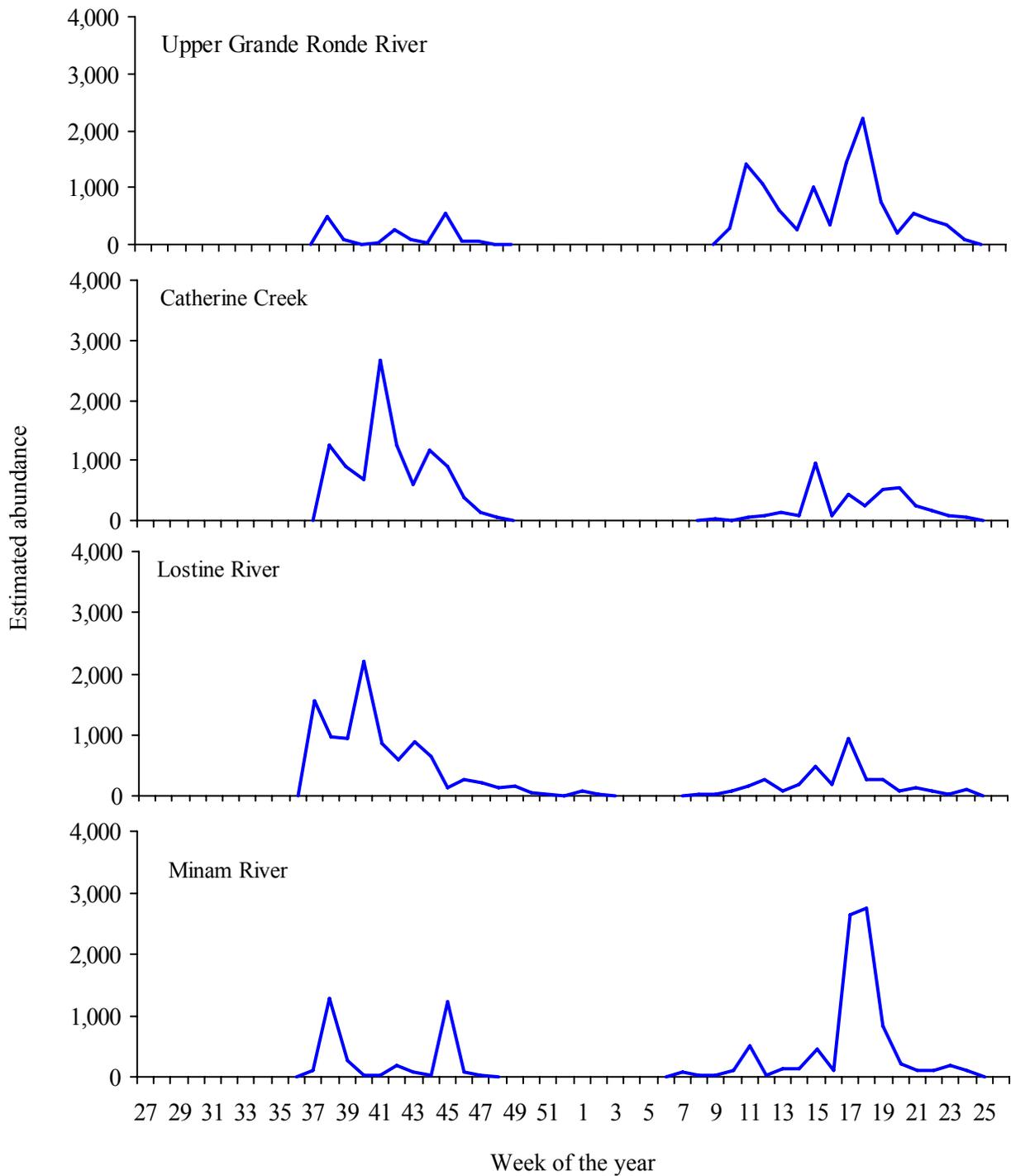


Figure 10. Estimated abundance and migration timing of steelhead migrants captured by rotary screw traps, during MY 2007. Traps were located at rkm 299 of the Grande Ronde River, rkm 32 of Catherine Creek, rkm 3 of the Lostine River, and rkm 0 of the Minam River.

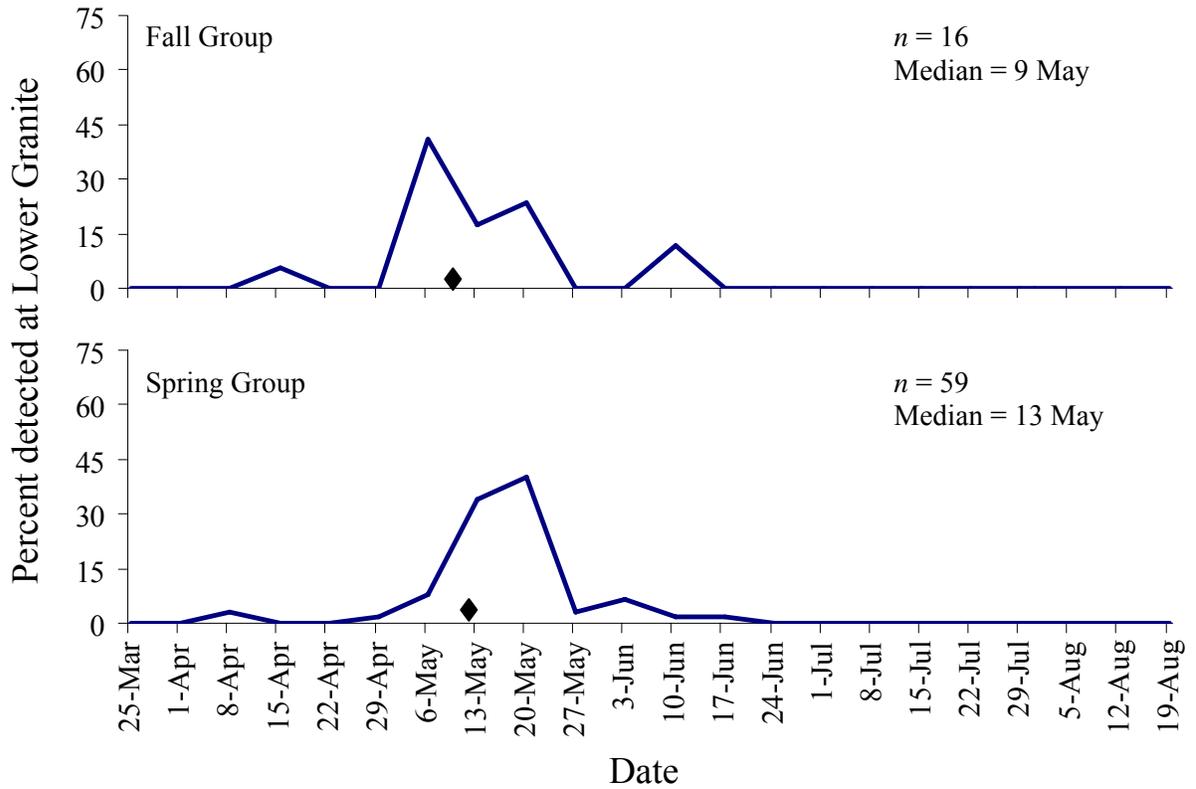


Figure 11. Dates of arrival in 2007 at Lower Granite Dam for the fall and spring tag groups of steelhead PIT-tagged on the upper Grande Ronde River, expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

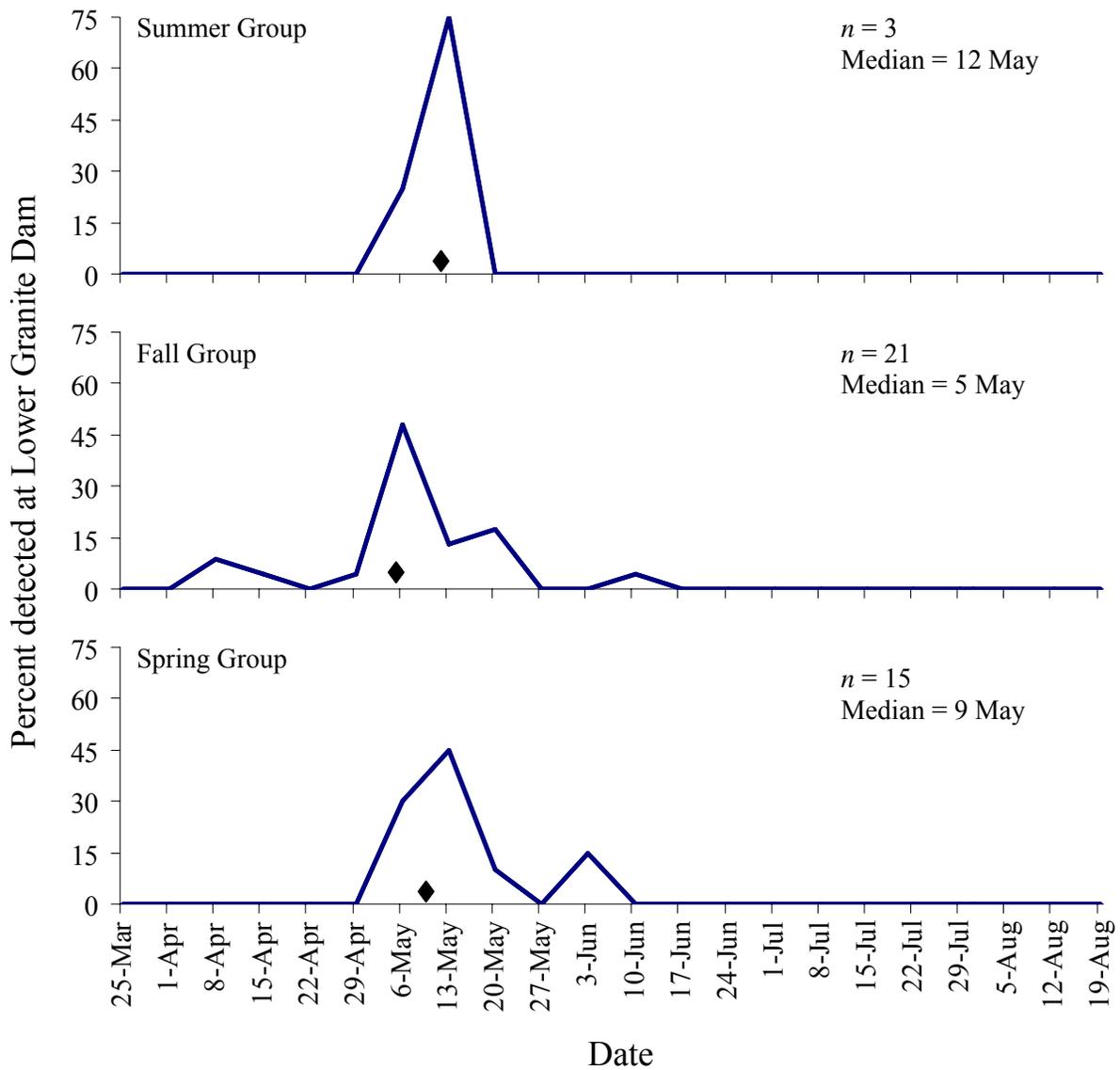


Figure 12. Dates of arrival in 2007 at Lower Granite Dam for the summer, fall, and spring tag groups of steelhead PIT-tagged on Catherine Creek, expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

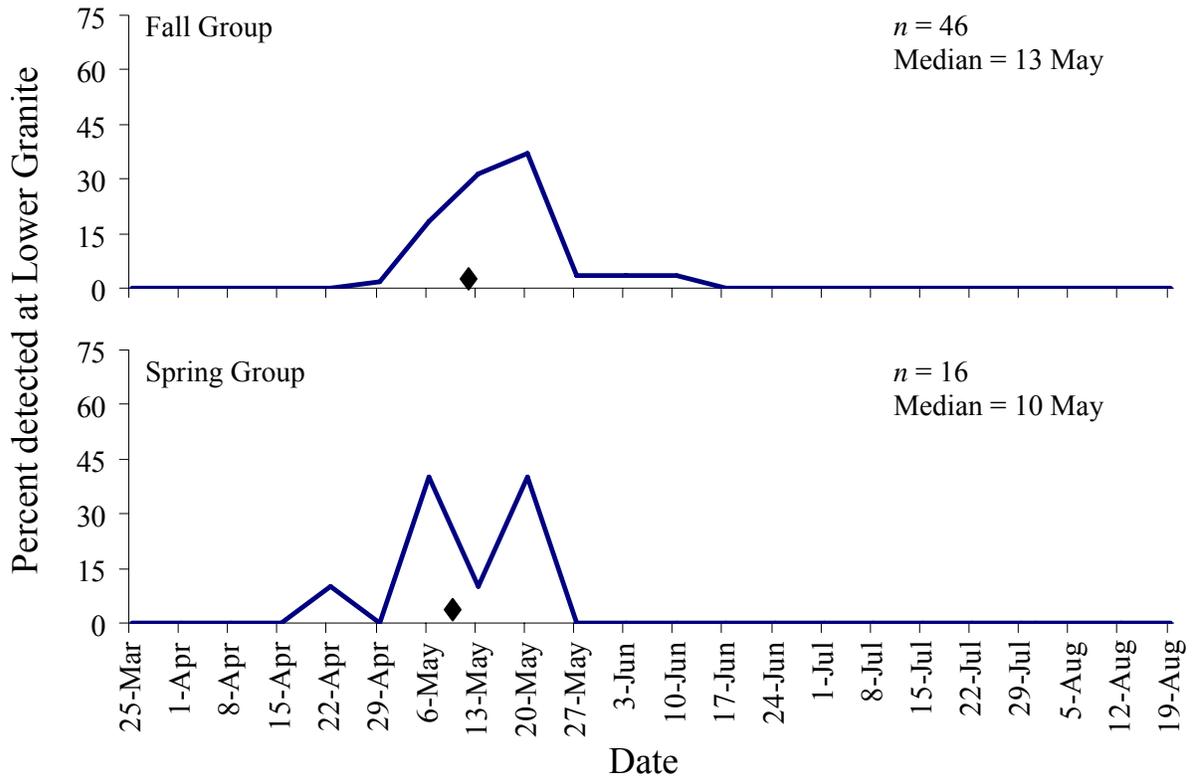


Figure 13. Dates of arrival in 2007 at Lower Granite Dam for the fall and spring tag groups of steelhead PIT-tagged on the Lostine River, expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

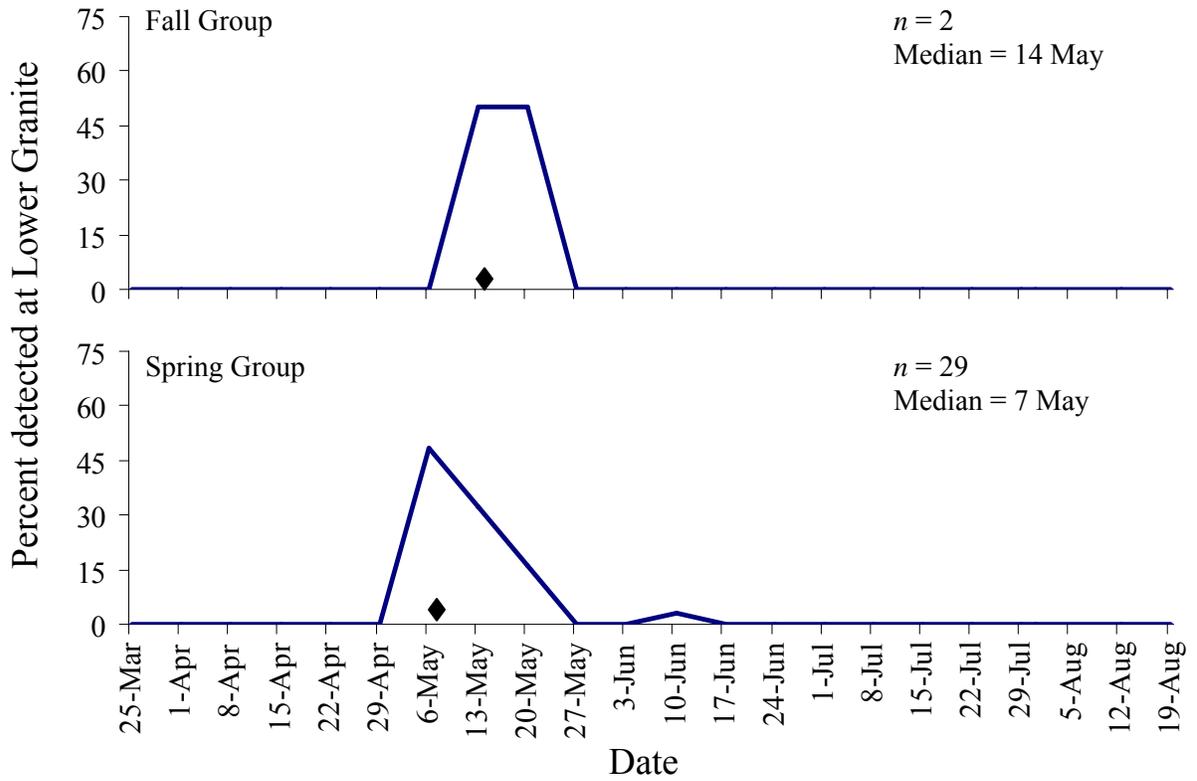


Figure 14. Dates of arrival in 2007 at Lower Granite Dam for the fall and spring tag groups of steelhead PIT-tagged on the Minam River, expressed as a percentage of the total detected for each group. ♦ = median arrival date. Detections were expanded for spillway flow.

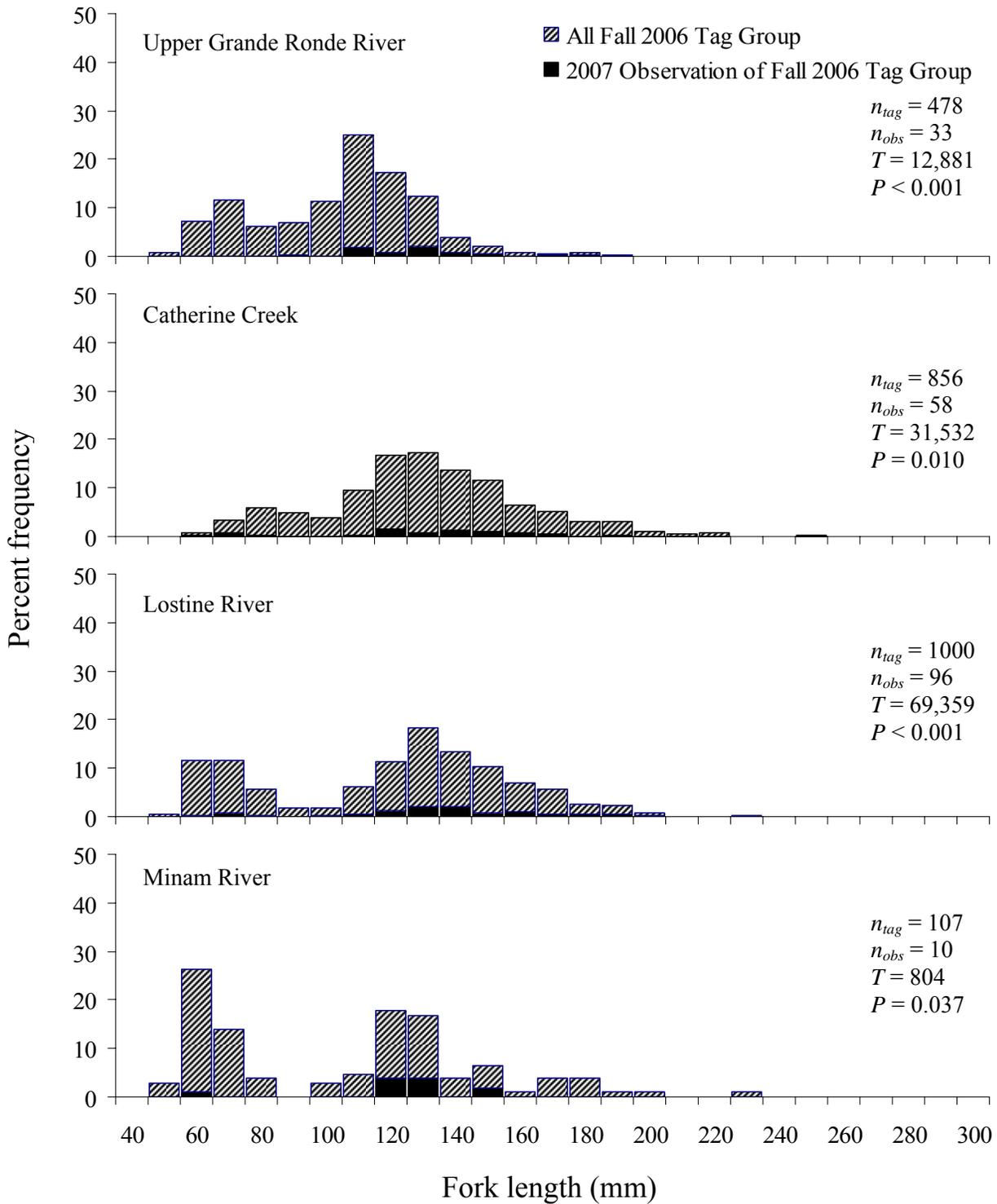


Figure 15. Length frequency distributions for all steelhead PIT-tagged at screw traps in the fall of 2006 and those subsequently observed at Snake River or Columbia River dams in 2007. Fork lengths are based on measurements taken at the time of tagging. Frequency is expressed as the percent of the total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

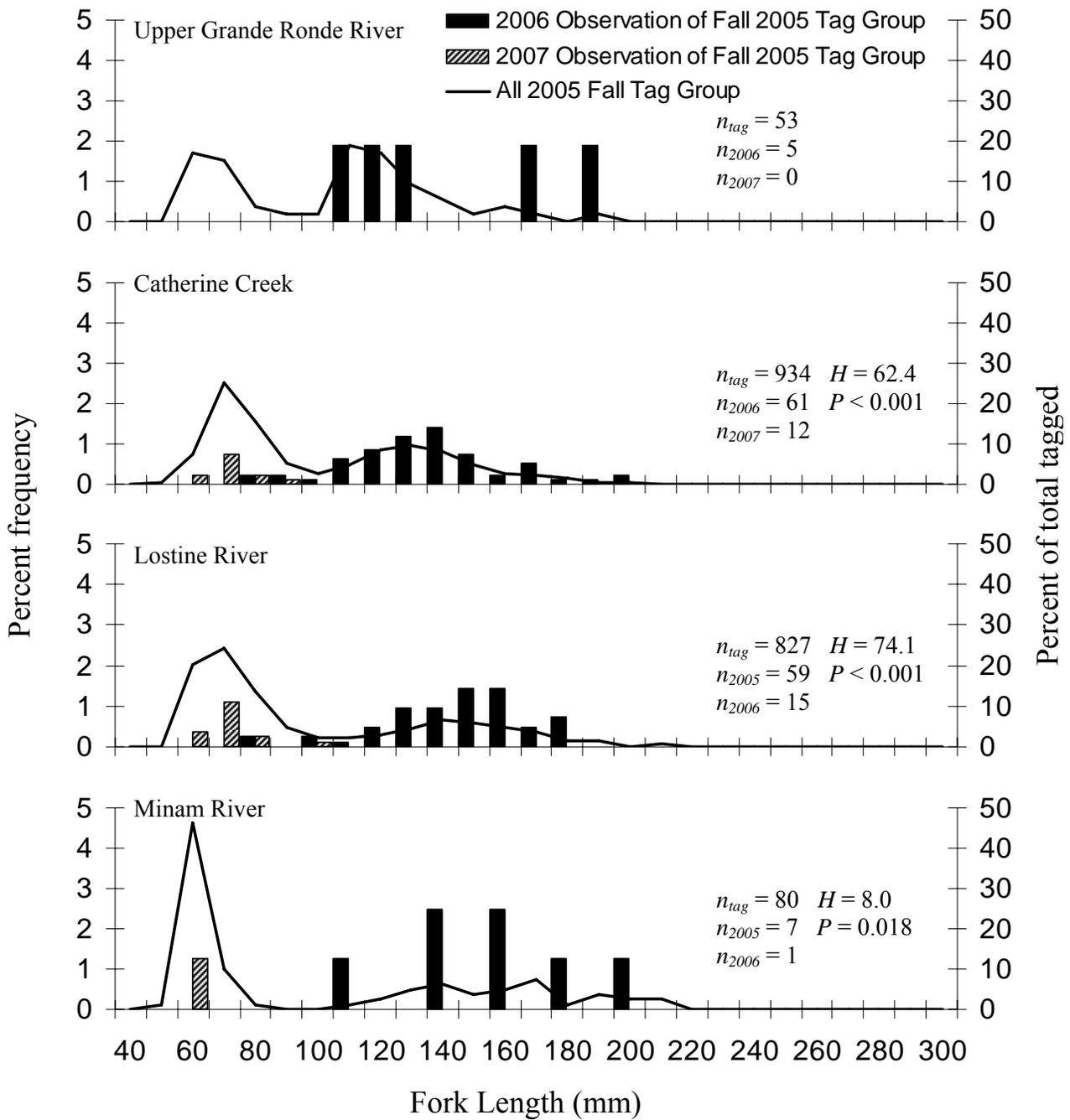


Figure 16. Length frequency distributions for all steelhead PIT-tagged at screw traps in the fall of 2005, and those subsequently observed at Snake River or Columbia River dams in 2006 and 2007. Fork lengths are based on measurements taken at the time of tagging. Frequency is expressed as the percent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

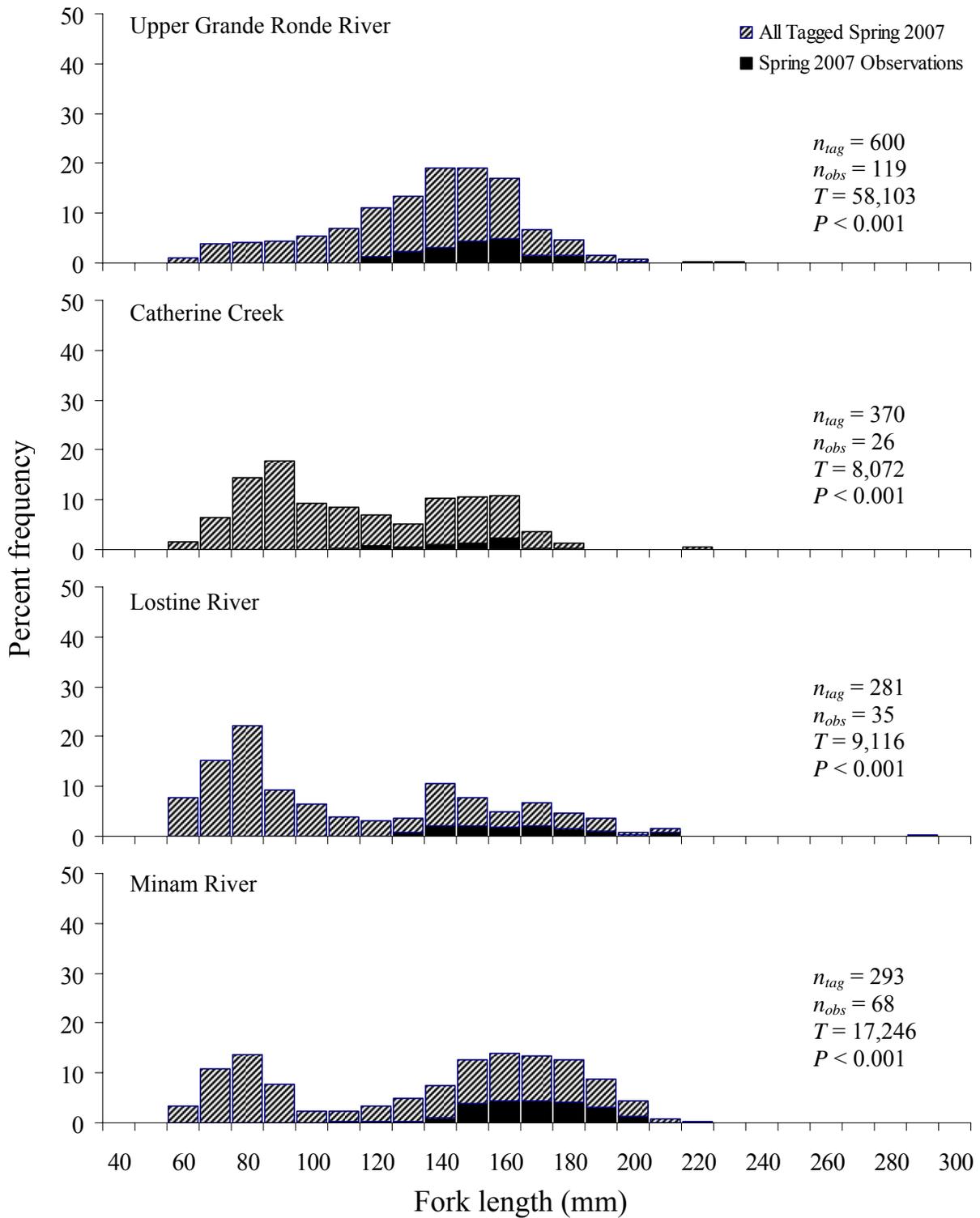


Figure 17. Length frequency distributions for all steelhead PIT-tagged at screw traps in the spring of 2007 and those subsequently observed at Snake River or Columbia River dams in 2007. Fork lengths are based on measurements taken at the time of tagging. Frequency is expressed as the percent of the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

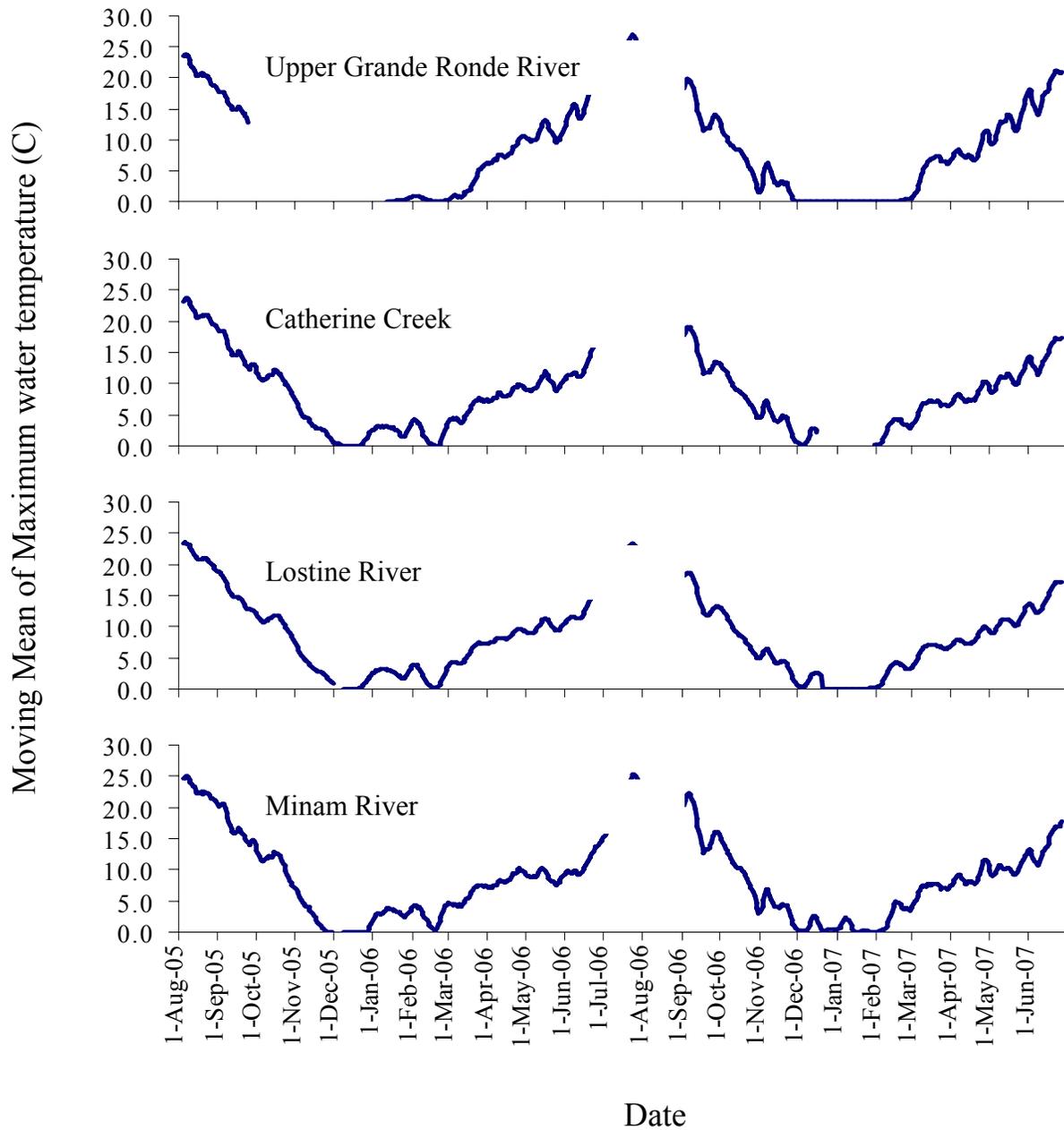


Figure 18. Moving mean of maximum water temperature during the in-basin life stages of egg-to-emigrant for juvenile spring Chinook salmon that migrated from four study streams in the Grande Ronde River basin during migratory year 2007. Missing portions of a trend line represent periods where data were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

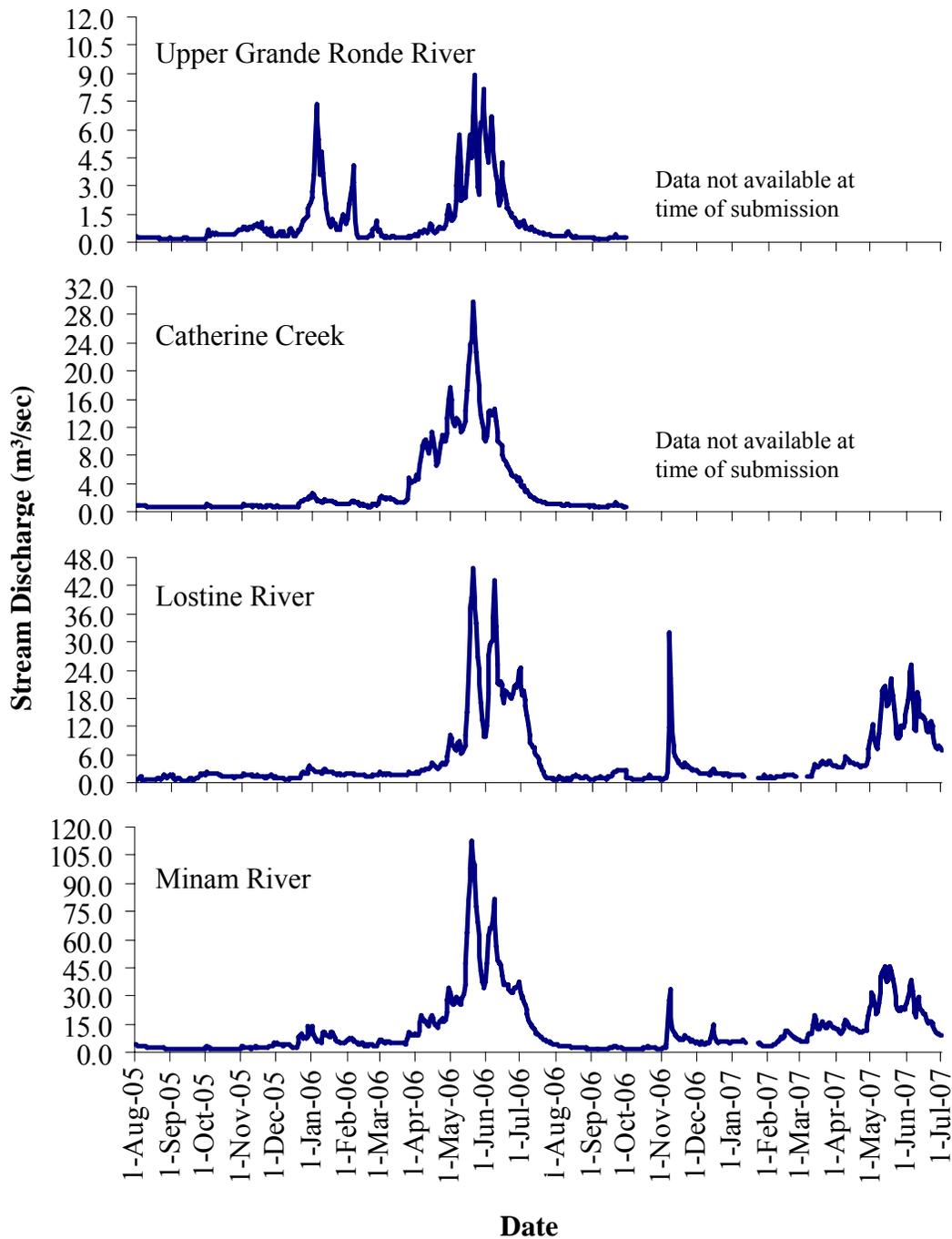


Figure 19. Average daily discharge during the in-basin life stages of egg-to-emigrant for juvenile spring Chinook salmon that migrated from the Lostine and Minam rivers during migratory year 2007. Discharge data was not available for the upper Grande Ronde River and Catherine Creek.

APPENDIX A

A Compilation of Spring Chinook Salmon Data

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

| Stream, MY | Population estimate | 95% CI | Median migration date | | 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 |
| 2007 | 17,109 | 1,708 | 20 Oct | 13 Mar | 69 |
| Catherine Creek | | | | | |
| 1995 | 17,633 | 2,067 | 1 Nov ^a | 21 Mar | 49 ^a |
| 1996 | 6,857 | 688 | 20 Oct | 11 Mar | 27 |
| 1997 | 4,442 | 1,123 | 1 Nov ^a | 13 Mar | 10 ^a |
| 1998 | 9,881 | 1,209 | 30 Oct | 19 Mar | 29 |
| 1999 | 20,311 | 2,299 | 14 Nov | 23 Mar | 38 |
| 2000 | 23,991 | 2,342 | 31 Oct | 23 Mar | 18 |
| 2001 | 21,936 | 2,282 | 8 Oct | 24 Mar | 13 |
| 2002 | 23,362 | 2,870 | 12 Oct | 2 Apr | 9 |
| 2003 | 34,623 | 2,615 | 28 Oct | 20 Mar | 14 |
| 2004 | 64,012 | 4,203 | 1 Nov | 18 Mar | 16 |
| 2005 | 56,097 | 6,713 | 11 Oct | 26 Mar | 10 |
| 2006 | 27,218 | 2,368 | 31 Oct | 22 Mar | 16 |
| 2007 | 13,831 | 1,032 | 14 Oct | 29 Mar | 21 |

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

^b Trap was located at rkm 257.

^c Median date based on small sample size: MY 1996, $n=4$; MY 1997, $n=6$; MY 2001, $n=2$.

^d Limited trapping operations prevented complete population estimates and migration timing

Appendix Table A-1. Continued.

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

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

^b Trap was located at rkm 257.

^c Median date based on small sample size: MY 1996, $n=4$; MY 1997, $n=6$; MY 2001, $n=2$.

^d Limited trapping operations prevented complete population estimates and migration timing

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

| Stream, MY | Tag group | Migration period | Number tagged | Number detected at LGD | Arrival dates | | |
|------------------------------------|--------------|---------------------|------------------|------------------------------|---------------|--------|--------|
| | | | | | Median | First | Last |
| Upper Grande Ronde River (rkm 299) | | | | | | | |
| 1993 | Summer | All | 918 | 117 | 17 May | 23 Apr | 20 Jun |
| 1994 | Summer | All | 1,001 | 57 | 29 May | 23 Apr | 29 Aug |
| | Fall | Early | 405 | 65 | 30 Apr | 21 Apr | 23 Jun |
| | Winter | Late | 505 | 27 | 29 May | 28 Apr | 16 Jul |
| | Spring | Late | 573 | 93 | <i>15 May</i> | 20 Apr | 06 Aug |
| 1995 ^a | Summer | All | 1,000 | 89 | 29 May | 12 Apr | 1 Jul |
| | Fall | Early | 424 | 57 | 5 May | 11 Apr | 2 Jun |
| | Winter | Late | 433 | 30 | 28 May | 17 Apr | 4 Jul |
| | Spring | Late | 368 | 109 | <i>2 Jun</i> | 15 Apr | 12 Jul |
| 1996 | Fall | Early | 4 | 0 | — | — | — |
| | Spring | Late | 327 | 47 | <i>16 May</i> | 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 | <i>5 May</i> | 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 | <i>4 May</i> | 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 | <i>11 May</i> | 15 Apr | 20 Jul |
| 2001 | Spring | Late | 6 | 4 | <i>17 May</i> | 4 May | 20 May |
| 2002 | Fall | Early | 344 | 20 | 20 May | 17 Apr | 2 Jun |
| | Spring | Late | 538 | 71 | <i>31 May</i> | 14 Apr | 28 Jun |
| 2003 | Fall | Early | 584 | 46 | 1 May | 3 Apr | 26 May |
| | Spring | Late | 571 | 95 | <i>17 May</i> | 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 | <i>21 May</i> | 17 Apr | 3 Jun |
| 2005 | Fall | Early | 368 | 39 | 7 May | 20 Apr | 1 Jun |
| | Winter | Late | 449 | 46 | 30 May | 3 May | 19 Jun |
| | Spring | Late | 615 | 131 | 19 May | 19 Apr | 13 Jun |

^a Trap was located at rkm 257.

Appendix Table A-2. Continued.

| Stream, MY | Tag group | Migration period | Number tagged | Number detected at LGD | Arrival dates | | |
|----------------------------------|--------------|---------------------|------------------|------------------------------|---------------|--------|--------|
| | | | | | Median | First | Last |
| Upper Grande Ronde River (cont.) | | | | | | | |
| 2006 | Fall | Early | 521 | 29 | 18 May | 16 Apr | 6 Jun |
| | Winter | Late | 464 | 12 | 3 Jun | 20 May | 14 Jun |
| | Spring | Late | 505 | 49 | 20 May | 30 Mar | 20 Jun |
| 2007 | Fall | Early | 534 | 54 | 11 May | 14 Apr | 3 Jun |
| | Winter | Late | 383 | 32 | 15 May | 27 Apr | 6 Jun |
| | Spring | Late | 501 | 79 | 14 May | 13 Apr | 11 Jun |
| Catherine Creek | | | | | | | |
| 1993 | Summer | All | 1,094 | 125 | 18 May | 29 Apr | 26 Jun |
| 1994 | Summer | All | 1,000 | 91 | 11 May | 13 Apr | 26 Jul |
| 1995 | Summer | All | 999 | 88 | 25 May | 26 Apr | 2 Jul |
| | Fall | Early | 502 | 65 | 7 May | 22 Apr | 19 Jun |
| | Winter | Late | 483 | 57 | 13 May | 27 Apr | 4 Jul |
| 1996 | Spring | Late | 348 | 88 | 5 Jun | 1 May | 8 Jul |
| | Summer | All | 499 | 60 | 1 May | 17 Apr | 29 May |
| | Fall | Early | 566 | 76 | 29 Apr | 14 Apr | 4 Jun |
| 1997 | Winter | Late | 295 | 14 | 18 May | 19 Apr | 14 Jun |
| | Spring | Late | 277 | 70 | 17 May | 17 Apr | 13 Jun |
| | Summer | All | 583 | 51 | 14 May | 24 Apr | 10 Jun |
| 1998 | 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 |
| 1999 | 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 |
| 2000 | Spring | Late | 453 | 109 | 21 May | 26 Apr | 26 Jun |
| | Summer | All | 502 | 20 | 26 May | 26 Apr | 26 Jun |
| | Fall | Early | 656 | 41 | 23 May | 19 Apr | 28 Jun |
| 2001 | Winter | Late | 494 | 35 | 29 May | 23 Apr | 9 Jul |
| | Spring | Late | 502 | 54 | 21 May | 20 Apr | 20 Jun |
| | Summer | All | 497 | 30 | 7 May | 12 Apr | 7 Jun |
| 2002 | 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 |
| 2003 | Summer | All | 498 | 33 | 17 May | 28 Apr | 3 Jul |
| | Fall | Early | 494 | 57 | 10 May | 27 Apr | 18 Jun |
| | Winter | Late | 538 | 27 | 1 Jun | 4 May | 6 Jul |
| | Spring | Late | 329 | 100 | 30 May | 29 Apr | 13 Jul |

Appendix Table A-2. Continued.

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

Appendix Table A-2. Continued.

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

Appendix Table A-2. Continued.

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

Appendix Table A-2. Continued.

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

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

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

Appendix Table A-3. Continued.

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

Appendix Table A-3. Continued.

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

Appendix Table A-3. Continued.

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

Appendix Table A-3. Continued.

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

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

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

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

Appendix Table A-4. Continued.

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

^b Limited trapping operations

Appendix Table A-5. Overwinter survival rates of spring Chinook salmon parr overwintering upstream of screw traps on Catherine Creek and the Lostine and Grande Ronde rivers. Screw traps are located on Catherine Creek at rkm 32, Lostine River at rkm 3, and Grande Ronde River at rkm 299, except MY 1995 when the upper Grande Ronde River trap was at rkm 257. Survival rates were calculated by dividing the survival probability of the winter tag group by the survival probability of the spring tag group.

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

Appendix Table A-6. Comparisons of overwinter survival of spring Chinook salmon pair 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).

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

APPENDIX B

A Compilation of Steelhead Data

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

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

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

^b Limited trapping operations prevented complete population estimates and migration timing

Appendix Table B-1. Continued.

| Stream, MY | Population estimate | 95% CI | Median migration date | | 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 |
| 2007 | 11,831 | 3,330 | 1 Oct | 30 Apr | 72 |

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

| Stream, MY | Tag group | Number tagged | Number detected | Median | Arrival dates | |
|--------------------------|-----------|------------------|--------------------|--------|---------------|--------|
| | | | | | First | Last |
| Upper Grande Ronde River | | | | | | |
| 2000 | Fall | 110 | 7 | 30 Apr | 18 Apr | 26 May |
| | Spring | 462 | 73 | 7 May | 31 Mar | 28 Jun |
| 2001 | Fall | 61 | 10 | 7 May | 28 Apr | 29 Jun |
| | Spring | 475 | 180 | 5 May | 26 Apr | 28 Aug |
| 2002 | Fall | 165 | 9 | 7 May | 26 Apr | 1 Jun |
| | Spring | 543 | 86 | 22 May | 14 Apr | 25 Jun |
| 2003 | Fall | 309 | 11 | 18 May | 8 Apr | 1 Jun |
| | Spring | 583 | 101 | 25 May | 4 Apr | 24 Jun |
| 2004 | Fall | 108 | 1 | 23 May | — | — |
| | Spring | 853 | 190 | 17 May | 15 Apr | 14 Jun |
| 2005 | Fall | 288 | 16 | 10 May | 19 Apr | 19 May |
| | Spring | 643 | 150 | 11 May | 21 Apr | 27 Jun |
| 2006 | Fall | 53 | 4 | 10 May | 25 Apr | 17 May |
| | Spring | 500 | 62 | 10 May | 15 Apr | 27 May |
| 2007 | Fall | 485 | 16 | 9 May | 15 Apr | 6 Jun |
| | Spring | 600 | 59 | 13 May | 7 Apr | 12 Jun |
| Catherine Creek | | | | | | |
| 2000 | Fall | 989 | 43 | 20 Apr | 2 Apr | 29 Jun |
| | Spring | 502 | 63 | 6 May | 6 Apr | 10 Jun |
| 2001 | Summer | 1,169 | 26 | 8 May | 25 Apr | 25 Jun |
| | Fall | 561 | 66 | 6 May | 18 Apr | 12 Jun |
| 2002 | Spring | 266 | 88 | 14 May | 22 Apr | 11 Jun |
| | Summer | 1,108 | 32 | 20 May | 14 Apr | 25 Jun |
| 2003 | Fall | 723 | 10 | 12 May | 16 Apr | 17 Jun |
| | Spring | 504 | 95 | 22 May | 20 Apr | 1 Jul |
| 2004 | Summer | 1,043 | 27 | 26 May | 26 Apr | 1 Jun |
| | Fall | 918 | 26 | 8 May | 27 Mar | 3 Jun |
| 2005 | Spring | 364 | 52 | 26 May | 22 Apr | 3 Aug |
| | Summer | 1,046 | 54 | 11 May | 10 Apr | 18 Aug |
| 2006 | Fall | 512 | 38 | 7 May | 3 Apr | 20 Jun |
| | Spring | 598 | 150 | 22 May | 26 Apr | 24 Jul |
| 2007 | Summer | 1,024 | 81 | 8 May | 4 Apr | 3 Jun |
| | Fall | 473 | 35 | 8 May | 23 Apr | 8 Jun |
| 2008 | Spring | 623 | 55 | 10 May | 18 Apr | 27 Jun |
| | Summer | 632 | 19 | 2 May | 15 Apr | 9 Jun |
| 2009 | Fall | 934 | 23 | 30 Apr | 2 Apr | 22 May |
| | Spring | 500 | 32 | 7 May | 15 Apr | 31 May |

Appendix Table B-2. Continued.

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

^a Limited trapping operations during MY 2004.

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

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

^a Data was insufficient to calculate a survival probability.

Appendix Table B-3. Continued.

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

Appendix Table B-3. Continued.

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

Appendix Table B-3. Continued.

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

^a Data was insufficient to calculate a survival probability.

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

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

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

Appendix Table B-4. Continued.

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

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

Appendix Table B-4. Continued.

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

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

| Stream, Year tagged | Year detected | N | Length at tagging (mm) | | | | |
|--------------------------|------------------|-----|------------------------|-----|------------|-----|-----|
| | | | Median | Min | Percentile | | Max |
| 25 th | 75 th | | | | | | |
| Upper Grande Ronde River | | | | | | | |
| 2000 | (a) | 453 | 133 | 71 | 108 | 152 | 225 |
| | 2000 | 99 | 155 | 115 | 139 | 166 | 208 |
| 2001 | 2001 | 6 | 80 | 72 | 77 | 109 | 126 |
| | (a) | 465 | 147 | 115 | 135 | 163 | 219 |
| 2002 | 2001 | 196 | 156 | 115 | 145 | 171 | 207 |
| | 2002 | 5 | 143 | 121 | 127 | 150 | 152 |
| 2003 | (a) | 543 | 150 | 115 | 135 | 164 | 216 |
| | 2002 | 192 | 155 | 115 | 144 | 170 | 209 |
| 2004 | 2003 | 1 | 159 | — | — | — | — |
| | (a) | 578 | 150 | 115 | 136 | 164 | 199 |
| 2005 | 2003 | 204 | 158 | 115 | 142 | 169 | 199 |
| | 2004 | 4 | 130 | 117 | 119 | 168 | 197 |
| 2006 | (a) | 853 | 123 | 60 | 82 | 147 | 204 |
| | 2004 | 228 | 148 | 98 | 135 | 167 | 202 |
| 2007 | 2005 | 31 | 81 | 64 | 74 | 98 | 123 |
| | (a) | 642 | 130 | 65 | 91 | 152 | 208 |
| 2008 | 2005 | 186 | 150 | 117 | 141 | 164 | 197 |
| | 2006 | 11 | 89 | 69 | 81 | 95 | 140 |
| 2009 | 2007 | 2 | 82 | 70 | 76 | 88 | 94 |
| | (a) | 500 | 132 | 62 | 94 | 150 | 276 |
| 2010 | 2006 | 170 | 150 | 111 | 135 | 166 | 203 |
| | 2007 | 10 | 91 | 65 | 76 | 105 | 124 |
| 2011 | (a) | 600 | 142 | 65 | 118 | 157 | 230 |
| | 2007 | 119 | 157 | 121 | 146 | 168 | 230 |
| Catherine Creek | | | | | | | |
| 2000 | (a) | 494 | 132 | 61 | 86 | 150 | 210 |
| | 2000 | 103 | 152 | 120 | 143 | 167 | 210 |
| 2001 | 2001 | 12 | 79 | 70 | 73 | 104 | 125 |
| | 2002 | 1 | 87 | — | — | — | — |
| 2002 | (a) | 247 | 142 | 115 | 131 | 154 | 190 |
| | 2001 | 96 | 150 | 115 | 138 | 161 | 190 |
| 2003 | 2002 | 2 | 120 | 115 | 117 | 122 | 124 |
| | (a) | 503 | 152 | 115 | 139 | 164 | 260 |
| 2004 | 2002 | 212 | 156 | 115 | 144 | 166 | 208 |
| | 2003 | 2 | 126 | 123 | 124 | 127 | 128 |

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

Appendix Table B-5. Continued.

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

Appendix Table B-5. Continued.

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

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

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

Appendix Table B-6. Continued.

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

Appendix Table B-6. Continued.

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