ANNUAL PROGRESS REPORT

FISH RESEARCH PROJECT
OREGON

PROJECT TITLE: Willamette Spring Chinook Salmon

PROJECT NUMBER: F-163-R-00

PROJECT PERIOD: May 1996 through September 1996

Prepared by: J.T. Grimes
R.B. Lindsay
K.R. Kenaston
K. Homolka
R.K. Schroeder

Oregon Department of Fish and Wildlife
2501 S.W. First Street
P.O. Box 59
Portland, Oregon 97207

This project was funded in part by the Sport Fish And Wildlife Restoration Program administered by the U.S. Fish and Wildlife Service.

CONTENTS

INTRODUCTION

The Willamette and Sandy rivers support an intense spring chinook salmon (*Oncorhynchus tshawytscha*) recreational fishery in the heart of Oregon's most populous region. The fishery relies primarily on annual hatchery production of 5-8 million juveniles. Hatchery programs exist in the McKenzie, Middle Fork Willamette, North Santiam, Clackamas and Sandy basins mainly as mitigation for dams that blocked natural production areas. Natural spawning populations occur in the McKenzie, North Santiam, Clackamas, and Sandy basins and a few smaller tributaries upstream of Willamette Falls.

The Oregon Fish and Wildlife Commission adopted a wild fish management policy to reduce adverse impacts of hatchery programs on wild native stocks (ODFW 1992). The main goal of the policy was to protect the genetic diversity of these stocks recognizing that genetic resources are a major component, not only in sustaining wild stocks, but in perpetuating hatchery programs and the fisheries they support.

In the past, spring chinook salmon management in the Willamette and Sandy basins focused on hatchery and fish passage issues. Limited information was collected on the genetic structure among basin populations, abundance and distribution of natural production, or on strategies for reducing risks that large hatchery programs pose for wild salmon populations. This study is being implemented to fill these information needs. A schematic of the study plan is presented in **Appendix A.**

The project began in May 1996 and focused on: (1) collecting scales from returning adults to determine if scale patterns can be used to separate hatchery from naturally produced fish and (2) determining distribution and abundance of natural spawners. Work was conducted in the McKenzie, North Santiam, Clackamas, and Sandy river basins (Figures 1, 2, 3, and 4). Basin descriptions and background information on management and fish runs can be found in subbasin plans by the Oregon Department of Fish and Wildlife (ODFW 1988, ODFW 1992a, ODFW 1992b, and ODFW 1996, respectively). This report mainly covers work from May through the spawning period in mid-October. Task headings below cross reference the study plan outlined in **Appendix A.**

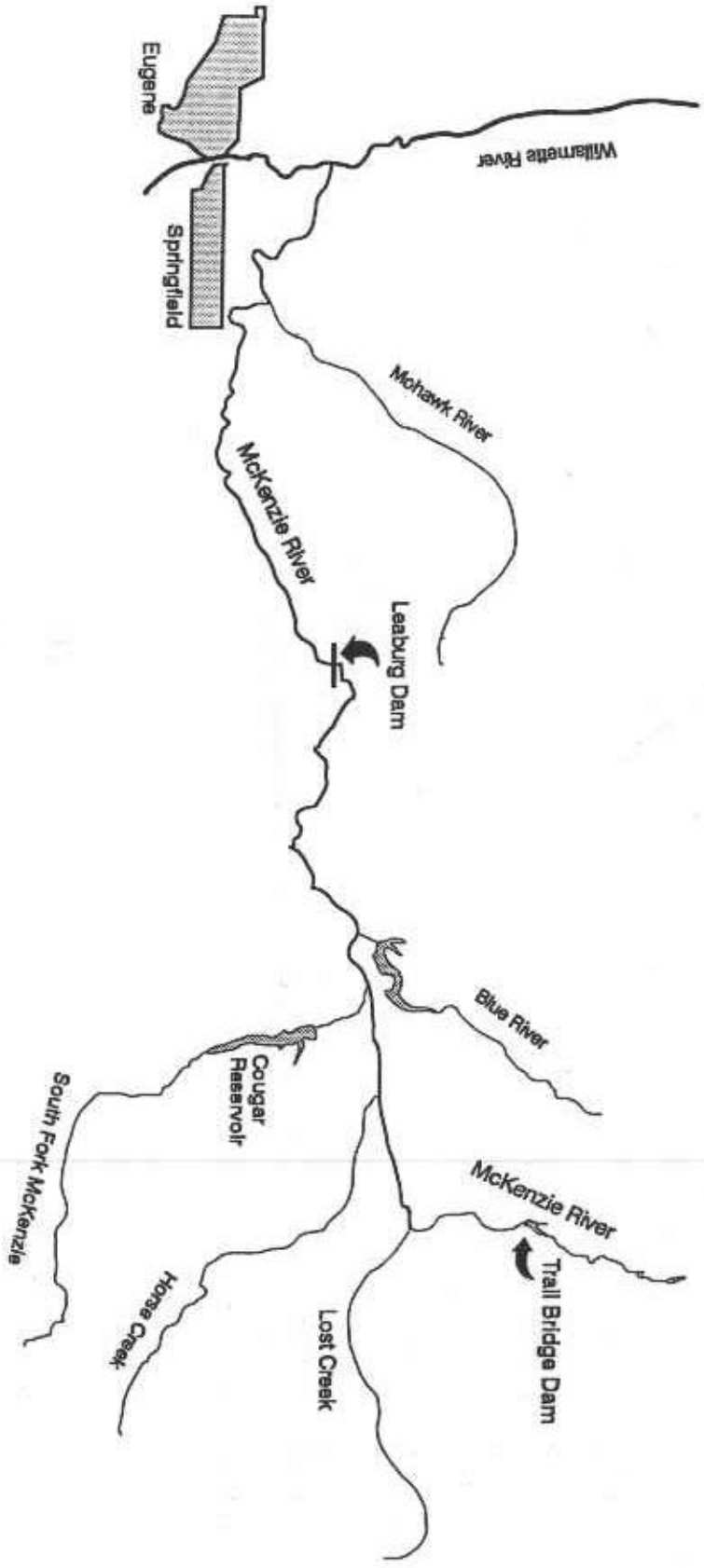

Figure 1. McKenzie River drainage.

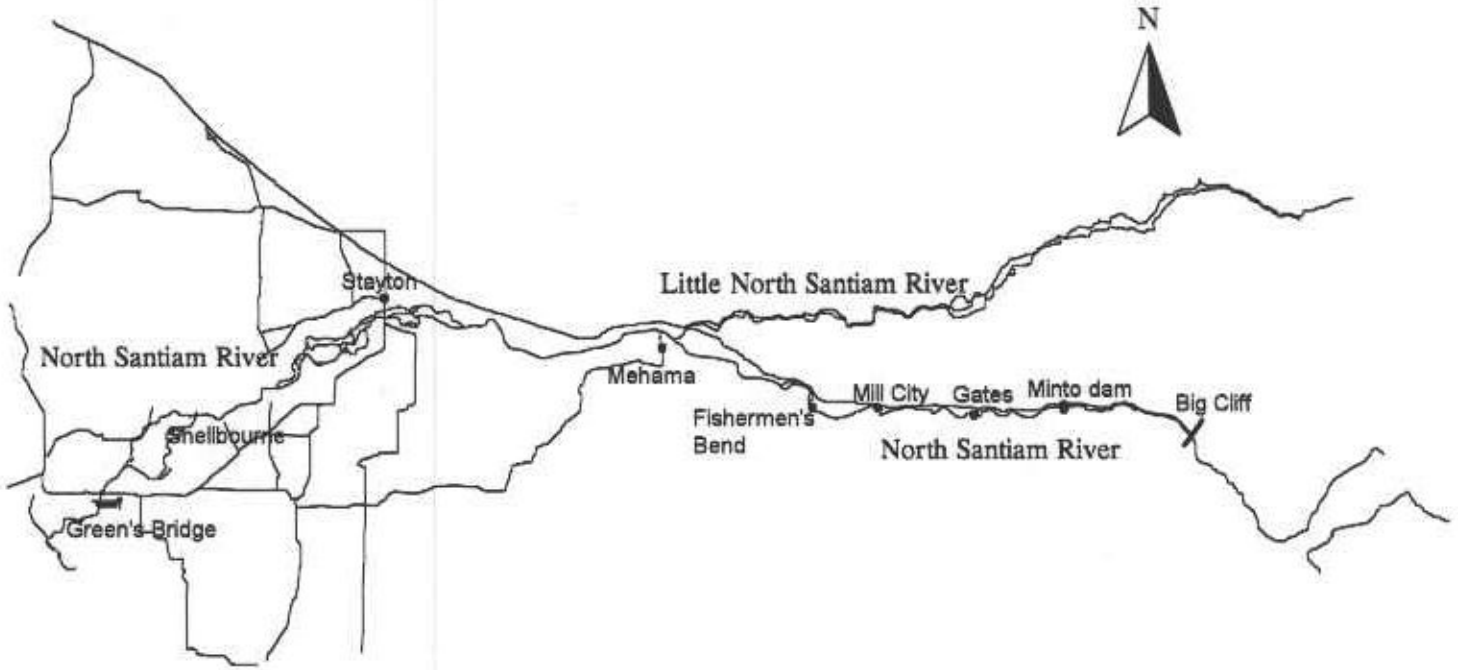

Figure 2. North Santiam River drainage.

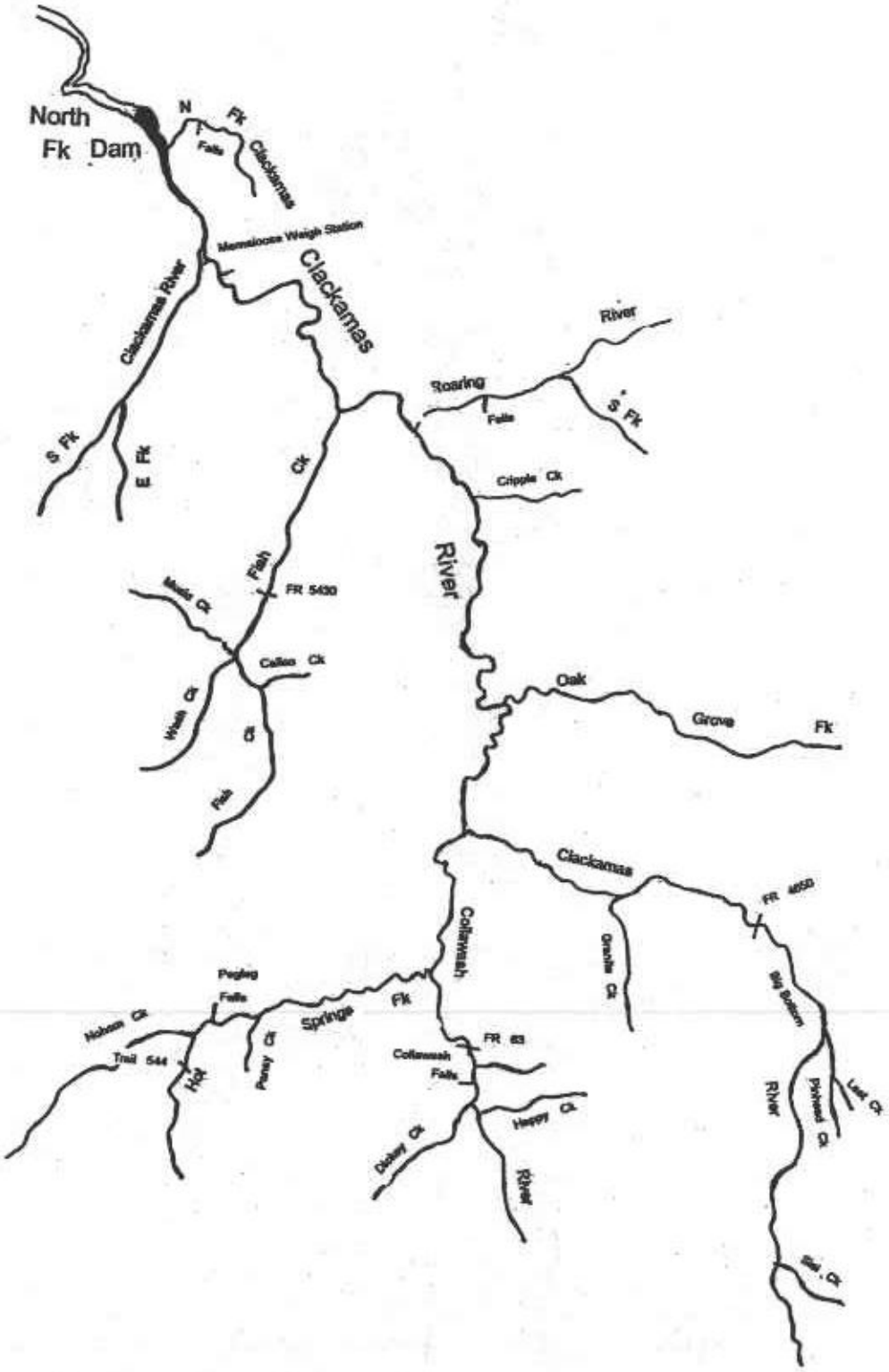

Figure 3. Clackamas River drainage.

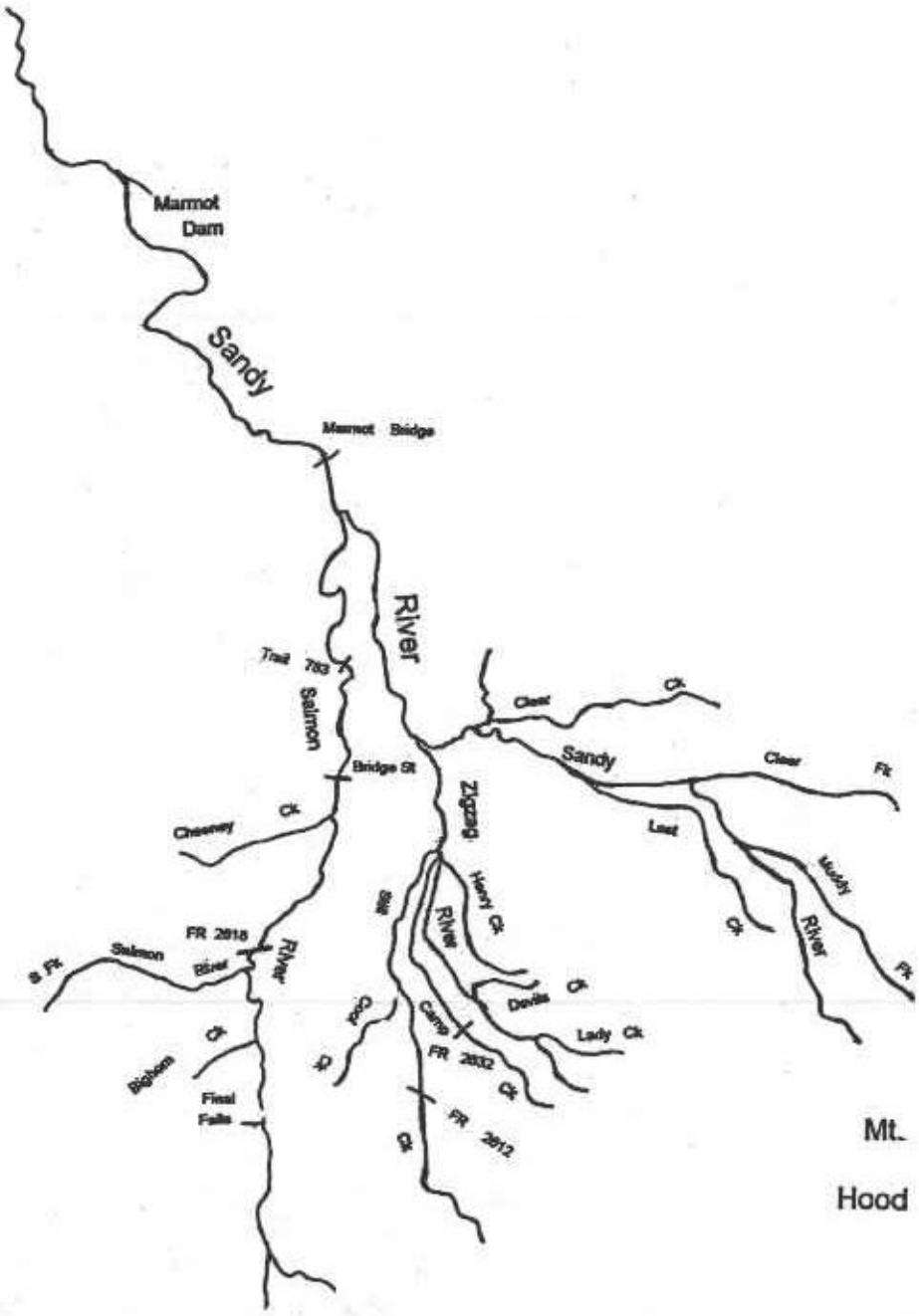

Figure 4. Sandy River drainage.

TASK 1.2--THE PROPORTION OF WILD FISH IN NATURAL SPAWNING POPULATIONS

We collected scales from returning adults in 1996 to determine if scale patterns can be used to separate hatchery fish from wild fish in natural spawning populations. Scales were collected from returning adults at Leaburg Dam and at McKenzie Hatchery on the McKenzie River. Scales were also collected from carcasses during fall spawning ground surveys on the McKenzie, North Santiam, Clackamas, and Sandy rivers (*see* Task 1.3).

Only adult scales from the McKenzie have the possibility of being used to develop a statistical function to separate hatchery from wild fish because all 1992 brood hatchery chinook were marked at McKenzie Hatchery. These fish returned as age 4 fish in 1996. Scales patterns on age 4 fish will be examined for differences between unmarked wild fish and marked hatchery fish. Adult scales collected from carcasses in other basins in 1996 will be archived for later classification if patterns on smolt scales, which will be collected beginning in 1997, show differences between hatchery and wild fish. Table 1 summarizes scale collections in 1996 in the McKenzie River.

TASK 1.3-- DISTRIBUTION AND ABUNDANCE OF NATURAL SPAWNERS

Methods

During 1996, the geographic distribution, timing, and magnitude of natural spawning was documented for the McKenzie, North Santiam, Clackamas, and Sandy basins. Initial survey areas were based on data provided by the U.S. Forest Service, Portland General Electric Company, and Oregon Department and Fish and Wildlife (ODFW). These core areas were expanded and other potential streams included to insure that all possible spawning areas were surveyed at least once during the spawning season. Survey sections were defined by using natural and man-made landmarks. We attempted to begin surveys before spawning began and to end them after spawning was completed to define the temporal distribution within and among the basins.

Survey sections in the North Santiam, Clackamas, and Sandy rivers were systematically walked or drifted in boats throughout the spawning period to count live fish and new redds. Daily totals were recorded by section and further summarized by survey cycle, the time required to survey all sections in a basin. Redd sites were flagged on the adjacent streambank, noting the date and number of new redds present. Redd sites were mapped manually on USGS maps and with "Garmin" hand-held global positioning system units after the final survey was completed.

Table 1. Age composition in scale samples of spring chinook salmon from Leaburg Dam and from McKenzie Hatchery on the McKenzie River, 1996. Samples were not taken randomly but were targeted on fish less than 860 mm. Based on past age-length relationships, fish less than 860 mm would include all age 4 and only a portion of age 5 fish.

Group, age	Number	Percentage	Mean length (mm)	95% CI[a]	MIN	MAX
			Leaburg Dam			
Unmarked:						
3	1	0.5	560.0	--	--	--
4	149	73.8	760.4	± 6.8	595	845
5	52	25.7	817.1	±11.0	670	890
Adipose:						
4	4	80.0	667.5	--	690	760
5	1	20.0	840.0	--	--	--
			McKenzie Hatchery			
Unmarked:						
3	2	0.4	575.0	--	555	595
4	91	18.5	773.8	±10.5	570	855
5	393	79.7	809.7	± 3.7	665	900
6	7	1.4	805.0	--	755	850
Adipose:						
3	2	0.8	555.0	--	525	585
4	197	75.5	743.8	± 6.4	590	860
5	62	23.8	811.7	± 9.9	690	905

[a] *No confidence interval was calculated for groups with < 10 fish.*

Survey protocol differed in the McKenzie River but was consistent with surveys conducted in 1990 and 1992. Every redd was counted during each survey, therefore, the total redd counts each week included redds counted during previous surveys. These areas were surveyed five to seven times over an eight week period, except for Gate Creek and the upper 8.3 miles of Horse

Creek, which were surveyed on two occasions during the spawning season. In addition, we conducted one aerial survey on the mainstem McKenzie River from Trail Bridge Dam to the mouth and on the South Fork McKenzie River below Cougar Dam. Specific redd sites were not mapped in the McKenzie.

Carcasses were counted and sampled whenever they could be collected. Carcasses were examined for marks, sexed, measured to the nearest centimeter fork length, and recorded as spawned or unspawned (females only). Snouts were removed from any carcass with a missing adipose fin, which indicated the presence of a coded wire tag. About 10 scales were collected from both sides of the fish from just above the lateral line and under the posterior insertion of the dorsal fin. Scales were later mounted, aged, and, except for McKenzie River fish, archived for later use. The caudal fin was removed from carcasses after sampling to indicate the fish had been sampled. Carcasses were then returned to the water.

Results and Discussion

Comparison of Spawn Timing among Basins

Spawning began about the first week of September and ended by October 15 in all four basins surveyed. The progression of spawning was the same for the Clackamas and North Santiam basins but was about a week later in the Sandy basin (Figure 5). Hatchery spring chinook salmon, presumably the majority of spawners in the Sandy and Clackamas rivers, are Clackamas stock reared at Clackamas Hatchery. The difference in timing suggests that environmental differences among the basins influences spawning timing or that our assumption that the majority of spawners in the Clackamas and Sandy rivers were hatchery fish is wrong.

Because all redds that could be identified were counted during each survey on the McKenzie River (Table 2), the progression of spawning relative to the other rivers could not be determined. Peak spawning time was estimated by backcalculating from weekly carcass counts (ODFW 1990) **(APPENDIX B)**. Because salmon exhibit an average postspawning longevity of 9 days (van der Berghe and Gross 1986) it was assumed that spawning in week X was reasonably demonstrated by summing half the number of carcasses collected in week X+1 and half the number of carcasses collected in week X+2. We combined all the carcass recoveries and calculated that the peak week of spawning centered around 18 September, when 29.3% of the total spawning occurred. The following week an estimated 27.5% of the total spawning occurred. These estimates are similar to estimates of peak spawning in 1992 when an estimated 30.3% of the

total spawning occurred during the week centered on 16 September, and 31.1% during the week centered on 23 September. Peak spawning in the North Santiam and Clackamas rivers occurred about 1 week later and in the Sandy River about 2 weeks later than in the McKenzie in 1996.

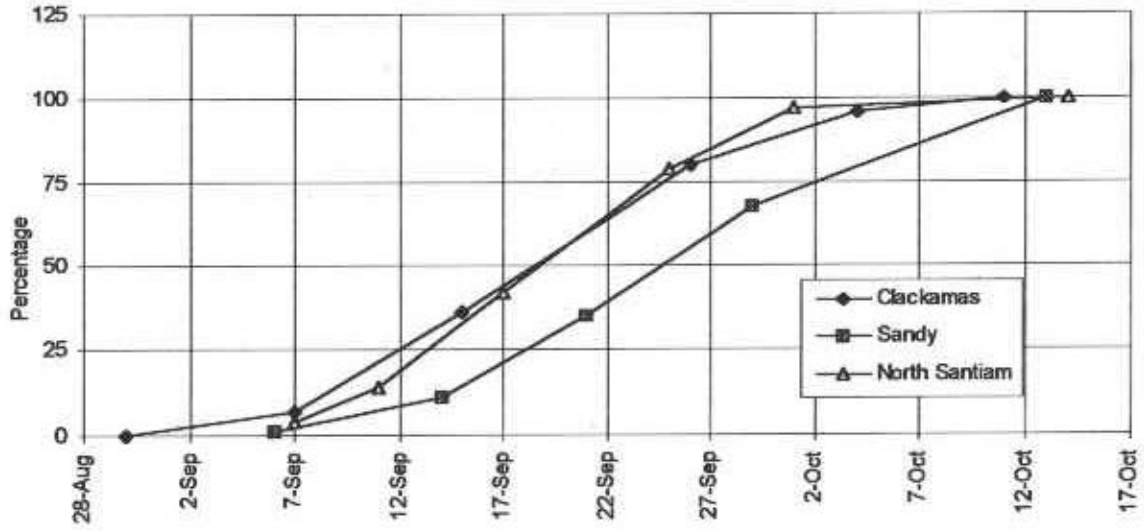

Figure 5. Progression of spawning of spring chinook salmon in the Clackamas, Sandy, and North Santiam rivers, 1996. Data points represent the cumulative distribution of new redds observed and are plotted by the midpoint of the survey week.

Spawning Ground Surveys in the McKenzie River Basin

We conducted extensive spawning ground surveys by boat and foot on the mainstem McKenzie River and major tributaries in 1996. We surveyed 45.0 miles of the mainstem McKenzie River between Olallie boat slide (rm 80.1) and Leaburg town ramp (rm 33.7), 2.2 miles of the South Fork McKenzie River, 10.7 miles of Horse Creek, 0.5 miles of Lost Creek, 2.7 miles of Gate Creek, and the Carmen-Smith spawning channel. Olallie boat slide is 1.5 miles below a velocity barrier which directs migrating salmon into the Carmen-Smith spawning channel. The spawning channel is considered the upstream limit for migrating salmon in the mainstem McKenzie River. Based on counts from annual aerial spawning ground surveys funded by the Eugene Water & Electric Board (EWEB) we know that spring chinook salmon spawn in areas below the Leaburg town ramp. Since 1989, spawning in sections below the Walterville Canal intake (rm. 28.5) has accounted for <6.7% of the mainstem redds. Our boat surveys between Olallie slide and Leaburg town ramp covered the areas where we estimate >90% of the redds were counted during the aerial survey in 1996.

Table 2. Redd counts of spring chinook salmon by survey date in the McKenzie River and major tributaries, 1996. All redds observed were counted each time a survey was conducted.

Survey section	Week of survey							
	Aug 25-31	Sep 1-7	Sep 8-14	Sep 15-21	Sep 22-28	Sep 29-Oct 5	Oct 6-12	Oct 13-19
Olallie Slide to Belknap Springs	--	3	13	32	36	40	--	--
Belknap Springs to McKenzie Bridge	--	1	10	31	32	37	--	--
McKenzie Bridge to Hamlin	--	0	16	9	10	11	--	--
South Fork to Forest Glen	--	0	2	0	0	0	--	0
Forest Glen to Ben & Kay Ramp	0	7	25	51	67	--	--	--
Helfrich Ramp to Leaburg Lake	--	0	0	3	6	9	--	--
Leaburg Dam to Leaburg Town Ramp	0	1	9	22	51	62	--	--
Carmen Spawning Channel	0	0	2	10	13	13	--	--
Lost Creek	0	0	0	0	0	0	2	--
Horse Creek-								
Separation Cr. to Avenue Cr.	--	2	--	--	6	--	--	--
Avenue Cr. to Rd. #2638	--	0	--	--	33	--	--	--
Rd. #2638 to McKenzie River	0	1	3	5	6	8	18	--
South Fork	--	1	1	6	9	8	--	2
Gate Creek	--	--	--	2	--	--	1	--

We counted 1,445 spring chinook salmon (including 15 jack salmon) passing over Leaburg Dam (rm. 38.1) in 1996 (Figure 6). This count was the sixth lowest since annual counting began in 1970. The Leaburg Dam count was 6.7% of the Willamette Falls count, which is within the range of approximately 5-10% observed in past years.

Spawning activity was highest in the section from Leaburg Dam to the Leaburg town ramp where a peak density of 11.9 redds per mile was observed (Table 3). Spawning fish in this section tend to concentrate in the discharge water from the Leaburg Trout Hatchery and downstream along the left river bank within the influence of the hatchery water. The peak redd count in this 5.2 mile section was highly influenced by the first 0.8 miles of survey, which included the hatchery outfall, where redd density was 42.5 per mile. In the sections above Leaburg Dam the highest redd counts were from Olallie slide to Belknap Springs (7.3/mile), Belknap Springs to McKenzie Bridge (5.8/mile), and Forest Glen to Ben and Kay ramp (5.5/mile) (Table 3).

Results of surveys on Lost Creek, South Fork McKenzie, and Gate Creek indicated relatively low levels of spawning with peak densities of 4 redds or fewer per mile. Survey results on the lower 6.0 miles of Horse Creek indicated higher levels of spawning than we observed on the other tributaries and the mainstem McKenzie River above Leaburg Dam. Peak redd counts ranged from 7.5 to 9.2 per mile on these two survey sections. Observations of the two upper Horse Creek routes (Separation Cr. to Avenue Cr. and Avenue Cr. to Rd. #2638) and Gate Creek were limited to two surveys during the spawning season. The second surveys were scheduled for the last week of September or the first week of October, one to two weeks after the observed peak of spawning in previous years. Sporadic surveys in recent years have indicated that Gate Creek has not been an important spawning area. Historic and recent surveys conducted on Horse Creek, Lost Creek, and the South Fork have shown that these tributaries can be important spawning areas.

We counted a total of 13 redds in the Carmen-Smith spawning channel. The artificial channel is maintained and operated by EWEB to mitigate for loss of spawning area by the construction of Trail Bridge Dam and associated hydroelectric projects. Therefore we did not calculate redds per mile for this survey as the spawning channel is not representative of typical upper river natural spawning areas. Redd counts since 1991 have not exceeded 22 in the 500 ft. channel.

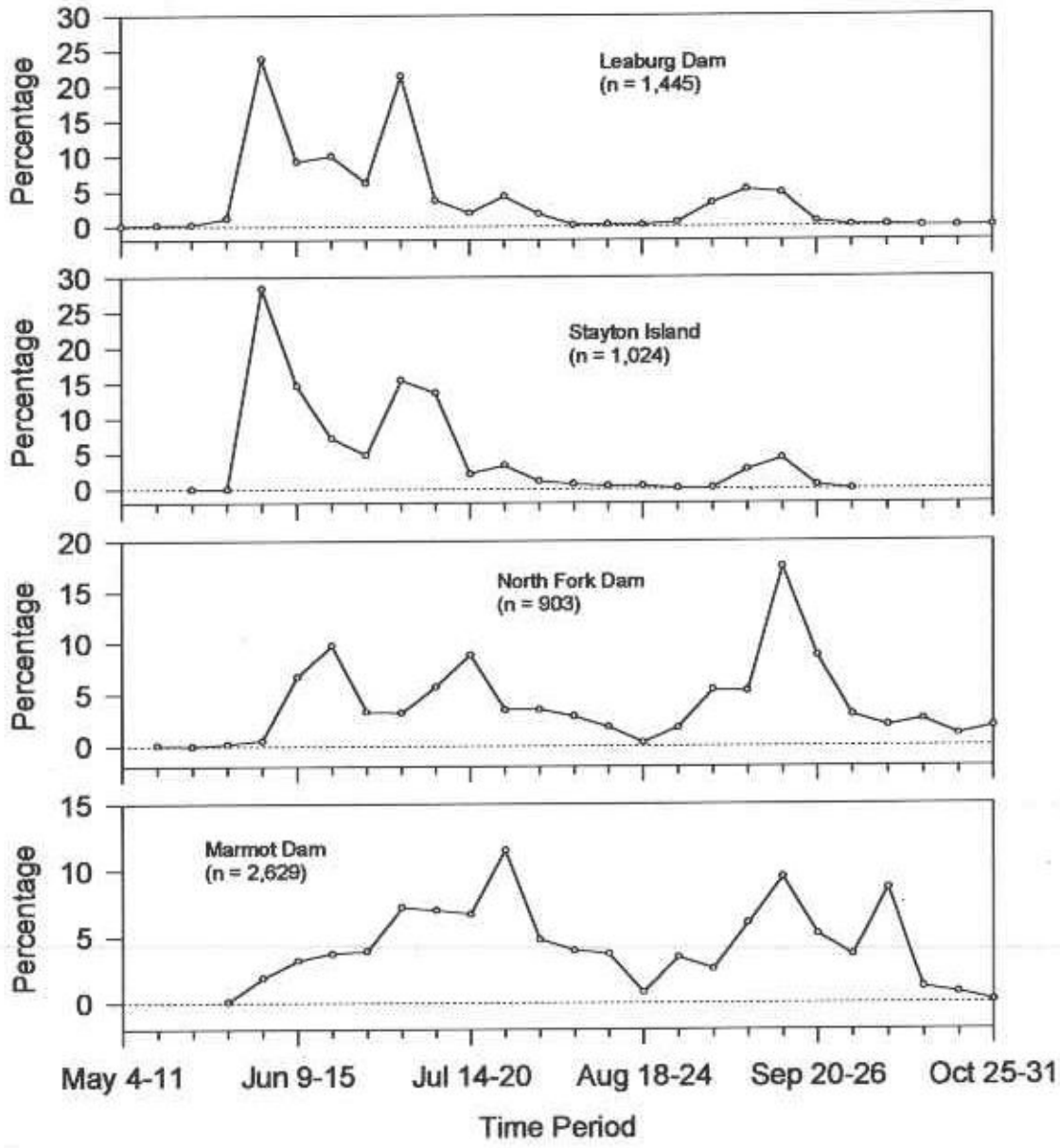

Figure 6. Migration timing of adult spring chinook salmon in the McKenzie River at Leaburg Dam, in the North Santiam River at Stayton Island, in the Clackamas River at North Fork Dam, and in the Sandy River at Marmot Dam, 1996. Fish in October at Marmot Dam may be fall chinook salmon.

We were able to recover and examine 82 carcasses, 48 which were females (Table 4). We determined that 3 (6.3%) of the females died prior to spawning. In 1992, 22 of 169 (13.0%) females died prior to spawning (ODFW 1995). Higher prespawning mortality in 1992 could be related to water temperature, as 1992 was considered a dry year with lower flows and potentially higher water temperatures. We recovered eight coded wire tags from carcasses marked with an adipose fin clip (Table 5). Three of these were strays from the Middle Fork Willamette and South Santiam rivers.

The ratio of the Leaburg Dam adult count (1430) to redds counted on spawning surveys above the dam (236) was 6.1:1, much higher than the North Santiam, Clackamas, and Sandy rivers. Assuming a sex ratio of males to females similar to that in McKenzie Hatchery (1.2:1), 64% of the fish that passed the dam were unaccounted for in spawning ground redd counts. Mortality of fish prior to spawning (angling for spring chinook salmon is closed above Leaburg Dam), and an undercounting of redds during spawning surveys are the most likely explanations for this difference.

Cramer et al. (1996) reported a pre-spawning mortality of Willamette spring chinook salmon of 20%. After adjusting the fish-to-redd ratio for this mortality, 51% of the fish were still unaccounted for in spawning surveys. Redd counts in the McKenzie River were based on the highest number counted in individual survey sections through the spawning season. Consequently, redds constructed early in the season may not have been included when peak counts were observed. In contrast each survey in the North Santiam, Clackamas, and Sandy rivers only counted previously un-counted redds and the redd counts through the season were cumulative. Our method in the McKenzie may have excluded redds that could no longer be seen. However, results from the North Santiam, Clackamas and Sandy rivers also suggest that pre-spawning mortality, excluding harvest, is higher than the 20% reported by Cramer et al. (1996).

Aerial Redd Counts:

The Eugene Water & Electric Board has funded annual helicopter spawning ground surveys of the entire mainstem McKenzie River below Trail Bridge Dam and the South Fork Below Cougar Dam since 1965. The survey in 1996 was the first in which comprehensive boat surveys were also conducted using similar survey sections to allow comparison of the two survey methods. The boat surveys conducted nearest to the 27 September aerial survey were used for comparison.

Comparison of total counts in survey sections between Trail Bridge and the Hawn gauge show that 130 redds were counted by helicopter and 188 by boat (Table 6). Aerial redd counts in the two uppermost sections were much lower

Table 3. Summary of spring chinook salmon spawning surveys for the McKenzie River, 1996. Survey data for shorter sections of the river are shown in **APPENDIX B.**

Survey section	Length (mi.)	Counts			Redds/ mile
		Live fish	Carcasses[a]	Redds[b]	
Olallie Slide to Belknap Springs	5.5	9	2	40	7.3
Belknap Springs to McKenzie Bridge	6.4	10	3	37	5.8
McKenzie Bridge to Hamlin	8.3	6	1	16	1.9
South Fork to Forest Glen	2.4	1	0	2	0.8
Forest Glen to Ben & Kay Ramp	12.2	27	28	67	5.5
Helfrich Ramp to Leaburg Lake	5.0	7	4	9	1.8
Leaburg Dam to Leaburg Town Ramp	5.2	60	28	62	11.9
Carmen-Smith Spawning Channel	0.1	4	0	13	--
Lost Creek	0.5	1	2	2	4
Horse Creek-					
Separation Cr. to Avenue Cr.	4.7	0	0	6	1.3
Avenue Cr. to Rd. #2638	3.6	0	1	33	9.2
#2638 to Mck. R.	2.4	11	5	18	7.5
South Fork	2.1	7	8	6	2.9
Gate Creek	2.7	0	0	2	0.7
Total	61.1	143	82	313	5.1

[a] *Includes carcasses that were not sampled.*
[b] *Peak count in each section.*

Table 4. Characteristics of spring chinook salmon carcasses sampled during spawning ground surveys in the McKenzie, North Santiam, Clackamas, and Sandy basins, 1996.

River, sex	Number[a]	Mean length (mm)	Number unspawned	Adipose fin clips
McKenzie:				
Males	26	855	2	4
Females	48	805	3	4
Unknown	8	--	--	--
North Santiam:				
Males	13	846	1	0
Females	28	855	9	2
Unknown	3	--	--	--
Clackamas:				
Males	7	883	0	0
Females	9	816	2	1
Unknown	1	--	--	--
Sandy:				
Males	227	855	2	1
Females	247	852	11	1
Unknown	17	--	--	--

[a] *Only includes those fish from which scales could be collected.*

than counts made from ground surveys. Visibility from the air is limited in these sections by the narrow river channel and tall trees along the river bank where most redds are located. In the wider, more open channel areas downstream, (McKenzie Bridge to Hawn gauge) 112 redds were counted from the air and 120 from the ground. Although the total count of redds was similar, differences between the two methods were not consistent within individual survey sections below McKenzie Bridge (Table 6).

Table 5. Coded wire tag information from fish marked with adipose fin clips and recovered in spawning ground surveys in the McKenzie, North Santiam, Clackamas and Sandy rivers, 1996. Abbreviations: PSC = Pacific Salmon Commission; BKD+ = bacterial kidney disease- positive.

Recovery location, tag code	Number	Brood year	Release site	Hatchery of origin	Stock	Experimental group
McKenzie River:						
07-58-18	1	1991	McKenzie	McKenzie	McKenzie	Small size
07-02-40	2	1992	McKenzie	McKenzie	McKenzie	Normal size
07-61-21	1	1992	McKenzie	McKenzie	McKenzie	Normal size
07-04-28	1	1992	McKenzie	Marion Fks.	McKenzie	--
07-59-35	1	1991	Middle Fk. Willamette	Willamette	Middle Fk Willamette	Oxygen
07-59-23	1	1991	Middle Fk. Willamette	Willamette	Middle Fk. Willamette	Oxygen
07-14-58	1	1991	S. Santiam	Dexter pond	S. Santiam	PSC index
No tag	1	--	--	--	--	--
North Santiam R.						
07-61-16	1	1991	N. Santiam	Marion Fks	N. Santiam	Direct/BKD+
07-14-59	1	1991	S. Santiam	Dexter pond	S. Santiam	PSC index
Salmon River						
07-03-54	2	1992	Sandy River	Clackamas	Clackamas, (early)	Production
Clackamas River						
07-59-03	1	1992	Clackamas	Clackamas	Clackamas, (early)	Production

Spawning Ground Surveys in the North Santiam River Basin

About 40 miles of the mainstem North Santiam River between Minto Dam (rm 43.5) and Greens Bridge (rm 3.0) were surveyed between one and five times in 1996 (Table 7). Migration is blocked at Minto Dam. Some spawning activity was found in all sections surveyed. Spawning activity was highest in the 10 mile reach from Minto to Fisherman's Bend (rm 33.5), accounting for 74% of the live fish, 60% of the carcasses, and 57% of the redds counted. The redd density in this uppermost section (7.8/mile) was higher than any other surveyed (Table 7). Some of the live fish observed in this section likely entered the fish trap at Minto Dam and were removed for broodstock for Marion Forks Hatchery (rm 73.3) on the North Santiam River.

Table 6. Comparison of redd counts from a helicopter with those from ground surveys in six standard survey sections in the McKenzie River, 1996.

Survey section	Aerial survey	Ground survey
Trailbridge to Belknap	13	36
Belknap to McKenzie Bridge	5	32
McKenzie Bridge to Blue River	35	11
Blue River to Rosboro	12	34
Rosboro to Leaburg Dam	36	41
Leaburg Dam to Hawn gauge	29	34
Total	130	188

Peak spawning in the North Santiam occurred during September 23-27 (Table 8) based on surveys upstream of Mehama (rm 27.0). The peak for sections downstream of Mehama could not be determined because they were not surveyed regularly.

We sampled 44 carcasses during spawning surveys in the North Santiam in 1996 (Table 4). Two coded wire tagged fish were recovered (Table 5).

We estimated pre-spawning mortality of fish that spawned above Stayton Island. Diversion dams at Stayton Island provided the opportunity to trap adults as they ascended fishways over the dams (Figure 6). The number of fish passing the fishways was based on the proportion of days the fishways were trapped. Fish taken for hatchery broodstock at Minto were subtracted from the estimated number past Stayton Island to obtain an estimate of potential spawners. The ratio of potential spawners (391) above Stayton Island to redds counted above the island (108) was 3.6:1. Assuming a ratio of males to females similar to that of fish taken for Marion Forks Hatchery (1.2:1), angling mortality of 20%, and that most redds in the basin were counted, the mortality prior to spawning (excluding harvest) was estimated to be 24%, similar to the 20% reported by Cramer et al. (1996) for the Willamette Basin.

We surveyed sections of the Little North Fork Santiam River on four dates between 9 September and 1 October. We never saw any chinook redds but observed approximately 20 chinook in a deep pool at the "narrows" (rm 13.5) on 9 September. District personnel observed one chinook in a 4.5 mile standard index area beginning at Elkhorn Bridge (rm 17.0) in July. High water flows caused by rainstorms beginning the end of September prevented surveys during the second week of October, a time district personnel have traditionally made spawning surveys in the Little North Fork Santiam River. Two chinook carcasses were recovered in the Little North Fork Santiam River on 9 September. Neither fish had spawned.

Table 7. Summary of spring chinook salmon spawning surveys for the North Santiam River, 1996. Survey data for shorter sections of the river are shown in **APPENDIX B.**

Survey section	Length (mi.)	Counts			Redds/ mile
		Live fish	Carcasses[a]	Redds	
North Santiam River:					
Minto - Fishermen's Bend	10.0	144	29	78	7.8
Fishermen's Bend - Meham	6.5	32	10	23	3.5
Mehama - Stayton	10.3	17	5	21	2.0
Stayton - Shellbourne	5.5	1	2	12	2.2
Shellbourne - Green bridge	8.2	0	2	3	0.4
Little North Santiam River	20.5	21	2	0	--
Total	61.0	215	50	137	2.2

[a] *Includes carcasses that were seen but not sampled.*

Table 8. Redd counts of spring chinook salmon by survey date in sections of the North Santiam River, 1996. Only redds not previously counted were included in each survey period.

Survey Section	Survey dates					
	Sep 5-9	Sep 10-12	Sep 16-18	Sep 23-27	Sep 30-Oct 6	Oct 14-16
Minto - Fishermen's Bend	3	10	21	34	7	3
Fishermen's Bend - Mehama	2	4	1	13	3	--
Mehama - Stayton	--	--	16	4	0	1
Stayton - Shellbourne	--	--	--	--	12	--
Shellbourne - Greens bridge	--	--	--	--	3	--
Total	5	14	38	51	25	4

Aerial Redd Counts:

ODFW has conducted aerial surveys of the North Santiam since 1970 to count chinook salmon redds as an index of spawning abundance. Although the surveys were designed and timed to index fall chinook spawners below the mouth of the Little North Fork Santiam River, surveys were done annually since 1991 (except 1995) up to Big Cliff Dam (rm 46.4) to include spring chinook spawning areas. On average, 45% of the redds observed were in the area above the Little North Fork Santiam River in primarily spring chinook spawning areas.

In 1996 we accompanied ODFW personnel in a small helicopter from Minto Dam downstream to the mouth of the North Santiam River. We also flew the Little North Santiam River from its mouth to Salmon Falls (rm 16.0). A total of 15 redds were observed in the mainstem North Santiam River from the air, only 11% of those observed from the ground through the season to that date (Table 9). A sharp increase in water flow began about 26 September and was partially responsible for redds not being visible from the air. Previously constructed redds, marked by flagging on adjacent vegetation, were difficult to see even from a boat after the flow increased. No redds were seen in the Little North Fork Santiam River.

Table 9. Comparison of redd counts from a helicopter with those from ground surveys for several time periods prior to the helicopter count in the North Santiam River, 1996.

Survey section	Helicopter (7-Oct)	Ground surveys: Two weeks (23 Sep-6 Oct)	Ground surveys: Season total (5 Sep-6 Oct)
Minto - Packsaddle	0	4	7
Packsaddle - Gates	4	17	31
Gates - Mill City	3	13	23
Mill City - Fish. Bend	0	7	14
Fish. Bend - Mehama	3	16	23
Mehama - Powerline	0	2	5
Powerline - Stayton Is.	2	0	2
N. channel - Stayton Br	1	2	2
S. channel - Stayton Br	0	0	11
Stayt. Br - Shellbourne	0	12	12
Shellbourne - Greens Br	2	3	3
Total	15	76	133

Spawning Ground Surveys in the Clackamas River Basin

Sixty-three miles of Clackamas basin streams above North Fork Dam (rm 30) were inventoried during six survey cycles in 1996 (Table 10). All spawning activity in the basin occurred in the mainstem Clackamas River and three tributaries, the Collawash River, Roaring River and Fish Creek. Redds in the mainstem Clackamas River were observed within a 33.5 mile reach as far upstream as Forest Road 4670 (rm 69.5) and as far downstream as Lazy Bend Campground (rm 36.0). In the Collawash River spawning occurred from the mouth upstream about 6 miles to Farm Creek (rm 5.7).

The mainstem Clackamas River had most spawning activity, accounting for 85% of the live fish, all but one of the carcasses, and 90% of the redds counted. Redd density in the mainstem was four times greater than that in the tributaries (Table 10). Few carcasses were recovered on the Clackamas (Table 4); one was coded wire tagged (Table 5).

The distribution of redds in the basin was similar to recent past years although the 1996 counts were significantly lower in the Riverside Overlook area (rm 55.5) in the mainstem and in Roaring River (Bob Diebel and Dan Shively, U.S. Forest Service, personal communication, 1996). The lower densities in those areas was attributed to habitat changes wrought by flood events in 1995 and 1996.

Peak spawning in the basin occurred during the fourth survey cycle, September 23-30 (Table 11) Peak timing was identical for both mainstem and tributary reaches (Table 11). Spawning activity increased in survey sections following significant rain in mid-September.

The ratio of the North Fork Dam adult count (819 through September, Figure 6) to redds counted on spawning surveys (182) was 4.6:1. Hatchery records show a sex ratio of returning adults of about one male to one female. If the sex ratio above the dam was the same as that in the hatchery, each redd should have represented 2 fish. A fish to redd ratio of 4.6 to 1 means that 56% of the fish that passed the dam were unaccounted for in spawning areas. Mortality of fish prior to spawning (angling for spring chinook salmon is closed above North Fork Dam), undercounting of redds during spawning surveys, fall-back at North Fork Dam, a sex ratio weighted to males, or a combination of all these could explain the discrepancy.

Based on carcasses in spawning areas above the dam (Table 4), the sex ratio in the Clackamas was not weighted to males. Fall-back at North Fork Dam was minor and fish counts were not inflated (Doug Cramer, Portland General Electric Co., personal communication, 1997). The most likely explanation for the high ratio of fish to redds is pre-spawning mortality and an undercounting of redds. If we use a pre-spawning mortality of 20% reported by Cramer et al. (1996) for Willamette spring chinook salmon, 44% of the redds were missed and not counted in the basin. We do not think we missed that many redds because of the extent and intensity of our surveys, although certainly some were missed. Data suggest pre-spawning mortality was much higher than the 20% reported by Cramer et al. (1996).

Aerial Redd Counts:

Redds were counted from a helicopter arranged and provided by Portland General Electric Company. Spring chinook redds have been counted from a helicopter for a number of years in the Clackamas River basin. The 1996 survey was conducted on October 10. Redds were counted from the topmost survey section of the Clackamas River downstream to North Fork Reservoir.

Redds in the Collawash River were also counted from the topmost section downstream to the confluence with the Clackamas River. No aerial surveys were made of the Oak Grove Fork, Roaring River, or Fish Creek.

Table 10. Summary of spring chinook salmon spawning surveys for the Clackamas River, 1996. Survey data for shorter sections of the river are shown in **APPENDIX B.**

Survey section	Length (mi.)	Counts			Redds/ mile
		Live fish	Carcasses[a]	Redds	
Clackamas River:					
Sisi Creek - Forest Rd 4650	9.1	30	0	29	3.2
Forest Rd 4650 - Collawash River	8.0	32	18	33	4.1
Collawash River - Cripple Creek	8.5	62	1	52	6.1
Cripple Creek - Memaloose Weigh Station	14.0	85	14	45	3.2
Collawash River:					
2.0 mi. above Collawash Falls - mouth	9.5	19	1	12	1.6[b]
Hot Springs Fork:					
Pegleg Falls - mouth	5.0	0	0	0	0.0
Pinhead Creek:					
Last Creek - mouth	1.0	0	0	0	0.0
Roaring River:					
2.0 mi. upstream - mouth	2.0	9	0	6	3.0
Fish Creek:					
Forest Rd 5430 - mouth	4.5	3	0	5	1.1
North Fork Clackamas River:					
1.5 mi. upstream - mouth	1.5	0	0	0	0.0
Total	63.1	240	34	182	2.9

[a] *Includes carcasses that were seen but not sampled.*

[b] *Redd density does not include the 2.0 miles upstream of Collawash Falls.*

Table 11. Redd counts of spring chinook salmon by survey date in sections of the Clackamas River, 1996. Only redds not previously counted were included i each survey period.

Survey Section	Survey dates					
	Aug 26-Sep 3	Sep 4-10	Sep 11-19	Sep 23-30	Oct 1-7	Oct 8-14
Clackamas River:						
Sisi Creek - Forest Rd 4650	0	1	10	12	2	4
Forest Rd 4650 - Collawash River	0	2	6	15	8	2
Collawash River - Cripple Creek	0	8	13	16	15	0
Cripple Creek - Memaloose Weigh Station	0	1	19	24	--	1
Pinhead Creek	--	--	0	--	--	--
Collawash River	0	0	5	5	2	--
Hot Springs Fork	0	0	0	0	0	--
Roaring River	0	--	0	4	2	--
Fish Creek	0	--	1	4	0	--
North Fork Clackamas River	--	--	--	0	--	--
Total	0	12	54	80	29	7

We compared counts of redds conducted from the air and from ground (foot and boat) surveys. The counts from the air were compared to ground surveys conducted from September 23-October 9, which encompassed the full two week period prior to the aerial counts and included the peak spawning period. Aerial counts were also compared to the cumulative redd count from ground surveys which began in late August.

The total number of redds counted from the air was 51% lower (range -75% to +18% for individual sections) than that counted during ground surveys in the previous two week period (Table 12). In addition, redd counts from the air were 70% lower (range -24% to -86%) than the cumulative redd count from ground surveys (Table 12). Although aerial surveys are less labor intensive than ground surveys, factors such as speed of flight and limited visibility (riparian vegetation and reflection of light) reduce the surveyor's ability to accurately count redds.

Table 12. Comparison of redd counts from a helicopter with those from ground surveys for several time periods prior to the helicopter count in the Clackamas River, 1996.

Survey section	Helicopter (Oct 10)	Ground surveys: Two weeks (23 Sep-9 Oct)	Ground surveys: Total prior (26 Aug-10 Oct)
Clackamas River:			
Above Collawash River	23	43	62
Collawash - Cripple Cr.	11	31	52
Cripple Cr - Memaloose	9	24	44
Collawash River	13	7	12
Total	56	105	170

Spawning Ground Surveys in the Sandy River Basin

Twenty nine miles of Sandy River basin streams above Marmot Dam (rm 30) were surveyed during six survey cycles in 1996 (Table 13). Some spring chinook spawning activity was documented in all survey sections except Henry, Devil Canyon, and Lady creeks. The primary locations of spawning activity were the Salmon River and the lower end of Still Creek from the mouth to Cool Creek.

Salmon River accounted for 90% of the live fish, 74% of the carcasses, and 86% of the redds counted in 1996 (Table 13). Average redd density in Salmon River was about 36 redds/mile. By contrast, the redd density in Still Creek was 10 redds/mile and the density in the other survey streams was 6 redds/mile or less.

The redd density in the Salmon River upstream of Forest Road 2618 (rm 10.3) estimated from our survey was 35 redds/mile, very similar to that estimated by the U.S. Forest Service (37 redds/mile) for the same section (Jeff Uebel, U.S. Forest Service, personal communication, 1996). The U.S. Forest Service has used this section as an index area in the past along with one near the Resort at the Mountains golf course (rm 6.0) and one in Still Creek (mouth to Cool Creek) to monitor trends in natural spawning in the Sandy

basin. The area near the golf course showed no spawning activity during 1996, likely a result of changes due to flood events in 1995 and 1996. The Still Creek index area was approximately one-third (14.2 redds/mile) of counts made in 1991-1995 (31-47 redds/mile).

The time of peak spawning in the basin overall occurred during September 26-October 2 (Table 14), later than in the Clackamas and North Santiam rivers. The peak was driven by spawners in the section of Salmon River downstream of Bridge Street (rm 6.8). The peak was less well defined in the section upstream of Forest Road 2618. The dates of peak spawning in Still Creek were less precisely estimated because no survey was done between September 26 and October 2. However, peak spawning appeared to occur between September 18 and October 2. The U.S. Forest Service documented peak spawning in Still Creek during a similar interval for 6 of the last 7 years (Jeff Uebel, U.S. Forest Service, personal communication, 1996).

More carcasses were sampled on the Sandy River than in all other rivers combined (Table 4). Of those sampled, only two were coded wire tagged (Table 5).

The ratio of adult counts over Marmot Dam (2,268 through September, Figure 6) to redds counted in the basin (569) was about 4.0:1. Assuming an equal ratio of males to females similar to the Clackamas River and that most redds in the basin were counted, 50% of the fish above Marmot Dam were unaccounted for in spawning areas. Adjusting this for an angler harvest above Marmot Dam of 8% based on punch card estimates and Marmot Dam counts from 1988 through 1994, still left 46% of the fish unaccounted for in spawning areas. Mortality of fish prior to spawning excluding angler harvest, undercounting of redds during spawning surveys, fall-back at Marmot Dam, a sex ratio weighted to males, or a combination of all these could explain the discrepancy.

Based on carcasses in spawning areas above the dam (Table 4), the sex ratio in the Sandy was not weighted to males. Fall-back at Marmot Dam is believed to be minor and fish counts were not inflated (Doug Cramer, Portland General Electric Co., personal communication, 1997). The most likely explanation for the high ratio of fish to redds is pre-spawning mortality and an undercounting of redds. If we use a pre-spawning mortality of 20% reported by Cramer et al. (1996) for Willamette spring chinook salmon, 32% of the redds were missed and not counted in the basin. While we do not think we missed that many redds because of the extent and intensity of our surveys, we do know we missed some. Incidental observations of redds in locations not routinely surveyed in 1996 such as the Zigzag River near Rhododendron, Oregon and the

Table 13. Summary of spring chinook salmon spawning surveys for the Sandy River, 1996. Survey data for shorter sections of the river are shown in **APPENDIX B.**

Survey section	Length (mi.)	Counts			Redds/ mile
		Live fish	Carcasses[a]	Redds	
Sandy River:					
Salmon River - Marmot bridge	1.0	5	0	0	0.0
Salmon River:					
Final Falls - Forest Rd 2618	3.2	321	127	127	39.7
Forest Rd 2618 - Bridge Street	3.6	112	72	71	19.7
Bridge Street - mouth[b]	6.7	775	308	278	41.5
Still Creek:					
Forest Rd 2612 - mouth[c]	5.3	98	28	65	12.3
Camp Creek:					
Forest Rd 2632 - mouth	2.0	1	9	6	3.0
Clear Creek:					
East Barlow Trail Rd - mouth	0.5	4	0	1	2.0
Clear Fork:					
1.5 miles upstream - mouth	1.5	14	9	9	6.0
Lady Creek:					
0.5 miles upstream - mouth	0.5	0	0	0	0.0
Henry Creek:					
1.0 mile upstream - mouth	1.0	0	0	0	0.0
Devil Canyon Creek:					
1.0 mile upstream - mouth	1.0	0	0	0	0.0
Lost Creek:					
Lost Creek Campground - mouth	2.5	9	8	12	4.8
Total	30.3	1,339	561	569	18.8

[a] *Includes carcasses that were not sampled.*

[b] *Includes surveys that did not cover the entire section.*

[c] *Includes 4 lives and 4 redds in the Zigzag River at the mouth of Still Creek.*

Table 14. Redd counts of spring chinook salmon by survey date in sections of the Sandy River, 1996. Only redds not previously counted were included in each survey period[a].

Survey Section	Survey dates					
	Sep 3-10	Sep 11-17	Sep 18-25	Sep 26-Oct 2	Oct 3-10	Oct 11-16
Salmon River:						
Final Falls - Forest Rd 2618	3	31	30	29	32	2
Forest Rd 2618 - Bridge Street	1	--	19	33	16	2
Bridge Steet - mouth	0	6	51	121	52	23
Still Creek	1	12	20	--	31	1
Camp Creek	0	0	--	--	6	0
Lost Creek	0	--	6	--	4	2
Clear Fork	0	3	4	1	0	0
Henry Creek	0	--	--	--	--	0
Lady Creek	--	--	--	--	--	0
Clear Creek	0	0	--	1	0	0
Devil Canyon Creek	0	--	--	--	--	0
Total	5	52	130	185	141	30

[a] *Counts do not include redds observed outside normal survey areas or dates.*

mainstem Sandy River near the confluence of Lost Creek suggest some redds were not counted. Subsequent surveys should include the Zigzag River and the mainstem Sandy River, although glacial silt in the mainstem often restricts visibility during the spawning season.

TASK 2.2-- MORTALITY FROM FIN MARKING HATCHERY FISH

Freshwater harvest of Willamette spring chinook salmon accounted for about 70% of the total harvest in ocean and freshwater fisheries over a 5-year period from 1989 through 1993 (Bennett 1994). Freshwater sport fisherman took 55% of the total catch and the Columbia River gill-net fishery accounted for another 15% of the catch (Bennett 1994). Harvest rates on 4 and 5 year old

fish in Willamette River sport fisheries averaged about 30% each year. Recreational catch is underestimated because it does not include fisheries in the upper mainstem Willamette or in tributaries above the falls (Bennett 1994).

From these data, it is clear that freshwater fisheries account for the bulk of the harvest mortality on Willamette spring chinook with most of that occurring in sport fisheries. These fisheries, driven by hatchery programs, may be contributing to overharvest of wild spring chinook salmon. To decrease harvest, we are evaluating the feasibility of a catch and release fishery on wild fish that will maintain traditional recreational fisheries on hatchery fish. In a catch and release fishery all hatchery fish would need to be externally marked so anglers could distinguish hatchery from wild fish. To evaluate mortality from marking, we marked groups of hatchery fish at three hatcheries in 1996. In addition we will be estimating the hooking mortality managers can expect on spring chinook salmon that are caught and released in Willamette sport fisheries beginning in spring 1997.

Methods

Two groups of 30,000 spring chinook salmon each were marked; one by removing a ventral fin, the other by removing a maxillary bone. Groups were marked at McKenzie, Marion Forks (North Santiam River), and Clackamas hatcheries in summer and early fall, 1996 for release in spring 1997. Coded wire tagged fish at each hatchery will be used as controls. In addition, two groups of 30,000 fish marked with coded wire tags will be additionally marked with ventral fin and maxillary bone marks in 1997 to evaluate regeneration. The experimental design for the mark evaluation is shown in **APPENDIX C**.

The maxillary mark was chosen because it had the least affect on survival in finclip studies of spring chinook salmon in the Deschutes River (Lindsay et al. 1996). However, that study did not evaluate a single ventral fin mark. Adipose finclips, generally accepted as causing the least finclip mortality, can only be used with coded wire tags on chinook salmon and coded wire tagging is much more expensive than fin marking.

Results and Discussion

One concern commonly raised about the maxillary bone is the incidence of missing maxillaries on fish not intentionally marked as juveniles. Spring chinook salmon returning to McKenzie Hatchery and the collection facility at Dexter Dam in 1996 were examined for the incidence of missing maxillary bones.

Only 0.7% of the salmon examined at McKenzie Hatchery and 1.3% of those at Dexter had a missing maxillary (Table 15). Five of the eight missing bones at McKenzie Hatchery were likely related to jaw injuries and were associated with healed jaw deformation. Five of the 16 missing maxillaries at Dexter were actually rolled under and into the mouth which gave the appearance of a missing maxillary. Lindsay et al. (1996) also reported a low incidence of unintentional maxillary marks in Deschutes River spring chinook salmon. Based on these data, the incidence of unintentional maxillary marks on spring chinook salmon is very low.

Table 15. Missing maxillary bones on Willamette spring chinook salmon in 1996.

Location and date	Number of fish without a maxillary	Total fish observed	Percentage without a maxillary
McKenzie Hatchery:			
May 30	0	77	0
June 4	0	199	0
June 7	3	145	2.1
June 11	0	194	0
June 18	1	276	0.4
June 25	1	106	0.9
July 2	2	109	1.8
July 9	0	61	0
July 16	1	32	3.1
Total	8	1199	0.7
Dexter Pond:			
June 18	16	1203	1.3

ACKNOWLEDGMENTS

Several individuals and groups helped with this project. We thank hatchery managers Dave Rogers, Gary Yeager, Terry Jones, and their crews for collecting data on maxillary marks on fish returning to their hatcheries, for accommodating fin mark studies, and for other data collections. Harry Lorz and Kevin Goodson also helped coordinate our activities with the hatcheries.

We acknowledge district biologists Jeff Ziller and Mark Wade for their help on the McKenzie River, John Haxton for help on the North Santiam, and Don Bennett and Pat Keeley for helping supervise our seasonal biologists on the Clackamas and Sandy rivers. We thank biologists Doug Cramer, with Portland General Electric Co., and Dan Shively, Bob Deibel, and Jeff Uebel with the U.S. Forest Service for their assistance on the Clackamas and Sandy rivers. Finally we want to recognize seasonal biologists, Paul Asbury, Chris Becker, Robert Bradley, Larry Funston, David Huff, and Cathleen Malone who collected much of the field data for us in 1996.

REFERENCES

Bennett, D.E. 1994. 1994 Willamette River spring chinook salmon run, fisheries, and passage at Willamette Falls. Oregon Department of Fish and Wildlife, Portland.

Craig, J.A. and A.J. Suomela. 1940. A survey of the Sandy River and its tributaries, 1940. U.S. Fish and Wildlife Service: Special Scientific Report No. 14.

Everest, F.H., G.H. Reeves, J.R. Sedell, J. Wolfe, D. Hohler and D.A. Heller. 1986. Abundance, behavior, and habitat utilization by coho salmon and steelhead trout in Fish Creek, Oregon, as influenced by habitat enhancement. United States Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, Annual Report to Bonneville Power Administration, Contract DE-Al 79 BP 16726, Portland, Oregon.

Homolka, K., and T.W. Downey. 1995. Assessment of thermal effects on salmon spawning and fry emergence, upper McKenzie River, 1992. Information Report Number 95-4. Fish Research and Development Section, Oregon Department of Fish and Wildlife, Corvallis.

Lindsay, R.B., D.E. Ratliff, and W.J. Nyara. 1996. Ocean survival of hatchery spring chinook salmon marked as juveniles by removing various combinations of fins and maxillary bones. Oregon Department of Fish and Wildlife and Portland General Electric Company. Unpublished manuscript

ODFW (Oregon Department of fish and Wildlife). 1988. McKenzie subbasin fish management plan. Oregon Department of Fish and Wildlife, Portland.

ODFW (Oregon Department of Fish and Wildlife). 1990 Effects of Lost Creek Dam on the distribution and timing of chinook salmon spawning in the Rogue River upstream of Gold Ray Dam. Rogue Basin fisheries evaluation report. Research and Development Section. Corvallis.

ODFW (Oregon Department of fish and Wildlife). 1992. Wild fish Management Policy. Oregon Department of Fish and Wildlife Administrative Rule No. 635-07-252 through 635-07-529, Portland.

ODFW (Oregon Department of fish and Wildlife). 1992a. Clackamas subbasin fish management plan. Oregon Department of Fish and Wildlife, Portland.

ODFW (Oregon Department of fish and Wildlife). 1992b. Santiam and Calapooia subbasins fish management plan. Oregon Department of Fish and Wildlife, Portland.

ODFW (Oregon Department of fish and Wildlife). 1993. Willamette Basin implementation plan for management of spring chinook salmon. Oregon Department of Fish and Wildlife, Portland.

ODFW (Oregon Department of fish and Wildlife). 1996. Sandy subbasin fish management plan (draft). Oregon Department of Fish and Wildlife, Portland.

van den Berghe, E.P., and M.R. Gross. 1986. Length of breeding life of coho salmon (Oncorhyncus kisutch). Canadian Journal of Zoology 64:1482-1486.

APPENDIX A

Schematic of Willamette Spring Chinook Salmon Study Plan

APPENDIX B

Spawning Surveys for Spring Chinook Salmon in the Willamette and Sandy Basins, 1996

Appendix Table B-1. Spring chinook salmon spawning surveys in the McKenzie River, 1996.

Survey section	Length (mi.)	Number of surveys	Counts[a] Live fish	Counts[a] Redds[b]
McKenzie River:				
Trail Bridge - Olallie	1.8	0	--	--
Olallie - Belknap	5.5	5	9	40
Belknap - McKenzie Trail	4.8	5	9	32
McKenzie Tr. - McKenzie Br.	1.6	5	1	5
McKenzie Bridge - Hamlin	8.3	5	6	16
Hamlin - South Fork	0.3	0	--	--
South Fork - Forest Glen	2.4	6	1	2
Forest Glen - Blue River	0.2	7	1	1
Blue River - Rosboro Bridge	5.5	7	6	34
Rosboro - Ben and Kay	6.5	7	20	32
Ben and Kay - Helfrich	0.9	0	--	--
Helfrich - Leaburg	5.0	6	7	9
Leaburg Dam - Hawn Gauge	0.8	7	31	34
Hawn Gauge - Leaburg Ramp	4.4	7	29	28
Carmen-Smith Spawning Channel	0.1	6	4	13
Lost Creek:				
Hwy 126 to Yale and Limberlost Campground	0.5	7	1	2
Horse Creek:				
Separation Cr. - Avenue Cr.	4.7	2	0	6
Avenue Cr. - Rd 2638	3.6	2	0	33
Rd 2638 - Mouth	2.4	7	11	18
South Fork McKenzie River:				
Above Bridge	0.1	5	3	3
Below Bridge	2.1	6	7	6
Gate Creek	2.7	2	0	2

[a] *Carcass counts are shown in Appendix Table B-2.*

[b] *Peak counts.*

Appendix Table B-2. Counts of spring chinook salmon carcasses, McKenzie River and major tributaries, 1996.

Survey section	Week of survey							
	Aug 25-31	Sep 1-7	Sep 8-14	Sep 15-21	Sep 22-28	Sep 29-Oct 5	Oct 6-12	Oct 13-19
Olallie Slide - Belknap Springs	--	0	0	0	0	2	--	--
Belknap Springs - McKenzie Bridge	--	0	1	2	0	0	--	--
McKenzie Bridge - Hamlin	--	0	0	1	1	0	--	--
South Fork - Forest Glen	--	0	0	0	0	0	--	0
Forest Glen - Ben & Kay Ramp	0	0	2	4	5	15	--	2
Helfrich Ramp - Leaburg Lake	--	0	1	1	0	1	1	--
Leaburg Dam - Leaburg Town Ramp	1	0	0	0	5	13	8	--
Carmen Spawning Channel	0	0	0	0	0	0	--	--
Lost Creek	0	0	0	1	0	0	1	--
Horse Creek: Rd. #2638 - mouth	0	0	0	1	1	2	2	--
Separation Cr. to Rd. #2638	--	0	--	--	0	--	--	--
South Fork	--	0	1	5	1	1	--	0
Gate Creek	--	--	--	0	--	--	0	--

Appendix Table B-3. Spring chinook salmon spawning surveys in the North Santiam River, 1996.

Survey section	Length (mi)	Number of surveys	Counts		
			Live fish	Carcasses[a]	Redds
North Santiam:					
Minto - Packsaddle	1.7	6	13	1	7
Packsaddle - Gates	2.6	6	73	14	31
Gates - Mill City	3.7	6	29	10	26
Mill City - Fishermen's Bend	2.0	6	29	4	14
Fishermen's Bend - Mehama	6.5	5	32	10	23
Mehama - Power line	3.5	4	2	3	5
Powerline - Stayton Island	3.5	4	1	1	2
N. + South Channels - Stayton[b]	3.3	4	14	1	14
Stayton - Shellbourne	5.5	1	1	2	12
Shellbourne - Greens bridge	8.2	1	0	2	3
Little North Santiam River:					
Cedar Creek - Elkhorn Bridge	3.5	1	0	0	0
Elkhorn Bridge - Salmon Falls	1.0	2	0	0	0
Salmon Falls - Golf bridge	3.5	2	20	2	0
Golf bridge - Middle bridge	5.3	1	0	0	0
Middle bridge - Mouth	7.2	2	1	0	0

[a] *Includes carcasses that could not be reached to sample.*

[b] *The north channel was surveyed once and no live fish, one carcass, and two redds were counted. The south channel was surveyed three times and 14 live fish, no carcasses, and 14 redds were counted.*

Appendix Table B-4. Spring chinook salmon spawning surveys in the Clackamas River, 1996.

Survey section	Lenght (mi.)	Number of surveys	Counts		
			Live fish	Carcasses[a]	Redds
Clackamas River:					
Sisi Creek - Pinhead Creek	5.8	4	0	0	1
Pinhead Creek - Forest Rd 4650	3.3	6	30	0	28
Forest Rd 4650 - Collawash River	8.0	7	32	18	33
Collawash River - Oak Grove Fork	3.8	6	33	0	31
Oak Grove Fork - Cripple Creek	4.7	6	29	1	21
Cripple Creek - Fish Creek	6.8	5	55	9	28
Fish Creek - Memaloose Weigh Station	7.2	4	30	5	17
Collawash River:					
2.0 miles upstream - Collawash Falls	2.0	3	0	0	0
Collawash Falls - Upper Forest Rd 63	1.0	1	0	0	0
Upper Forest Rd 63 - Hot Springs Fork	2.0	5	1	0	2
Hot Springs Fork - mouth	4.5	5	18	1	10
Hot Springs Fork:					
Pegleg Falls - mouth	5.0	5	0	0	0
Pinhead Creek:					
Last Creek - mouth	1.0	1	0	0	0
Roaring River:					
2.0 miles upstream - mouth	2.0	6	9	0	6
Fish Creek:					
Forest Rd 5430 - mouth	4.5	5	3	0	5
North Fork Clackamas River:					
1.5 miles upstream - mouth	1.5	1	0	0	0

[a] *Includes carcasses that could not be reached to sample.*

Appendix Table B-5. Spring chinook salmon spawning surveys in the Sandy River, 1996.

Survey section	Lenght (mi.)	Number of surveys	Counts		
			Live fish	Carcasses[a]	Redds
Sandy River:					
Salmon R. - Marmot bridge	1.0	5	5	0	0
Salmon River:					
Final Falls - Forest Rd 2618	3.2	8	321	127	127
Forest Rd 2618 - Bridge Street	3.6	5	112	72	71
Bridge Street - mouth[b]	6.7	7	775	308	278
Still Creek:					
Forest Rd 2612 - Cool Creek	2.0	1	0	0	1
Cool Creek - mouth[c]	3.3	7	98	28	64
Camp Creek:					
Forest Road 2632 - mouth	2.0	4	1	9	6
Clear Creek:					
East Barlow Trail Road - mouth	0.5	5	4	0	1
Clear Fork:					
1.5 miles upstream - mouth	1.5	6	14	9	9
Lady Creek:					
0.5 miles upstream - mouth	0.5	1	0	0	0
Henry Creek:					
1.0 mile upstream - mouth	1.0	2	0	0	0
Devil Canyon Creek:					
1.0 mile upstream - mouth	1.0	2	0	0	0
Lost Creek:					
Lost Cr. Campground - mouth	2.5	4	9	8	12

[a] *Includes carcasses that could not be reached sample.*
[b] *Includes surveys that did not cover the entire section.*
[c] *Includes four live fish and four redds in the Zigzag River at the mouth of Still Creek.*

APPENDIX C

Experimental Design for the Finclip Mortality Study in the Willamette Basin.

Brood year	Hatchery	Mark	Number	Release date
1995	McKenzie	Ad+CWT	30,000	March 1997
		LV	30,000	March 1997
		LM	30,000	March 1997
	Marion Fks[a]	Ad+CWT	30,000	March 1997
		RV	30,000	March 1997
		RM	30,000	March 1997
	Clackamas	Ad+CWT	30,000	March 1997
		LV	30,000	March 1997
		LM	30,000	March 1997
1996	McKenzie	Ad+CWT	88,000	March 1998
		RV	30,000	March 1998
		RM	30,000	March 1998
		RVAd+CWT	30,000	March 1998
		RMAd+CWT	30,000	March 1998
	Marion Fks[a]	Ad+CWT	357,000	March 1998
		LV	30,000	March 1998
		LM	30,000	March 1998
	Clackamas	Ad+CWT	30,000	March 1998
		RV	30,000	March 1998
		RM	30,000	March 1998

APPENDIX C

(Continued)

Brood year	Hatchery	Mark	Number	Release date
1997	McKenzie	Ad+CWT	30,000	March 1999
		LV	30,000	March 1999
		LM	30,000	March 1999
		LVAd+CWT	30,000	March 1999
		LMAd+CWT	30,000	March 1999
	Marion Fks[a]	Ad+CWT	30,000	March 1999
		RV	30,000	March 1999
		RM	30,000	March 1999
	Clackamas	Ad+CWT	30,000	March 1999
		LV	30,000	March 1999
		LM	30,000	March 1999
1998	McKenzie	Ad+CWT	30,000	March 2000
		RV	30,000	March 2000
		RM	30,000	March 2000
		RVAd+CWT	30,000	March 2000
		RMAd+CWT	30,000	March 2000
	Marion Fks[a]	Ad+CWT	30,000	March 2000
		LV	30,000	March 2000
		LM	30,000	March 2000
	Clackamas	Ad+CWT	30,000	March 2000
		RV	30,000	March 2000
		RM	30,000	March 2000

[a] *Marion Forks Hatchery is located on the North Santiam River.*