FISH RESEARCH PROJECT OREGON INVESTIGATIONS INTO THE EARLY LIFE HISTORY OF NATURALLY PRODUCED SPRING CHINOOK SALMON IN THE GRANDE RONDE RIVER BASIN

Project Period: 1 September 1995 to 31 August 1996

Annual Progress Report

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OREGON

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

ANNUAL PROGRESS REPORT

Project Period: 1 September 1995 to 3 1 August 1996

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EXECUTIVE SUMMARY

Objectives

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

2. Estimate and compare survival indices from tagging to smolt detection at mainstem Columbia and Snake River dams for juveniles that leave the upper river rearing areas at different times of the year.

3. Determine summer and winter habitat utilization and preference of juvenile spring chinook salmon in the Grande Ronde River and Catherine Creek.

Accomplishments

We accomplished all of our objectives in 1996. We were able to collect and PIT-tag only four juvenile chinook salmon during fall and no juvenile chinook salmon during winter in the upper Grande Ronde River due to their extremely low abundance.

Findings

Juvenile spring chinook salmon were captured at the upper Grande Ronde River trap in the fall from 13 October through 29 October 1995 and in the spring from 16 February through 13 May 1996. Approximately 99% of the migrants passed the upper trap during the spring period. A total of 339 spring chinook salmon migrants were captured, and we estimated that 1,15 1 migrants passed our upper trap. Juvenile spring chinook salmon were captured at the Catherine Creek trap in the summer and fall from 7 June through ice-up on 23 December 1995, and in the spring from 15 February through 11 May 1996. A total of 2,294 spring chinook salmon migrants were captured, and we estimated that 6,341 migrants passed our Catherine Creek trap. Approximately 74% of the spring chinook migrants from Catherine Creek left upper river rearing areas in the summer and fall and the remaining 26% left in the spring. Juvenile spring chinook salmon were captured in our lower Grande Ronde River trap as they left the Grande Ronde Valley from 9 October 1995 through 15 June 1996. A total of 72 1 spring chinook salmon migrants were captured, and we estimated that 9,001 migrants passed our lower Grande Ronde River trap. Over 99% of migrants passing our lower trap did so during the spring migration.

PIT-tagged spring chinook salmon from the upper Grande Ronde River population were detected at Lower Granite Dam from 19 April to 6 June 1996, with a median passage date of 16 May. The cumulative mainstem dam detection rate for fish tagged in spring was 36.1%. PIT-tagged spring chinook salmon from the Catherine Creek population were detected at Lower Granite Dam from 14 April to 6 June 1996, with a median passage date of 13 May. Cumulative mainstem dam detection rates by tag group ranged from 13.6 to 43.0%, with fish tagged during the spring migration detected at the highest rate among tag groups. Juvenile salmon tagged during their fall migration were detected at a higher rate than fish tagged during winter in the upper rearing areas, 27.9% and 13.6% respectively.

Juvenile spring chinook salmon were found in the greatest abundance in pool habitats during winter and summer surveys. During winter we observed juvenile spring chinook salmon from river kilometer (rkm) 15 to rkm 52 in Catherine Creek and in Milk and Pyles creeks near the mouths of these creeks and in the lower 1.5 km of North Fork Catherine Creek. During summer we observed juvenile chinook salmon from rkm 27 to rkm 52 in Catherine Creek and in the lower 0.8 km of Little Catherine Creek and the lower 0.1 km of Milk Creek. in the upper Grande Ronde river during summer we observed one juvenile spring chinook salmon in the Grande Ronde River and four in the lower 2 km of Fly Creek.

Management Implications and Recommendations

The Grande Ronde Valley provides more than a migration corridor for juvenile spring chinook salmon, as a portion of both the Grande Ronde River and Catherine Creek populations leave the upper rearing areas during the fall to overwinter in the Grande Ronde Valley before leaving the valley in the spring. Juvenile spring chinook salmon put on significant growth during the spring in the Grande Ronde Valley. Enhancing habitat conditions to promote overwinter survival and food production should be given priority in the Grande Ronde Valley.

Spring chinook salmon that leave the upper rearing areas of Catherine Creek during the fall and overwinter in the Grande Ronde Valley arrive at Lower Granite Dam earlier in the spring than fish that overwinter in the upper rearing areas. As spring flow patterns change in the Snake and Columbia rivers from year to year, survival rates may change for fish arriving at the dams at different periods of the migration season. In 1996, spring chinook salmon that overwintered in the Grande Ronde Valley had higher overwinter survival than fish that overwintered in the upper rearing areas, whereas in 1995, fish that overwintered in the upper rearing areas had a higher overwinter survival. These differences point out the need to maintain the diversity in life history strategies observed in the Grande Ronde River basin, as environmental conditions change from year to year and what may be a successful strategy one year may not be as successful in another year under different conditions.

Habitat should be protected or enhanced not only in the spawning streams but also in the tributaries as juvenile spring chinook salmon use the lower reaches of non-natal tributaries in addition to the spawning streams for rearing in both the Grande Ronde River and Catherine Creek. Maintenance of existing pool habitat and complexity should be a component of habitat management as juvenile spring chinook salmon are more abundant in pools than glides or riffles during both summer and winter.

INTRODUCTION

The Grande Ronde River originates in the Blue Mountains in northeast Oregon and flows 334 km to its confluence with the Snake River near Rogersburg, Washington. Historically, the Grande Ronde River produced an abundance of salmonids including stocks of spring, summer and fall chinook salmon, sockeye salmon, coho salmon, and summer steelhead (ODFW 1990). During the past century, numerous factors have caused the reduction of salmon stocks such that only sustainable stocks of spring chinook salmon and summer steelhead remain. The sizes of spring chinook salmon populations in the Grande Ronde River basin also have been declining steadily and are substantially depressed from estimates of historic levels. It is estimated that prior to the construction of the Columbia and Snake river dams, more than 20,000 adult spring chinook salmon returned to spawn in the Grande Ronde River basin (ODFW 1990). A spawning escapement of 12,200 adults was estimated for the basin in 1957 (USACE 1975). Recent population estimates have been variable year to year, yet remain at least an order of magnitude lower than historic estimates. In 1994, the escapement estimate for the basin was 370 adults (2.4 adults / redd x 154 redds). In addition to a decline in population abundance, a reduction of spring chinook salmon spawning distribution is evident in the Grande Ronde River basin. Historically, 2 1 streams supported spawning chinook salmon, yet today the majority of production is limited to eight tributary streams and the mainstem upper Grande Ronde River (ODFW 1990).

Numerous factors are thought to contribute to the decline of spring chinook salmon in the Snake River and its tributaries. These factors include passage problems and increased mortality of juvenile and adult migrants at mainstem Columbia and Snake river dams, overharvest, and habitat degradation associated with timber, agricultural, and land development practices. More than 80% of anadromous fish habitat in the upper Grande Ronde River is considered to be degraded (USFS 1992). Habitat problems throughout the Grande Ronde River basin (reviewed by Bryson 1993) include poor water quality associated with high sedimentation and poor thermal buffering, moderately to severely degraded habitat, and a decline in abundance of large pool habitat.

Precipitous declines in Snake River spring chinook salmon resulted in these stocks, including the Grande Ronde River stocks, being listed as threatened under the Endangered Species Act in October 1992. Development of sound recovery strategies for these salmon stocks requires knowledge of stock specific life history strategies and critical habitats for spawning, rearing, and downstream migration (Snake River Recovery Team 1993; NWPPC 1992; ODFW 1990). In addition, we need to increase our knowledge of juvenile migration patterns, smolt production and survival, and winter rearing habitat utilization for juvenile spring chinook salmon in the Grande Ronde River basin. Both historic and recent estimates of juvenile production in the basin are lacking. However, given the decrease in total number of adult salmon returning to the basin and the extent of habitat degradation, it is reasonable to assume that juvenile production in the basin also has declined. Recent parr-to-smolt survival estimates for the Grande Ronde River basin range from 8.9% to 22.1% (Walters et al. 1993, 1994; Sankovich et al. 1995). These estimates are based on data from parr that were individually tagged with passive integrated transponder (PIT) tags in late summer and were detected at mainstem Columbia and Snake river dams. Therefore, we have not been able to separate mortality that occurs during the smolt migration from mortality that occurs during the fall and winter prior to the smolt migration from existing data.

Nickelson et al. (1992) demonstrated that availability of winter habitat was an important factor limiting salmon production in many Oregon coastal streams based on work with coho salmon. Typically the chinook salmon smolt migration occurs in the spring, although data from Lookingglass Creek (Burck 1993), Catherine Creek (Keefe et al. 1995) and mainstem Grande Ronde River (Keefe et al. 1994, 1995) indicate that some juveniles move out of summer rearing areas during the fall and overwinter downstream of summer rearing areas. In this study we are acquiring information about the extent and importance of this fall migration.

We are also lacking information on where these fall migrants overwinter. "Data from 1993 indicated that 99% of fish that left upper Grande Ronde River rearing areas during fall overwintered somewhere between the upper (rkm 299) and lower (rkm 1.64) traps.. Much of the habitat in these mid-reaches of the Grande Ronde River is degraded. Stream conditions in the Grande Ronde River below La Grande consist of both meandering and channelized 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. If the fall migration from rearing areas constitutes a substantial portion of the juvenile production, then overwintering habitat may be an important factor influencing spring chinook salmon smolt production in the Grande Ronde River basin.

GOALS AND OBJECTIVES

This study was designed to describe aspects of the life history strategies exhibited by spring chinook salmon in the Grande Ronde River basin. During the past year we focused on rearing and migration patterns of juveniles in the upper Grande Ronde River and Catherine Creek. The study design included three objectives: (1) document the annual in-basin migration patterns for spring chinook salmon juveniles in the upper Grande Ronde River and Catherine Creek, including the abundance of migrants, migration timing and duration; (2). estimate and compare smolt survival indices to mainstem Columbia and Snake river dams for fall and spring migrating spring chinook salmon; (3) determine summer and winter habitat utilization and preference of juvenile spring chinook salmon in the upper Grande Ronde River and Catherine Creek.

METHODS

In-Basin Migration Timing and Abundance

The seasonal migration timing and abundance of juvenile spring chinook salmon in the upper Grande Ronde River and Catherine Creek were determined by operating juvenile migrant traps from ice-out to ice-up. One rotary screw trap was located below spawning and upper rearing areas in the upper Grande Ronde River near the town of Starkey (rkm 299) and another was located in the middle Grande Ronde River at the lower end of the Grande Ronde Valley near the town of Elgin (rkm 164, Figure 1). A third rotary screw trap was placed in Catherine Creek below spawning and upper rearing areas (rkm 32, near the town of Union). Catherine Creek enters the Grande Ronde River at rkm 225 and is a major tributary for spring chinook salmon spawning and rearing. At our upper Grande Ronde River trap site, a 1.5 m diameter trap was fished from 19 July to 3 1 October 1995 and again from 15 February through 16 July 1996. At our lower Grande Ronde River trap site, a 1.5 m diameter trap was fished from 3 October 1995 to 28 January 1996. We fished a 2.4 m diameter trap at this site from 4 March 1996 to 16 June 1996. A 1.5 m diameter trap was fished continuously at the Catherine Creek site from 6 February 1995 through 23 December 1995 and again from 14 February 1996 to 6 June 1996.

The rotary screw traps were equipped with live boxes which safely held hundreds of , chinook salmon trapped over a 24 to 72 h time interval. The traps were usually checked daily, but were checked as infrequently as every third day when we were catching only a few fish each day. All juvenile spring chinook salmon were removed from the traps for enumeration, measurement, or interrogation of PIT tags. We assumed that all juveniles captured in these traps were migrants. Prior to sampling, juvenile chinook salmon were anesthetized with MS-222 (40-60 mg/L). Fish were sampled as quickly as possible and were allowed to recover fully before release into the river. Scale samples were taken from 24 juvenile spring chinook salmon per week at each trap site for age determination. River height was recorded daily from permanent staff gauges. Water temperatures were recorded daily at each trap location using thermographs or hand held thermometers. Smolt condition was assessed at the lower Grande Ronde River site using digital photographs from 24 juvenile spring chinook salmon per week during the spring migration. These juvenile spring chinook salmon were lightly anesthetized, placed into a small Plexiglas aquarium, and their picture was taken. These photos were later downloaded to a computer and the smolt condition of each juvenile spring chinook salmon was assessed following the methods outlined in Beeman et al. (1994). To better understand the morphological changes of the spring migrants, their smolt condition will be compared to that of spring chinook salmon parr collected and photographed previously. These data will be analyzed at a later time.

Trap efficiency tests were conducted throughout each trapping season at each trap. A small amount of non-toxic paint was injected just below the surface of a fish's skin with a Panjet marking instrument (Hart and Pitcher 1969) to mark fish for estimating trap efficiencies. Trap efficiencies were determined by releasing known numbers of paint marked or PIT-tagged juveniles above the traps and counting the number of recaptures. Trap efficiency was estimated from the equation: $\hat{E} = R / M$, where $\hat{E}$ is the estimated trap efficiency, Mis the number of marked fish released upstream and R is the number of marked fish recaptured.

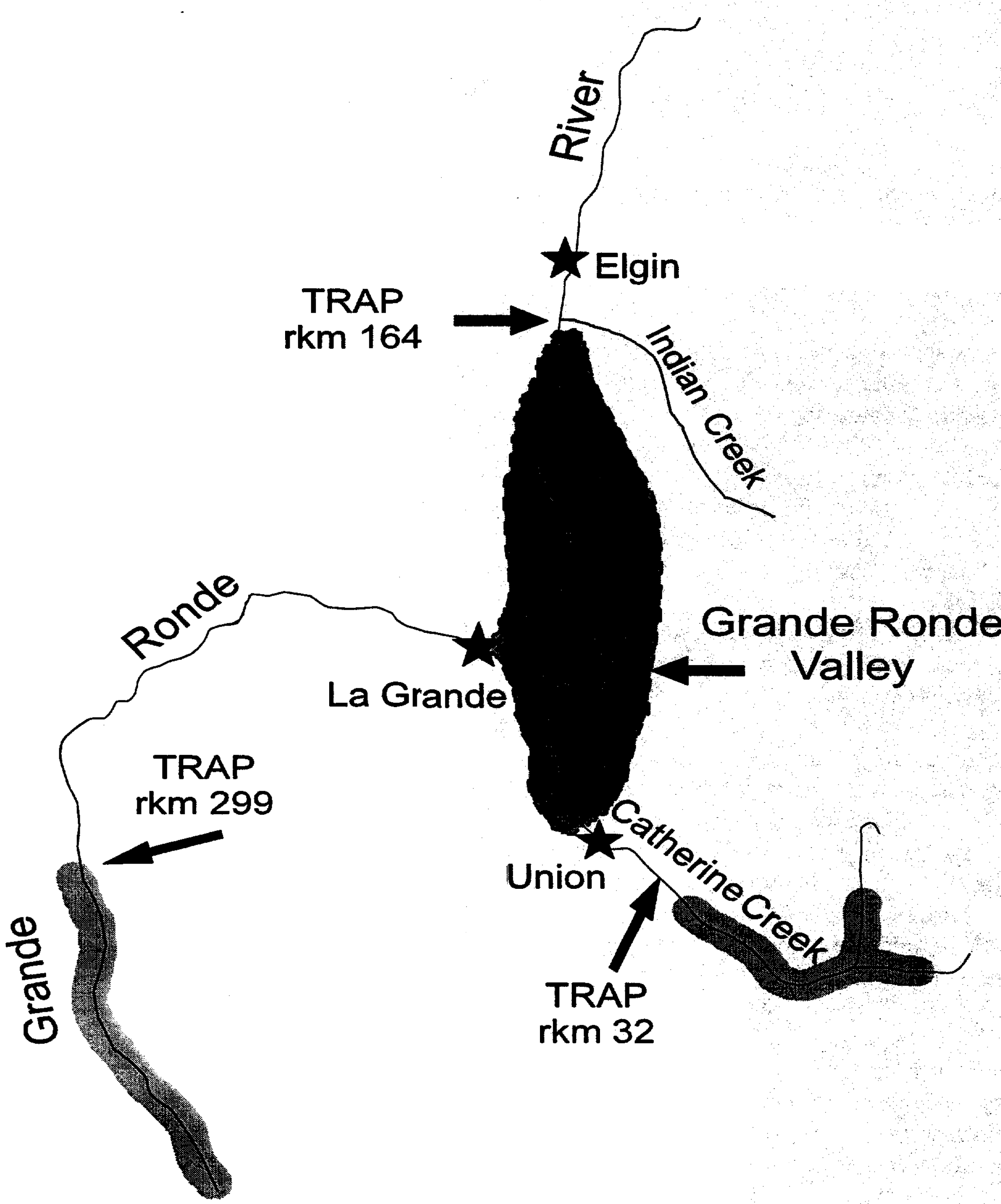

Figure 1. Locations of fish traps on the Grande Ronde River and Catherine Creek during the study period. The lighter shaded areas of the Grande Ronde River and Catherine Creek delineate the spring chinook salmon spawning areas.

Numbers of migrants at each trap site were estimated for the entire trapping season (fall or spring) from the equation: $\hat{N} = C / \hat{E}$ where $\hat{N}$ is the estimated number of fish migrating past the trap, C is the total number of unmarked fish in the catch and $\hat{E}$ is the estimated trap efficiency. Variance for each $\hat{N}$ was determined by the bootstrap method (Efron and Tibshirani 1986; Thedinga et al. 1994) with 1,000 iterations. Confidence intervals for $\hat{N}$ were calculated from the equation: $95\% CI = 1.96\sqrt{V}$, where V is the variance of $\hat{N}$ determined from the bootstrap.

Seasonal migration timing within the Grande Ronde River basin was determined by dividing the daily catch at each trap by the appropriate trap efficiency to estimate the number of chinook salmon migrants passing each trap daily.

Migration Timing and Survival to Mainstem Dams

PIT-tag technology allows for fish to be individually marked and for subsequent observations to be made on marked fish without sacrificing the fish. Therefore, we used data from mainstem detections of PIT-tagged fish to estimate and compare survival among spring and fall migrating spring chinook salmon. Presently, PIT-tag monitors are used in juvenile bypass systems at six mainstem Columbia River and Snake River dams to monitor PIT-tagged fish passage.

Fish that migrate at different times of the year and overwinter in different habitat types are subject to different environmental conditions which can result in variable survival. There is a fall migration from summer rearing areas in the upper Grande Ronde River and Catherine Creek to areas downstream where fish overwinter and then migrate to the sea the following spring. Other individuals remain in upper rearing areas through the fall and winter and then begin their seaward migration in the spring. To determine if juveniles that overwintered in different locations exhibited differential survival to mainstem dams, we PIT-tagged approximately 250 - 500 juvenile spring chinook salmon at the Catherine Creek screw trap during the fall and spring migration and in the winter rearing areas upstream of our traps after the fall migration had ended. We had hoped to tag 500 juvenile spring chinook salmon in the fall and spring at our screw trap in the upper Grande Ronde River, but we fell short due to the low abundance of juveniles from the 1994 brood year. We defined the fall migration as downstream movement past our upper trap sites between September and December and the spring migration as downstream movement past our upper trap sites between February and June. These times encompassed a majority of the spring and fall migrations. In addition, 499 juvenile spring chinook salmon were PIT-tagged in Catherine Creek as part of a separate study conducted under the Fish Passage Center Smolt Monitoring Program. These fish were tagged as parr in early September and were typically detected at mainstem dams during spring. Thus, there were four tag groups (one per season) for estimating relative smolt survival to mainstem dams. It is important to note that fish tagged in these groups do not necessarily represent unique life history strategies. For example, fish tagged in the summer rearing areas may leave as fall or spring migrants and thus the summer tagged group contains fish with life history strategies of all the other tag groups. PIT-tagged fish were interrogated upon recapture in screw traps and in bypass systems at mainstem dams. All recaptured and interrogated fish were identified by their original tag group, thereby insuring independence of tag groups for analysis. For example, dam detections of fish that were tagged in the summer and were recaptured at a river trap in the fall were analyzed as summer tagged fish.

At the upper Grande Ronde River trap, we PIT-tagged four fall and 329 spring migrating spring chinook salmon juveniles that were not previously tagged. At the Catherine Creek trap, we PIT-tagged 569 fall and 277 spring migrating spring chinook salmon juveniles that were not previously tagged. In addition, we seined or dipnetted and PIT-tagged 295 parr from rearing areas above the Catherine Creek trap after our fall trapping had ceased due to ice-up. We monitored PIT-tagged migrants captured at the lower Grande Ronde River trap.

After the migration through the Columbia River was completed, we obtained tag detection information for interrogations at Lower Granite, Little Goose, Lower Monumental, McNary, John Day and Bonneville dams. We examined migration timing to Lower Granite Dam for each of the tag groups. Because some PIT-tagged fish may have passed undetected over the spillway at Lower Granite Dam and the amount of spill varied throughout the migration, arrival timing data for the tag groups were adjusted for spillway flow. We determined the arrival dates of fish detected at Lower Granite Dam and multiplied the number of fish detected each day by an expansion factor, which was calculated as

(Powerhouse Flow + Spillway Flow) / Powerhouse Flow.

We added the daily products and then rounded the sum to the nearest integer to estimate the number of fish arriving by week at Lower Granite Dam.

We calculated survival indices for the individual tag groups by dividing the number of individual fish detected at the Columbia and Snake river interrogation sites by the total number of fish tagged within a tag group, and this proportion was expressed as a percentage. We did not adjust the number of fish detected at the dams to compensate for tagged fish passing the dams without being detected as we are unsure of the most appropriate estimate of collection efficiencies at each dam at the time of this report. Survival index data were compared among tag groups. Comparison of survival indices of fall tagged fish and winter tagged fish allowed us to estimate the relative success of fish that leave the upper rearing areas in the fall versus fish that overwinter in the upper rearing areas and leave in the spring as alternate life history strategies. In addition, a comparison of survival indices of fish tagged as spring migrants versus winter-tagged fish allowed us to estimate overwintering mortality, as the winter-tagged fish that survive should become spring migrants. Survival index data from the summer-tagged fish provides information about overall population survival from late summer to the following spring migration.

Habitat Utilization

We conducted detailed investigations into habitat utilization and rearing distribution of juvenile spring chinook salmon during the summer and winter in Catherine Creek and several tributaries and during summer in the upper Grande Ronde River and several tributaries. Sites were sampled by snorkel observation with two or three persons. Winter observations were made during night with the use of dive lights, while summer observations were made during daylight. We recorded the fish species present and the following habitat variables: habitat type, area, depth, cover, substrate composition, water temperature, water velocity, slope, shade, and underwater visibility. We observed only one year class (1994 brood year) of spring chinook salmon during winter sampling in December 1995 and January 1996, whereas during summer sampling in July and early August 1996 we identified juvenile spring chinook salmon as either young-of-the-year (1995 brood year, generally less than 75 mm fork length), or yearling (1994 brood year, generally greater than 85 mm fork length).

During winter we surveyed Catherine Creek from rkm 2 to rkm 5 1 and near the mouths in Milk and Pyles creeks and the lower 1.6 km of North Fork Catherine Creek after the streams and trap had frozen. During summer we surveyed Catherine Creek from rkm 27 to rkm 52, the lower 0.8 km of Little Catherine Creek, the lower 1.1 km of Milk Creek, the lower 2 km of North Fork Catherine Creek, and the lower 0.8 km of South Fork Catherine Creek. We also surveyed the Grande Ronde River from rkm 301 to rkm 328, Sheep Creek from rkm 2.7 to rkm 5.0, the lower 2 km of Limber Jim and Fly creeks, and the lower 0.3 km of Clear Creek during summer. We selected sampling sites based on redd surveys and rearing distribution surveys from previous years, physical habitat surveys, and accessibility.

RESULTS AND DISCUSSION

In-Basin Migration Timing and Abundance

We captured four fall migrating juvenile spring chinook salmon (1994 brood year) and 401 precocious male spring chinook salmon (1993 brood year) in the upper Grande Ronde River trap from 19 July 1995 through ice-up on 3 1 October 1995. The juvenile spring chinook salmon were captured between 13 October and 29 October 1995, and all of precocious males were captured between 14 August and 11 October 1995. We began fishing the trap again on 14 February 1996 after the ice began to clear from the river, and captured 3 3 5 spring migrating juvenile spring chinook salmon (1994 brood year) from 16 February through 13 May 1996. The median date of the fall migration of 1994 brood spring chinook salmon was 21 October and for the spring migration was 15 March. Based on estimated trap efficiencies of 50.0% during fall and 29.3% during spring, we estimated that 8 ± 12 fall migrants and 1,143 ± 2 16 spring migrants left the upper Grande Ronde River rearing areas (Figure 2), for less than 1% of the migrants moving out in the fall and more than 99% moving out in the spring. We did not estimate the number of precocious male chinook salmon passing our trap during the fall.

We captured 1,869 fall migrating juvenile spring chinook salmon (1994, brood year) and 96 precocious male spring chinook salmon (1993 brood year) in the Catherine Creek trap from 1 June 1995 through ice-up on 23 December 1995. The juvenile spring chinook salmon were captured between 7 June to 23 December 1995, and all of the precocious males were captured between 14 August and 29 September 1995. We began fishing the trap again on 14 February 1996 after the ice began to clear from the creek, and captured 425 spring migrating juvenile spring chinook salmon from 15 February through 11 May 1996. The median date of the fall migration was 20 October and for the spring migration was 10 March. Based on estimated trap efficiencies of 40.1% during fall and 25.3% during spring, we estimated that 4,661 ± 134 fall migrants and 1,680 ± 346 spring migrants left the Catherine Creek rearing areas (Figure 2), for approximately 74% of the migrants leaving Catherine Creek in the fall and the remaining 26% leaving in the spring. Recently emerged chinook salmon fry (1995 brood year) were first captured in the Catherine Creek trap on 17 March and are not included in our estimate of chinook salmon migrants. We did not estimate the number of precocious male chinook salmon passing our trap during the fall.

Juvenile spring chinook salmon were captured in our trap in Catherine Creek up to the time the trap was removed in the fall when the stream iced up, and immediately after our trap was deployed after the ice began to clear from the stream in February. An unknown number of juvenile spring chinook salmon may have passed our trap site while the stream was iced up and the trap was not fishing. If this is the case, our estimate of total migrants leaving Catherine Creek would be low.

The lower Grande Ronde River trap was fished from 3 October 1995 to 28 January 1996 and from 4 March 1996 to 16 June 1996. We captured eight juvenile spring chinook salmon (1994 brood year) and two precocious male chinook salmon (1993 brood year) before 28 January and 716 juveniles after 4 March. The precocious male chinook salmon were captured on 9 October and 13 October. The median migration date for the fish captured after 4 March was 25 April. Based on estimated trap efficiencies of 15.8% for our 1.5 m trap and 8.0% for our 2.4 m trap, we estimated that 9,001 ± 2,771 juvenile spring chinook salmon migrants left the Grande Ronde Valley (Figure 2). More than 99% of the migrants passed during the spring months, compared to less than 1% during fall and winter combined.

Data from 1995-96 showed that less than 1% of the upper Grande Ronde River juveniles migrated from upper rearing areas into the Grande Ronde Valley in the fall which is lower than we observed in 1993-94 and 1994-95 (11% and 10% fall migrants, respectively). The total estimate of migrants from the upper Grande Ronde River was an order of magnitude lower in 1995-96 (1,151 migrants) than in the two previous years (26,417 migrants in 1993-94 and 30,926 migrants in 1994-95), suggesting that juvenile chinook salmon abundance in rearing areas may influence the proportion of fall migrants. Such possible relationships will be evaluated as more years are added to the data set.

Data from 1995-96 showed that 74% of the Catherine Creek juveniles migrated from upper rearing areas into the Grande Ronde Valley in the fall which is higher than we observed in 1994-95 (48% fall migrants). We operated the trap longer into the winter months in 1995-96 than we did in 1994-95 and thus captured later migrating chinook salmon which we included in the total for fall migrants. If juvenile chinook salmon continue to move out of the upper rearing areas through the winter months when were are not able to operate our trap due to icing, then our estimate of the proportion of fall versus spring migrants may be more of a reflection of when we are able to trap than the actual timing of the migration from the upper rearing areas.

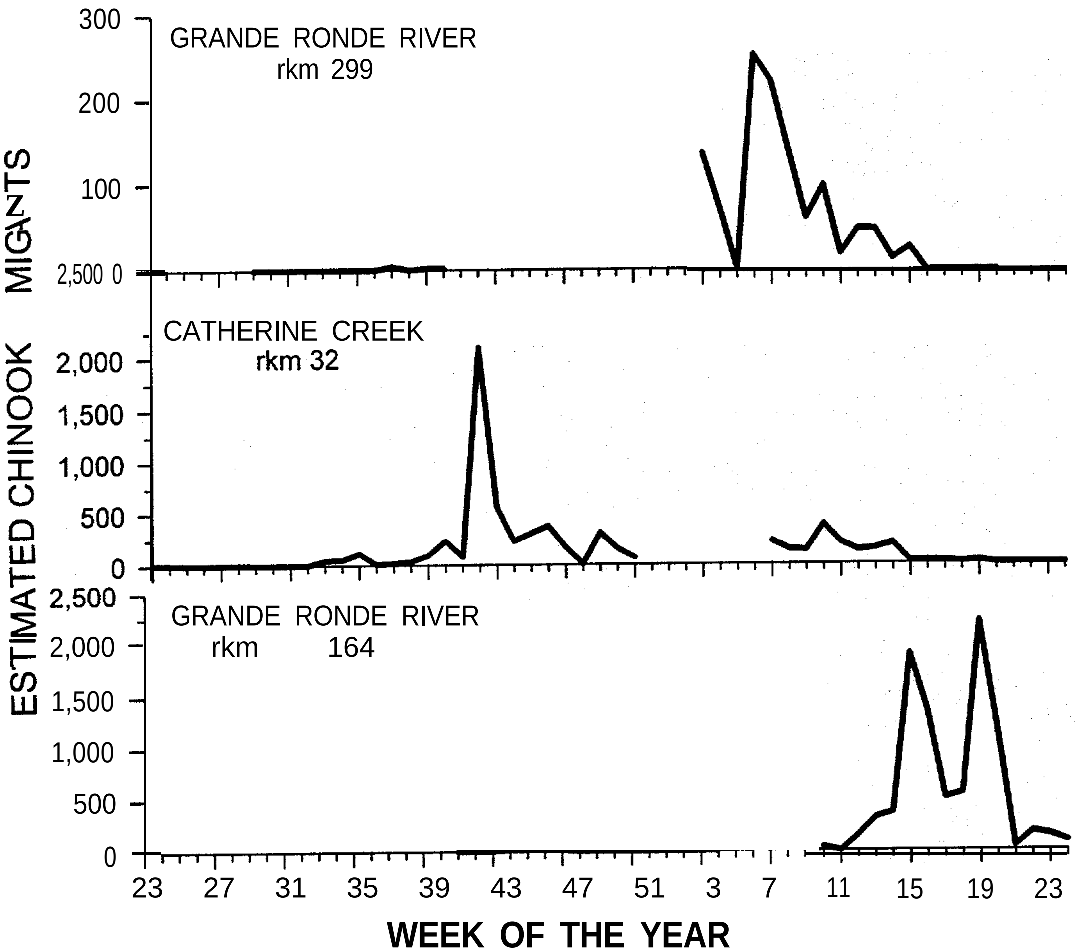

Figure 2. Timing and estimated abundance of juvenile spring chinook salmon migrants (1994 brood year), captured by rotary screw traps at rkm 299 and 164 of the Grande Ronde River and rkm 32 of Catherine Creek, fall 1995 through spring 1996. We estimated that eight spring chinook salmon migrated in the fall and 1,143 migrated in the spring past our Grande Ronde River rkm 299 trap; 4,661 spring chinook salmon migrated in the fall, and 1,680 migrated in the spring past our Catherine Creek rkm 32 trap; and 9,001 spring chinook salmon migrants passed our Grande Ronde River rkm 164 trap. The Grande Ronde River rkm 299 trap was not fished from week 45, 1995 to week 6, 1996 and the Catherine Creek rkm 32 trap was not fished from week 52, 1995 to week 6, 1996 due to icing. The Grande Ronde River rkm 164 trap was not fished from week 5 to week 9, 1996 due to high flows and mechanical problems.

A small proportion (approximately 1%) of salmon moved past the lower. Grande Ronde River trap (rkm 164) during the fall and winter, consistent with movements-observed in 1993 and 1994. We estimated that 99% of the total fish caught at the lower trap were captured during the spring outmigration. These data indicate that most juvenile salmon that left the upper rearing areas during the fall overwintered in the valley reaches of the Grande Ronde River. Protection and enhancement of habitat in the Grande Ronde Valley should be given high priority to maintain or enhance over-winter survival of these juvenile chinook salmon that reside in the valley during winter.

The mean lengths of juvenile spring chinook salmon captured from the upper Grande Ronde River and PIT-tagged are shown in Table 1, and the mean weights of these fish are shown in Table 2. The mean lengths of juvenile spring chinook salmon captured from Catherine Creek and PIT-tagged are shown in Table 3, and the mean weights of these fish are shown in Table 4. Length frequency distributions of juvenile chinook salmon caught in all three traps are shown in Figure 3.

Weekly averages of length and weight demonstrated trends for increasing size of migrants over time and from the Grande Ronde Valley (Table 5), the upper Grande Ronde River (Table 6), and from Catherine Creek (Table 7). These trends in increasing size of migrants over time were consistent for both populations and are similar to what we observed in previous years.

Table 1. Fork lengths (mm) of juvenile spring chinook salmon collected from the Grande Ronde River, fall 1995 and spring 1996. All fish were captured with a rotary screw. trap at rkm 299. SE = standard error, Min = minimum length, Max = maximum length.

	Collected				
Group	*N*	Mean	SE	Min	Max
Fall	4	96.3	2.66	90	102
Spring	329	90.0	0.55	72	118
Release	Tagged and Released				
Group	*N*	Mean	SE	Min	Max
Fall	4	96.3	2.66	90	102
Spring	327	90.0	0.55	72	118

Table 2. Weights (g) of juvenile spring chinook salmon collected from the Grande Ronde River, fall 1995 and spring 1996. All fish were captured with a rotary screw trap at rkm 299. SE = standard error, Min = minimum weight, Max = maximum weight.

	Collected				
Group	N	Mean	SE	Min	Max
Fall	4	10.18	1.002	8.2	12.7
Spring	329	8.08	0.165	3.3	18.9
Release	Tagged and Released				
Group	N	Mean	SE	Min	Max
Fall	4	10.18	1.002	8.2	12.7
Spring	327	8.07	0.165	3.3	18.9

Table 3. Fork lengths (mm) of juvenile spring chinook salmon collected from Catherine Creek, summer 1995 to spring 1996. Summer fish were captured with seines and winter fish were captured with seines or dipnets in Catherine Creek from rkm 42 to 50. Fall and spring fish were captured with a rotary screw trap at rkm 32. SE = standard error, Min = minimum length, Max = maximum length.

	Collected				
Group	N	Mean	SE	Min	Max
Summer[a]	1,075	83.0	0.26	66	139
Fall	876	89.0	0.23	66	116
Winter	294	92.1	0.40	72	114
Spring	346	96.0	0.36	77	125
Release	Tagged and Released				
Group	N	Mean	SE	Min	Max
Summer[a]	496	82.3	0.29	66	104
Fall	566	89.1	0.29	67	116
Winter	294	92.1	0.40	72	114
Spring	248	96.7	0.41	81	125

[a] *From Sankovich, et al., 1995.*

Table 4. Weights (g) of juvenile spring chinook salmon collected from Catherine Creek, summer 1995 to spring 1996. Summer fish were captured with seines and winter fish were captured with seines or **dipnets** in Catherine Creek from rkm 42 to 50. Fall and spring fish were captured with a rotary screw trap at rkm 32. SE = standard error, Min = minimum length, Max = maximum weight.

Group	Collected				
	N	Mean	SE	Min	Max
Summer[a]	499	6.75	0.075	3.2	13.6
Fall	825	8.21	0.064	3.5	16.0
Winter	293	8.59	0.116	4.0	16.0
Spring	345	9.40	0.111	5.2	22.0
Release Group	Tagged and Released				
	N	Mean	SE	Min	Max
Summer[a]	499	6.75	0.075	3.2	13.6
Fall	529	8.34	0.084	3.0	16.0
Winter	293	8.59	0.116	4.0	16.0
Spring	248	9.54	0.133	5.4	22.0

[a] *From Sankovich, et al., 1995.*

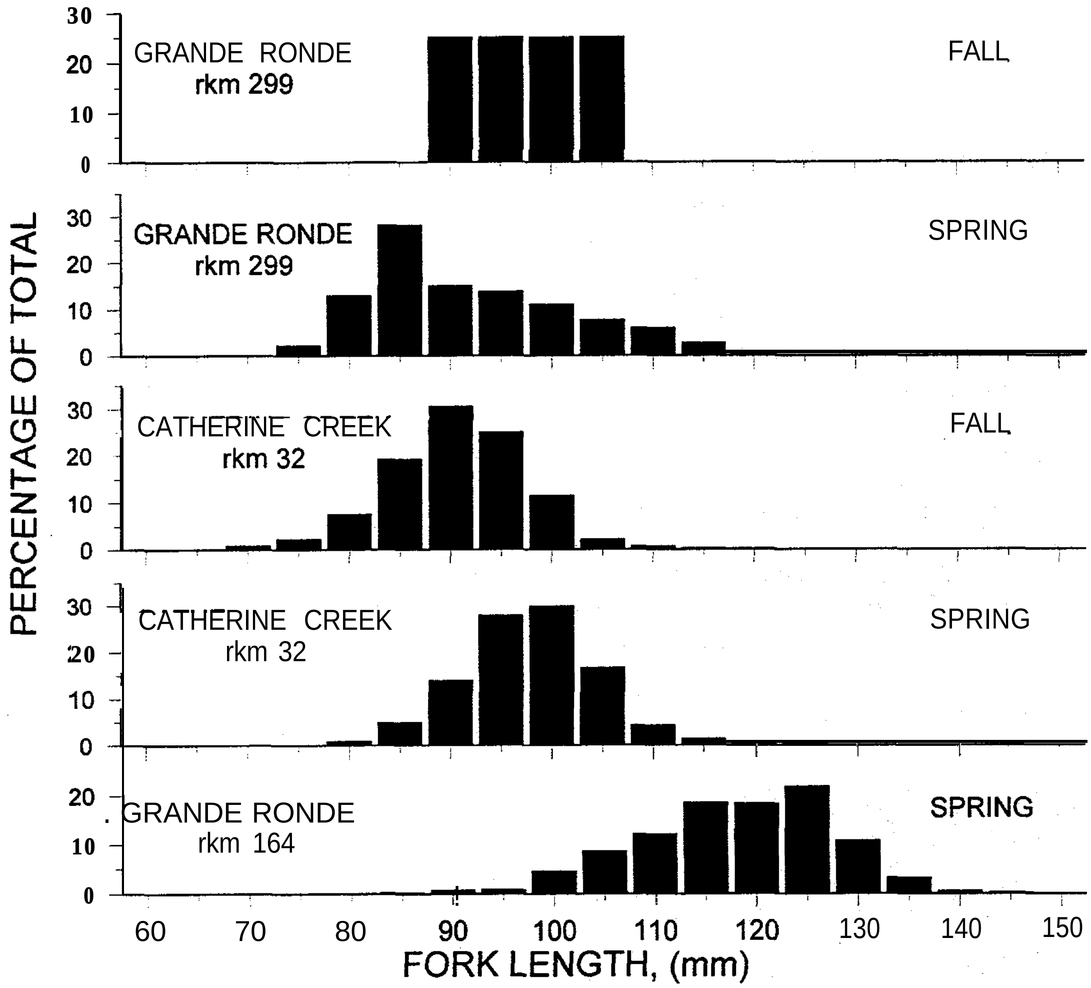

Figure 3. Length frequency (fork length, mm) of juvenile spring chinook salmon migrants captured by rotary screw traps on the Grande Ronde River and Catherine Creek, fall 1995 and spring 1996.

Table 5. Lengths (mm) and weights (g) of juvenile spring chinook salmon captured by a rotary screw trap at rkm 164 of the Grande Ronde River, weeks 44 to 47, 1995 and weeks 10 to 23, 1996.

Year,	Length					Weight				
week	N	Mean	SE	Min	Max	N	Mean	SE	Min	Max
1995:										
44	2	110.0	0.00	110	110	2	13.75	2.650	11.1	16.4
46	2	96.0	1.00	95	97	2	10.15	1.150	9.0	11.3
47	2	97.5	3.50	94	101	2	9.70	1.000	8.7	10.7
1996:										
10	3	115.3	8.88	105	133	3	17.27	3.749	12.7	24.7
12	11	110.5	2.97	98	136	11	14.55	1.481	8.4	27.9
13	24	110.0	1.34	100	124	24	14.75	0.587	11.3	20.6
14	29	111.7	1.76	93	128	29	15.26	0.699	9.4	22.8
15	152	113.5	0.62	95	135	152	16.31	0.271	9.5	26.7
16	114	113.3	0.65	90	129	114	16.15	0.271	7.0	24.0
17	39	115.9	1.11	103	128	33	17.22	0.535	12.3	22.2
18	43	119.0	1.21	101	133	43	18.89	0.648	10.9	33.7
19	175	119.1	0.77	93	143	175	18.61	0.333	8.5	31.5
20	93	117.6	0.81	90	128	93	18.21	0.351	9.3	25.1
21	2	122.5	2.50	120	125	2	20.35	0.650	19.7	21.0
22	12	115.6	4.81	88	136	12	18.59	1.895	8.4	29.2
23	12	114.8	4.59	84	130	12	17.76	1.805	7.3	25.0

Table 6. Lengths (mm) and weights (g) of juvenile spring chinook salmon captured by a rotary screw trap at rkm 299 of the Grande Ronde River, weeks 41 to 44, 1995 and weeks 7 to 19, 1996.

Year,	Length					Weight				
week	N	Mean	SE	Min	Max	N	Mean	SE	Min	Max
1995:										
41	2	96.0	6.00	90	102	2	10.45	2.250	8.2	12.7
43	1	99.0				1	10.80			
44	1	94.0				1	9.00			
1996:										
7	40	90.3	1.39	75	106	40	7.77	0.380	3.7	13.1
8	20	87.8	1.62	72	100	20	7.02	0.445	3.5	11.6
9	1	80.0				1	5.30			
10	74	85.7	0.91	74	115	74	6.87	0.260	4.3	15.6
11	62	86.7	1.14	72	110	62	7.15	0.316	3.3	14.6
12	41	91.7	1.74	76	112	41	8.59	0.500	4.7	15.5
13	17	91.8	2.86	80	115	17	8.78	0.946	4.2	17.6
14	29	94.9	2.09	74	113	29	9.65	0.657	3.3	16.2
15	6	104.7	3.72	94	118	6	12.87	1.522	9.2	18.0
16	13	94.2	2.43	80	108	13	9.59	0.674	6.1	12.6
17	14	96.5	1.77	88	113	14	10.41	0.794	8.3	18.9
18	4	92.8	2.36	86	97	4	8.80	0.540	7.4	9.7
19	8	100.3	2.40	91	110	8	10.76	0.916	8.2	14.4

Table 7. Lengths (mm) and weights (g) of juvenile spring chinook salmon captured by a rotary screw trap at rkm 32 of Catherine Creek, weeks 23 to 51, 1995 and weeks 7 to 19, 1996.

Year,	Length					Weight				
week	N	Mean	SE	Min	Max	*N*	Mean	SE	Min	'Max
1995:										
23	2	40.5	2.12	39	42	2	0.75	0.212	0.6	0.9
24	2	52.5	3.54	50	55	2	1.70	0.300	1.4	2.0
28	2	66.0	3.00	63	69	2	3.55	0.750	2.8	4.3
33	18	84.7	1.41	73	98	18	7.59	0.365	3.9	9.6
34	21	85.0	1.43	73	96	21	7.82	0.399	5.0	11.1
35	48	84.5	1.03	67	100	48	7.18	0.250	3.5	12.4
36	3	92.7	3.93	85	98	3	9.57	1.335	6.9	11.0
37	8	87.9	2.81	76	100	8	8.20	0.711	5.2	11.0
38	13	87.1	1.55	78	95	13	7.89	0.451	5.3	10.2
39	38	85.7	1.07	74	100	38	7.51	0.298	4.8	11.7
40	94	86.7	0.65	72	99	94	7.74	0.180	4.6	12.5
41	31	88.5	1.03	74	105	31	7.89	0.334	3.0	13.4
42	170	90.7	0.51	70	106	170	9.11	0.154	4.1	14.6
43	97	88.9	0.69	70	111	95	8.17	0.200	4.1	16.0
44	60	88.5	0.74	66	100	60	8.04	0.203	4.2	12.8
46	101	89.3	0.63	74	106	71	8.09	0.187	4.0	11.8
47	47	92.3	1.24	69	116	32	8.57	0.343	5.5	12.5
48	2	88.0	10.00	78	98	2	7.65	2.850	4.8	10.5
49	77	91.7	0.67	79	107	77	8.30	0.183	5.3	12.5
50	21	90.9	0.96	85	100	21	8.08	0.259	6.2	10.6
51	27	91.9	1.19	80	103	27	8.40	0.364	5.3	12.8
1996:										
7	57	93.3	0.82	77	105	56	8.69	0.237	5.2	12.2
8	37	94.2	0.99	79	108	37	9.11	0.281	5.5	13.6
9	34	95.6	1.03	85	110	34	9.06	0.307	6.4	13.7
10	81	96.3	0.59	85	108	81	9.28	0.174	6.2	13.0
11	52	96.0	0.77	83	108	52	9.50	0.227	5.3	13.6

Table 7. Continued.

Year,	Length					Weight				
week	N	Mean	SE	Min	Max	N	Mean	SE	Min	Max
1996:										
12	33	96.5	1.27	81	115	33	9.52	0.390	5.8	16.2
13	36	94.9	0.99	83	105	36	8.99	0.267	5.4	12.7
14	20	99.5	1.64	87	117	20	10.59	0.509	7.1	16.7
15	26	97.2	1.18	83	108	26	9.37	0.268	7.2	14.2
16	7	105.4	4.19	94	125	7	12.90	1.803	8.0	22.0
17	4	97.5	1.94	93	102	4	9.50	0.767	7.3	10.8
18	3	104.0	4.93	95	112	3	13.23	2.083	9.5	16.7
19	6	100.0	3.18	89	109	6	12.00	1.132	7.2	15.2

PIT tags allow us to identify individual fish, and thus assess growth of individuals as fish are recaptured. Tagged chinook salmon from the upper Grande Ronde River grew about 10 mm from the time of tagging in the fall and spring to attain a length of approximately 100 mm as they left the Grande Ronde Valley (Table 8), whereas tagged chinook salmon from Catherine Creek grew 20 - 37 mm from the time of tagging (summer through spring) to attain a length of approximately 120 mm as they left the Grande Ronde Valley (Table 9). Chinook salmon from Catherine Creek leave the Grande Ronde Valley at approximately the same length, whether they reared overwinter in the Grande Ronde Valley or in the upper rearing areas of Catherine Creek. Most of the growth of the Catherine Creek fish occurs in the spring after the fish leave the upper rearing areas of Catherine Creek. Recaptures of summer-tagged and winter-tagged fish at our Catherine Creek trap shows that these fish leave the Catherine Creek rearing areas at a mean length of 87 mm (range 76 - 103 mm) in the fall, and mean length of 94 mm (range: 79 - 113 mm) in the spring, yet they leave the Grande Ronde Valley at a mean length of 120 (range: 104 - 135 mm). When comparing populations, the tagged fish from Catherine Creek were larger than the upper Grande Ronde River fish as they left the Grande Ronde Valley in 1996, as we also saw in 1995 (Keefe et al. 1995).

In conclusion, the Grande Ronde Valley provides more than a migration corridor for juvenile spring chinook salmon, as a portion of both the Grande Ronde River and Catherine Creek populations leave the upper rearing areas during the fall to overwinter in the Grande Ronde Valley before leaving the valley in the spring, and juvenile spring chinook salmon put on significant growth during the spring between the time they leave the upper rearing areas and they pass our trap at rkm 164 to leave the Grande Ronde Valley.

Table 8. Mean fork lengths of juvenile spring chinook salmon PIT-tagged in the upper Grande Ronde River and recaptured by a rotary screw trap on the Grande Ronde River at rkm 164 during spring 1996. Standard errors are in parentheses.

		Mean length	
Group	N	Tagging	Recapture
Fall	1	94.0	103.0
Spring	25	89.2 (1.64)	99.4 (1.20)

Table 9. Mean fork lengths of juvenile spring chinook salmon PIT-tagged in Catherine Creek and recaptured by a rotary screw trap on the Grande Ronde River-at rkm 164 during spring 1996. Standard errors are in parentheses.

		Mean length	
Group	*N*	Tagging	Recapture
Summer	8	81.3 (2.06)	118.0 (2.71)
Fall	18	89.2 (1.45)	121.5 (1.50)
Winter	3	97.3 (1.67)	118.0 (6.81)
Spring	20	98.1 (1.37)	119.0 (1.33)

Migration Timing and Survival to Mainstem Dams

PIT-tagged fish from the upper Grande Ronde River were detected at Lower Granite Dam from 19 April 1996 to 6 June 1996, with 50% of the Grande Ronde River fish passing Lower Granite Dam by 16 May 1996 (Figure 4). PIT-tagged fish from Catherine Creek were detected at Lower Granite Dam from 14 April 1996 to 14 June 1996, with 50% of the Catherine Creek fish passing Lower Granite Dam by 12 May 1996 (Figure 5).

Juvenile spring chinook salmon PIT-tagged in spring in the upper Grande Ronde River and in Catherine Creek had similar migration timing to Lower Granite Dam (date of median passage = 16 May). Travel times to Lower Granite Dam for fish tagged during spring from the upper Grande Ronde River ranged from 14 to 88 days (mean = 57.1 days), and fish from Catherine Creek ranged from 9 to 91 days (mean = 54.6 days).

We examined migration timing past Lower Granite Dam by individual tag group and found considerable variability within Catherine Creek (Figure 5). In Catherine Creek the median arrival date to Lower Granite Dam by tag group was 1 May for summer, 29 April for fall, 18 May for winter, and 17 May for spring. The earliest fish detected at Lower Granite Dam were tagged, during fall and had moved lower into the valley habitat to overwinter. Timing of PIT-tagged fish past our lower Grande Ronde River trap followed the same pattern as the timing to Lower

Granite Dam, i.e., the fall tagged fish were earlier and the winter and spring tagged fish were later, based on date of median passage (Figure 6).

Juvenile spring chinook salmon PIT-tagged during spring at our upper Grande Ronde River trap were detected at Snake and Columbia river dams at a rate of 36.1% (Table 10), compared to 32.1% in 1994 (Keefe et al. 1994) and 55.2% in 1995 (Keefe et al. 1995). We were not able to compare detections rates by tag groups in the upper Grande Ronde River, as we only tagged four fish during fall, and none during the winter. One of the four fish tagged during fall was detected at Little Goose Dam on 7 May 1996.

Detection rates by tag group for fish from Catherine Creek ranged from 13.6% for fish tagged during winter upstream of our migrant trap, to 43.0% for fish tagged during spring at our trap (Table 11). The highest detection rate for spring-tagged fish was expected because this group was the only group tagged after overwinter mortality had occurred. Fall-tagged fish from Catherine Creek were detected at higher rates in 1996 than winter-tagged fish, suggesting better overwinter survival for fish that left the upper rearing areas of Catherine Creek and overwintered in the Grande Ronde Valley. In 1995, we found that fish tagged during winter had higher detection rates than fish tagged during fall, suggesting better overwinter survival for fish remaining in the upper rearing areas of Catherine Creek. Comparing detection rates of winter-tagged fish to spring-tagged fish from Catherine Creek suggests that overwinter survival of fish remaining in the upper rearing areas may be approximately 32% in 1996, whereas data from 1995 indicated that overwinter survival in the upper rearing areas was approximately 53% (Keefe et al. 1995).

In conclusion, spring chinook salmon that leave the upper rearing areas of Catherine Creek during the fall and overwinter in the Grande Ronde Valley arrive at Lower Granite Dam earlier in the spring than fish that overwinter in the upper rearing areas. As spring flow patterns change in the Snake and Columbia rivers from year to year, survival rates may change for fish arriving at the dams at different periods of the migration season. In 1996, spring chinook salmon that overwintered in the Grande Ronde Valley had higher overwinter survival than fish that overwintered in the upper rearing areas, whereas in 1995, fish that overwintered in the upper rearing areas had a higher over-winter survival. These differences point out the need to maintain the diversity in life history strategies observed in the Grande Ronde River basin, as environmental conditions change from year to year and what may be a successful strategy one year may not be as successful in another year under different conditions.

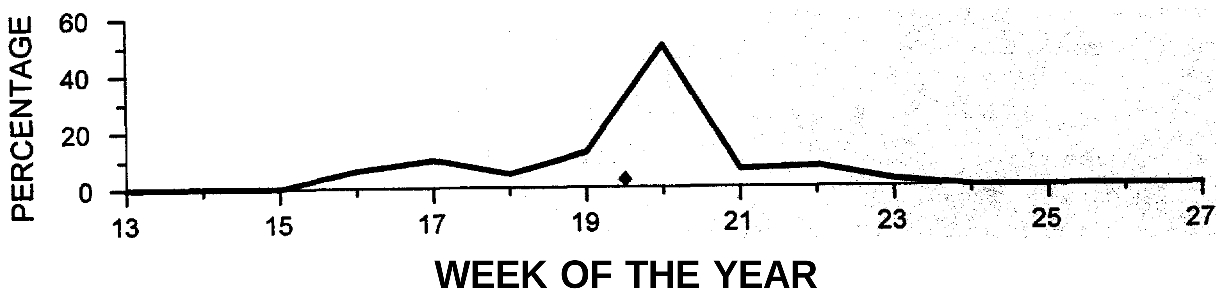

Figure 4. Migration timing at Lower Granite Dam for juvenile spring chinook salmon tagged during spring from the Grande Ronde River, 1996 migration year. ♦ = median arrival date. Data were expanded for spillway flow.

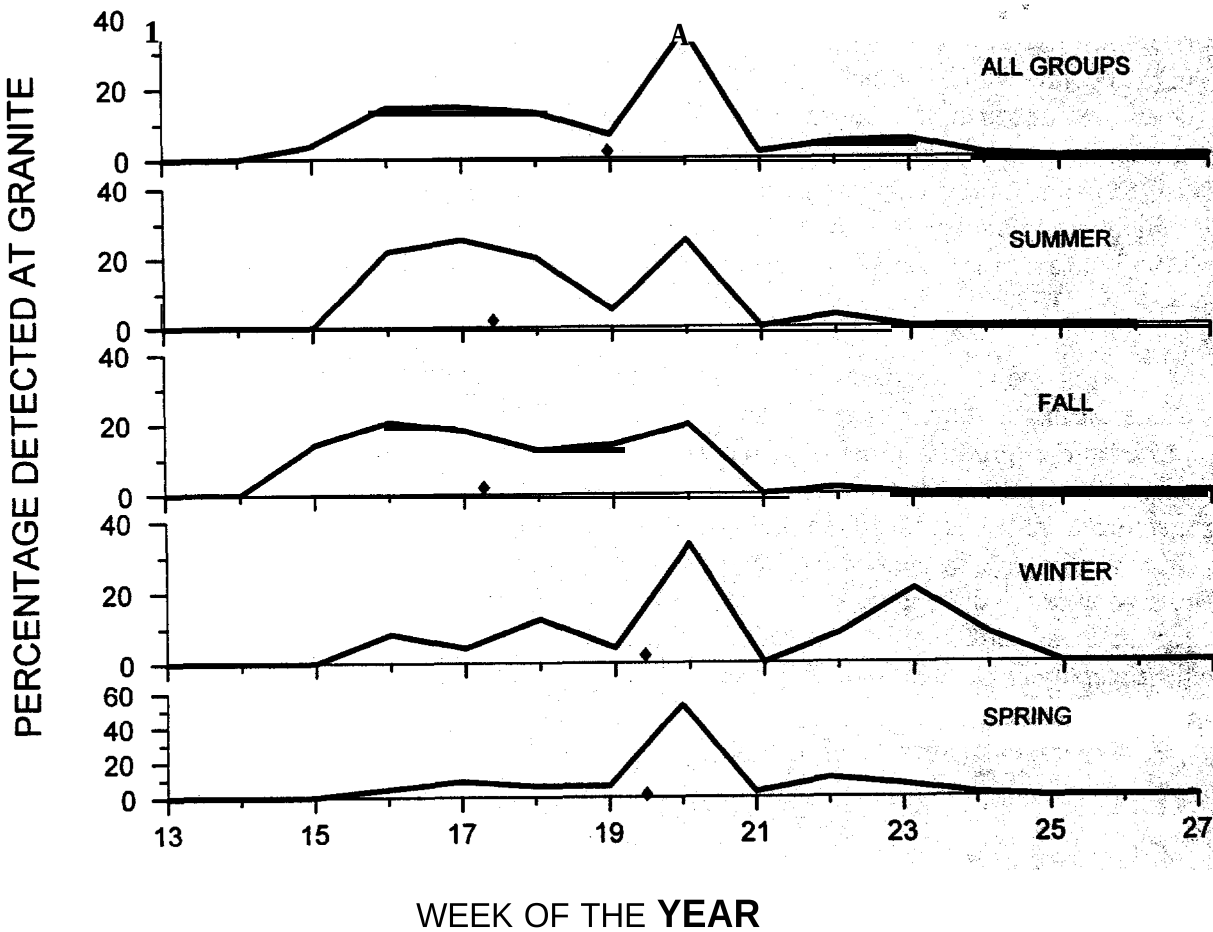

Figure 5. Migration timing at Lower Granite Dam for juvenile spring chinook salmon from Catherine Creek, by tag group, 1996 migration year. ♦ = median arrival date. Data were expanded for spillway flow.

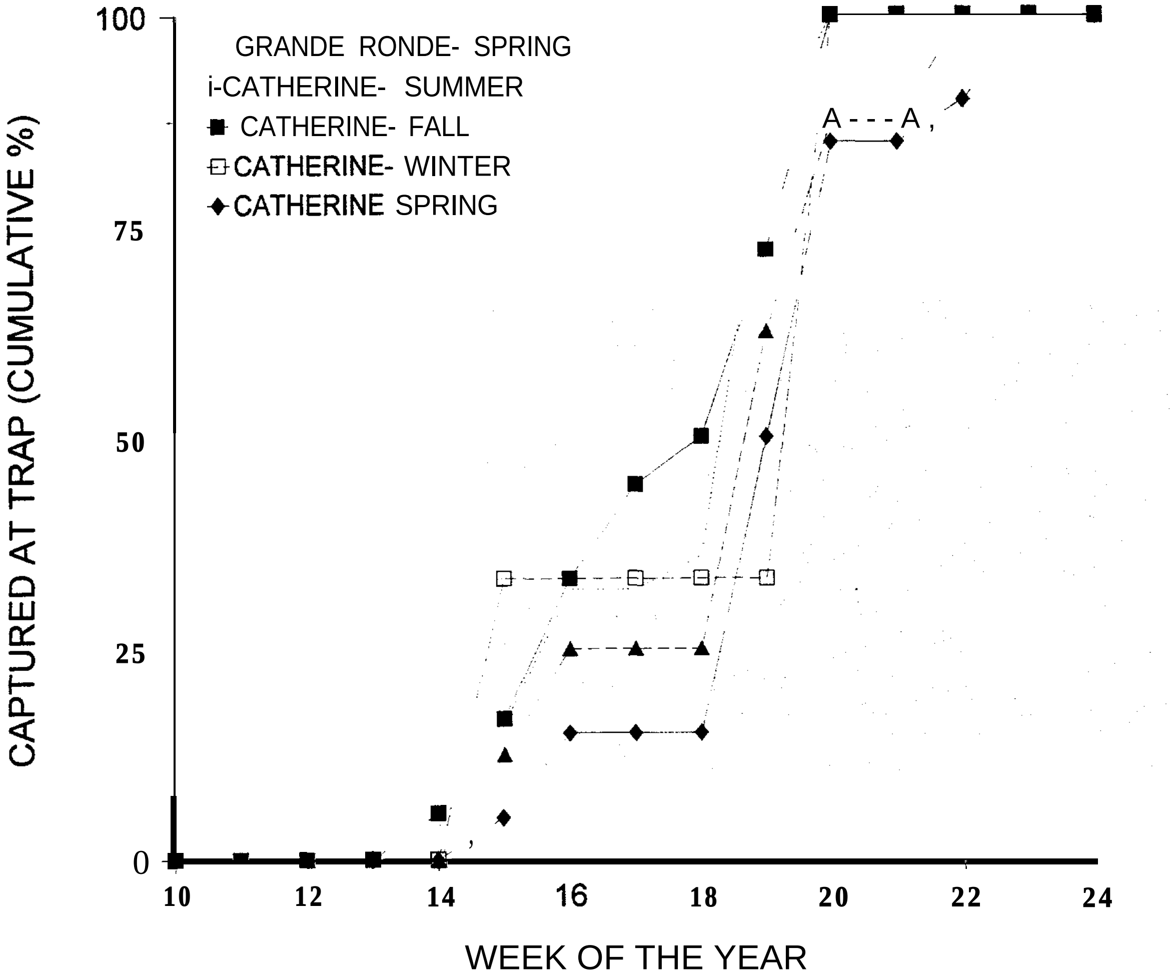

Figure 6. Timing of PIT-tagged juvenile spring chinook salmon migrants captured by a rotary screw trap at rkm 164 of the Grande Ronde River, by tag group, in 1996.

Table 10. First-time detections of Grande Ronde River spring chinook salmon, by dam site, during the 1996 migration year. Chinook salmon were PIT-tagged on the Grande Ronde River during the previous seasons as indicated. Detections are presented as a percentage of the total fish released. Lower Mon. = Lower Monumental Dam, Bonn. = Bonneville Dam.

Group	Number released	Lower Granite	Little Goose	Lower Mon.	McNary	John Day	Bonn.	Total
Fall	4	0.0	25.0	0.0	0.0	0.0	0.0	25.0
Spring	327	14.4	10.4	9.5	1.5	0.0	0.3	36.1
Total	331	14.2	10.6	9.4	1.5	0.0	0.3	36.0

Table 11. First-time detections of Catherine Creek spring chinook salmon, by darn site, during the 1996 migration year. Chinook salmon were PIT-tagged on Catherine Creek during the previous seasons as indicated. Detections are presented as a percentage of the total fish released. Lower Mon. = Lower Monumental Dam, Bonn. = Bonneville Dam.

Group	Number released	Lower Granite	Little Goose	Lower Mon.	McNary	John Day	Bonn.	Total
Summer"	499	8.0	5.4	3.6	0.8	0.2	0.0	18.0
Fall	566	13.4	7.6	4.8	1.8	0.0	0.4	27.9
Winter	295	4.7	5.1	3.7	0.0	0.0	0.0	13.6
Spring	277	25.3	7.6	5.8	3.2	0.4	0.7	43.0
Total	1,637	12.2	6.5	4.4	1.4	0.1	0.2	24.8

[a] *From Sankovich, et al., 1995.*

Habitat Utilization

We surveyed 60 habitat units in 50 km of Catherine Creek and the mouths of several tributaries during winter and observed 4 17 juvenile spring chinook salmon. Chinook salmon were observed in all habitat types sampled in winter, and were most abundant in pools (Table 12). We observed juvenile chinook salmon from rkm 15 to rkm 52 in Catherine Creek and in Milk and Pyles creeks near the mouths of these creeks and in the lower 1.5 km of North Fork Catherine Creek.

We surveyed 159 habitat units in 25 km of Catherine Creek and 4.5 km of the lower ends of several tributaries during summer and observed 1,008 young-of-the-year and 87 yearling spring chinook salmon. Chinook salmon were observed in all habitat types except rapids (n=1), and were most abundant in pools (Table 13). These results are similar to those of our sampling in 1995 when we found higher densities of juvenile chinook salmon in pools than other habitat types. We observed juvenile chinook salmon from rkm 27 (water temperature = 22° C in mid-afternoon) to rkm 52 in Catherine Creek and in the lower 0.8 km of Little Catherine Creek and the lower 0.1 km of Milk Creek.

We surveyed 146 habitat units in 27 km of the upper Grande Ronde River and 9 km of the lower ends of several tributaries and observed five young-of-the-year and one yearling chinook salmon. The few chinook salmon observed were found in pools and a glide (Table 14). Four of the five young-of-the-year chinook salmon observed during sampling in the upper Grande Ronde River were in the lower 2 km of Fly Creek. The extremely low abundance of juvenile chinook salmon in the upper Grande Ronde River is reflected in density estimates and our observations of only five young-of-the-year chinook salmon. As we reported for sampling conducted in 1995 (Keefe et al. 1995), we view the habitat utilization data for the upper Grande Ronde River as equivocal given the low abundance of chinook salmon. We hope to be able to repeat surveys in the upper Grande Ronde River in the future when juvenile chinook salmon are more abundant.

In conclusion, protection of tributaries to spawning streams is important as juvenile spring chinook salmon use the lower reaches of non-natal tributaries for rearing in both the Grande Ronde River and Catherine Creek. Habitat protection or enhancement efforts in spring chinook salmon rearing areas should emphasize pool-type habitat as the juveniles are more abundant in pools than glides or riffles in the summer and winter.

Table 12. Habitat selection and density (fish/l 00 m^2) of juvenile spring chinook salmon in Catherine Creek (rkm 2 to rkm 52) and tributaries during winter 1996.

Habitat type	N	Age 0	Age 1
Glide	7	4.69	0.00
Backwater pool	7	25.23	0.00
Dam pool	2	35.96	0.00
Lateral scour pool	34	12.72	0.00
Plunge pool	2	31.49	0.00
Straight scour pool	3	4.63	0.00
Riffle	5	2.33	0.00

Table 13. Habitat selection and density (fish/100 m2) of juvenile spring chinook salmon in Catherine Creek (rkm 27 to rkm 52) and tributaries during summer 1996.

Habitat type	N	Age 0	Age 1
Glide	24	2.64	0.08
Backwater pool	13	11.12	0.00
Dam pool	8	4.58	0.06
Lateral scour pool	46	12.22	0.96
Plunge pool	16	8.39	0.47
straight scour pool	20	8.74	1.25
Rapids	1	0.00	0.00
Riffle	21	0.60	0.26
Riffle with pockets	10	1.95	0.19

Table 14. Habitat selection and density (fish/100 m2) of juvenile spring chinook salmon in the Grande Ronde River (rkm 301 to rkm 328) and tributaries during summer 1996.

Habitat type	*N*	Age 0	Age 1
Glide	26	0.07	0.02
Backwater pool	11	0.44	0.00
Dam pool	1	0.00	0.00
Lateral scour pool	49	0.10	0.00
Plunge pool	15	0.00	0.00
Straight scour pool	17	0.08	0.00
Rapids	2	0.00	0.00
Riffle	23	0.00	0.00
Riffle with pockets	2	0.00	0.00

FUTURE DIRECTIONS

We will continue this early life history study of spring chinook salmon in the upper Grande Ronde River and Catherine Creek, and we will expand the study to include populations of spring chinook salmon in the Lostine and Wallowa rivers in fall 1996 and plan to include populations in the Minam and Wenaha rivers later. Initially, we will document the in-basin migration patterns, estimate survival indices from tagging to smolt detection at Snake and Columbia river dams, and determine seasonal habitat utilization and preference of juvenile spring chinook salmon in these other populations.

We plan to examine life history characteristics of parr in greater detail, including the use of non-natal tributaries for rearing, and deviations from the typical yearling smolt life history, such as two-year old smolts and precocity.

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