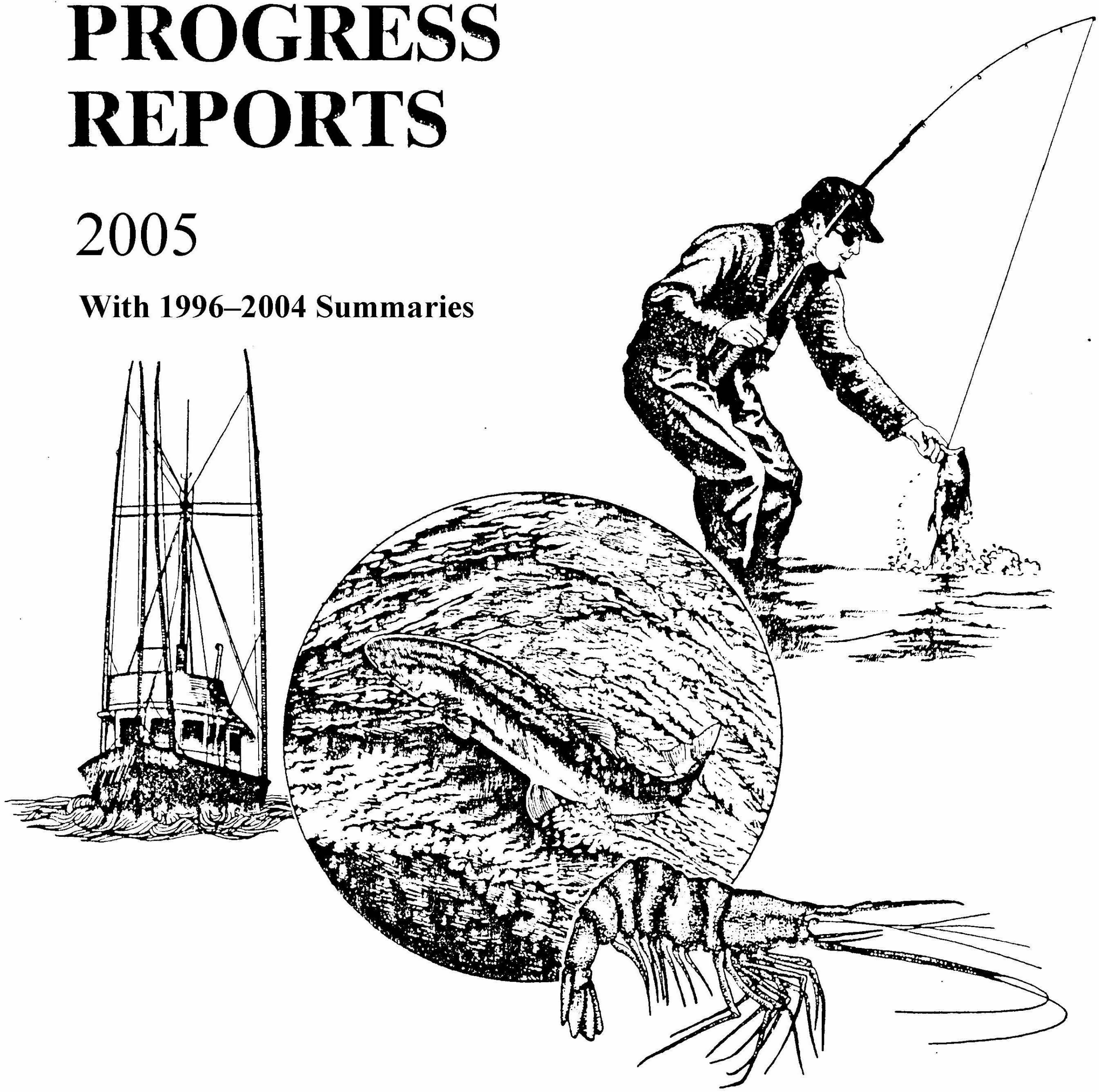
PROGRESS REPORTS

2005

With 1996–2004 Summaries



FISH DIVISION

Oregon Department of Fish and Wildlife

Spring Chinook in the Willamette and Sandy Rivers

ANNUAL PROGRESS REPORT

FISH RESEARCH PROJECT
OREGON

PROJECT TITLE: Spring Chinook Salmon in the Willamette and Sandy Rivers

PROJECT NUMBER: F-163-R-10

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CONTENTS

KEY FINDINGS

1. The number of wild spring Chinook salmon in 2004 in the four rivers where we can estimate adult runs using otolith analysis was:
   - 4,419 (McKenzie above Leaburg Dam), 14% higher than 2001–2003;
   - 489 (North Santiam above Bennett dams), 34% higher than 2001–2003;
   - 3,812 (Clackamas above North Fork Dam), 85% higher than 2002–2003;
   - 2,399 (Sandy above Marmot Dam), 165% higher than 2002–2003.

2. The percentage of wild spring Chinook incorporated into hatchery broodstocks in 2004 as determined by otolith analysis increased over that in 2002–2003:
   - 2.4% (McKenzie), compared to 1.3%;
   - 2.1% (North Santiam), compared to 0.5%;
   - 7.8% (South Santiam), compared to 2.2%; and
   - 0.9% (Willamette), compared to 0.3%.

   The general guideline in draft Hatchery Genetic Management Plans (HGMP) is 10%.

3. Within the Willamette Basin, the McKenzie River accounted for almost 40% of the redds counted in 2002–2005 and had the highest number of wild fish (3,000–5,000). The South Santiam and Clackamas (upstream of North Fork Dam) accounted for about 20% of the redds, but the percentage of wild fish in the Clackamas (70–80%) was much higher than in the South Santiam (10%). The average number of redds in the Sandy Basin upstream of Marmot Dam (400) was similar to the North Santiam, but the percentage of wild fish was much higher in the Sandy (80–95%) than in the North Santiam (<10%).

4. The percentage of hatchery fish upstream of Leaburg Dam increased from 2001 to 2004, but the increase estimated from recovery of carcasses was less (30 to 34%) than that estimated from dam counts (33 to 49%). Because of potential bias in dam counts, the recovery of carcasses has provided a more accurate estimate of the percentage of hatchery fish present in the spawning population.

5. Age 0 (subyearling) Chinook salmon were found throughout the lower McKenzie, upper and lower Willamette, and Santiam rivers in late May–July, 2002–2005. Most juvenile spring Chinook tagged in spring and summer in the Willamette and Santiam rivers migrated past Willamette Falls in the summer, whereas over 50% of the fish tagged in the lower McKenzie River migrated in the fall and following spring.

6. The percentage of wild adult Chinook with an age 0 life history (subyearling smolt) was 75–90% lower in the 2004 return year in most rivers than in 2002 and 2003. The 0-age life history in adult returns was lowest in the McKenzie, Clackamas, and Sandy rivers (3–7%), was 10% in the Middle Fork Willamette and North Santiam rivers, and was highest (23%) in the South Santiam River.

INTRODUCTION

The Willamette and Sandy rivers support intense recreational fisheries for spring Chinook salmon (*Oncorhynchus tshawytscha*). Fisheries in these basins rely primarily on annual hatchery releases of 5–8 million juveniles. Hatchery programs exist in the McKenzie, Middle Fork Willamette, North and South Santiam, Clackamas, and Sandy rivers mainly as mitigation for dams that blocked natural production areas. Some natural spawning occurs in most of the major basins and a few smaller tributaries upstream of Willamette Falls.

The Oregon Fish and Wildlife Commission adopted the Native Fish Conservation Policy (ODFW 2003a) and the Hatchery Management Policy (ODFW 2003b) in part to reduce adverse impacts of hatchery programs on wild native stocks. The Native Fish Conservation Policy recognizes that naturally produced native fish are the foundation for long-term sustainability of native species and hatchery programs, and the fisheries they support.

In the past, hatchery programs and fish passage issues were the focus of spring Chinook salmon management in the Willamette and Sandy basins. Limited information was collected on the genetic structure among basin populations, on abundance and distribution of natural spawning, on rearing and migrating of juvenile salmon, or on strategies for reducing risks that large hatchery programs pose for wild salmon populations. This study is being implemented to gather this information. We conducted work in the main-stem Willamette River at Willamette Falls, and in the Middle Fork Willamette, McKenzie, North Santiam, South Santiam, Molalla, Clackamas, and Sandy rivers in 2004–2005. Task headings below cross reference the study plan outlined in **APPENDIX A.** This report covers tasks that were worked on in late 2004 through early fall 2005, and summarizes data from 1996–2004.

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

Restoration of spring Chinook salmon under the Endangered Species Act and the implementation of ODFW's Native Fish Conservation Policy require information on hatchery and wild fish in spawning populations. In response to this need and to implement a selective fishery, all hatchery spring Chinook salmon in the Willamette basin, beginning with the 1997 brood, were marked with adipose fin clips. Although intentions were to fin-clip all juvenile hatchery fish, some are missed during marking. Given the large numbers of hatchery fish released, even a small percentage of non fin-clipped hatchery fish can bias estimates of wild spawners, especially because the number of wild fish in the basin is low. To help separate non fin-clipped hatchery fish from wild fish, otoliths were thermally marked on all hatchery spring Chinook released into the McKenzie and North Santiam rivers in the 1995 and 1996 brood years, and on all Willamette basin releases beginning with the 1997 brood year. In 2005, all returning spring Chinook salmon originating from Willamette basin hatcheries should be otolith marked. Analysis of otolith marks in returning adults is scheduled to continue through analysis of the 2005 run year, which will give us three brood years (1998–2000) to evaluate the proportion of hatchery and wild fish in the non fin-clipped portion of the run. Otolith marking may be discontinued if analyses of these brood years show that the number of unclipped hatchery fish: (1) can be predicted from the percentage of non fin-clipped hatchery fish at time of release, (2) is a minor component of the run, or (3) is a consistent proportion of the run.

Methods

Juveniles

Thermal marks were placed on otoliths of all hatchery spring Chinook salmon in the 2004 brood that were released in the Willamette and Sandy basins. Reference samples were collected at the hatcheries (Table 1) and were analyzed for mark quality at the otolith laboratory operated by Washington Department of Fish and Wildlife (WDFW). Results indicated thermal marks were of high quality that should be identifiable in returning adults.

Table 1. Data on thermal marking of spring Chinook salmon in Willamette River hatcheries and collection of reference samples, 2004 brood. Reference samples consisted of 40–50 fry (35–50 mm) from each egg take.

Stock	Egg takes	Treatment (hrs on/off)	Temperature differential (°C) [a]	Cycles[b]	Comments
McKenzie	5	Chilled (24/72)	3.7–4.4	8[c]	--
N. Santiam	4	Heated (48/48)[d]	5.6–5.8	10	--
Willamette	4	Heated (48/48)	6.7–8.0	6	--
S. Santiam	3	Heated (48/48)	6.0–7.3	6	Marked at Willamette H.
Clackamas	3	Heated (48/48)	6.3–6.9	6	Marked at Willamette H.
Sandy	3	Heated (48/48)	7.7–7.9	6	Marked at Willamette H.

[a] *Average difference between heated or chilled treatment and ambient incubation temperature.*
[b] *Number of treatment cycles for hatched fry, except where noted.*
[c] *4–5 cycles were administered to eggs and 3–4 cycles to hatched fry.*
[d] *Time between cycles was 144 hrs after cycle 8.*

Adults

We collected otoliths from adult Chinook salmon on spawning grounds and at hatcheries in most of the major tributaries in the Willamette and Sandy basins in 2005 (**APPENDIX B**). Carcass surveys were conducted throughout the spawning period to collect otoliths from non fin-clipped Chinook salmon. Otoliths were removed from carcasses and placed into individually numbered vials. We collected otoliths from adult hatchery fish that had coded wire tags at Clackamas, Minto (North Santiam River), South Santiam, McKenzie, and Willamette hatcheries to serve as reference samples for blind tests of accuracy in identifying thermal marks (**APPENDIX B**); and from non fin-clipped fish at the hatcheries. However, given the high accuracy of identifying thermal marks (*see* **Results**) and a reduction in funds from the Army Corps of Engineers, we will have only a few otoliths from each hatchery for each brood year analyzed as references for thermal mark patterns. Otolith samples will be sent to WDFW for analysis and will be reported in 2006.

We estimated the proportion of naturally produced ("wild") fish on spawning grounds in the Willamette and Sandy basins from otoliths collected in 2004 (Table 2). Wild fish were determined by absence of a fin clip and absence of an induced thermal mark in the otoliths. We previously documented a significant difference between the distribution of redds and the distribution of carcasses recovered among survey areas within some watersheds (Schroeder et al. 2003). Therefore, we used the distribution of redds among survey areas to weight the number of no clip carcasses in each area. We then used results of otolith analysis to estimate the number of wild fish that would have spawned within a survey area.

Table 2. Number of otoliths collected from adult spring Chinook in the Willamette and Sandy basins that were analyzed for presence of thermal marks, 2004.

Location	Number
McKenzie River	271
McKenzie Hatchery	129
North Santiam River	70
Minto Pond	25
South Santiam River	114
South Santiam Hatchery	94
Middle Fork Willamette River	27
Willamette Hatchery	44
Fall Creek	22
Molalla River	4
Clackamas River	256
Sandy River	200
Sandy River broodstock	70

We estimated the number of wild fish in the North Santiam, McKenzie, Clackamas, and Sandy rivers upstream of dams from the proportion of wild and hatchery fish collected in spawning surveys upstream of the dams. The number of wild fish (N_w) was estimated using the equation:

$$N_w = N_{nc} (1 - T_{nc})$$

where N_{nc} is the estimated number of non fin-clipped fish passing over dams, and T_{nc} is the percentage of non fin-clipped carcasses recovered upstream of dams with thermal marks in their otoliths.

We estimated the percentage of non fin-clipped hatchery fish that returned in 2002–2004, which included fish handled at hatcheries, the estimated run of fish in the McKenzie, North Santiam, Clackamas, and Sandy rivers, and the carcasses recovered in the Middle Fork Willamette and South Santiam rivers where estimates of run size were not available. The numbers of non fin-clipped fish that were of hatchery origin was determined by otolith analysis. We also estimated the number of wild fish in the McKenzie River by using the percentage of juvenile hatchery fish released without clips and the number of fin-clipped adults counted at dams to estimate the number of additional hatchery fish without a clip.

We tested the accuracy of identifying induced thermal marks by submitting otoliths to the WDFW lab from known hatchery adults as determined by adipose fin clips and coded wire tags. These samples were randomly mixed with samples collected from non fin-clipped carcasses and were not identified as “hatchery” samples. We also tested the accuracy of identifying the absence of thermal marks in wild fish by submitting otoliths from juvenile fish of known origin. Otoliths from wild juvenile salmon were taken from mortalities that occurred when we sampled fish in the Leaburg bypass or in the lower McKenzie and upper Willamette rivers. These samples were randomly mixed with otoliths collected from juvenile hatchery fish.

We used handheld tag detectors (Northwest Marine Technology, Inc.) to check for coded wire tags in carcasses with adipose fin clips. We collected the snouts of fish with a tag, which were then put into plastic bags along with an identification number. We also scanned all carcasses in the Clackamas River upstream of North Fork Dam to detect non fin-clipped hatchery fish with coded wire tags (double-index release). Tags were extracted from snouts and binary codes were read and summarized. Although all hatchery spring Chinook salmon released in the Willamette Basin have been marked with an adipose fin clip beginning with the 1997 brood, the percentage of hatchery fish coded wire tags (CWT) varied between years. All hatchery fish from the 1997 brood year release were fin-clipped and tagged, whereas the percentage of tagged fish from other brood years varied among release groups and basins. For example, all hatchery fish used in an experimental evaluation of acclimation were fin-clipped and tagged compared to other releases in which 5–20% were fin-clipped and tagged. Therefore, we estimated the extent and origin of stray hatchery fish by expanding the numbers of tagged fish recovered in spawning surveys by the percentage of tagged fish in each of the release groups. The percentage of local and stray hatchery fish was multiplied by run estimates of hatchery fish (including non fin-clipped hatchery fish) in the McKenzie and North Santiam rivers, and was multiplied by the number of hatchery carcasses (including non fin-clipped hatchery fish) recovered in the Middle Fork Willamette and South Santiam rivers where run estimates were not available.

Results

Composition and Size of Run

Wild spring Chinook composed the highest percentage of carcasses recovered in the Sandy, Clackamas, and McKenzie rivers and the lowest percentage in the North and South Santiam, and Middle Fork Willamette rivers in 2004 (Table 3). We continued to find relatively high numbers of wild carcasses in the South Santiam River, although fewer than in previous years. Within the McKenzie and Clackamas rivers, the percentage of non fin-clipped hatchery fish was highest in the lower reaches of the river upstream of Leaburg Dam and North Fork Dam, respectively. In the Clackamas River upstream of North Fork Dam, 61% of the non fin-clipped hatchery carcasses (n = 75) had coded wire tags (double-index release). Had these fish been removed at the dam, the percentage of hatchery carcasses recovered upstream of the dam would have decreased from 27% to 13%. Of the double-index carcasses recovered, 64% were in areas downstream of Fish Creek, with the South Fork Clackamas River accounting for the highest percentage (43%).

In the four rivers where we were able to estimate the number of wild spring Chinook, the McKenzie and Clackamas rivers had the highest number and the North Santiam had the lowest number (Table 4). The estimated number of wild spring Chinook in the McKenzie River was lower in 2004 than in 2003, and the number of hatchery fish upstream of Leaburg Dam was higher than in previous years. Consequently, the percentage of wild fish in the McKenzie River upstream of Leaburg Dam decreased in the 2004 run year to just under half the fish counted at Leaburg Dam. Wild fish numbers increased in the North Santiam, Clackamas, and Sandy rivers, with the largest increase occurring in the Sandy (Table 4). The number of wild fish in the North Santiam River was higher in 2004 than in 2003, and the percentage of wild fish increased, although the abundance of wild fish remained low. In the Sandy River, an additional 195 fish without fin clips were collected at Marmot Dam on the Sandy River and were taken to Clackamas Hatchery to start a new brood stock. Of the 70 otoliths sampled from these fish, 99% were wild.

Table 3. Composition of spring Chinook salmon in the Willamette and Sandy basins based on carcasses recovered. Weighted for distribution of redds among survey areas within a watershed (except Middle Fork Willamette).

River (section), run year	Fin-clipped	Non fin-clipped[a] Hatchery	Non fin-clipped[a] Wild	Percent wild[b]
McKenzie (above Leaburg Dam)				
2001	62	50 (16)	265	70 (69)
2002	140	78 (15)	454	68 (62)
2003	130	44 (11)	351	67 (62)
2004	136	26 (8)	312	66 (60)
North Santiam (Minto–Bennett dams[c])				
2001	385	43 (43)	56	12 (6)
2002	230	44 (49)	45	14 (13)
2003	855	89 (77)	27	3 (4)
2004	321	21 (27)	56	14 (15)
South Santiam (Foster–Waterloo)				
2002	1,604	37 (14)	224	12 (12)
2003	970	31 (17)	151	13 (13)
2004	838	30 (26)	85	9 (9)
Middle Fk Willamette (Dexter–Jasper[d])				
2002	167	151 (91)	15	(5)
2003	62	48 (92)	4	(4)
2004	120	32 (59)	22	(13)
Molalla (Copper Creek–Trout Creek)				
2002	94	5 (63)	3	3 (2)
2003	17	6 (86)	1	4 (4)
Clackamas (above North Fork Dam)				
2002	d	31 (31)	70	69 (59)
2003	5[e]	40 (22)	145	76 (79)
2004	48[f]	29 (12)	211	73[f] (67)
Sandy (above Marmot Dam)				
2002	3[e]	26 (18)	121	81 (81)
2003	9[e]	14 (12)	106	82 (80)
2004	2[e]	8 (4)	207	95 (95)

[a] *The proportion of hatchery and wild fish was determined by presence or absence of thermal marks in otoliths. Number in parentheses is percentage of non fin-clipped fish that had a thermal mark (non fin-clipped hatchery fish).*

[b] *Percentage not weighted for redd distribution is in parentheses.*

[c] *Including Little North Fork Santiam.*

[d] *Including Fall Creek.*

[e] *Fish were sorted at the dams and all or most of fin-clipped fish were removed.*

[f] *Includes 46 non fin-clipped carcasses with coded wire tag (double-index release).*

Table 4. Estimated number of wild and hatchery adult spring Chinook salmon in the McKenzie, North Santiam, Clackamas, and Sandy rivers upstream of dams. Estimated from counts at the dams and from presence of induced thermal marks in otoliths of non fin-clipped carcasses recovered on spawning grounds. Numbers at dams were from video counts (McKenzie), daily trap counts (Clackamas and Sandy), and expanded trap counts (North Santiam, from 4 d/wk counts).

	Dam count		Non fin-clipped	Estimated number		
Run year	Non fin-clipped	Fin-clipped	with thermal marks (%)[a]	Wild	Hatchery	Percent wild
			McKenzie			
2001	3,433	869	15.9	2,887	1,415	67
2002	4,223	1,864	14.7	3,602	2,485	59
2003	5,784	3,543	11.1	5,142	4,185	55
2004	4,788	4,255	7.7	4,419	4,624	49
			North Santiam			
2000[b]	1,045	1,241	90.7[b]	97	2,189	4
2001	388	6,398	43.4	220	6,566	3
2002	1,233	6,407	51.0[c]	604	7,036	8
2003	1,262	11,570	78.5[c]	271	12,561	2
2004	1,510	12,021	67.6[c]	489	13,042	4
			Clackamas			
2002	2,168	**d**	30.7	1,502	666	69
2003	3,338	**d**	21.6	2,617	721	78
2004	5,165	**d**	26.2[e]	3,812	1,353[e]	74[e]
			Sandy			
2002	1,159	**d**	17.7	954	205	82
2003	969	**d**	11.7	856	113	88
2004	2,491	**d**	3.7	2,399	92	96

[a] *Adjusted by distribution of redds among survey areas.*
[b] *Escapement at Bennett dams was likely underestimated* (see *Schroeder et al. 2001).*
[c] *Weighted average of adjusted spawning ground samples and samples from Minto Pond.*
[d] *Fish were sorted at North Fork (Clackamas) and Marmot (Sandy) traps and only non fin-clipped fish were allowed to pass.*
[e] *Includes non fin-clipped fish with coded wire tag (double-index release).*

The highest percentages of wild spring Chinook salmon in the McKenzie River basin upstream of Leaburg Dam were in the upper main-stem (85%) and in Horse and Lost creeks (82%) (Figure 1). The percentages of wild fish were lower in the areas closer to Leaburg Dam (35%), areas most susceptible to the influence of hatchery fish passing over the dam. Similar results were observed in the Clackamas River basin upstream of North Fork Dam where the hatchery component of spawners was highest in the areas nearest the dam (Figure 2).

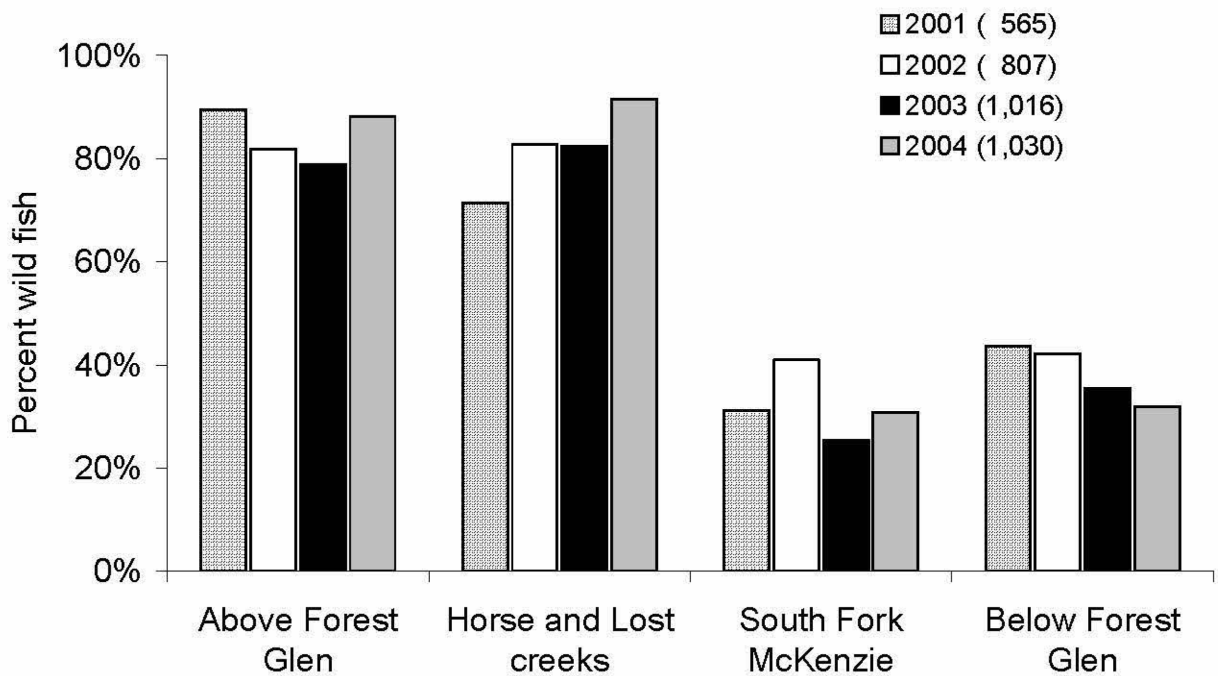

Figure 1. Percentage of wild Chinook salmon in four areas of the McKenzie River basin upstream of Leaburg Dam based on recovery of non fin-clipped carcasses with no induced thermal marks in the otolith, 2001–2004. Total redds counted in the McKenzie upstream of Leaburg Dam are in parentheses of the legend.

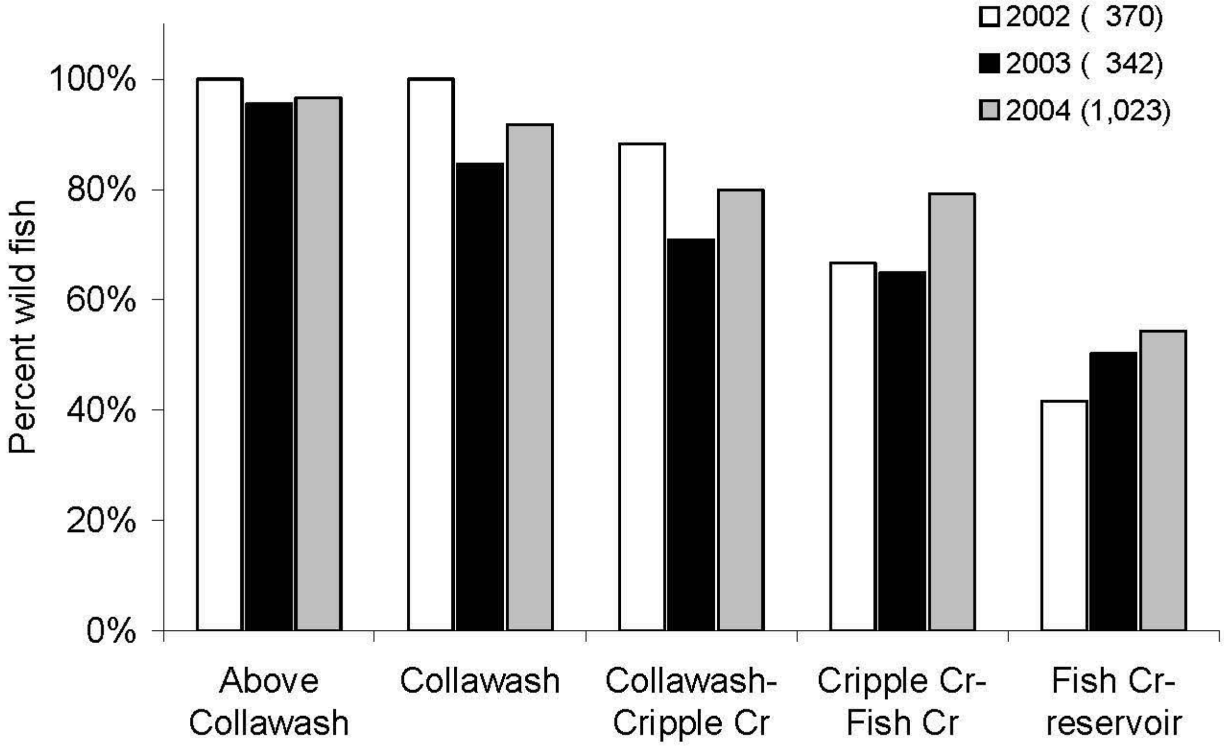

Figure 2. Percentage of wild Chinook salmon in five areas of the Clackamas River basin upstream of North Fork Dam based on recovery of non fin-clipped carcasses with no induced thermal marks in the otolith, 2002–2004. Total redds counted in the Clackamas upstream of North Fork Dam are in parentheses of the legend.

The WDFW otolith laboratory correctly identified a high percentage of adult hatchery spring Chinook in the blind tests (Table 5), and identified 100% of known wild juvenile Chinook in a blind test conducted with wild and known juvenile hatchery Chinook.

Table 5. Accuracy of the WDFW otolith laboratory in identifying presence or absence of thermal marks in spring Chinook salmon (blind tests), 2004.

Marking location, stock	Number	Classified— Correctly	Incorrectly	Percent correct
McKenzie Hatchery				
McKenzie	30	30	0	100
Marion Forks Hatchery				
North Santiam	13	13	0	100
Willamette Hatchery				
Middle Fork Willamette	27	27	0	100
South Santiam	25	25	0	100
Clackamas[a]	19	18	1	95

[a] *Some Clackamas fish were incubated at Oxbow Hatchery and did not get a thermal mark.*

Hatchery Fish in Spawning Population

The percentage of adult hatchery Chinook salmon without a fin clip that returned to the Willamette River basin upstream of Willamette Falls decreased from 2002 to 2004 (Figure 3). Adult Chinook in the Willamette Basin are comprised primarily of age 4 and age 5 fish, therefore these results likely reflect an increase in quality of fin clipping from the 1997–1998 brood years (2002 return) to the 1999–2000 brood years (2004 return). With the exception of returns to the South Santiam, the percentage of the 2002 hatchery return without a fin clip was greater than the estimated percentage of hatchery fish released without a fin clip (Figure 3). By the 2004 return year, the hatchery return to the North Santiam was the only one in which the percentage of non fin-clipped adults exceeded that of the non fin-clipped juveniles at release. Some of the difference between the percentage of non fin-clipped fish at release and at return may be because of differential harvest of fin-clipped fish. The effect of harvest of the fin-clipped fish (26% of run) and the effect of catch and release mortality of non fin-clipped fish (3.2% of run) would reduce the percentage of non fin-clipped hatchery returns by about 23%, but the trends and results listed above would be the same (harvest data *from* Foster and Boatner 2002 and Lindsay et al. 2004).

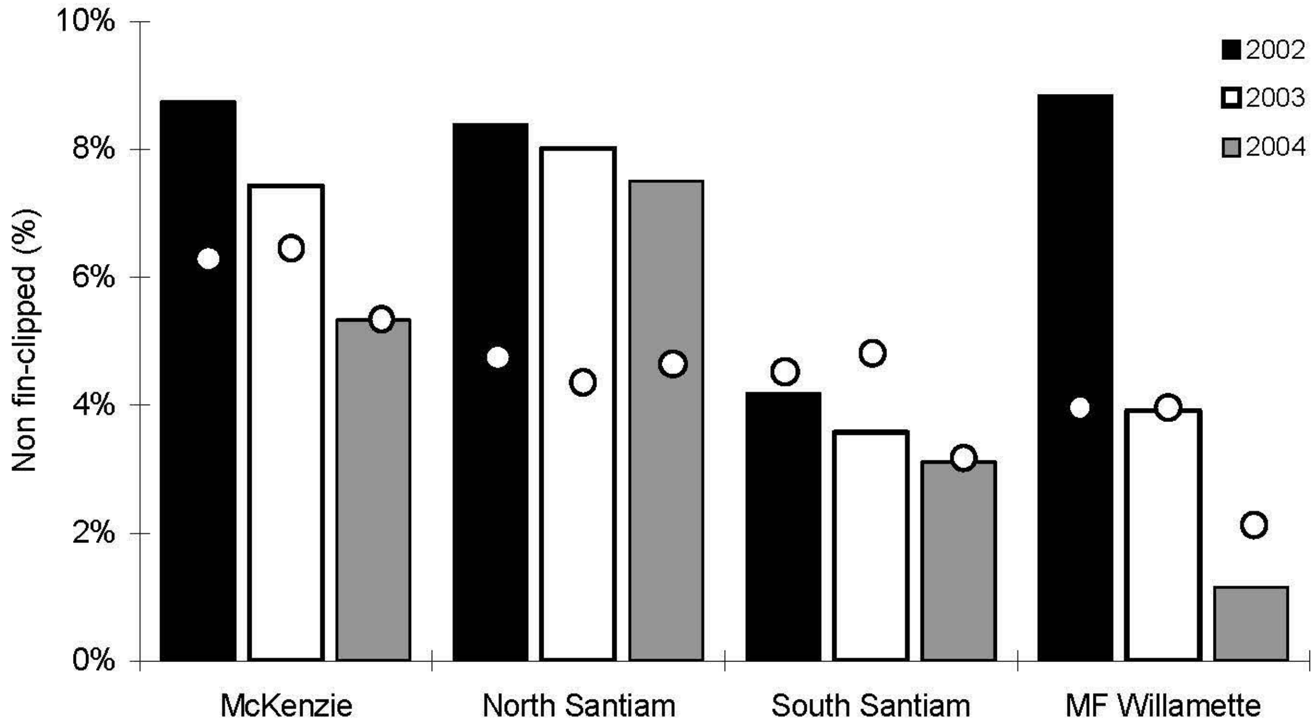

Figure 3. Percentage of non fin-clipped hatchery spring Chinook that returned to four Willamette basin watersheds, 2002–2004, determined by analysis of otoliths. Open circles are the average percentages of hatchery smolts released without a fin clip for the brood years corresponding to age 4 and age 5 returns.

We compared percentages of hatchery spring Chinook in the McKenzie River basin using two methods of estimation: (1) number of fin-clipped carcasses plus non fin-clipped hatchery fish from otolith analysis and (2) number of fin-clipped carcasses expanded by the ratio of fin-clipped to non fin-clipped hatchery fish at time of release. The percentage of hatchery fish in the spawning population was underestimated by 12–70% using the second method to estimate the number of non fin-clipped hatchery fish compared to use of otolith analysis to determine the number of non fin-clipped hatchery fish (Table 6). Percentages of hatchery fish in the population tended to track similarly between years and among sections with both methods, but the difference between the two estimates varied, with the two estimates closest in the 2004 return year (Figure 4). These data indicate that analyses of otoliths have provided the most accurate estimate of the percentage of hatchery fish in the spawning population. However, the percentage of non fin-clipped hatchery fish declined in the 2004 return year (Figure 3) and the difference between the methods was lowest for that return year (Figure 4).

Table 6. Average percentage of hatchery spring Chinook salmon in the spawning population of the McKenzie River basin estimated by number of recovered fin-clipped carcasses and otolith analysis of non fin-clipped fish, and by number of fin-clipped carcasses expanded by the ratio of fin-clipped to non fin-clipped fish at time of release, 2001–2004 return years.

	Hatchery fish in spawning population (%) estimated by—	
Section	otolith analysis	release data
Upstream of Forest Glen	17.9	10.6
Horse and Lost creeks	18.0	5.4
South Fork McKenzie	67.8	59.5
Forest Glen–Leaburg	61.6	45.1
Downstream of Leaburg Dam	90.2	77.8

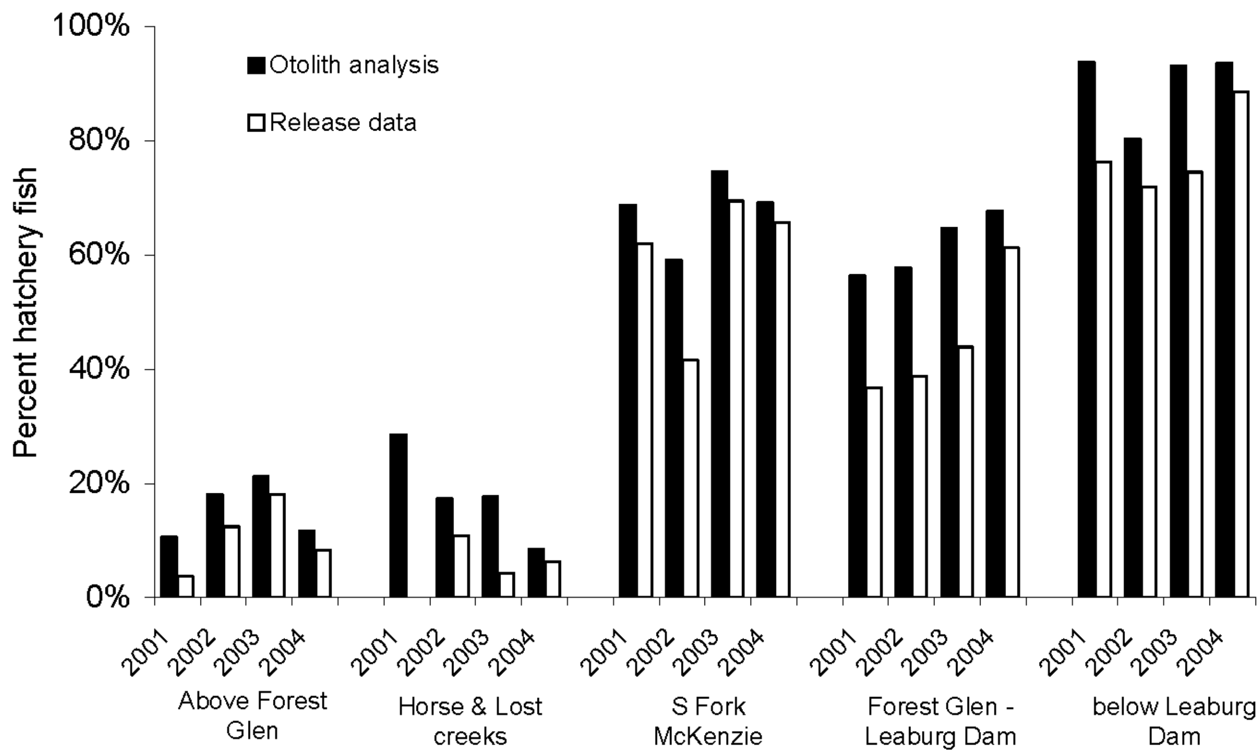

Figure 4. Percentage of hatchery spring Chinook in the spawning population for five sections of the McKenzie River basin estimated by number of recovered fin-clipped carcasses and otolith analysis of non fin-clipped fish, and by number of fin-clipped carcasses expanded by the ratio of fin-clipped to non fin-clipped fish at time of release, 2001–2004 return years.

We compared the estimated percentage of hatchery spring Chinook recorded at Leaburg Dam to that directly measured from recovery of carcasses upstream of the dam. The number of hatchery fish at the dam included fin-clipped fish and an estimated number of non fin-clipped hatchery fish based on otolith analysis of carcasses recovered upstream of the dam. The percentage of hatchery fish upstream of Leaburg Dam increased from 2001 to 2004 (Figure 5), but the increase estimated directly from recovery of carcasses was less (30 to 34%) than that estimated from dam counts (33 to 49%). We also compared the percentage of fin-clipped spring Chinook observed at the dam (not adjusted for otolith marks) with the percentage of fin-clipped carcasses upstream of the dam and found similar increases in 2001–2004 (Figure 6), with a larger increase in the dam counts (20 to 53%) than in carcasses recovered upstream of the dam (16 to 29%).

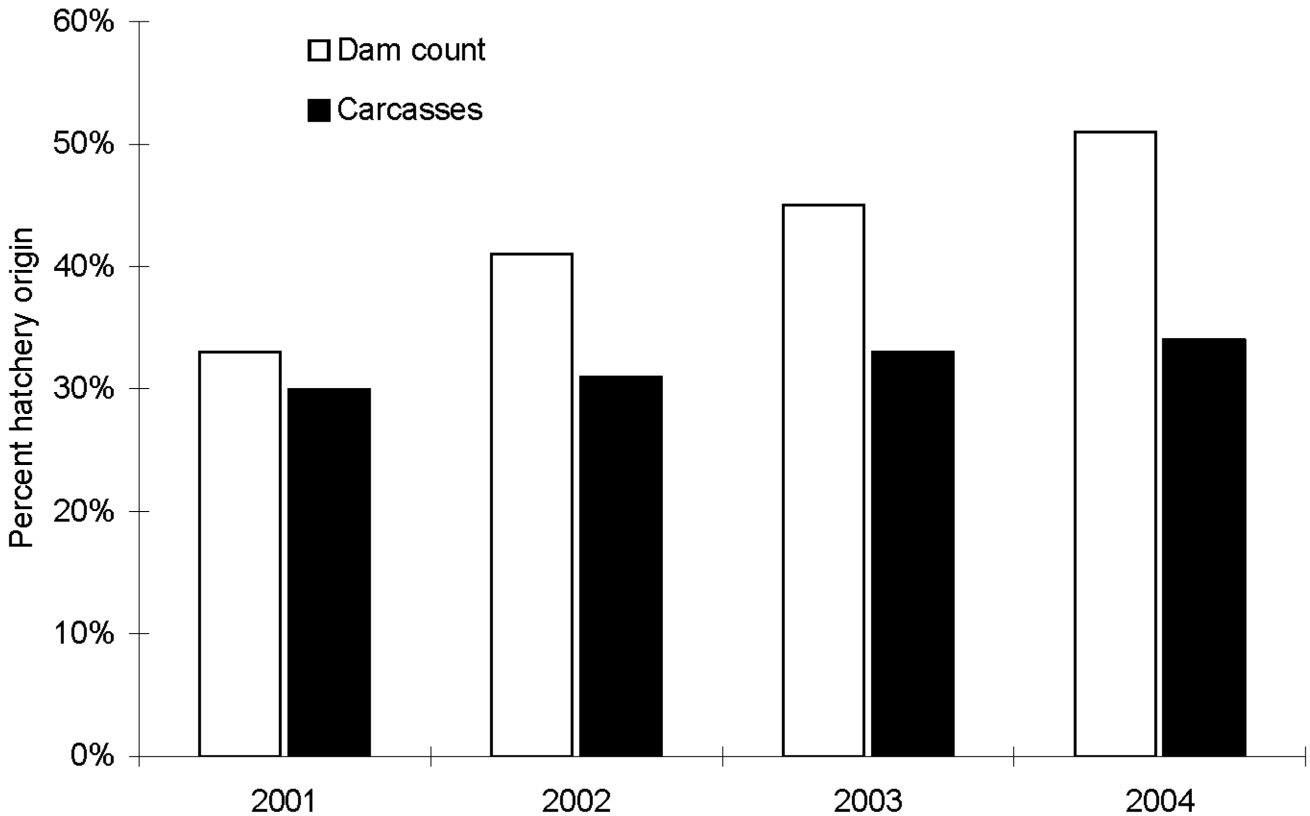

Figure 5. Percentage of hatchery Chinook salmon in the McKenzie River basin upstream of Leaburg Dam, measured by recovery of carcasses with fin-clips or thermal marks in otoliths of non fin-clipped fish, and estimated for fish visually counted at the dam.

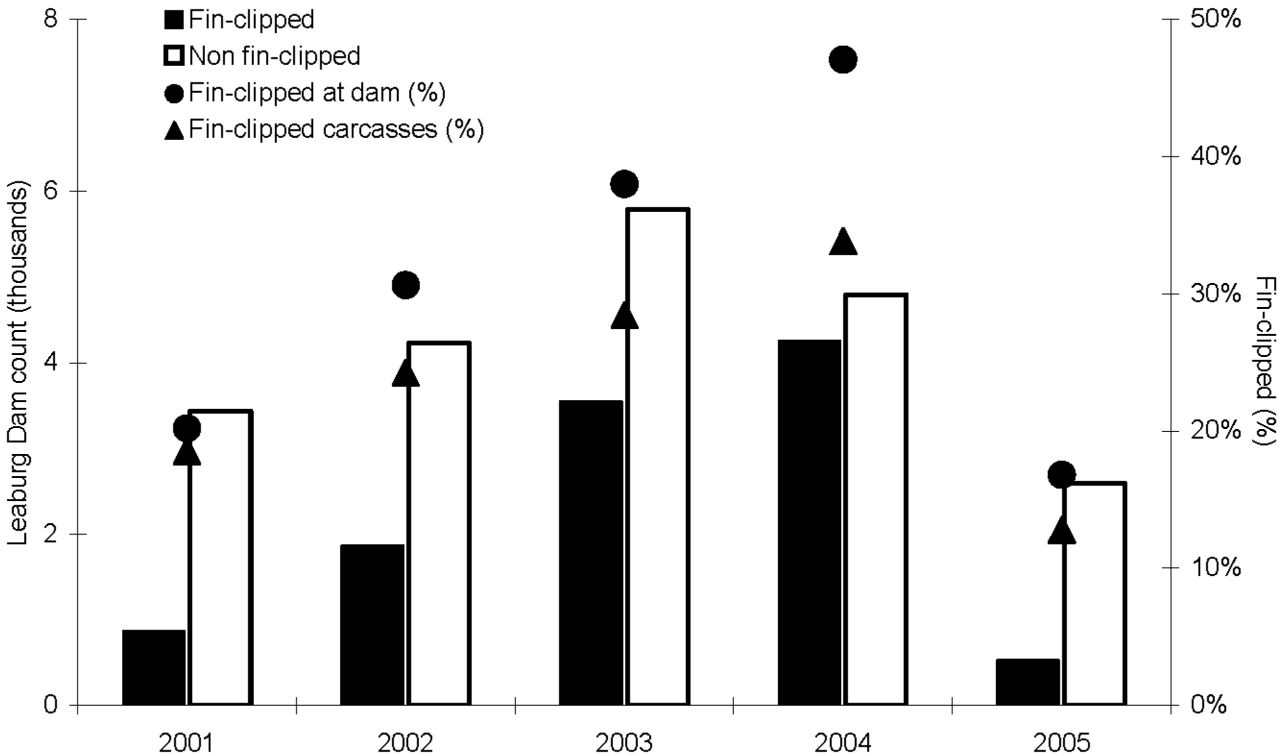

Figure 6. Number of fin-clipped and non fin-clipped Chinook salmon counted at Leaburg Dam, and the percentage of fin-clipped Chinook counted at the dam and recovered as carcasses in the McKenzie River basin upstream of the dam, 2001–2005.

We believe that recovery of carcasses has provided a more accurate estimate of the percentage of hatchery fish present in the spawning population of the McKenzie River upstream of Leaburg Dam than that estimated from dam counts. McKenzie Hatchery is located a short distance downstream of the dam (3 km) and hatchery fish may continue upstream and over the dam before correcting their course. Construction of a new fishway at Leaburg Dam in 2004 likely increased the efficiency of fish passage at the dam. Spring Chinook salmon have been observed to fall back in the Leaburg Power canal bypass after passing the dam, and most of these were fin-clipped fish (M. Hogansen, ODFW, personal communication). Some of these fish could remain downstream of the dam or ascend the fishway multiple times. These factors would inflate the count of clipped fish passing the dam. In addition, construction in the Leaburg Canal in 2003 likely lowered the effectiveness of attracting adult fish into McKenzie Hatchery because of reduced water supply from the canal and increased water temperature. Interestingly, the percentage of clipped hatchery fish was 68% lower in 2005 than in 2004 at Leaburg Dam and was 55% lower among carcasses recovered upstream of the dam (Figure 6).

We examined the relationship between the percentage of fin-clipped spring Chinook recovered in spawning areas upstream of Leaburg Dam and the number of fin-clipped fish passing over the dam. The percentage of fin-clipped spring Chinook recovered in spawning areas upstream of Leaburg Dam increased as the count of fin-clipped fish at the dam increased (Figure 6). The rate of return of hatchery fish may have increased in 2001–2004 or the number of hatchery fish remaining in the river (rather than returning to the hatchery) may have increased because factors such as the 2003 construction in Leaburg Canal reduced the number of fish returning to the hatchery (*see* above). Thus, the potential for interbreeding between hatchery and wild fish increased as the total number of spring Chinook increased. These data illustrate the importance of modifying the Leaburg Dam fishways to allow hatchery Chinook salmon to be excluded from spawning areas upstream of the dam.

The quality of fin clips on hatchery fish has increased, initially because of higher quality control and more recently (beginning with the 2000 brood year) because an automatic fin clipping system was implemented at McKenzie Hatchery. Consequently, the percentage of hatchery carcasses that did not have a fin clip (as determined by presence of an otolith mark) has decreased (Figure 3).

Stray Hatchery Fish

The percentage of stray hatchery Chinook increased from 2002 to 2003–2004 in the McKenzie, North Santiam and South Santiam rivers (Figure 7). Stray fish increased in the North Santiam River from 2% of the return in 2002 to 41% of the return in 2004, and they increased in the McKenzie River from about 1% of the return in 2002 to 13% in 2004. The number of hatchery fish in these rivers increased about 85% from 2002 to 2004, which could explain some of the increase in stray hatchery fish. Strays of South Santiam hatchery fish released into the South Santiam and Molalla rivers were the major contributing factor to the increased percentage of stray fish in the North Santiam from 2003 to 2004, whereas strays of experimental releases to evaluate netpen acclimation in the Lower Willamette basin were the primary cause of the increase in the McKenzie (Table 7). The percentage of stray hatchery fish in the return of Chinook salmon to the South Santiam River decreased from 20% in 2003 to 5% in 2004 (Figure 7) primarily because of a decrease in strays from releases in the Molalla River and lower Willamette Basin (Table 7). The number of all hatchery carcasses recovered in the South Santiam (with and without coded wire tags) decreased from about 1,400 in 2002 to 840 in 2004.

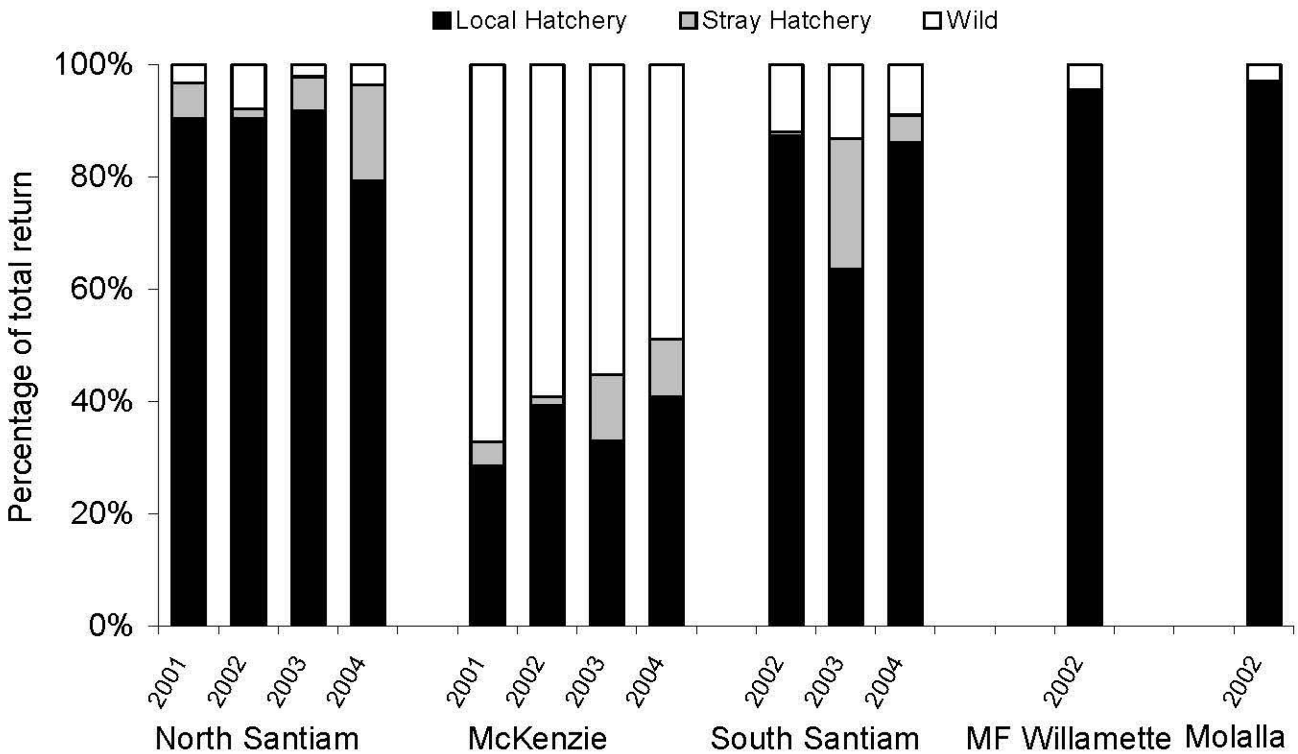

Figure 7. Percentages of Chinook returns to five Willamette basin rivers that were composed of hatchery fish released within the basin (local) or released in other locations (stray) determined by recoveries of coded wire tags (CWT) in carcasses. Expanded for percentage of the hatchery release that was tagged.

The origin of stray hatchery fish varied within each basin and between years (Table 7). McKenzie stock fish that were released in the Lower Columbia, Willamette, and Clackamas basins as part of a netpen and direct release evaluation (Schroeder and Kenaston 2004) represented much of the stray returns (Table 7). These experimental releases composed 54% of the stray returns to the McKenzie basin, 24% of the stray returns to the North Santiam, and 78% of the stray returns to the South Santiam. Hatchery fish released in the North Santiam River did not stray to the South Santiam, but hatchery fish released in the South Santiam comprised 29% of the strays in the North Santiam.

Table 7. Percentages of hatchery Chinook salmon that were released within the basin (local) or released in other basins, 2001–2005, determined by recoveries of coded wire tags in carcasses on spawning grounds. Expanded for percentage of hatchery release that was tagged. Includes only rivers and years when >10 tags were recovered.

		Origin of Release								
River, year	N[a]	Local	Netpen[b]	Lower Willamette[c]	Molalla[d]	North Santiam	South Santiam	McKenzie	Middle Fork Willamette	Youngs Bay[e]
McKenzie										
2001	55 (53)	87.2	7.3	0	1.9	0	0		3.6	0
2002	263 (95)	96.4	3.2	0.4	0	0	0		0	0
2003	81 (16)	73.7	0.9	6.5	0	18.9	0		0	0
2004	79 (19)	80.0	2.5	8.9	0	0	8.5		0	0
North Santiam										
2001[f]	374 (369)	93.4	1.3	0	3.3		0.5	0	0	0
2002	217 (80)	98.1	0.5	0	1.4		0	0	0	0
2003	634 (46)	93.8	0.3	1.3	1.7		1.7	1.1	0	0.2
2004	228 (28)	82.3	0.4	3.9	5.4		7.9	0	0	0
South Santiam										
2002	1,111 (310)	99.3	0	0.7	0	0		0	0	0
2003	640 (97)	73.2	20.7	4.2	1.7	0		0	0	0.2
2004	605 (121)	94.5	0.8	3.8	0.9	0		0	0	0
2005	299 (50)	94.1	0	0.3	1.5	0		3.8	0	0.3
Middle Fk Willamette										
2002	1,736 (356)	99.9	0.1	0	0	0	0	0	0	0
Molalla										
2002	57 (22)	100	0	0	0	0	0	0	0	0

[a] *Expanded for percentage of a release that had coded wire tags (unexpanded number is in parentheses).*

[b] *McKenzie stock acclimated or directly released in the lower Clackamas River.*

[c] *McKenzie stock acclimated or directly released in the lower Willamette River.*

[d] *South Santiam and McKenzie stocks.*

[e] *Middle Fork Willamette stock released into netpens near mouth of Columbia River.*

[f] *Five (expanded = 5) additional carcasses were recovered from Clackamas release, or 1.4% of carcasses.*

TASK 1.3–DISTRIBUTION AND ABUNDANCE OF NATURAL SPAWNERS

We surveyed most of the major tributaries in the Willamette and Sandy basins in 2005 by boat and on foot to count spring Chinook salmon carcasses and redds. We counted redds during peak times of spawning based on data from past surveys. In areas where we regularly surveyed to collect otoliths from carcasses, we used the highest number of redds counted in any one survey as the total number of redds for an individual section.

Redd Counts and Distribution

The North Santiam River was regularly surveyed July 13–October 4, 2005 to recover carcasses and count redds. Redd digging was first observed on August 25 and peak spawning occurred in late September, similar to previous years. The number of redds counted upstream of Bennett dams was similar in 2005 and 2004 (Table 8, Figure 8), despite a count at the dams that was 64% lower in 2005 (4,883) than in 2004 (13,531). The redd density in 2005 was highest in the area immediately downstream of Minto Dam (Table 8), and was similar to the 1999–2002 average (18.2 redds/mi), but was much lower than in 2003 (55.5 redds/mi). The number of redds counted in the North Santiam upstream of Bennett dams was 2–5 times higher in 2001–2005 than in 1996–1998, and the count of Chinook at Bennett dams was 2–13 times higher. Generally, the number of redds in each section increased in each year in 2001–2005 from the 1996–1998 average (Figure 8). Almost 70% of the redds we counted upstream of Bennett dams were in the uppermost section, and the percentage of redds counted in the Little North Fork Santiam River was higher than in previous years (Figure 9). Non fin-clipped Chinook have been transported from the collection facility at Minto Dam and released into the Little North Santiam since 2002 (Table 8, *see* **EFFORTS TO RE-ESTABLISH POPULATIONS**). Although there are annual fluctuations in the distribution of redds, the uppermost section consistently has accounted for over 50% of the redds in the basin, and as high as 84% in 2003, whereas the other sections rarely accounted for more than 25% of the redds in any year (Figure 9). The uppermost section downstream of Minto Dam probably accounts for such a large percentage of the redds because hatchery Chinook comprise a high percentage of the run in the North Santiam River (*see* **The Proportion of Wild Fish in Natural Spawning Populations**) and because the hatchery collection and release site is at Minto Dam, which blocks passage of fish. Although the peak passage at Bennett dams occurs late May to early July, most hatchery fish do not enter the trapping facility at Minto Dam until mid August, probably because of low water temperature from release of water at Detroit Dam (Beidler and Knapp 2005).

Table 8. Summary of spawning surveys for spring Chinook salmon in the North Santiam River, 2005, and comparison to redd densities in 1996–2004. Spawning in areas downstream of Stayton may include some fall Chinook.

Survey section	Length (mi)	Counts		Redds/mi									
		Carcass	Redd	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996
Minto–Fishermen's Bend	10.0	153	206	20.6	17.7	55.5	16.2	17.9	23.0[a]	15.6	11.8	8.5	7.8
Fishermen's Bend–Mehama	6.5	26	20	3.1	2.8	6.5	9.4	5.7	5.8	3.1	4.3	2.5	3.5
Mehama–Stayton Is.	7.0	23	14	2.0	12.6	4.7	6.1	10.0	**b**	--	0.6	0.9	1.0
Stayton Is.–Stayton	3.3	37	24	7.3	7.9	3.6	3.0	6.7	**b**	--	10.0	3.6	2.0
Stayton–Greens Bridge	13.7	7	4	0.3	0.2	0.1	0.4	0.1	--	0.0	0.4	1.1	0.1
Greens Br.–mouth	3.0	3	0	0.0	0.0	1.7	4.7	--	--	--	4.7	9.7	--
Little North Santiam	17.0	81	61	3.6[f]	3.0[e]	1.8[d]	1.8[c]	1.1[a]	1.3[a]	1.0	2.2[a]	0.6[a]	0.0

[a] *Corrected number.*

[b] *Data was recorded for Mehama–Stayton and density was 0.9 redds/mi.*

[c] *400 unclipped adult spring Chinook were released on August 20 and 30, September 5 and 6, 2002.*

[d] *268 unclipped adult spring Chinook were released in June (25th), July (9th, 15th, 22nd), August (25th), and September (2nd, 4th).*

[e] *377 unclipped adult spring Chinook were released on July 9, August 19 and 27, and September 9.*

[f] *329 unclipped adult spring Chinook were released on July 27, August 30, and September 2, 6, 9, and 12.*

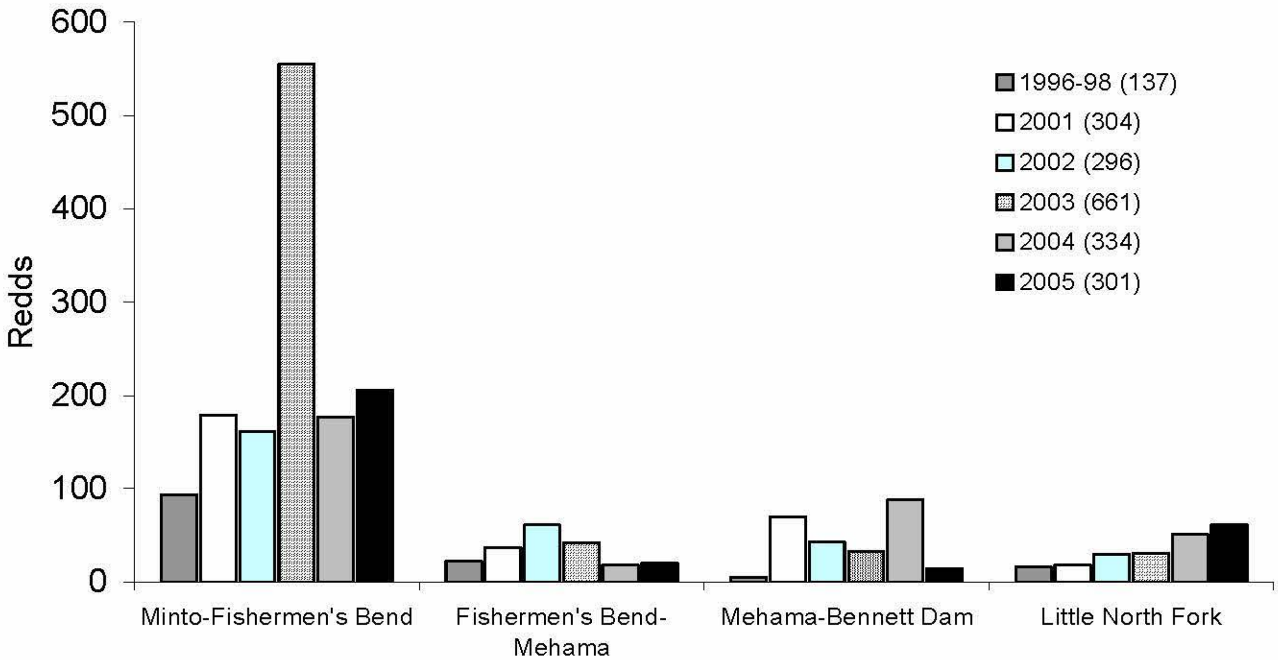

Figure 8. Spring Chinook salmon redds counted in four areas of the North Santiam basin upstream of Bennett dams, 1996–1998 average and 2001–2005. Total redds counted in the basin are in parentheses in the legend.

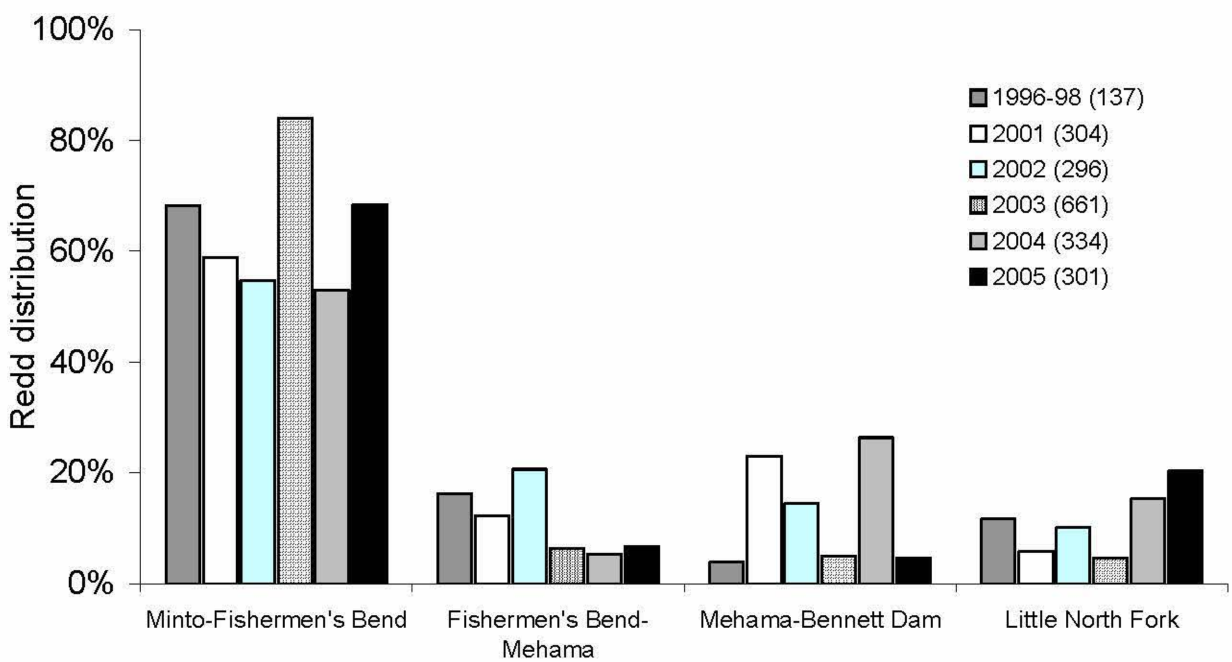

Figure 9. Distribution of spring Chinook salmon redds among four areas of the North Santiam basin upstream of Bennett dams, 1996–1998 average and 2001–2005. Total redds counted in the basin are in parentheses in the legend.

The McKenzie River basin was regularly surveyed August 10–October 12, 2005 to recover carcasses and count redds. Active redd building began in early September and peak spawning occurred in late September, similar to previous years. The number of Chinook redds counted upstream of Leaburg Dam was similar in 2005 to that in 2003–2004 (Table 9, Figure 10), although the count of adult fish over Leaburg Dam was 66% lower in 2005 (3,108) than in 2003–2004 (average = 9,181). The density of redds in several sections of the McKenzie River basin was different in 2005 than in previous years. The largest increase in numbers of redds in 2005 over that of previous years was observed in Horse and Lost creeks, and the largest decrease in redds was observed in the lowest sections of the McKenzie River (Figure 10). In 2005, 74% of all redds were counted in the upper basin upstream of the South Fork McKenzie River, compared to 51% in 2002–2004, primarily because the percentage of redds in Horse and Lost creeks was twice as high (Figure 11). The percentage of redds that occurred in the McKenzie River downstream of Forest Glen in 2005 (18%) was less than half that in 2002–2004 (39%).

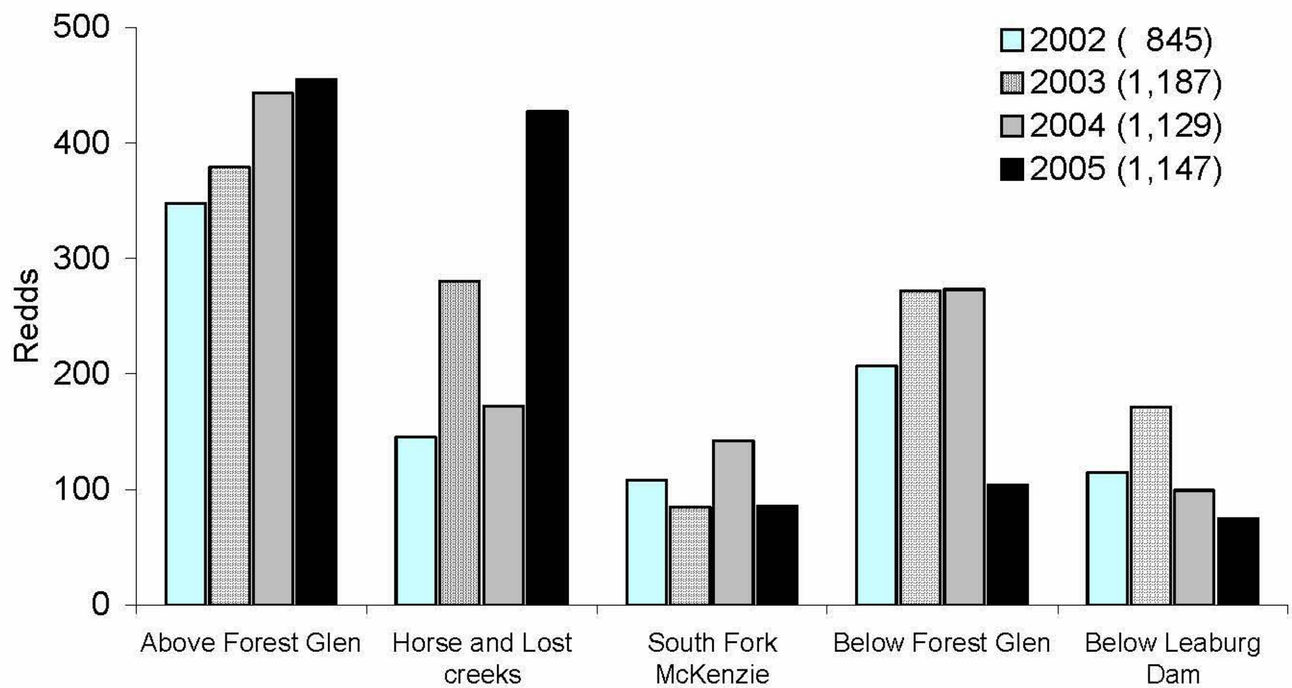

Figure 10. Spring Chinook salmon redds counted in five areas of the McKenzie River basin, 2002–2005. Total redds counted in the basin are in parentheses in the legend.

Table 9. Summary of Chinook salmon spawning surveys in the McKenzie River, 2005, and comparison to redd densities (redds/mi, except redds/100 ft for spawning channel) in 1996–1998 and 2000–2004.

Survey section	Length (mi)	Carcass	Redds	Redds/mi[a] 2005	2004	2003	2002	2001	2000	1998	1997	1996
McKenzie River:												
Spawning channel	0.1	7	64	12.8	18.6	7.2	15.4	--	--	--	1.0	2.6
Olallie–McKenzie Trail	10.3	63	320	31.1	22.1	24.7	16.3	17.7	5.6	--	11.4	7.0
McKenzie Trail–Hamlin	9.9	40	42	4.2	9.4	4.0	5.2	4.9	1.6	--	--	2.1
Hamlin–S. Fork McKenzie	0.3	--	--	--	--	10.0	36.7	--	--	--	--	--
South Fork–Forest Glen	2.4	7	29	12.1	12.1	19.2	16.7	0.8	2.1	--	--	0.8
Forest Glen–Rosboro Br.	5.7	12	21	3.7	36.1	26.8	14.9	13.2	5.8	--	--	6.1
Rosboro Br.–Ben and Kay	6.5	34	81	12.5	10.3	7.4	16.2	6.3	3.2	--	--	4.9
Ben and Kay–Leaburg Lake	5.9	1	2	0.3	--	12.0	2.9	3.2	--	--	--	1.8
South Fork McKenzie:												
Cougar Dam–Road 19 Br.	2.3	21	51	22.2	49.1	31.7	36.5	--	--	--	--	--
Road 19 bridge–mouth	2.1	12	35	16.7	13.8	5.7	11.4	8.1	7.6	--	--	2.9
Horse Creek:												
Pothole Cr.–Separation Cr.	2.8	0	15	5.4	5.4	18.6	--	--	--	--	--	--
Separation Cr.–mouth	10.7	62	205	19.2	10.3	13.6	12.1	7.4	--	--	--	5.3
Lost Creek:												
Spring–Limberlost	2.8	7	43	15.4	6.4	9.3	--	--	--	--	--	--
Limberlost–Hwy 126	2.0	33	157	78.5	13.5	21.0	--	--	--	--	--	--
Hwy 126–mouth	0.5	0	7	14.0	4.0	30.0	32.0	--	--	--	--	--
McKenzie River:												
Leaburg Dam–Leaburg Landing	6.0	28	75	12.5	16.5	28.5	19.2	12.3	--	15.3	19.8	10.3

[a] *Except redds/100 ft for spawning channel.*

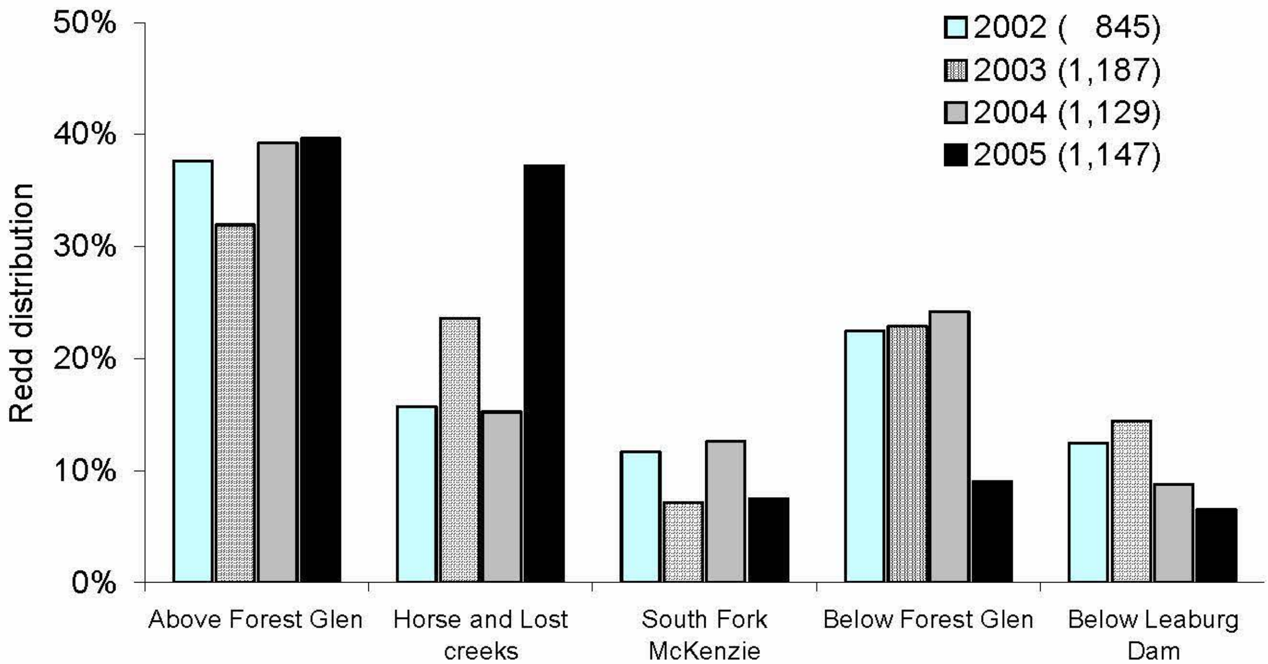

Figure 11. Distribution of spring Chinook salmon redds counted in five areas of the McKenzie River basin, 2002–2005. Total redds counted in the basin are in parentheses in the legend.

We regularly surveyed the Clackamas River basin upstream of North Fork Dam August 22–October 21 to recover carcasses and count redds (Table 10). Peak spawning generally occurred in late September to early October. A higher percentage of redds was counted in the Clackamas River from the confluence with the Collawash River to Cripple Creek (near Three Lynx) in 2005 than in previous years and a lower percentage of redds was counted in the Clackamas River upstream of the Collawash confluence (Table 10 and Figure 12). Over half of the total redds in Roaring River were counted in a 1.5 mi section upstream of the bedrock chute where the surveys had previously ended. Fish passage through the chute may depend on water flow at certain times of year and this area should be regularly surveyed in the future. The flow in Fish Creek remained low throughout the survey period and fish passage near the mouth appeared to be difficult. Consequently, no redds were counted in 2005 (Table 10). The count of adult Chinook passed at North Fork Dam was 45% lower in 2005 than in 2004 and the number of redds counted upstream of the dam was 42% lower (Table 11). We accounted for a higher percentage of the spring Chinook salmon run over North Fork Dam in 2005 (43%) than the 2002–2004 average (31%), but less than in 1996–1999 (53%) (Table 11). Although fall Chinook may be present downstream of River Mill Dam, 64% of all the carcasses we processed had adipose fin clips indicating they were hatchery spring Chinook.

Table 10. Summary of spawning surveys for spring Chinook salmon in the Clackamas River basin, 2005 and comparison to redd densities in 1996–1999 and 2002–2004.

Survey section	Length (mi)	Counts: Carcass	Counts: Redd	Redds/mi: 2005	2004	2003	2002	1999	1998	1997	1996
Clackamas River:											
Sisi Creek–Forest Rd 4650	9.1	7	53	5.8	18.9	9.8	5.4	3.2	9.6	7.5	3.2
Forest Rd 4650–Collawash R.	8.0	9	64	8.0	13.2	5.5	4.8	4.1	7.0	5.9	4.1
Collawash R–Cripple Cr.	8.5	23	205	24.1	31.2	10.7	7.2	4.2	11.4	7.3	6.1
Cripple Cr.–South Fork	14.5	79	144	9.9	17.0	4.2	10.2	4.3	5.2	7.4	3.2
South Fork–Reservoir	1.0	46	24	24.0	42.0	10.0	15.0	1.0	7.0	17.0	--
South Fork Clackamas:											
Falls–mouth	0.6	34	30	50.0	95.0	18.3	70.0	16.7	5.0	11.7	--
Collawash River:											
Forest Rd 63–Hot Sprs. Fork	2.0	0	0	0.0	2.5	2.5	--	--	6.0	11.0	1.0
Hot Sprs. Fork–mouth	4.5	36	32	7.1	12.2	4.9	1.6	1.1	6.4	4.9	2.2
Fish Creek:											
Forest Rd 5430–mouth	4.5	0	0	0.0	12.0	0.7	0.4	--	1.7	2.6	1.1
Roaring River:											
Chute–mouth	2.0	8	21[a]	10.5	10.5	1.5	2.5	--	1.5	3.0	3.0
North Fork Clackamas:											
Mouth area	0.2	1	6	30.0	20.0	15.0	15.0	--	0.0	0.0	0.0
Below Faraday Dam:											
Free-flowing stretch	1.5	12	2	1.3	29.3	0.7	0.0	--	--	--	--
Below River Mill Dam:[b]											
McIver–Barton[c]	9.5	358	78	8.2	e	11.5	6.5	3.9	3.4	--	--
Barton–mouth	13.5	16	0[d]	0.4	e	0.6	0.3	0.3	1.2	--	--

[a] *26 additional redds counted in a 1.5 mi area upstream of bedrock chute.*
[b] *Some fall Chinook salmon could spawn in this area.*
[c] *18 additional carcasses and 9 additional redds were in the 0.3 mi River Mill Dam–McIver section.*
[d] *Redd surveys were not conducted after September 23.*
[e] *Redds were not counted in 2004.*

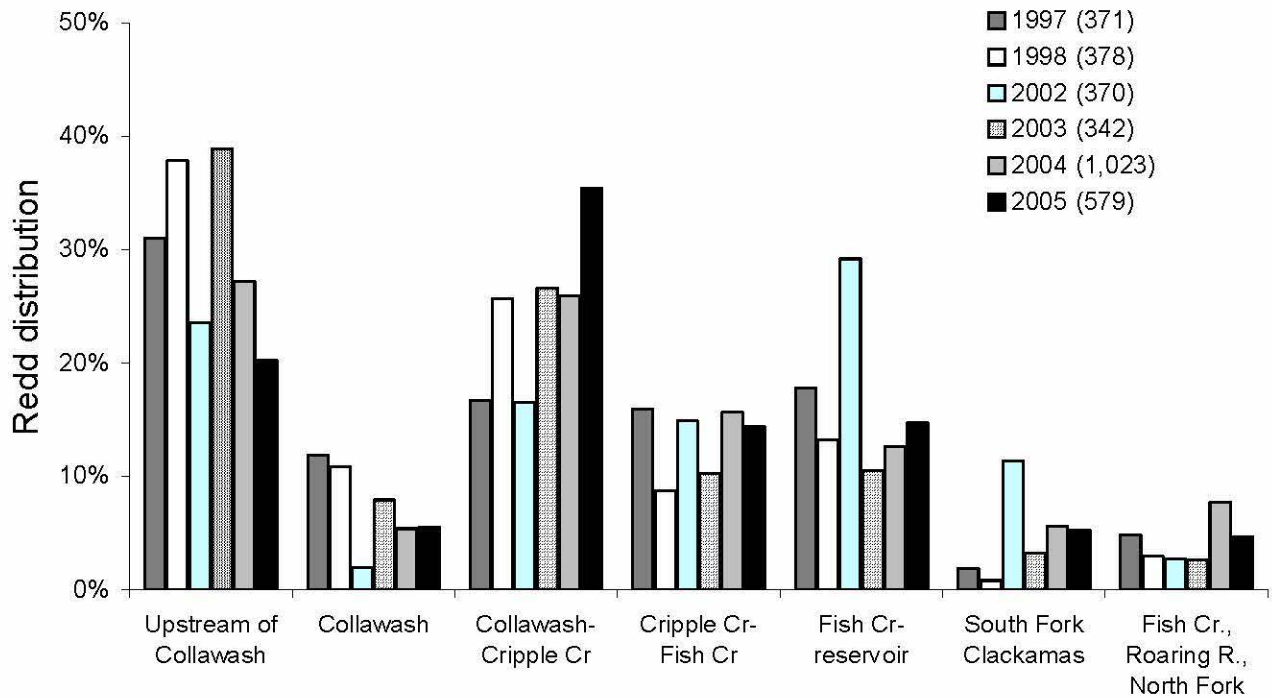

Figure 12. Distribution of spring Chinook salmon redds among seven areas of the Clackamas River upstream of North Fork Dam, 1997–1998 and 2002–2005. Total redds counted in the basin are in parentheses in the legend.

Table 11. Counts of adult spring Chinook salmon upstream of North Fork Dam and the relationship to successful spawners upstream of the dam, 1996–1999, 2002–2005.

	Counts			
Year	North Fork Dam[a]	Total Redds	Spawners[b]	Fish/redd[c]
1996	824	182	364	4.53
1997	1,261	376	752	3.35
1998	1,382	380	760	3.64
1999	818	212	424	3.86
2002	2,168	370	740	5.86
2003	3,338	342	684	9.76
2004	5,165	1,028	2,056	5.02
2005	2,844	605[d]	1,210	4.70

[a] *Total from video counts (1996–1998) or fishway trap counts (after 1999) up to one week prior to last spawning survey.*
[b] *Estimated from redds using 1:1 sex ratio and two fish per redd.*
[c] *Fish from dam count divided by redds.*
[d] *Includes 26 redds counted in upper area of Roaring River.*

We regularly surveyed the Sandy River basin upstream of Marmot Dam August 23–October 20 to recover carcasses and count redds (Table 12). Peak spawning generally occurred in late September, similar to other years. The number of redds was about 40% lower in 2005 than in 2004, but was about twice the average number of redds counted in 2002 and 2003. The general distribution of redds in 2005 was similar to previous years, with 70% of all redds in the Salmon River and 17% in Still Creek (Figure 13). The percentage of redds in the upper section of the Salmon River (18%) was less than the long-term average (27%) and was similar to that in 2002 (Figure 13). We accounted for a higher percentage of the spring Chinook salmon run over Marmot Dam in 2005 (60%) than the long-term average (50%), but slightly less than in 2004 (64%) (Table 13). Additional surveyors provided by the U.S. Forest Service in 2004 and 2005 increased the frequency of redd surveys. Only one survey of the Sandy River downstream of Marmot Dam was conducted in 2005 in late August and few carcasses were recovered.

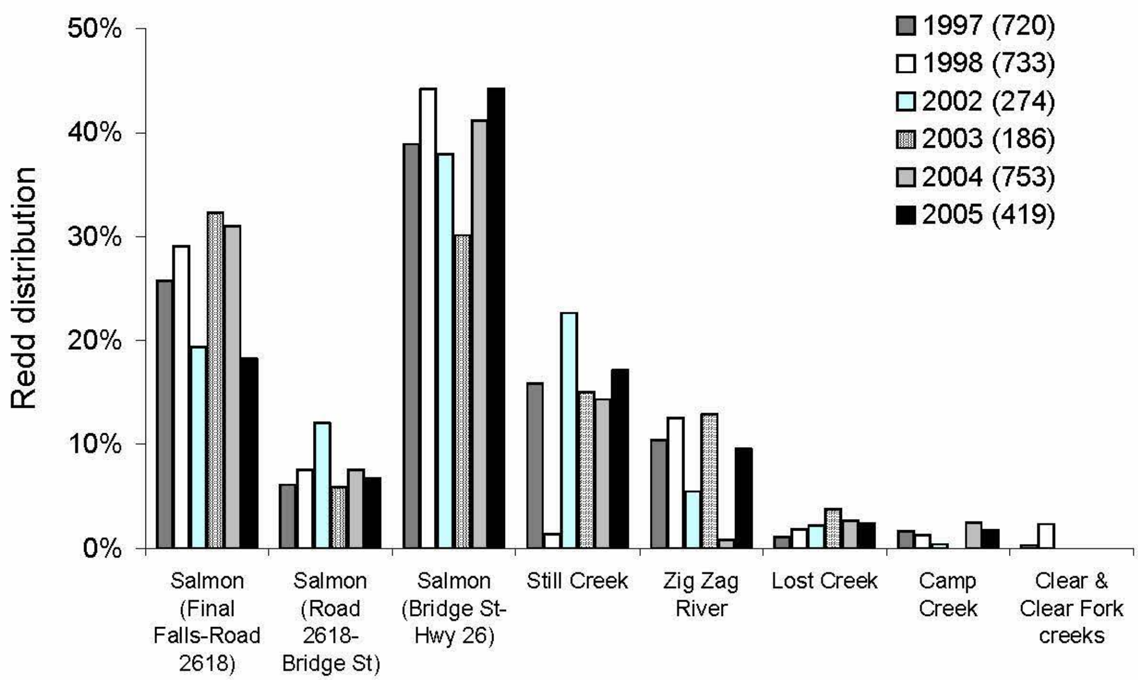

Figure 13. Distribution of spring Chinook salmon redds among eight areas of the Sandy River basin upstream of Marmot Dam, 1997–1998 and 2002–2005. Total redds counted in the basin are in parentheses in the legend.

Table 12. Summary of spawning surveys for spring Chinook salmon in the Sandy River basin, 2005, and comparisons to redd densities in 1996–1999, 2002–2004.

Section	Length	Counts		Redds/mi							
	(mi)	Carcass	Redd	2005	2004	2003	2002	1999	1998	1997	1996
Salmon River:											
Final Falls–Forest Rd 2618	3.2	61	84	26.3	72.8	18.8	16.6	19.1	66.6	57.8	39.7
Forest Rd 2618–Bridge St.	3.6	9	31	8.6	15.8	3.1	9.2	9.4	15.3	12.2	19.7
Bridge St.–Highway 26	6.2	111	204	32.9	50.0	8.4	15.3	20.0	52.3	45.2	41.5
Still Creek:											
Cool Creek– mouth	3.3	53	79	23.9	32.7	8.5	18.8	10.0	27.9	33.3	19.4
Zigzag River:											
Camp Creek– mouth	4.0	16	44	11.0	13.5	6.0	3.8	--	2.5	18.8	--
Lost Creek:											
Riley Campground–mouth	2.0	8	11	5.5	10.0	3.5	3.0	--	6.5	4.0	6.0
Camp Creek:											
Campground–mouth	2.0	3	8	4.0	9.5	0.0	0.5	--	4.5	6.0	3.0
Clear Fork Creek:											
Barrier–mouth	0.6	--	--	--	0.0	--	0.0	--	28.3	5.0	15.0
Clear Creek:											
E. Barlow Rd–mouth	0.5	0	0	0.0	0.0	0.0	0.0	--	0.0	0.0	2.0
Sandy River:											
Marmot Dam–Revenue Br.	6.2	8[a]	b	0.0	30.0	14.2	--	--	--	--	--
Revenue Br.–Oxbow Park	11.9	0[a]	b	0.0	8.9	8.0	--	--	--	--	--

[a] *Surveyed for carcasses August 31, 2005. No additional surveys were conducted.*
[b] *Redds were not counted in 2005.*

Table 13. Counts of adult spring Chinook salmon at Marmot Dam and the relationship to successful spawners in the Sandy River basin upstream of the dam, 1996–1999, 2002–2004.

	Counts				
Year	Marmot Dam[a]	Harvest[b]	Total Redds	Spawners[c]	Fish:redd[d]
1996	2,461	78	569	1,138	4.19
1997	3,277	233	731	1,462	4.16
1998	2,606	185	744	1,488	3.25
1999	1,828	--	310	620	5.90
2002	1,159	--	274	548	4.23
2003	969	--	181	362	5.35
2004	2,491	--	801	1,602	3.11
2005	1,541	--	461	922	3.34

[a] *Total from video counts (1996–1998) or fishway trap counts (1999, 2002-2005) up to one week prior to last spawning survey.*
[b] *Sandy River upstream of the dam from punchcard estimates. No fishery after 1998.*
[c] *Estimated from redds using 1:1 sex ratio and two fish per redd.*
[d] *Fish from dam count minus harvest divided by redds.*

In 2005, we regularly surveyed the Santiam River (9 dates, 21 July–13 October) and the Middle Fork Willamette River (7 dates, 29 July–5 October), and surveyed the Molalla River twice. Of these rivers, the highest number of redds was in the South Santiam and in Fall Creek (Middle Fork Willamette basin), which is similar to previous years (Table 14 and Figure 14). Although we do not have a measure of the run size in the South Santiam, the count of spring Chinook salmon was lower in 2005 than in 2004 at Willamette Falls (63%) and at Bennett dams (73%). However, the number of redds counted in the South Santiam River was 42% higher in 2005 (530) than in 2004 (373). The number of redds counted in the Molalla River was relatively low in 2005, but the redd density was slightly higher because we surveyed a shorter section of the river than in previous years (Table 14).

Table 14. Summary of Chinook salmon spawning surveys in the Middle Fork Willamette, South Santiam, and Molalla basins, 2005.

River, section	Length (mi)	Carcasses: Non fin-clipped[a]	Carcasses: Fin-clipped	Redds	Redds/mi: 2005	2004	2003	2002	1998
Middle Fork Willamette									
Dexter–Jasper	9.0	8	37	9	1.0	1.0	1.5	7.1	1.1
Fall Creek (above reservoir)	16.0	12	c	130	8.1	12.9	6.1	12.9	--
South Santiam									
Foster–Pleasant Valley	4.5	124	401	507	112.7	75.1	132.0	194.4	36.0
Pleasant Valley–Waterloo	10.5	14	68	23	2.2	3.3	1.5	1.8	1.8
Lebanon–mouth	20.0	1	6	--	--	0.2	1.0	3.4	2.9
Molalla									
Horse Cr–Pine Cr[b]	6.2	4	19	25	4.0	2.7	1.3	3.2	--

[a] *Otoliths have not yet been read to determine the proportion of wild and hatchery fish.*
[b] *A segment of the Haybarn Cr–Trout Cr section of which we surveyed 16.1, 11.5, and 16.3 mi in 2004, 2003, and 2002, respectively.*
[c] *No fin-clipped fish were processed.*

Within the Willamette River basin, the McKenzie River basin accounted for almost 40% of the redds we surveyed in 2002–2005 (Figure 15), and had the highest number of naturally produced fish in 2002–2004 (3,000–5,000, *see* **The Proportion of Wild Fish in Natural Spawning Populations**). Of the other basins, the South Santiam and the Clackamas upstream of North Fork Dam accounted for the second highest number of redds (Figure 15), each averaging about 20% of the redds we counted. Although the number of wild fish recovered in the South Santiam River has been relatively high (100–200), the percentage of wild fish in the basin is about 10% compared to 70–80% in the Clackamas upstream of North Fork Dam (*see* **The Proportion of Wild Fish in Natural Spawning Populations**). The North Santiam basin accounted for 14% of the redds in the Willamette basin (Figure 15), but the percentage of wild fish was low (2–8%). The average number of redds in the Sandy basin upstream of Marmot Dam was about 400 (Figure 15), similar to the North Santiam, but the percentage of wild fish upstream of the dam was 80–95%.

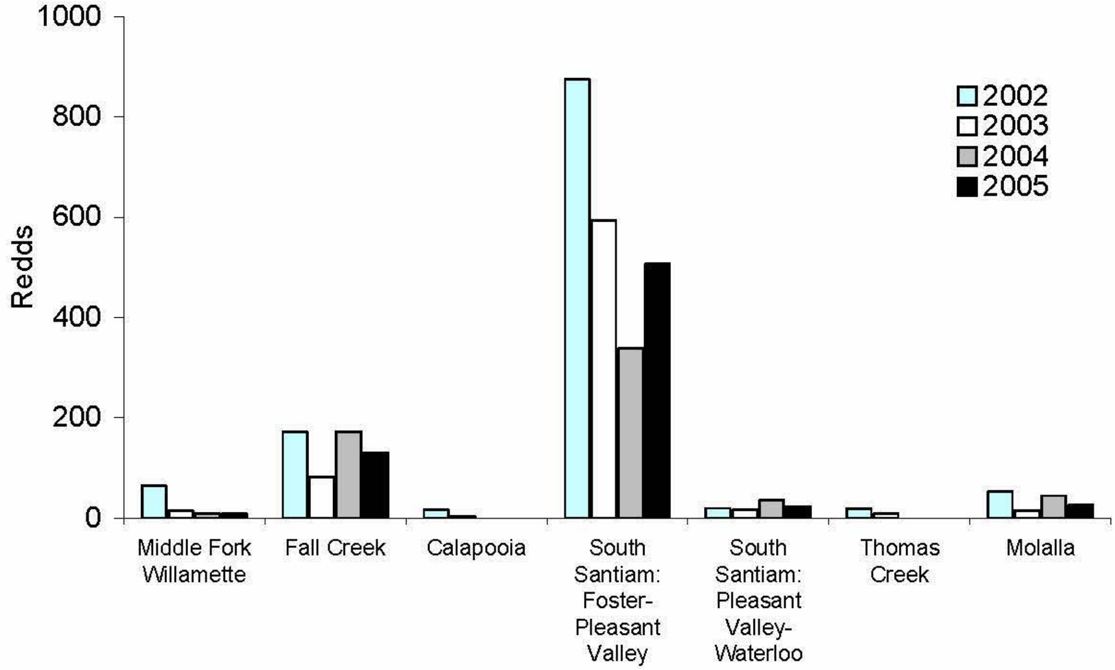

Figure 14. Spring Chinook salmon redds counted in seven areas of the Willamette River basin, 2002–2005. A shorter section of the Molalla River was surveyed in 2005 than in 2002–2004.

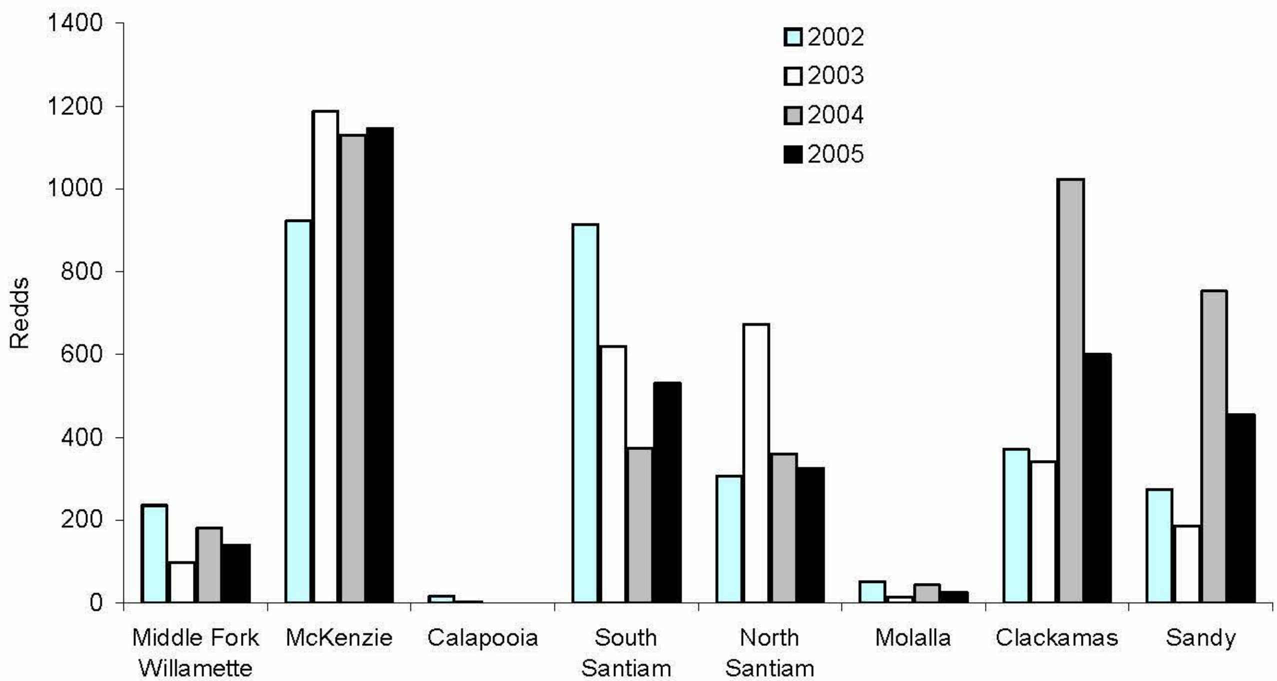

Figure 15. Spring Chinook salmon redds counted in eight watersheds of the Willamette River and Sandy River basins, 2002–2005. Redds in the Middle Fork Willamette basin include Fall Creek and redds in the South Santiam basin include Thomas Creek. Redds in the Clackamas and Sandy basins were upstream of dams.

Variability in Redd Counts

We conducted a preliminary assessment of variability in counts of spring Chinook salmon redds in some sections of the North and South Santiam, McKenzie, Clackamas, and Sandy rivers. Sections were classified as large rivers that were surveyed from a raft with a viewing tower, medium-large streams that were surveyed from a small raft or kayak, and medium and small streams that were surveyed on foot. Areas were re-surveyed by a different set of surveyors usually a day after the first survey, and in the case of surveys conducted on large rivers, the same side of the river was surveyed on both days. To minimize potential bias, surveyors on the first day did not know that the area was to be re-surveyed.

The average difference between successive counts of redds was 19–33% for the four types of surveys (Figure 16). The largest differences between counts were for medium-large and medium streams. Large rivers may have had lower variability than medium-large streams because surveys from a raft with a tower allow better visibility of redds than from a small raft or kayak, and because the same side of the river was surveyed on both dates, thus reducing the chances of missing redds. The variability in counts of redds was almost 75% higher for medium streams that were walked than for small streams (Figure 16), likely because the medium streams are more difficult to cover thoroughly by a single surveyor.

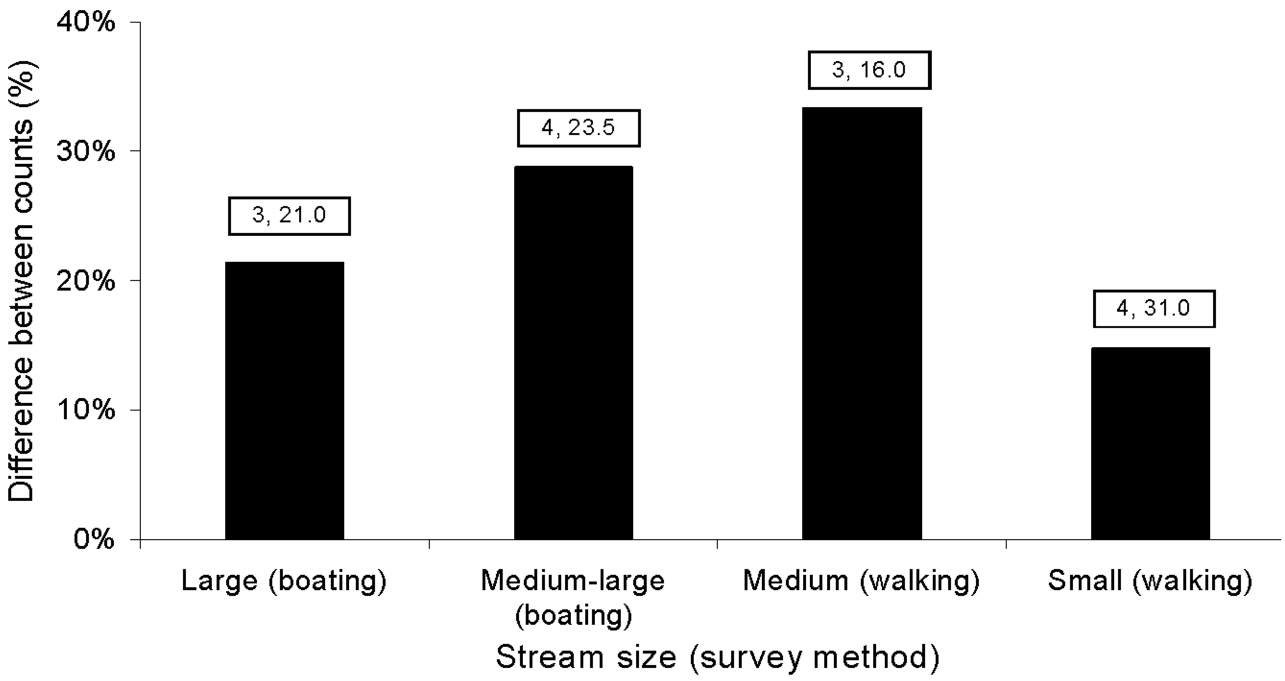

Figure 16. Average difference (%) between counts of spring Chinook salmon redds made on consecutive days by different surveyors for four types of streams (size and survey method). Numbers in boxes above bars are the number of sections that were re-surveyed and the median redd density (redds/mi).

Pre-spawning Mortality

We estimated pre-spawning mortality of Chinook salmon in the upper Willamette Basin by the ratio of spawned to unspawned female carcasses determined by presence of eggs. We did not use male fish in the estimates because we could not reliably determine if they had spawned before dying. Most of the surveys were not conducted explicitly to estimate pre-spawning mortality, and beginning dates varied between years and among rivers. Surveys in some years began in early to mid summer while adult fish were holding in deep pools and continued through the end of the spawning season in October, and in other years surveys did not begin until late summer. In addition, recovering carcasses and counting redds can be difficult when flows increase during the spawning season, either from late summer rain or from increased discharge from reservoirs. Therefore, caution should be used in comparing estimates of pre-spawning mortality between years within basins or among basins.

We used an estimate of potential spawners in the North Santiam and McKenzie rivers from counts of Chinook salmon at Bennett and Leaburg dams as a secondary measure of pre-spawning mortality (percentage of potential spawners that spawned). The number of potential spawners was estimated from counts of Chinook salmon at Bennett dams minus estimated harvest and fish removed at Minto collection pond for the North Santiam, and from counts at Leaburg Dam for the McKenzie basin. The estimated number of successful spawners was estimated from redd counts by using a sex ratio of 1.2 males:1 female (from counts of fish returning to hatcheries).

Estimated pre-spawning mortality in the North Santiam was lower in 2005 than in 2003–2004, and was similar to 2002 (Figure 17). Estimates of pre-spawning mortality from recovery of female carcasses were generally lower than those from estimates of potential and successful spawners, but the trend was similar for both estimates (Figure 17). The estimates of fish:redd also tended to track similarly with the mortality estimates, but the ratios were more variable (Figure 17). However, because surveys began on different dates each year, the estimates are not wholly comparable. For example, we surveyed the North Santiam basin from mid June through October in 2003 and 2004, and found that pre-spawning mortality would be underestimated by 30–50% if only data from late August through October were collected compared to estimates from surveys beginning in late June (Figure 18). The difference between the estimates was greater in 2003 than in 2004 because a higher proportion of the total mortality occurred in early summer. These data indicate that, at least in some years, carcass recovery surveys beginning in late summer can underestimate pre-spawning mortality, and estimates will depend on the pattern of mortality that occurs throughout the run.

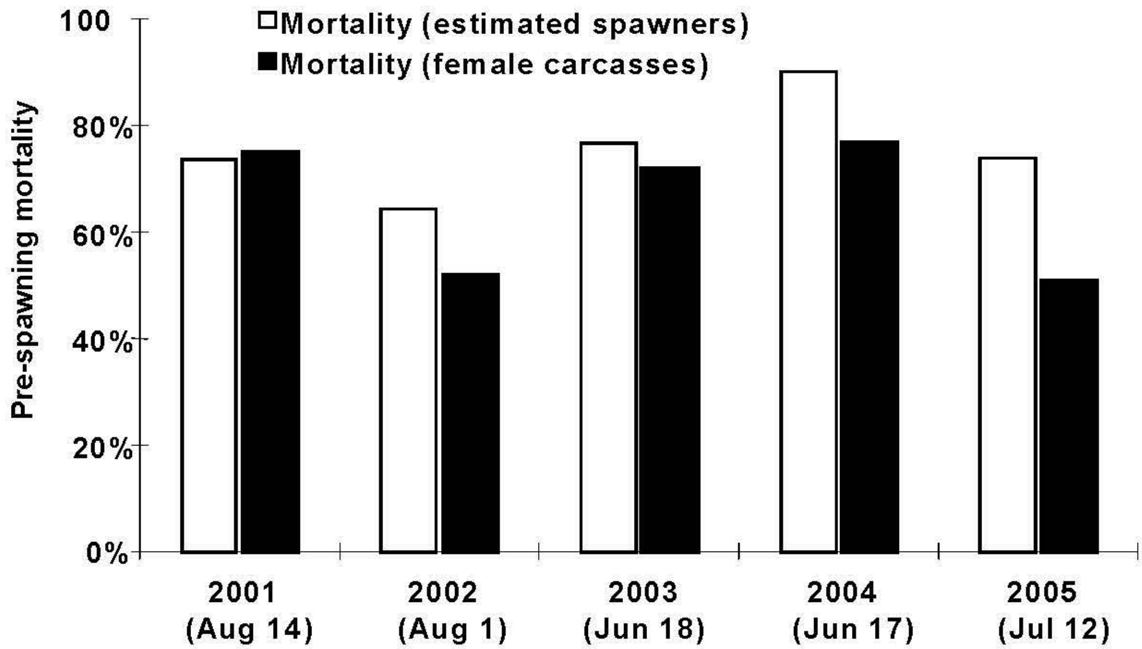

Figure 17. Pre-spawning mortality (%) of Chinook salmon in the North Santiam basin estimated from recovery of female carcasses that died before spawning, and from number of successful spawners to number of potential spawners, 2001–2005. Starting dates of carcass surveys for each year are given in parentheses.

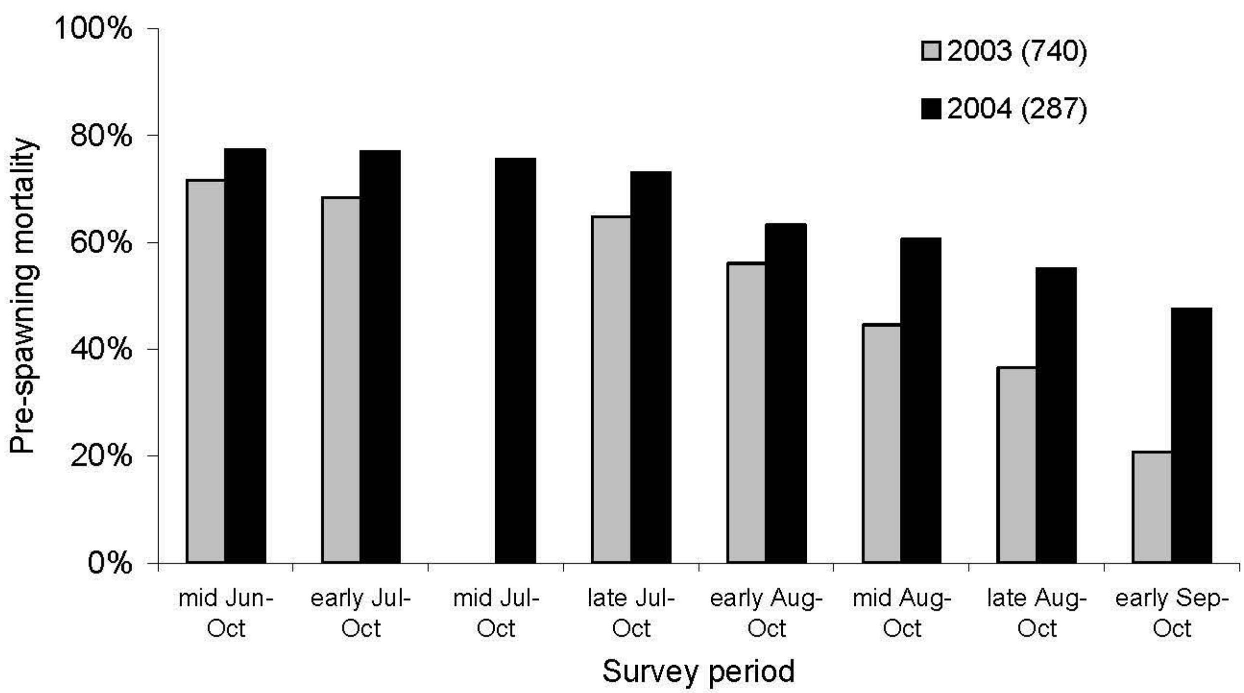

Figure 18. Percentage of Chinook salmon females that died before spawning in the North Santiam River, estimated for eight survey periods of progressively later starting dates, 2003–2004. Total number of female carcasses is in parentheses in the legend.

Pre-spawning mortality in the McKenzie River basin estimated from recovery of carcasses was similar in 2005 to that in 2003–2004 (Figure 19). Estimates of pre-spawning mortality from recovery of female carcasses generally were much lower than those from estimates of potential and successful spawners, which is in contrast to results in the North Santiam basin where the two estimates were relatively similar. We believe the estimates from recovery of carcasses are a better gauge of mortality in the McKenzie Basin than those from estimates of potential spawners. Several factors may affect estimates of spawners in the McKenzie Basin: 1) counts of Chinook salmon at Leaburg may be high, especially for hatchery fish (*see* **Hatchery Fish in Spawning Population**), which would overestimate the number of potential spawners; 2) variability in redd counts could occur because of factors such as accuracy of counting redds in different sizes of streams (*see* **Variability in Redd Counts**) or by changes in water conditions that might affect visibility of redds, which would tend to underestimate the number of redds; 3) surveys in the McKenzie began in mid to late August and data from the North Santiam River indicated that mortality could be underestimated with surveys that start late (Figure 18). Although pre-spawning mortality may be higher than that estimated from recovery of carcasses, it is unlikely that mortality rates exceeding 60% would go unnoticed in the basin.

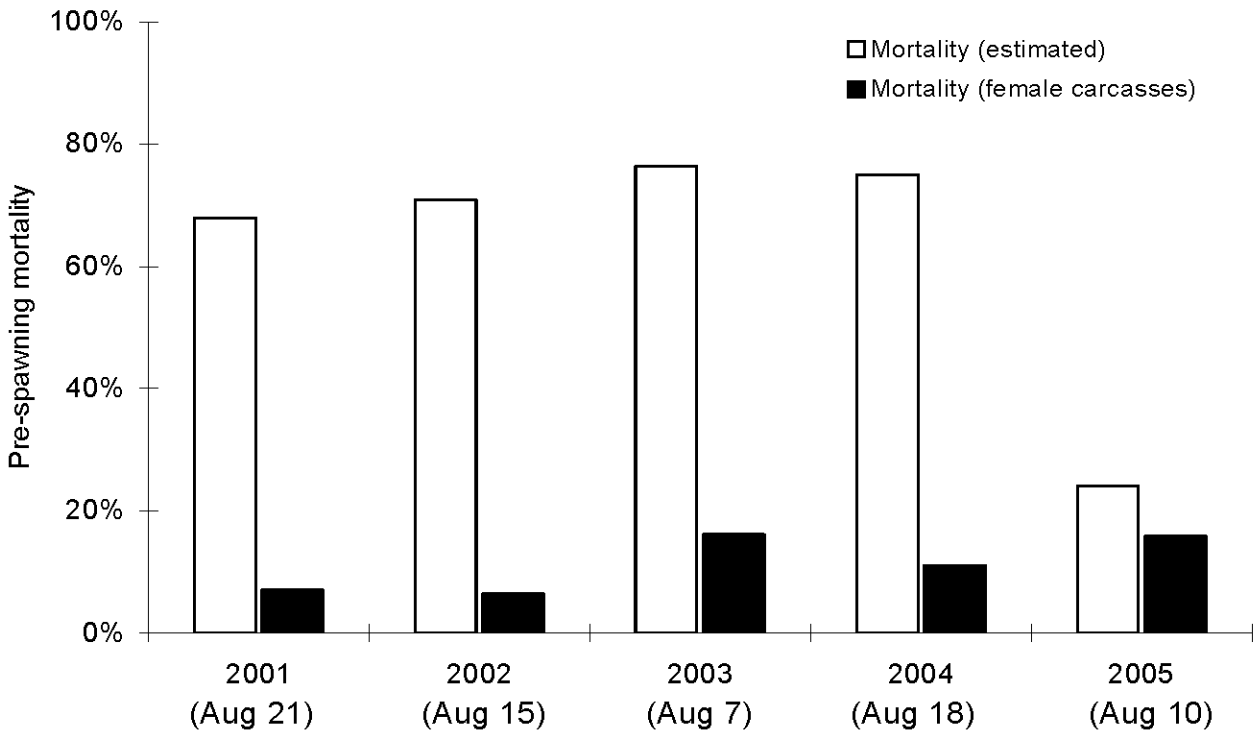

Figure 19. Pre-spawning mortality (%) of Chinook salmon in the McKenzie Basin estimated from recovery of female carcasses that died before spawning, and from number of successful spawners upstream of Leaburg Dam (from redd counts) to number of potential spawners (from counts of fish passing Leaburg Dam), 2001–2005. Starting dates of carcass surveys for each year are given in parentheses.

Of the female carcasses we recovered in 2005 in the Clackamas River upstream of North Fork Dam, 26% died before spawning, which was the highest we have recorded in this basin (Figure 20). In contrast, the pre-spawning mortality in the Sandy River upstream of Marmot Dam in 2005 was similar or lower than in 2003–2004. The average pre-spawning mortality in the Clackamas generally was higher in 2003–2005 (average 19%) than in 1996–1998 (average 10%), but was variable and the difference was not significant ($P = 0.13$). However, pre-spawning mortality was significantly higher (P = 0.01) in the Sandy basin in 2003–2005 (average 12%) than in 1996–1998 (2%).

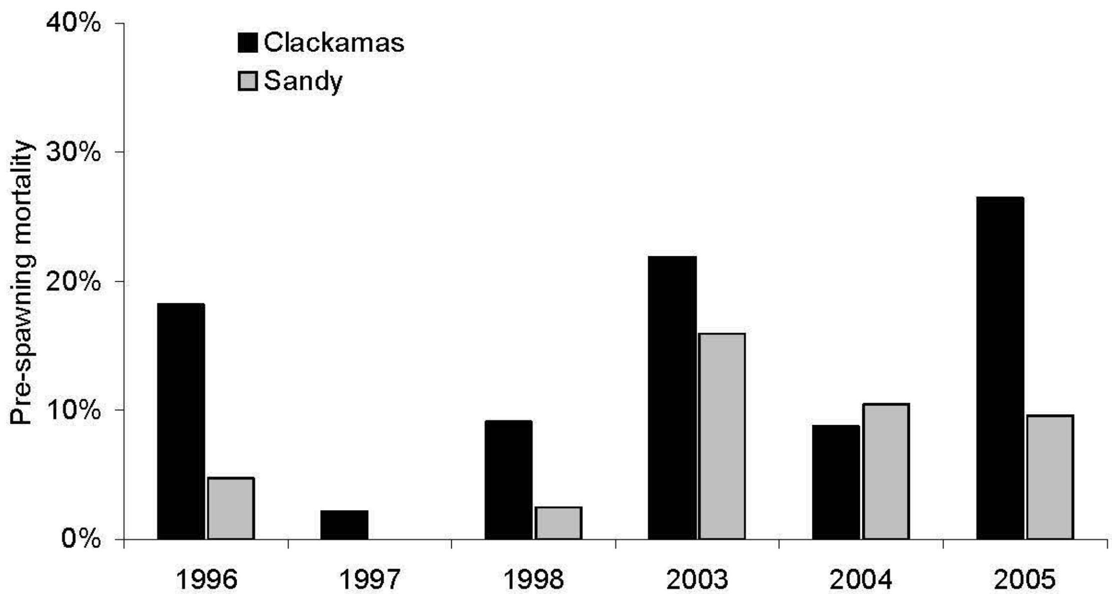

Figure 20. Pre-spawning mortality (%) of Chinook salmon in the Clackamas and Sandy basins upstream of North Fork and Marmot dams, respectively, 1996–1998 and 2003–2005. Estimated from recovery of female carcasses that died before spawning.

The Middle Fork Willamette River downstream of Dexter Dam had the highest pre-spawning mortality of Chinook salmon (consistently above 80%) as estimated from recovery of female carcasses (Table 15). Although we estimated 100% pre-spawning mortality in the Middle Fork Willamette River in 2003, we counted 14 redds indicating some survival of adult fish to spawning. Mortality in the South Santiam River appeared to be much lower than that in the North Santiam River, with the exception of 2004. Non fin-clipped Chinook (300–400) were transported from Minto Pond and released in the Little North Santiam River. Stress from handling and transportation likely increased pre-spawning mortality of these fish (Table 15).

Table 15. Estimates of pre-spawning mortality of Chinook salmon in the upper Willamette River basin, based on recovery of female fish carcasses, 2001–2005.

Year	2001	2002	2003	2004	2005
Middle Fork Willamette		83 (Aug 7)	100 (Jul 15)		94 (Jul 29)
Fall Creek		58 (Aug 27)	44 (Aug 27)	57 (Aug 10)	
McKenzie	7 (Aug 21)	8 (Aug 15)	21 (Aug 7)	17 (Aug 18)	18 (Aug 10)
South Santiam		26 (Aug 15)	28 (Jul 14)	72 (Jul 20)	32 (Jul 14)
North Santiam	75 (Aug 14)	52 (Aug 1)	72 (Jun 27)	77 (Jun 17)	51 (Jul 12)
Little No. Santiam			81 (Jul 10)	50 (Jul 14)	41 (Aug 31)
Clackamas[a]			22 (Aug 20)	9 (Aug 19)	26 (Aug 22)
Sandy[a]			16 (Aug 19)	10 (Aug 18)	10 (Aug 23)

[a] *Upstream of dams.*

An analysis of potential effects of environmental factors such as water flow and temperature on pre-spawning mortality was not possible because of the confounding effect of different starting dates for the surveys, and other uncertainties about the estimates. In the North and South Santiam rivers, water flow and temperature throughout the summer is likely to affect pre-spawning mortality because of stress and associated effects on resistance to disease of fish that are holding in the river or negotiating dams and shallow riffles. In years with large numbers of returning fish, flow and temperature may have an increased effect on survival if suitable holding habitat is limited because more fish would be holding in marginal habitat. For example, passage at dams such as Bennett dams may be more difficult during low flow, which could result in fish holding for longer periods of time in limited areas downstream.

TASK 3.1– EVALUATION OF NET PENS IN THE LOWER WILLAMETTE RIVER

A study was begun in 1994 to determine if acclimation prior to release could be used to increase sport harvest of hatchery spring Chinook salmon returning to the lower Willamette River. We used McKenzie River stock in the study because of concerns about straying of other stocks into the McKenzie, a stronghold for wild spring Chinook salmon. The evaluation of straying was an important part of the study. Fish were acclimated in net pens and compared to fish trucked directly from the hatchery. Control groups were released into the McKenzie River from McKenzie Hatchery. The study was originally planned for four brood years. However, numerous problems led to modifications in study design beginning with the 1995 brood and an extension of the study for four additional years through 1999 brood releases. Smolt releases from 1992–1999 broods are described in Lindsay et al. (1997, 1998, 2000), and Schroeder et al. (1999, 2001). The types of experimental groups released in all brood years are summarized in Schroeder et al. 2002.

Adult Recapture of 1996–1999 Brood Releases

Coded wire tags from experimental releases were recovered primarily from adults captured in fisheries, in hatcheries, in traps at dams and on spawning grounds. Most of the sport fishery for spring Chinook salmon in the Willamette River occurs downstream of Willamette Falls. Although some catch of spring Chinook salmon occurs upstream of Willamette Falls, these fisheries generally are not surveyed. Based on salmon catch card records, the fishery upstream of Willamette Falls accounted for about 26% of the total basin harvest annually in 1981–1995 (calculated from Foster and Boatner 2002). We previously reported adult captures from 1992 through 1995 broods and conclusions based on these data (Schroeder et al. 2002 and 2003).

Adult captures from 1996–1999 broods are in Appendix Tables D-1–D-4. The 1996 brood represents the first of four consecutive brood years with duplicated releases, which should help identify differences among groups after all four broods have returned. Based on returns through the 2004 run year, several tentative conclusions can be reached. First, direct smolt releases into the lower Willamette River (Multnomah Channel) generally did not increase sport catch. Sport catch downstream of Willamette Falls (including Clackamas River) of control fish released from McKenzie Hatchery was generally higher than catch of fish from groups released directly into the lower main-stem Willamette, although preliminary returns from the 1999 brood showed a higher catch of the direct release groups (Figure 21). In contrast, preliminary returns suggest that sport catch of fish acclimated in net pens in the fall was equal to or higher than the control group in three of four releases. Second, fish released into the lower Willamette River tended to stray into the Clackamas and most other spawning tributaries, and direct river releases strayed more than the acclimated releases (Figure 22). Third, based on hatchery recoveries, fish released into Clackamette Cove returned mainly to the Clackamas River, and generally was higher than for fish released directly into the lower Clackamas River (Table 16). Finally, for groups released into the Clackamas River in spring, those acclimated in Clackamas Cove appeared to contribute more to sport fisheries in the Willamette and Clackamas rivers than groups released directly into the Cove or into the Clackamas River, although preliminary returns from the 1998–1999 broods showed slightly higher catch of the direct river releases (Figure 23). On average, all releases in the Clackamas River contributed more to the sport fishery than did returns from control groups released at McKenzie Hatchery.

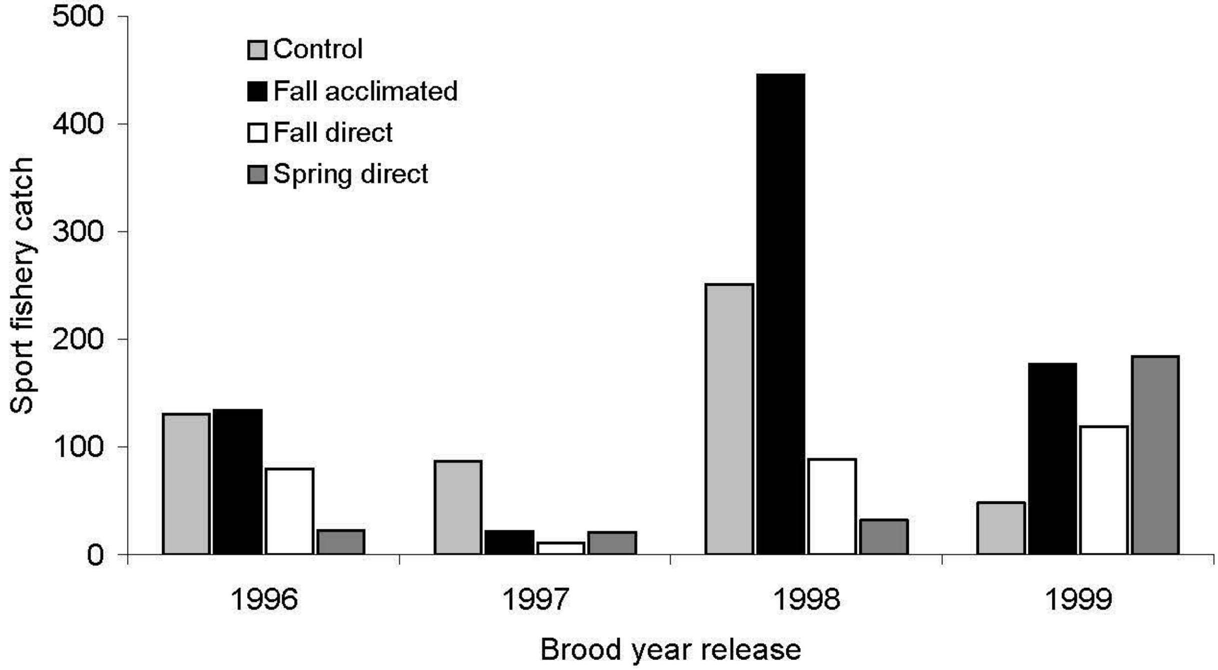

Figure 21. Catch of adult spring Chinook salmon in sport fisheries in the lower Willamette and Clackamas rivers from releases of smolts (McKenzie stock) into Multnomah Channel in the lower Willamette River compared to control releases, 1996–1999 broods. Data are preliminary for 1998 and 1999 broods.

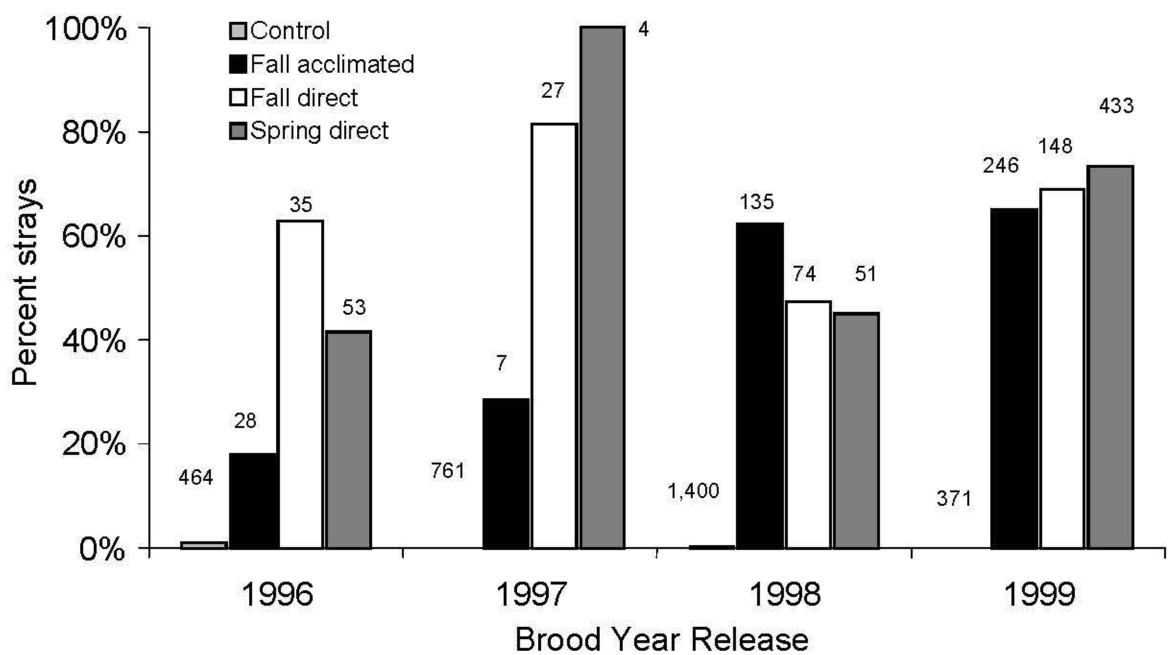

Figure 22. Percentage of adult spring Chinook salmon that strayed from releases of smolts (McKenzie stock) into Multnomah Channel in the lower Willamette River, 1996–1999 broods. Data are preliminary for 1998 and 1999 broods. Numbers in graph are returns from the four experimental release groups.

Table 16. Capture of adult spring Chinook salmon at hatcheries from the net pen evaluation of smolt releases into the lower Willamette River basin, 1996–1999 broods. Numbers were adjusted to a standard release of 100,000 smolts. Data were obtained from the coded wire tag database of the Pacific States Marine Fisheries Commission, April 2006. Data for 1998 and 1999 brood returns are preliminary.

		Smolts released in spring into—		
	McKenzie	Clackamas Cove		Clackamas River
Brood year, hatchery	Control	Acclimated	Direct	Direct
1996				
Clackamas	0	77	36	14
McKenzie	436	3	2	1
Other	0	2	0	0
1997				
Clackamas	0	17	1	0
McKenzie	746	0	0	4
Other	0	1	0	1
1998				
Clackamas	2	241	131	116
McKenzie	1369	0	4	22
Other	2	3	4	10
1999				
Clackamas	0	272	238	130
McKenzie	365	5	5	15
Other	0	6	11	7

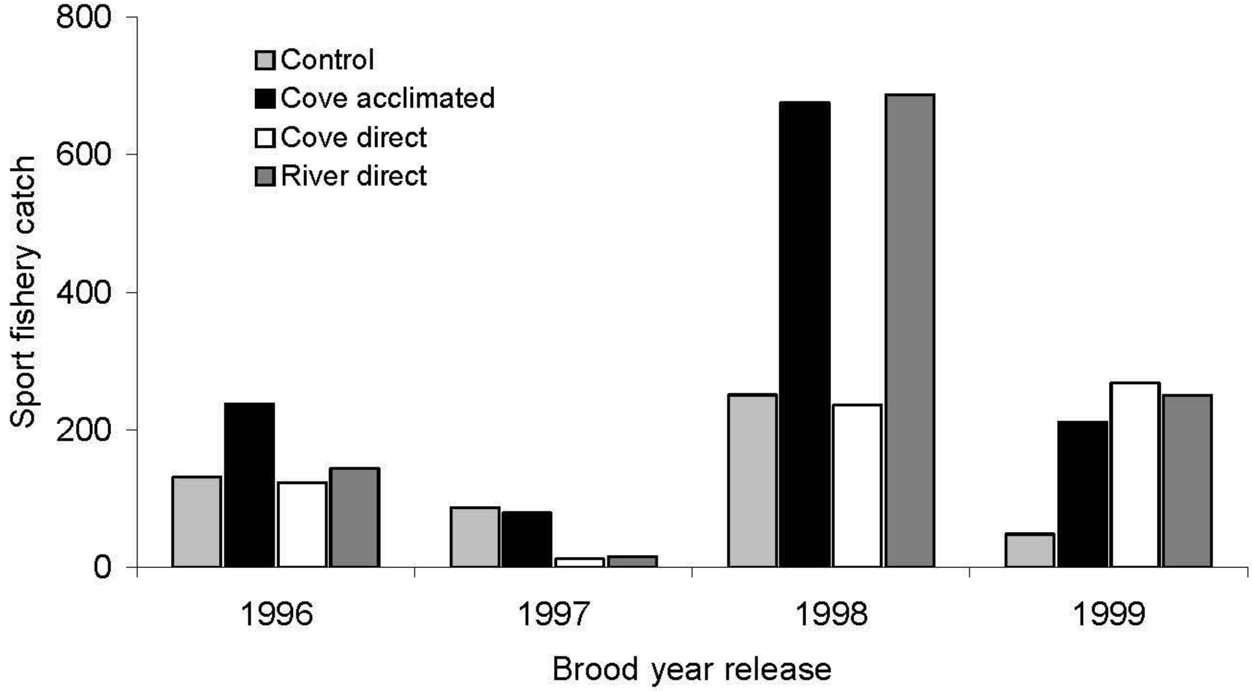

Figure 23. Catch of adult spring Chinook salmon in sport fisheries in the lower Willamette and Clackamas rivers from releases of smolts (McKenzie stock) into the Clackamas River compared to control releases, 1996–1999 broods. Data are preliminary for 1998 and 1999 broods.

TASK 3.4– INCORPORATING WILD FISH INTO HATCHERY BROODSTOCKS

Otoliths were collected in 2004 from spring Chinook salmon without fin clips that were spawned at Willamette basin hatcheries to determine the number of wild fish that are being incorporated in the broodstocks. The percentage of wild fish incorporated into the broodstocks was higher for all hatcheries in 2004 compared to 2002 and 2003, with the largest increases in the North and South Santiam rivers (Table 17). The number of wild fish spawned at McKenzie and Minto represented a small proportion of the estimated run of wild fish in the McKenzie and North Santiam rivers. Estimates of wild fish are not available for South Santiam and Middle Fork Willamette rivers.

Table 17. Composition of spring Chinook salmon without fin clips that were spawned at Willamette basin hatcheries, based on the presence or absence of thermal marks in otoliths, 2002–2004.

River, year	Non fin-clipped Wild	Non fin-clipped Hatchery	Fin-clipped hatchery	Percent wild— in broodstock	Percent wild— of run
McKenzie					
2004	24	105	880	2.4	0.5
2003	14	42	953	1.4	0.3
2002	13	101	933	1.2	0.4
North Santiam (Minto)					
2004	12	13	541	2.1	2.4
2003	2	17	599	0.3	0.7
2002	4	7	671	0.6	0.7
South Santiam					
2004	78	16	905	7.8	
2003	25	23	1,048	2.3	
2002	26	19	1,174	2.1	
Willamette					
2004	16	28	1,807	0.9	
2003	5	59	1,465	0.3	
2002	5	53	1,602	0.3	

TASKS 4.1 AND 4.3– MIGRATION TIMING, LIFE HISTORIES, AND HABITAT USE OF JUVENILES

Migration Timing and Life Histories––Seining and PIT Tags

Information on migration timing and life history of juvenile Chinook salmon will allow managers to better understand spatial and temporal use of habitat by wild fish in the Willamette basin and to better protect existing natural production areas. In 2005, we finalized plans and began installation of an adult PIT tag detection system in the Willamette Falls fishway to identify the contribution to adult returns of different juvenile life histories and of juvenile fish from different watersheds in the basin.

We used migration timing of juveniles from spawning areas upstream of Leaburg Dam in the McKenzie as a baseline for our studies: (1) age 0 fry that migrate in late winter through early spring, (2) age 0 fingerlings that migrate in fall, and (3) yearling smolts that migrate in early spring.

Methods

We used PIT tags to monitor migration of juvenile spring Chinook salmon in the McKenzie, Willamette, and Santiam rivers. Age 0 Chinook salmon representative of the fry migrants were seined and tagged in the lower McKenzie and upper Willamette rivers in June and July because fry are too small to tag when they migrate past Leaburg Dam in February–April. We sampled these fish in the lower McKenzie and upper Willamette rivers downstream of the major spawning areas. We also tagged a sample of juvenile Chinook released in the spring from McKenzie Hatchery. In addition, we seined in sections of the Willamette River from Harrisburg to Newburg and in the Santiam River basin. We were not able to capture and tag at the Leaburg bypass flume in fall 2003 or spring 2004 because of construction at the site.

Migrating juvenile Chinook salmon were scanned with a tag detector (Destron-Fearing® FS1001) at Willamette Falls in the bypass of the Sullivan hydroelectric plant operated by Portland General Electric Company (PGE). Only a portion of the juvenile salmon migrating past Willamette Falls uses the bypass system (Royer et al. 2001). The detection system was not operated June 14–November 2, 2004 because of construction at the plant (*see* Appendix Table E-5). Tags also were detected and reported by the NOAA Fisheries during their juvenile salmonid studies in the Columbia River estuary. Additional methods are in Schroeder et al. (2003).

Results

We tagged 6,762 wild spring Chinook salmon in the McKenzie and upper Willamette rivers, 2,418 hatchery fish from McKenzie Hatchery, and 1,020 wild Chinook salmon in the lower Willamette and Santiam rivers in May 2004–March 2005 (Table 18). In addition, we tagged over 4,700 age 0 wild Chinook salmon in the lower McKenzie and upper Willamette rivers, and over 1,100 in the lower Willamette River and Santiam basin in spring and summer 2005 (Table 19).

Most of the detections of fish tagged in May 2004–March 2005 occurred at Willamette Falls (Table 18). The efficiency of the passive interrogator depends on river flow, which affects the proportion of juveniles using the bypass system at the Sullivan Plant and the proportion of time the interrogator can be operated because of debris. The detection rate of hatchery fish released in fall 2004 was lower than most previous years, although the flow in the Willamette River was not particularly high until early December, and the detection rate of hatchery fish released in the spring was very high (Table 20) because of low flow in February and early March. The mean fork length of juvenile Chinook salmon tagged and later detected was significantly larger ($P < 0.05$) than the mean fork length of all fish tagged and released, with the exception of fish tagged in the Lower Willamette and Santiam rivers (Table 18).

Table 18. Detection of juvenile wild and hatchery spring Chinook salmon given PIT tags and released in May 2004–May 2005. Tags were detected at the PGE Sullivan Plant at Willamette Falls unless noted. Numbers in parenthesis indicate number of fish tagged.

	U. Willamette R. & McKenzie R.	L. Willamette R. & Santiam R.	Leaburg Bypass	Leaburg Bypass	McKenzie Hatchery	
	May 19–Jul 22 2004 (2,848)	May 26–Jul 13, 2004 (1,020)	Feb 2–May 3, 2005 (1,091)	Oct 28–Dec 6, 2004 (2,823)	Nov 1, 2004 (1,006)	Feb 1, 2005 (1,412)
Month tag detected:						
May	6[b]	0	--	--	--	--
June[a]	19[c]	27[b]	--	--	--	--
July[a]	--	--	--	--	--	--
August[a]	--	--	--	--	--	--
September[a]	--	--	--	--	--	--
October[a]	--	--	--	--	--	--
November	0	0	--	3	60	--
December	1	0	--	5	4	--
January	0	0	--	3	1	--
February	1	0	0	38	1	7
March	4	1	4	71	1	119
April	1	0	47	5	0	7
May	0	0	11	0	0	0
June	0	0	3	0	0	0
Detection rate at Willamette Falls (%)	1.1	2.8	6.0	4.4	6.7	9.4
95% CI	0.7-1.5	1.8-3.8	4.6-7.4	3.7-5.2	5.1-8.2	7.9-11.0
Mean length (mm) at time of tagging for—						
Fish released	82.3	92.9	103.4	103.0	158.9	137.3
Fish detected	87.4	94.8	109.3	109.4	162.3	145.5

[a] *PGE Sullivan Plant shut down Jun 14 – Nov 2*

[b] *Does not include four fish detected in the Columbia River estuary (rm 47)*

[c] *Does not include two fish detected in the Columbia River estuary (rm 47)*

Table 19. Number and mean fork length of wild spring Chinook salmon (age 0) that were seined, PIT-tagged, and released in the McKenzie River downstream of Hendricks Bridge (rm 21), in the Willamette River upstream and downstream of the Santiam River, and in the Santiam River watershed in 2002 (June–July), 2003 (late May–mid July), 2004 (mid May–mid July), and 2005 (mid May-mid July).

	Number tagged				Mean length (mm)			
River	2002	2003	2004	2005	2002	2003	2004	2005
McKenzie	1,848	1,949	1,337	1,972	84.8	78.6	80.0	79.5
Upper Willamette	1,606	1,868	1,511	2,785	83.3	85.1	84.4	83.6
Lower Willamette	225	733	377	547	90.6	94.9	95.8	96.7
Santiam[a]	487	193	239	400	90.3	90.1	89.7	86.2
North Santiam		966	258	187		90.7	91.8	100.5
South Santiam		330	146	--		86.2	92.1	--

[a] *From confluence of North and South Santiam to mouth.*

Table 20. Detection rate (%) at Willamette Falls of spring Chinook salmon that were PIT-tagged and released in Willamette River basin in October 1999–May 2005.

	Summer				McKenzie fall		McKenzie spring		
Years	McKenzie River	Upper Willamette River	Lower Willamette River	Santiam River	Wild	Hatchery	Wild	Hatchery standard[a]	Hatchery volitional[b]
1999–2000					1.3	4.4			
2000–2001	3.7	0.8			6.9	11.7	14.1		
2001–2002	1.5	0.8			0.9	9.4	8.5	2.4	
2002–2003	0.4	0.1	1.3	3.1	0.6	15.3	2.3	0.2	
2003–2004	0.7	1.6	4.6	11.6	--	--	--	2.1	
2004–2005	0.7	1.5	2.4	3.0	4.4	6.7	6.0	14.7	7.4

[a] *Released in early February.*
[b] *Screens pulled in early February, most fish left when pond was lowered in early March.*

A higher percentage of wild Chinook salmon tagged in the lower McKenzie River as age 0 fish in summer 2004 migrated the following spring compared to those tagged in 2003 (Figure 25), but the PGE Sullivan Plant was shut down in mid June. As in previous years, fish tagged in the lower McKenzie River exhibited more diversity in their migration pattern than fish tagged in other areas, and over 50% of the McKenzie fish migrated in the fall and following spring (Figure 25).

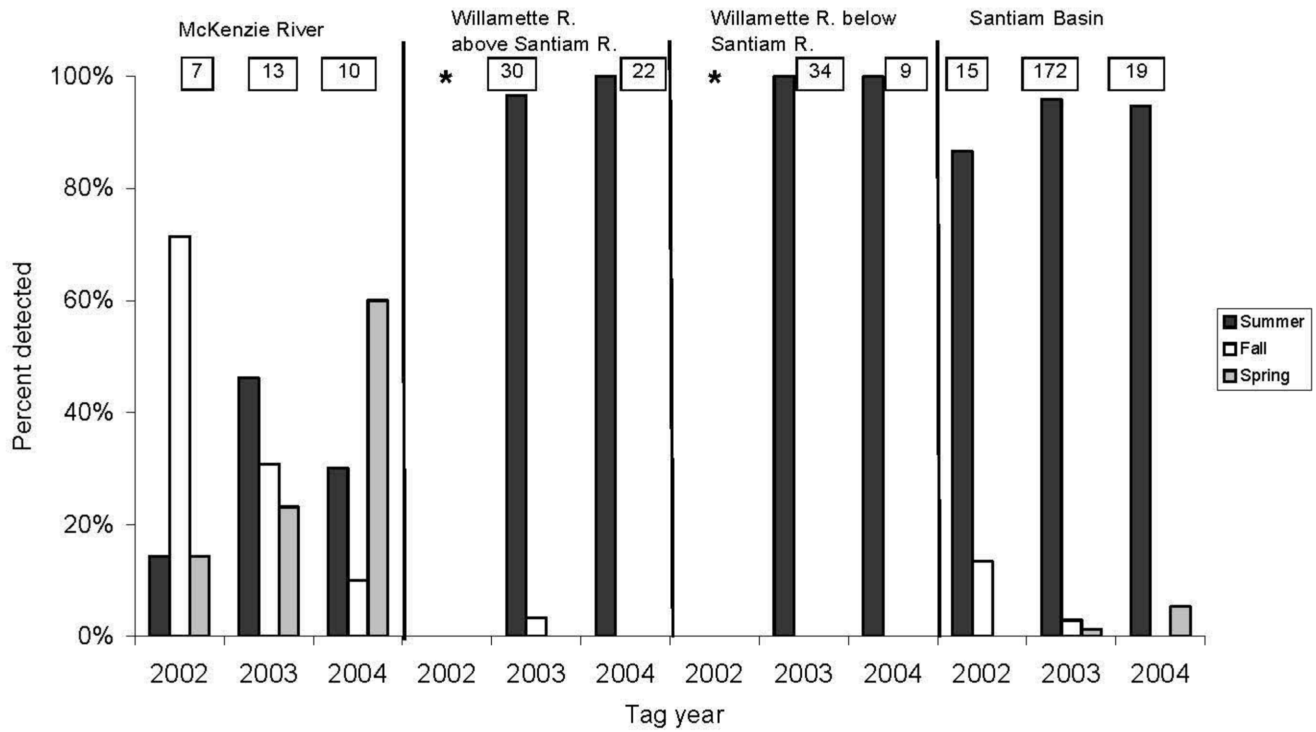

Figure 25. Migration timing of juvenile spring Chinook salmon past Willamette Falls, summer 2002–spring 2005. Based on detection of fish given PIT tags in the McKenzie, Willamette, and Santiam rivers in 2002–2004. Numbers in boxes are number of tag detections; asterisks indicate detections of fewer than five fish.

Age 0 Chinook salmon were found throughout the lower McKenzie, upper and middle Willamette, and lower Santiam rivers. The relative catch of juvenile Chinook salmon in 2005 was similar to that in 2004 with the exceptions that catch was lower in the South Santiam and higher in the upper Willamette (Table 21). As in previous years, we documented an early summer migration of age 0 Chinook salmon past Willamette Falls that were tagged in the Willamette and Santiam rivers in spring and early summer 2005 (Table 22). However, no McKenzie River fish were detected at Willamette Falls, and no fish from the lower North Santiam were detected probably because of the small number of tagged fish. NOAA Fisheries reported detections of 10 age 0 fish that had been tagged and released in the Santiam River and in the Willamette River upstream of the confluence with the Santiam. Based on efficiency estimates of the trawl sampler (R.D. Ledgerwood, NOAA Fisheries, personal communication), we estimated that 17–41% of the age 0 Chinook we tagged and released in these areas migrated to the estuary with an average travel rate of 11 mi/d. Age 0 Chinook tagged and released in the Lower Willamette and McKenzie rivers were not detected in the trawl. However, most of the fish tagged in the lower Willamette River were after June 16, when the trawl sampling effort was reduced.

Table 21. Catch rate with a beach seine (fish/seine set) of juvenile Chinook salmon in the Willamette, McKenzie, and Santiam rivers, 2000–2005.

	Willamette River				Santiam River		
Dates	Newburg–Santiam R.	Santiam R.–Harrisburg	Harrisburg–McKenzie R.	McKenzie River	North	South	Mouth to confluence
Jul 25–Sep 11, 2000		3.8	4.1	5.3			
Jul 2–Aug 9, 2001		1.4	6.1	10.9			
Jun 19–Jul 31, 2002	3.4	11.0	16.6	22.0			10.2
May 21–Jul 28, 2003	37.5	21.1	20.2	59.6	33.0	21.1	67.3
May 19–Jul 22, 2004	6.5	19.4	16.1	23.6	11.5	6.5	11.3
May 25–July 28,2005	10.8	17.1	29.7	21.3	10.6	0.8	12.6

Table 22. Detection rate (%) and travel time (median days) of age 0 juvenile Chinook salmon that were PIT-tagged and released in Willamette River basin May 19–July 22, 2005, and detected in the PGE bypass detector at Willamette Falls in late May–July 9, 2005.

Location	Number tagged	Percent detected	Median days to Willamette Falls
McKenzie River	1,967	0	--
Willamette River:			
Above Santiam R.	2,785	2.8	11.0
Below Santiam R.	547	9.1	5.0
Santiam River			
Mouth to confluence	400	6.0	5.5
North	187	0	--

The mean fork length of spring Chinook salmon in the McKenzie River increased significantly ($P \leq 0.001$) between sampling dates within sections of the river (Figure 26). The decrease in mean length from early July to late July between sections likely reflects continued migration of smaller subyearling fish into the upper section (Hendricks Bridge to Hayden Bridge). Additional data collected during field activities are in Appendix Tables E-1–E-4.

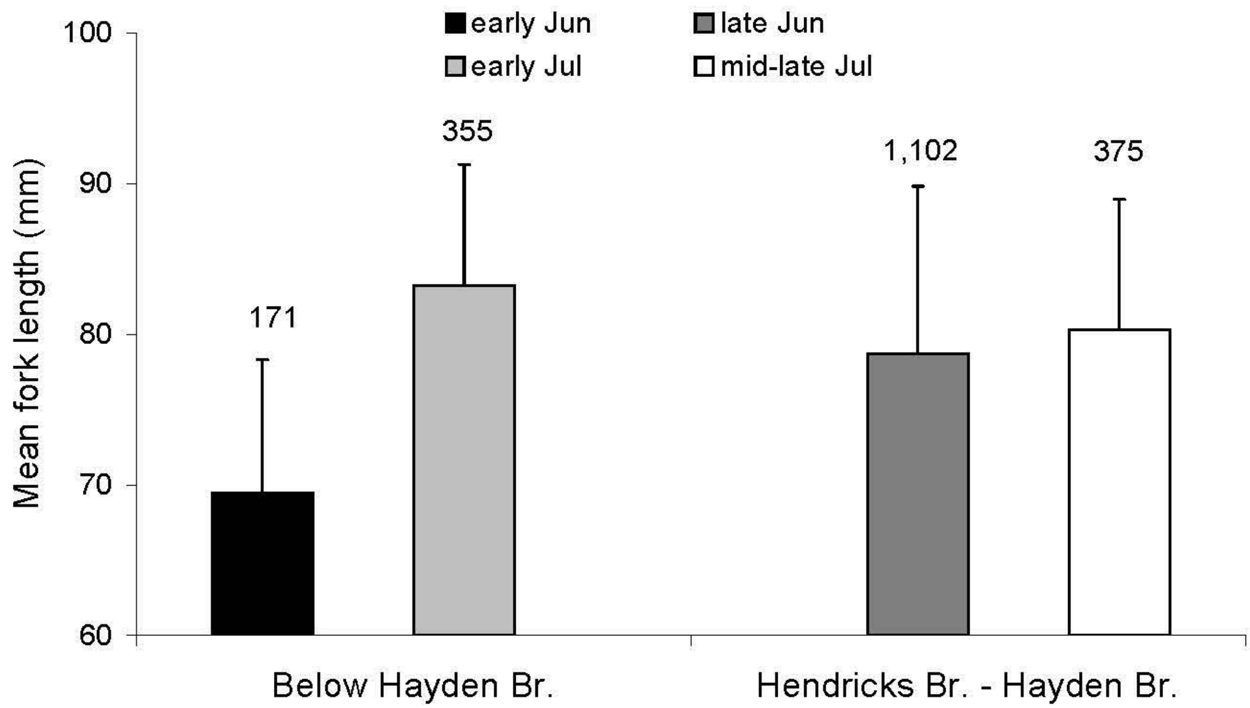

Figure 26. Mean fork length (± SD) of juvenile Chinook salmon that were seined in the McKenzie River, 2005. Numbers above the bars are sample sizes.

Our investigations through use of PIT tags and studies by other biologists in the basin have documented a broad diversity of rearing and migratory types of juvenile spring Chinook that use multiple habitats throughout the year (Figure 24). Juvenile spring Chinook may migrate as fry soon after emergence and disperse into the lower reaches of spawning tributaries or into the main-stem Willamette River. Some of these fish rear through spring and migrate as subyearling smolts to the ocean, and others migrate in the fall or following spring (Figure 24). Other fish remain in the upper reaches of spawning tributaries until fall before migrating and although some continue to migrate past Willamette Falls in the fall, most appear to rear in the lower reaches of the spawning tributaries or in the main-stem Willamette River until the following spring. Finally, some fish rear in the upper reaches of spawning tributaries and migrate as yearling smolts. Other migratory types likely are present such as migration of fall migrants into the lower Columbia River or ocean, but have yet to be documented by our sampling. Migratory types such as fry into the lower Willamette River in winter and early spring also may be present (Figure 24), but these will have to be documented with sampling techniques such as genetic identification. Upper Willamette spring Chinook likely exhibit a continuum of life history types, the expression of which would depend on presence of quality habitat and access to that habitat.

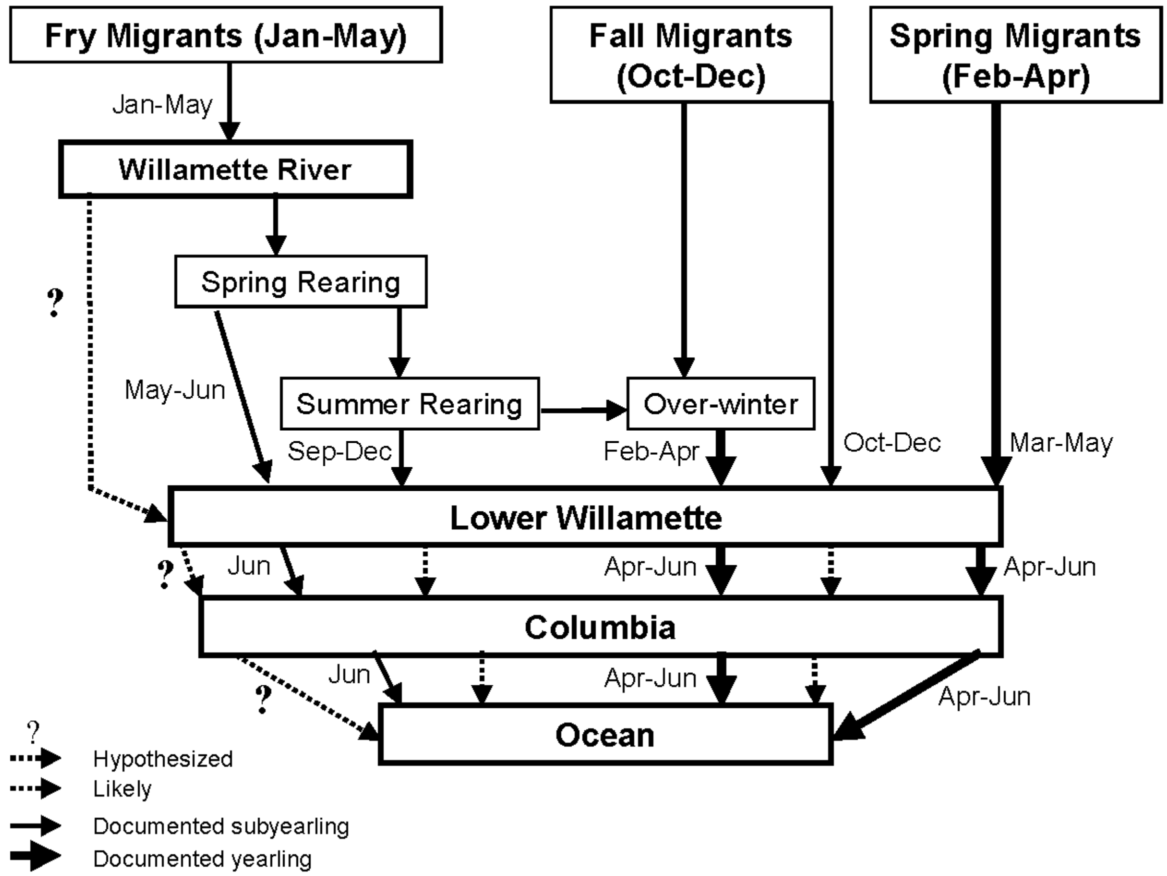

Figure 24. Schematic representation of the migratory and rearing diversity in upper Willamette River spring Chinook salmon. Starting point at the top of the diagram is based on observed peaks of migration from upper McKenzie River spawning areas.

Life Histories—Scales

Otolith marking of all hatchery spring Chinook released in the Willamette and Sandy basins offered an opportunity to collect scales from known wild spring Chinook adults. Scales and otoliths were collected from non fin-clipped adult Chinook recovered in spawning areas. We used otoliths to identify and exclude scales collected from non fin-clipped hatchery fish. Scales were analyzed to determine the freshwater age of smolts and the total age of adults in some years. Below are preliminary results for the 2001–2004 adult returns.

In the McKenzie and Clackamas rivers upstream of fish hatcheries, the percentage of adult spring Chinook that had a 0-age life history was lowest in the upper reaches of the rivers, with the exception of the Clackamas River for the 2004 run year (Figure 27). The percentage of subyearling smolts in adult Chinook recovered in 2002–2004 varied between basins and between years (Table 23), and generally was lower in

2004. Chinook in the South and North Santiam basins had the highest percentage of 0-age life history in the 2002 and 2003 run years, although the percentages were considerably lower in 2004. An analysis of 0-age life history by brood year will be conducted when all scales have been read through the 2005 run year to determine the total age of adult fish.

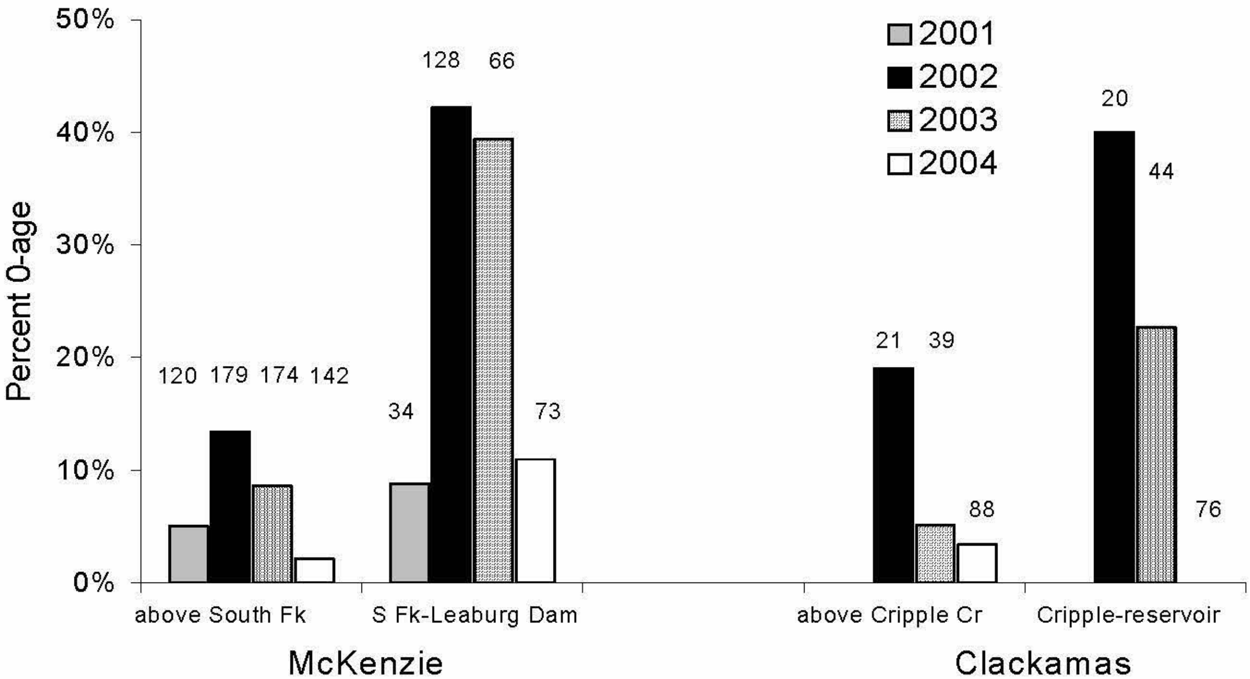

Figure 27. Percentage of the adult spring Chinook recovered in spawning areas in the Clackamas and McKenzie rivers upstream of hatcheries that had a 0-age life history, 2001–2004 run years. Numbers above bars are sample sizes.

Table 23. Percentage of the adult Chinook recovered in spawning areas in the Willamette and Sandy basins that had an age 0 life history, 2002–2003 run years. Sample size is in parentheses.

Basin	Run year 2002	2003	2004
Middle Fork Willamette	5.6 (18)		10.5 (19)
McKenzie	26.0 (339)	17.3 (243)	6.0 (183)
South Santiam	79.6 (186)	90.7 (140)	23.2 (82)
North Santiam	52.4 (42)	40.0 (35)	10.2 (49)
Clackamas	32.3 (62)	14.5 (83)	3.1 (196)
Sandy	6.8 (73)		6.6 (244)

Genetic Classification of Chinook Salmon

Methods

Tissues were collected from juvenile Chinook salmon in the Willamette River downstream of the mouth of the Santiam River in summer 2003 (Schroeder et al. 2003) and a portion of them were classified by run timing (spring or fall) by NOAA Fisheries using DNA microsatellite analysis (Teel et al. 2003; Schroeder et al. 2003). Analyses of juvenile salmon of unknown run assigned most fish to the spring or fall run with probabilities >90% (Teel et al. 2003).

Juvenile Chinook salmon sampled at the TJ Sullivan Hydroelectric Plant at Willamette Falls have been identified as spring or fall run by Portland General Electric biologists although accuracy of the identification has been uncertain. Biologists have used migration timing, size of fish, and general appearance of the juveniles to classify the fish as spring or fall run Chinook. In June 2003, we collected tissue samples from a random sample of 30 Chinook from the fish bypass system at the Sullivan plant, of which 25 were analyzed by NOAA Fisheries. In addition, PGE biologists collected tissue samples from juvenile salmonids at Willamette Falls in September–October 2003 and in February–June 2004, and genetic analyses was conducted by NOAA Fisheries.

Tissues from adult Chinook salmon were collected from 16 non fin-clipped carcasses in the Clackamas River downstream of River Mill Dam during spawning surveys in 2002 (Schroeder et al. 2002), and were analyzed by NOAA Fisheries. Tissues also were collected and analyzed from 15 Chinook salmon carcasses in the Sandy River downstream of Marmot Dam during spawning surveys in 2003.

Results

Of the juvenile Chinook sampled in the Willamette River downstream of the Santiam River in 2002 and 2003, 80–100% were spring Chinook (Table 24). The percentage of spring Chinook was lowest in the lower Santiam River (Table 24), where most of the residual fall Chinook presently spawn. In 2002, the average proportion of spring Chinook in mixed schools of juvenile fish (>10 fish) was the same in June and July (82%), and the mean fork length of spring and fall Chinook was not significantly different ($P > 0.05$) (Schroeder et al. 2003).

Table 24. Classification of run lineage by DNA microsatellite analysis of juvenile Chinook salmon collected by beach seine in the Santiam and Willamette rivers, 2002–2003.

General location (rm)	Date	Run lineage		Percent spring Chinook
		Fall	Spring	
Mouth of Yamhill River (53)	Jun 25, 2003	4	20	83
Upstream of Wheatland (73)	May 28, 2003	1	27	96
Mouth of Rickreall Creek (88)	May 27, 2003	4	21	84
Lambert Bar–Wheatland (66–71)	Jun 24, 2002	5	18	78
Keizer–Rickreall Creek (81–86)	Jun 24, 2002	3	22	88
Buena Vista–Santiam R. (103–107)	Jun 20, 2002	3	11	79
Santiam River (2)	Jun 19, 2002	24	46	66
upstream of Santiam R. (112)	Jun 19, 2002	0	15	100
Jackson Bend–Wheatland (63–71)	Jul 31, 2002	3	10	77
Keizer–above Rickreall Cr. (83–88)	Jul 30, 2002	3	19	86
Independence and upstream (94–98)	Jul 30, 2002	0	2	100

The percentage of juvenile Chinook salmon sampled in the bypass of the PGE Sullivan Plant at Willamette Falls was 97–100% spring run fish (Table 25). The use of field identification to distinguish juvenile fall Chinook from juvenile spring Chinook was highly inaccurate during the time period when fish from both runs may be present (Table 25). Therefore, previous counts at Willamette Falls of juvenile Chinook by run lineage are likely to be incorrect.

Table 25. Classification of run lineage by DNA microsatellite analysis of juvenile Chinook salmon collected at the PGE Sullivan Plant at Willamette Falls, and comparison to field identification, 2003–2004. Data from Teel et al. (2006).

Date	Sample size	Percent spring Chinook by––		Size range (mm)	
		Genetics	Field I.D.	Spring	Fall
Jun 24, 2003	16	100	31	81–125	
Sep–Oct 2003	42	100	100	130–210	
Feb–Mar 2004	40[a]	100	100	110–200[a]	
Apr 28–30, 2004	49	100	24	60–160	
May 5–14, 2004	85	100	19	40–144	
May 26–29, 2004	174	98	3	40–140	45–110
Jun 4–10, 2004	58	97	0	60–100	70–80

[a] *Includes 36 hatchery spring Chinook smolts.*

Of the 14 samples from adult Chinook carcasses recovered in the lower Clackamas River, all were spring run fish (Table 26). In contrast, scale analysis used to classify adult Chinook salmon in 1998 and 1999 suggested that spring Chinook composed an average of 65% of the adults in the McIver–Barton Park section and an average of 28% of the fish in the Barton Park–mouth section (Lindsay et al. 1998; Schroeder et al. 1999). Classification by scale analysis was based on the assumption that fall Chinook were age-0 smolts and spring Chinook were yearling smolts. In 2002, the percentage of adult Chinook in the McIver–Barton Park section with a yearling smolt life history was 48%, but the genetic classification indicated all samples were spring Chinook. Therefore, smolt life history is not a valid technique to classify the run lineage of Chinook salmon in the lower Clackamas River, and is unlikely to be valid in other rivers of the Willamette or Sandy basins (*see* **Life Histories—Scales**). Additional samples from adult Chinook will be collected in the upper Clackamas and Sandy watersheds in 2006 to increase the reference collection of spring Chinook.

Analysis of tissues collected from adult Chinook carcasses recovered in the Sandy River in 2003, indicated that 93% were spring Chinook (Table 26). Fall Chinook spawn in the lower Sandy River, but generally spawn later in the year than when we collected our samples.

Table 26. Classification of run lineage by DNA microsatellite analysis of adult Chinook salmon collected in the lower Clackamas and Sandy rivers, 2002 and 2003.

River and year, section	Date	Run lineage Fall	Spring
Clackamas River, 2002			
McIver Park–Barton Park	Sep 11	0	2
	Oct 16	0	8
Barton Park–mouth	Sep 11	0	3
	Oct 16	0	1
Sandy River, 2003			
Revenue Bridge–Dodge Park	Sep 25	1	0
Dodge Park–Oxbow Park	Sep 25	13	1

Winter Habitat Use by Juvenile Chinook

Floodplain Investigations

A Benton County farmer contacted us in March 2004 because he had seen juvenile salmon in a pool upstream of a water control dam on his floodplain land. The Kenagy farm contains Willamette River floodplain downstream of Albany (rm 117). Chinook fry can access the floodplain via a drainage channel that flows from the Willamette River during high water events, and in 2004 we captured over 100 fry in traps draining the floodplain or in ponds on the floodplain (Schroeder and Kenaston 2004). In October 2004, we installed a two-way juvenile trap in a small outlet channel that provides access to the floodplain during high flow and that drains the floodplain. The two-way trap was 66 in. high, with vertical V-slots for entry, which allowed for capture of fish over a range of water levels. The trap was made of galvanized expanded steel mesh (inner size 3/4-in. by 5/16-in.), and two traps were attached together to trap upstream and downstream migrants in the separate chambers. We used two 12 ft. long panels covered with 1/4 in. hardware cloth to guide fish to the V-slots of each side of the trap.

Only three high water events of relatively short duration occurred in November 2004–June 2005 (Figure 28), and we caught no Chinook salmon. A variety of other species were captured in the traps including redside shiner, largescale sucker, northern pikeminnow, white crappie, sculpin, yellow perch, brown bullhead, chiselmouth, peamouth, and red-legged frogs. The trap will be operated in 2005–2006.

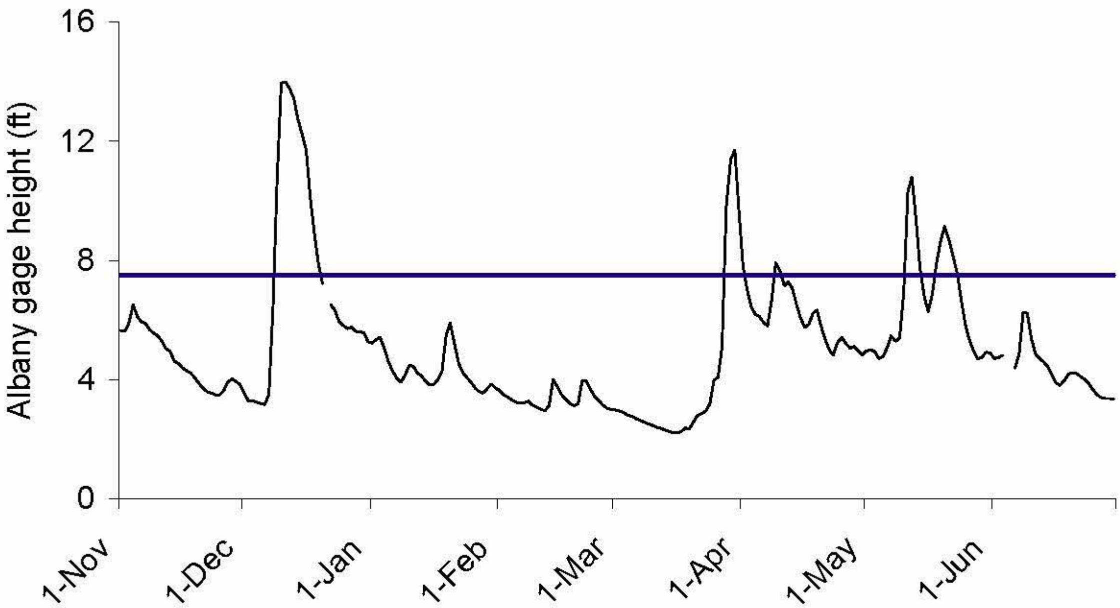

Figure 28. Gage height of the Willamette River at Albany (USGS), November 1, 2004 through June 30, 2005. Kenagy farm drainage channels are flooded by the Willamette River at gage heights >7.5 ft.

Non-natal Tributaries

We previously reported use by juvenile Chinook salmon of Willamette River tributaries where adult salmon are not known to spawn (Schroeder and Kenaston 2004). Juvenile Chinook salmon were captured by Oregon State University (OSU) scientists in surveys of intermittent streams in the mid-Willamette Valley conducted in fall through spring of 2002–2003 and 2003–2004. Sample sites were located in agricultural fields and were sampled with minnow traps, hoopnets, and backpack electrofishers (R. Colvin, OSU, personal communication).

Although the catch of Chinook salmon was low, the capture location of half of the fish indicated they migrated up to 3 mi from the Calapooia River and up to 23 mi from the Willamette River (Table 27). Other juvenile Chinook were captured within the floodplain area of the Calapooia River, and were in small drainages on agricultural fields. Because the numbers of adult spring Chinook spawners in the Calapooia River have been low in recent years, the juvenile fish captured in the Calapooia could have migrated upstream from the Willamette River.

Table 27. Distance from Calapooia or Willamette rivers that juvenile Chinook salmon were captured in non-natal tributaries in fall through spring 2002–2004. Data are from Randy Colvin, Oregon State University.

Stream	Tributary of––	Proximity	Distance from main stem[a] (mi)
Lake Cr.	Calapooia R.	Tangent	2.9
N Fork Lake Cr.	Calapooia R.	Tangent	2.5
Ridge Road Cr.	Calapooia R.	Tangent	0.2
Ridge Road Cr.	Calapooia R.	Tangent	0.4
Bull Run Cr.	Muddy Cr. (Marys R.)	Philomath	13.5
Unnamed	Luckiamute R.	Airlie	23.3

[a] *Willamette River for Bull Run Creek and unnamed tributary of Luckiamute River.*

TASK 5.3–EFFORTS TO RE-ESTABLISH POPULATIONS

Surveys to count spawning spring Chinook salmon have been conducted in the Little North Fork Santiam prior to (1996–2001) and after (2002–2005) unclipped fish were transported from the Minto collection facility and released into the river. The density of redds averaged 1.0 redds/mi (range 0–2.2) in 1996–2001 and 2.5 redds/mi (range 1.8–3.6) in 2002–2005 (Figure 29). We previously reported on the poor survival of transported fish (Schroeder et al. 2002, 2003). Few of these fish survived to spawn and the number of redds counted in the Little North Santiam River in 2002 (30) and 2003 (31) was only slightly higher than the 1996–2001 average (17). An increase in spawning success of the transported fish in 2004 was attributed to an increase in flows and decrease in water temperatures from rains in August and September (Schroeder and Kenaston 2004). Spawning success appeared to increase in 2005 and likely was because fish were released at a new site located near the Narrows, a section of river with a large pool (50 ft deep) that is inaccessible to the public, thus providing good holding habitat. Fish were released directly into the pool via a large pipe (12 in. diameter, 100 ft long).

Spawning success of transported fish released into the Little North Fork Santiam River has improved since 2002 (Figure 29) because of favorable water conditions in 2004 and likely because of better water conditions at the new release site used in 2005. We used the number of transported (tagged) fish and the percentage of tagged fish in carcass recoveries to estimate the number of potential spawners in the river. In 2004, we used the ratio of tags recovered in the Little North Fork to those recovered in the

North Santiam to estimate the number of transported fish that remained in the Little North Fork, the only year that tags from transported fish were recovered in the North Santiam. Approximate fish:redd ratios in the Little North Fork Santiam were calculated from estimates of potential spawners and redds counted in the river. With the exception of the 2002 release, the approximate fish:redd ratio of fish in the Little North Santiam has been equal to or lower than that in the North Santiam River upstream of Bennett dams (excluding redds counted in the Little North Fork Santiam) (Figure 30). Although we estimated high pre-spawning mortality for transported fish in 2002 and 2003, the percentage of carcasses with tags in 2002 (44%) was about half that in 2003 (91%), which increased the estimate of potential spawners in the river and consequently increased the fish:redd ratio (Figure 30).

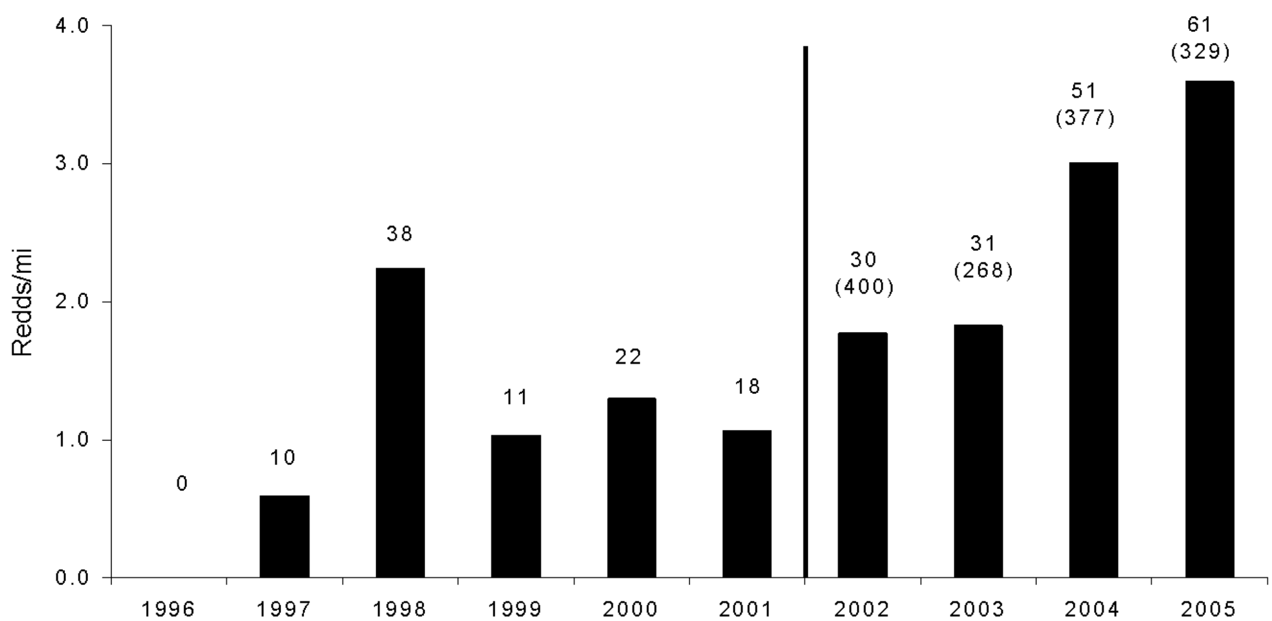

Figure 29. Density of spring Chinook salmon redds in the Little North Fork Santiam River before (1996–2001) and after (2002–2005) transport and release of unclipped fish collected at Minto Pond. Numbers above bars are redds counted in the river, with numbers of fish released in parentheses. Survey area was Elkhorn Bridge–mouth (17.0 mi), except in 1999 when the survey area was 10.7 mi, Elkhorn Bridge–Lunkers Bridge.

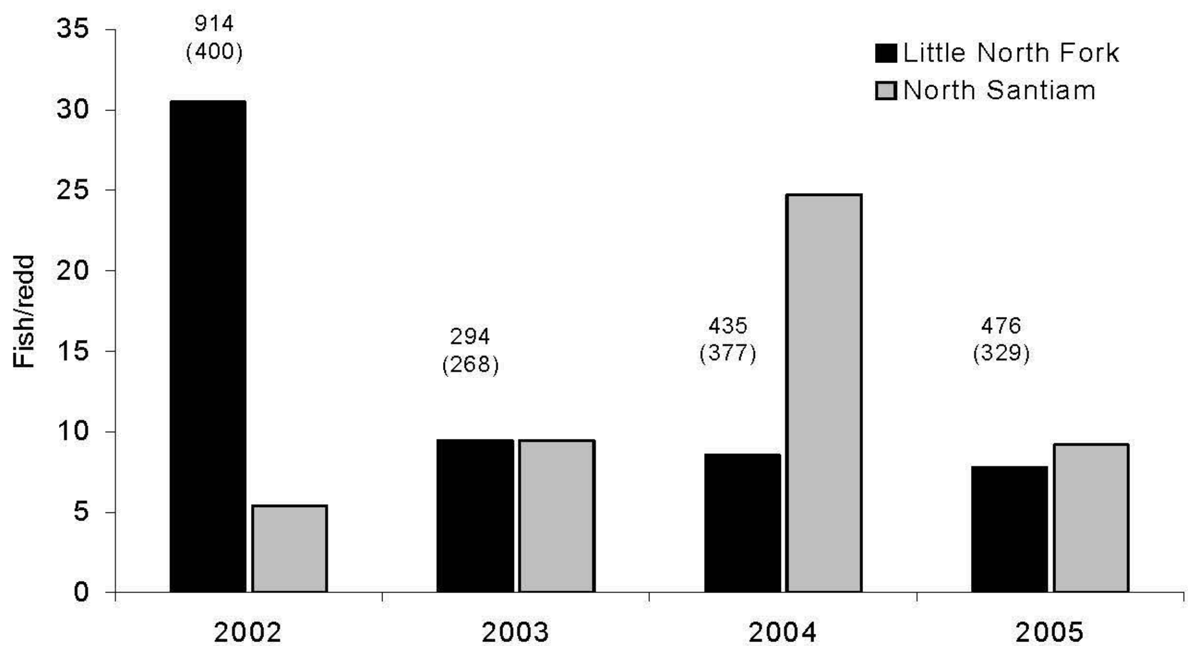

Figure 30. Estimates of fish:redd ratios for spring Chinook salmon in the Little North Fork Santiam and North Santiam rivers, 2002–2005. Numbers in the graph are estimates of potential spawners, with the number of transported fish from Minto Collection Pond in parentheses.

Non fin-clipped adult spring Chinook were collected at Minto Pond in 2005, were tagged with uniquely numbered Floy® tags, and were released at the Narrows. A total of 329 fish were released July 27–September 12 on six dates (Table 25).

Table 25. Number of male and female unclipped spring Chinook released into the Little North Fork Santiam River at the Narrows (rm 13.5), July–September, 2005.

	27July	30 Aug	2 Sep	6 Sep	9 Sept	12 Sep	Total
Male	26	80	36	26	18	23	209
Female	26	42	13	9	22	8	120

In addition to Floy® tags, radio tags were inserted by US Army Corp of Engineer biologists into 42 of the 52 adults transported on July 27. Radio tags were monitored until August 22, three weeks before redds were observed in the Little North Fork Santiam. In 2005, all tagged fish (radio or Floy®) were located in the Little North Fork Santiam, whereas 54% of the tags recovered in 2004 were in the North Santiam, up to

28 mi from the release site. However, in 2005 one radio-tagged fish was located 2–3 miles upstream of the mouth, about 10–11 miles downstream of the release site. As of August 22, 36% of the radio-tagged fish had stayed in the release pool, 43% had moved downstream within one mile of the release site, and 19% had moved upstream within three miles of the release site. Rain in late August and mid September 2004 substantially increased flow in the Little North Fork Santiam River (Figure 31) and allowed the transported fish to distribute upstream and downstream of the release site and improved survival to spawning. In contrast, flow increased briefly in early October 2005 before returning to late summer levels (Figure 31).

By August 22, 40% of the radio-tagged fish released on July 27 had died. We recovered 81 Chinook carcasses in the Little North Fork on five surveys after August 22, of which 56 had Floy® tags or tag scars (69%), including two with radio tags. Of the 81 fish were recovered, 47 were females and 17 had died prior to spawning (36%), similar to that of the radio-tagged fish.

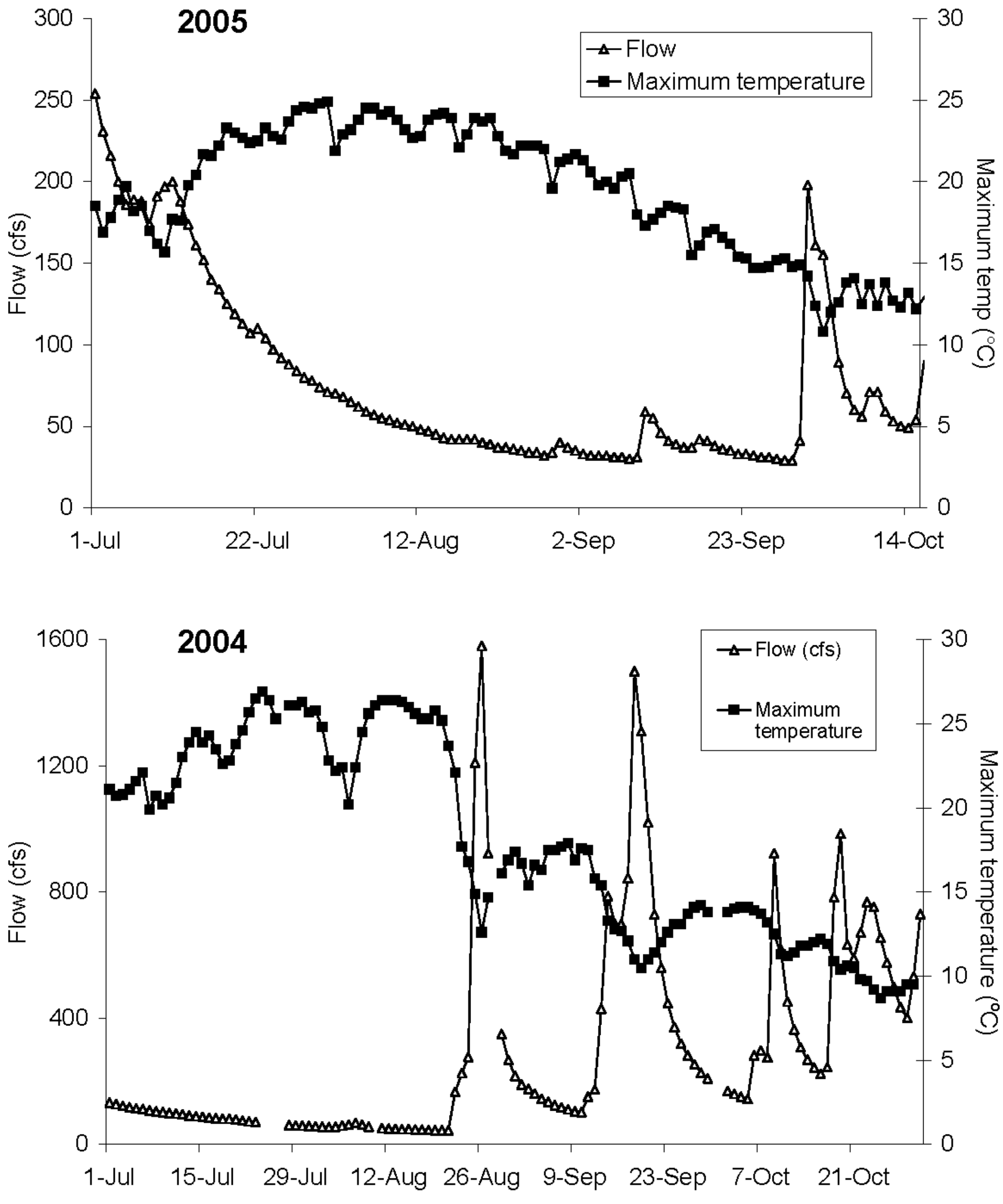

Figure 31. Flow (cfs) and maximum water temperature (°C) in the Little North Fork Santiam River, July–October 2004 and 2005.

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APPENDIX A

Schematic of Willamette Spring Chinook Salmon Study Plan

STUDY PLAN OVERVIEW
(see proposal for details)

MANAGEMENT GOAL: A management strategy for spring chinook salmon in the Willamette and Sandy basins that (1) protects the genetic integrity of natural populations, and (2) maintains sport and commercial fisheries and the programs that support them.

To Achieve this Goal, R&D will Help Managers:

OBJ. 1

Determine the numerical status of existing natural populations and develop methods for monitoring that status. Determine if these populations belong to one or more gene conservation groups.

- **1.1.** Determine if Sandy and Clackamas ChS belong to the same gene conservation group as ChS above the falls
- **1.2.** Estimate the proportion of wild fish in spawning populations
- **1.3.** Develop annual indexes for monitoring natural spawner abundance of ChS
- **1.4.** Establish escapement goals for natural production in Willamette subbasins and in the Sandy

OBJ. 2

Decrease mortality of wild fish in fisheries by determining feasibility of catch and release sport fisheries and by exploring options for reducing mortality in commericial fisheries.

- **2.1.** Estimate sport angling mortality of caught and released fish
- **2.2.** Estimate mortality that would occur from finclipping hatchery fish so that anglers could tell hatchery from wild
- **2.3.** Evaluate other mass marking techniques so anglers can identify hatchery adults in sport fisheries
- **2.4.** Explore options with Salmon Program Mgr. and Columbia River Mgt for reducing mortality of wild fish in commericial fisheries

OBJ. 3

Reduce the risk that large hatchery programs pose for natural populations by developing ways of decreasing interactions between wild and hatchery in streams and by determining need for more wild fish in hatchery broodstocks

- **3.1.** Evaluate fishery contribution and straying from netpen releases below the falls
- **3.2.** Determine if hatchery fish released in the fall overwinter, potentially competing with wild ChS
- **3.3.** Explore options for trapping hatchery ChS above or near traditional fisheries but below wild spawning areas
- **3.4.** Determine need and look at ways of incorporating wild fish into hatchery broodstock
- **3.5.** Look at overlap of spawning between fall and ChS

OBJ. 4

Protect existing natural production areas by defining temporal and spatial use patterns by life stages of ChS and identify the habitat/environmental attributes conducive to that use.

- **4.1.** Document distribution of spawning and rearing, timing of emergence and migration in basins used by ChS
- **4.2.** Identify ChS habitat & environmental attributes
- **4.3.** Identify life histories and the habitat/environment critical to maintaining them

OBJ. 5

Increase natural production by improving habitat in existing production areas and by re-establishing populations where they were found historically.

- **5.1.** Identify opportunities to re-establish populations and to improve habitat
- **5.2.** Estimate the potential of Willamette/Sandy (post-dam) to produce wild ChS
- **5.3.** Evaluate current efforts to re-establish ChS (S. Santiam above dams, Thomas, Crabtree, and Calapooia)

APPENDIX B

Proportion of Wild Adult Spring Chinook in Populations

Appendix Table B-1. Otoliths collected from adult spring Chinook salmon, 2005.

Basin and location	Number
Middle Fork Willamette:	
Dexter–Pengra	8
Fall Creek	12
Willamette Hatchery	43
McKenzie:	
Carmen-Smith spawning channel	6
Ollalie Boat Ramp–McKenzie Trail	65
McKenzie Trail–Forest Glen	46
Forest Glen–Ben and Kay Doris Park	35
Horse Creek	53
Lost Creek	38
South Fork McKenzie below Cougar Reservoir	17
Below Leaburg Dam	15
McKenzie Hatchery	53
South Santiam:	
Foster–Pleasant Valley	127
Pleasant Valley–Waterloo	14
Below Lebanon	1
South Santiam Hatchery	63
North Santiam:	
Minto–Fishermen's Bend	24
Fishermen's Bend–Mehama	3
Mehama–Stayton Island	7
Stayton Island–Stayton	9
Stayton–mouth	4
Little North Santiam	67
Minto collection pond	22

Appendix B. Continued.

Basin and location	Number
Clackamas:	
Sisi Creek–Collawash River	15
Collawash River–Cripple Creek	20
Cripple Creek–reservoir	111
South Fork Clackamas	24
Collawash River	36
Fish Creek	0
Roaring River	7
North Fork Clackamas	1
River Mill Dam–Barton	133
Barton–mouth	4
Sandy:	
Final Falls–Road 2618 bridge	61
Road 2618 bridge–Arrah Wanna	16
Arrah Wanna–Highway 26 bridge	91
Still Creek	27
Zigzag River	14
Lost and Camp creeks	11
Marmot Dam–Revenue Bridge	12
Bull Run River	25
Clackamas Hatchery (Sandy stock)	83

Appendix Table B-2. Number of non fin-clipped and fin-clipped carcasses recovered in spawning surveys of five Willamette Basin rivers, 2001–2005.

River, area	2001		2002		2003		2004		2005	
	Non fin-clipped	Fin-clipped	Non fin-clipped	Fin-clipped	Non fin-clipped	Fin-clipped	Non fin-clipped	Fin-clipped	Non fin-clipped	Fin-clipped
McKenzie										
above Leaburg Dam	308	70[a]	509	163	375	149	313	161	260	38
below Leaburg Dam	9	23	56	116	24	55	9	52	15	16
North Santiam										
above Bennett dams	62	414[a]	73	230	95	829	68	320	35	167
below Bennett dams	5	8	19	52	26	197	6	65	15	28
Little North Fork	3	4	12	4	39	7	12	3	70[c]	3
South Santiam										
Foster–Pleasant Valley			238	1,256[b]	159	845	73	535	124	401
below Pleasant Valley			33	147	21	138	41	308	15	74
Middle Fork Willamette										
Dexter–Coast Fork			59	201	35	58	29	110	8	37
Fall Creek			49	31	17	4	16	8	12	d
Molalla			7	95	5	19	4	4	4	19

[a] *Includes 2 fish with fin clips other than adipose fin clips in McKenzie and 6 fish in North Santiam.*
[b] *Includes expanded number for subsampling (every third fish) on one survey; 859 fin-clipped carcasses sampled.*
[c] *Includes 7 non fin-clipped fish sampled in re-sample survey (October 3).*
[d] *No fin-clipped fish were processed in Fall Creek in 2005.*

Appendix Table B-3. Number of wild and hatchery spring Chinook salmon in five areas of the McKenzie River basin from recovery of carcasses, 2001–2004. Wild fish were those without a fin clip or thermal mark in otoliths. The number of non fin-clipped hatchery fish was estimated by two methods: (1) otolith analysis or (2) expansion of fin-clipped fish using the ratio of fin-clipped to non fin-clipped fish at time of release.

Section, origin	2001	2002	2003	2004
Upstream of Forest Glen				
Wild	178	183	182	134
Fin-clipped hatchery	7	26	39	12
Non fin-clipped hatchery (otolith)	14	14	10	6
Non fin-clipped hatchery (release)	0	2	3	1
Horse and Lost creeks				
Wild	27	98	83	76
Fin-clipped hatchery	0	12	4	5
Non fin-clipped hatchery (otolith)	11	8	14	2
Non fin-clipped hatchery (release)	0	1	0	0
South Fork McKenzie				
Wild	19	72	29	32
Fin-clipped hatchery	35	69	74	64
Non fin-clipped hatchery (otolith)	6	36	11	7
Non fin-clipped hatchery (release)	2	5	5	4
Forest Glen–Leaburg				
Wild	35	65	28	45
Fin-clipped hatchery	28	56	32	80
Non fin-clipped hatchery (otolith)	18	33	18	13
Non fin-clipped hatchery (release)	2	4	2	5
Downstream of Leaburg Dam				
Wild	2	34	5	4
Fin-clipped hatchery	23	116	55	52
Non fin-clipped hatchery (otolith)	7	22	19	6
Non fin-clipped hatchery (release)	1	8	4	3

Appendix Table B-4. Number of wild and hatchery spring Chinook salmon in five areas of the Clackamas River basin from recovery of carcasses, 2002–2004. Wild fish were those without a fin clip or thermal mark in otoliths. The non fin-clipped hatchery fish in 2004 includes those identified as double-index release by presence of a coded wire tag, given in parentheses. Carcasses were not scanned for presence of coded wire tags in 2002 or 2003.

Section, origin	2002	2003	2004
Upstream of Collawash River			
Wild	8	68	33
Fin-clipped hatchery	0	0	0
Non fin-clipped hatchery	0	3	1
Collawash River			
Wild	4	24	37
Fin-clipped hatchery	0	0	1
Non fin-clipped hatchery	0	4	2 (1)
Collawash R.–Cripple Creek			
Wild	17	26	52
Fin-clipped hatchery	0	2	0
Non fin-clipped hatchery	2	8	13 (8)
Cripple Creek–Fish Creek			
Wild	4	24	48
Fin-clipped hatchery	0	2	1
Non fin-clipped hatchery	2	11	12 (9)
Fish Creek–reservoir			
Wild	27	9	73
Fin-clipped hatchery	0	1	0
Non fin-clipped hatchery	37	8	62 (29)

Appendix Table B-5. Return of fin-clipped and non fin-clipped hatchery spring Chinook to four watersheds of the Willamette River basin, 2002–2004, determined by analysis of otoliths in recoveries of non fin-clipped fish in carcass surveys or at the hatcheries.

	2002		2003		2004	
River, return	Fin-clipped	Non fin-clipped	Fin-clipped	Non fin-clipped	Fin-clipped	Non fin-clipped
McKenzie						
Run	1,864	621	3,543	642	4,255	369
Hatchery	6,616	191	6,106	133	4,803	142
N Santiam						
Run	6,407	629	11,570	991	12,021	1,021
Hatchery	4,646	383	9,473	366	5,552	241
S Santiam						
Carcasses	1,604	37	970	31	838	30
Hatchery	6,525	318	5,834	221	9,729	309
Middle Fork Willamette						
Carcasses	167	151	62	48	120	32
Hatchery	9,740	810	5,928	195	11,029	98

Appendix Table B-6. Number of hatchery and wild Chinook salmon in the McKenzie River basin upstream of Leaburg Dam, measured by the recovery of carcasses with fin clips or thermal marks in the otoliths of non fin-clipped fish, and estimated for fish visually counted at the dam, 2002–2004.

	Leaburg Dam			Carcasses		
	Hatchery			Hatchery		
Run year	fin-clipped	non fin-clipped	Wild	fin-clipped	non fin-clipped	Wild
2001	869	532	2,901	62	50	265
2002	1,864	621	3,602	140	78	454
2003	3,543	642	5,142	130	44	351
2004	4,255	369	4,419	136	26	312

Appendix Table B-7. Fin-clipped and non fin-clipped spring Chinook salmon in the McKenzie River basin from visual counts at Leaburg Dam and from recovery of carcasses upstream of the dam, 2001–2005

	Leaburg Dam count		Carcass recovery	
Year	Fin-clipped (%)	Non fin-clipped	Fin-clipped (%)	Non fin-clipped
2001	869 (20.2)	3,433	70 (18.5)	308
2002	1,864 (30.6)	4,223	163 (24.3)	509
2003	3,543 (38.0)	5,784	149 (28.4)	375
2004	4,255 (47.1)	4,788	161 (33.8)	315
2005	522 (16.8)	2,586	38 (12.8)	260

Appendix Table B-8. Estimated number of spring Chinook salmon in spawning areas that were of wild, local hatchery, and stray hatchery origin for five Willamette Basin rivers, 2001–2005, determined by analyses of otoliths in non fin-clipped fish and coded wire tags in fin-clipped fish (expanded for percentage of the hatchery release with tags).

		Hatchery	
River, year	Wild	local	stray
North Santiam			
2001	220	6,134	432
2002	604	6,913	123
2003	271	11,783	778
2004	489	10,723	2,319
McKenzie			
2001	2,887	1,233	182
2002	3,602	2,396	89
2003	5,142	3,077	1,108
2004	4,419	3,691	933
South Santiam			
2002	224	1,629	12
2003	151	1,001	733
2004	85	821	47
Middle Fork Willamette			
2002	15	318	0
2003	4	110	0
2004	22	152	0
Molalla			
2002	3	99	0
2003	1	23	0

Appendix Table B-9. Numbers of spring Chinook salmon returns that were composed of hatchery fish released within the basin (local) or released in other basins, 2001-2005, determined by coded wire tags in carcasses on spawning grounds. The sample size was expanded for the percentage of each release group that was tagged (in parentheses).

River, Run Year	n	Origin of release								
		Local	Netpen[a]	Lower Willamette[a]	Molalla[b]	North Santiam	South Santiam	McKenzie	Youngs Bay[c]	Clackamas
McKenzie										
2001[e]	53 (55)	46 (48)	4 (4)	0	1 (1)	0	0		0	0
2002	95 (263)	93 (254)	1 (8)	1 (1)	0	0	0		0	0
2003	16 (81)	8 (53)	1 (1)	7 (7)	0	1 (20)	0		0	0
2004	19 (79)	9 (63)	2 (2)	7 (7)	0	0	1 (7)		0	0
2005	3 (29)	2 (22)	0	0	0	0	1 (7)		0	0
North Santiam										
2001	369 (374)	345 (349)	5 (5)	0	12 (12)		2 (2)	0	0	5 (5)
2002	80 (217)	76 (213)	0	1 (1)	3 (3)		0	0	0	0
2003	46 (634)	29 (594)	2 (2)	8 (8)	4 (11)		1 (11)	1 (7)	1 (1)	0
2004	28 (228)	10 (188)	1 (1)	9 (9)	5 (12)		3 (18)	0	0	0
2005	7 (114)	1 (10)	0	5 (98)	0		1 (6)	0	0	0
South Santiam										
2002	310 (1111)	302 (1103)	0	8 (8)	0	0		0	0	0
2003	97 (640)	53 (468)	12 (133)	27 (27)	4 (11)	0		0	1 (1)	0
2004	121 (605)	91 (572)	5 (5)	23 (23)	2 (5)	0		0	0	0
2005	50 (299)	45 (281)	0	1 (1)	2 (5)	0		1 (11)	1 (1)	0
Middle Fk Willamette										
2002	356 (1736)	355 (1735)	0	1 (1)	0	0	0	0	0	0
2003	1 (19)	1 (19)	0	0	0	0	0	0	0	0
2004	5 (38)	5 (38)	0	0	0	0	0	0	0	0
2005	3 (22)	3 (22)	0	0	0	0	0	0	0	0
Molalla										
2002	22 (57)	22 (57)	0	0		0	0	0	0	0
2003	5 (14)	5 (14)	0	0		0	0	0	0	0
2004	2 (3)	1 (2)	0	1 (1)		0	0	0	0	0
2005	4 (9)	4 (9)	0	0		0	0	0	0	0

[a] *McKenzie stock acclimated or directly released into the lower Clackamas (netpen) or into the lower Willamette.*
[b] *South Santiam and McKenzie stocks.*
[c] *Middle Fork Willamette stock released into netpens near mouth of Columbia River.*
[d] *Two (expanded = 2) additional carcasses were recovered in Fall Creek (Middle Fork Willamette).*

APPENDIX C

Distribution and Abundance of Natural Spawners

Appendix Table C-1. Spring Chinook salmon redds counted in the North Santiam River basin, 1996–2005.

Section	1996	1997	1998	2001	2002	2003	2004	2005
Minto–Fishermen's Bend	78	85	118	179	162	555	177	206
Fishermen's Bend–Mehama	23	16	28	37	61	42	18	20
Mehama–Bennett dams	7	5	4	70	43	33	88	14
Little North Fork	0	10	38	18	30	31	51	61

Appendix Table C-2. Distribution (%) of spring Chinook salmon redds in the North Santiam River basin, 1996–2005.

Section	1996	1997	1998	2001	2002	2003	2004	2005
Minto–Fishermen's Bend	72.2	73.3	62.8	58.9	54.7	84.0	53.0	68.4
Fishermen's Bend–Mehama	21.3	13.8	14.9	12.2	20.6	6.4	5.4	6.6
Mehama–Bennett dams	6.5	4.3	2.1	23.0	14.5	5.0	26.3	4.7
Little North Fork	0.0	8.6	20.2	5.9	10.1	4.7	15.3	20.3

Appendix Table C-3. Density (redds/mi) of spring Chinook salmon redds in the North Santiam River basin, 1996–2005.

Section	1996	1997	1998	2001	2002	2003	2004	2005
Minto–Fishermen's Bend	7.8	8.5	11.8	17.9	16.2	55.5	17.7	20.6
Fishermen's Bend–Mehama	3.5	2.5	4.3	5.7	9.4	6.5	2.8	3.1
Mehama–Bennett dams	1.0	0.7	0.6	10.0	6.1	4.7	12.6	2.0
Little North Fork	0.0	0.6	2.2	1.1	1.8	1.8	3.0	3.6

Appendix Table C-4. Spring Chinook salmon redds counted in the McKenzie River basin, 2002–2005.

Section	2002	2003	2004	2005
Above Forest Glen	455	443	379	347
Horse and Lost creeks	427	172	280	145
South Fork McKenzie	86	142	85	108
Below Forest Glen	104	273	272	207
Below Leaburg Dam	75	99	171	115

Appendix Table C-5. Distribution (%) of spring Chinook salmon redds in the McKenzie River basin, 2002–2005.

Section	2002	2003	2004	2005
Above Forest Glen	39.7	39.2	31.9	37.6
Horse and Lost creeks	37.2	15.2	23.6	15.7
South Fork McKenzie	7.5	12.6	7.2	11.7
Below Forest Glen	9.1	24.2	22.9	22.5
Below Leaburg Dam	6.5	8.8	14.4	12.5

Appendix Table C-6. Density (redds/mi) of spring Chinook salmon redds in the McKenzie River basin, 2002–2005.

Section	2002	2003	2004	2005
Above Forest Glen	19.8	19.3	16.5	15.8
Horse and Lost creeks	22.7	9.1	14.9	12.9
South Fork McKenzie	19.5	32.2	19.3	24.5
Below Forest Glen	5.7	15.1	15	11.4
Below Leaburg Dam	12.5	16.5	28.5	19.2

Appendix Table C-7. Spring Chinook salmon redds counted in the Clackamas River basin, 1997–1998 and 2002–2005.

Section	1997	1998	2002	2003	2004	2005
Above Collawash River	115	143	87	133	278	117
Collawash River	44	41	7	27	55	32
Collawash R–Cripple Cr.	62	97	61	91	265	205
Cripple Cr.–Fish Cr.	59	33	55	35	160	83
Fish Cr.–reservoir	66	50	108	36	129	85
South Fork Clackamas R.	7	3	42	11	57	30
Fish Cr., Roaring R., North Fork Clackamas R.	18	11	10	9	79	27[a]

[a] *Does not include 26 redds counted in a new area of Roaring River.*

Appendix Table C-8. Distribution (%) of spring Chinook salmon redds in the Clackamas River basin, 1997–1998 and 2002–2005.

Section	1997	1998	2002	2003	2004	2005
Above Collawash River	31.0	37.8	23.5	38.9	27.2	20.2
Collawash River	11.9	10.8	1.9	7.9	5.4	5.5
Collawash R–Cripple Cr.	16.7	25.7	16.5	26.6	25.9	35.4
Cripple Cr.–Fish Cr.	15.9	8.7	14.9	10.2	15.6	14.3
Fish Cr.–reservoir	17.8	13.2	29.2	10.5	12.6	14.7
South Fork Clackamas R.	1.9	0.8	11.4	3.2	5.6	5.2
Fish Cr., Roaring R., North Fork Clackamas R.	4.9	2.9	2.7	2.6	7.7	4.7

Appendix Table C-9. Density (redds/mi) of spring Chinook salmon redds in the Clackamas River basin, 1997–1998 and 2002–2005.

Section	1997	1998	2002	2003	2004	2005
Above Collawash River	6.7	8.4	5.1	7.8	16.3	6.8
Collawash River	5.9	5.5	1.1	4.2	8.5	4.9
Collawash R–Cripple Cr.	7.3	11.4	7.2	10.7	31.2	24.1
Cripple Cr.–Fish Cr.	8.7	4.9	8.1	5.1	23.5	12.2
Fish Cr.–reservoir	7.6	5.7	12.4	4.1	14.8	9.8
South Fork Clackamas R.	11.7	5.0	70.0	18.3	95.0	50.0
Fish Cr., Roaring R., North Fork Clackamas R.	2.2	1.3	1.5	1.3	11.8	4.0

Appendix Table C-10. Passage by month (%) of adult spring Chinook salmon at North Fork Dam on the Clackamas River, 1996–2005.

Month	1996	1997	1998	1999	2002	2003	2004	2005
May	0	1	1	0	1	9	8	7
Jun	20	6	14	1	19	31	29	18
Jul	24	23	29	19	29	37	36	50
Aug	9	21	12	25	20	9	15	17
Sep	39	44	37	44	28	11	11	7
Oct	8	5	6	11	4	3	2	1

Appendix Table C-11. Spring Chinook salmon redds counted in the Sandy River basin, 1997–1998 and 2002–2005.

Section	1997	1998	2002	2003	2004	2005
Salmon R.: Final Falls–Rd 2618	185	213	53	60	233	84
Salmon R.: Rd 2618–Bridge St.	44	55	33	11	57	31
Salmon R.: Bridge St.–Hwy 26	280	324	104	56	310	204
Still Creek	110	92	62	28	108	79
Zigzag River	75	10	15	24	6	44
Lost Creek	8	13	6	7	20	11
Camp Creek	12	9	1	0	19	8
Clear and Clear Fork creeks	2	17	0	0	0	0

Appendix Table C-12. Distribution (%) of spring Chinook salmon redds in the Sandy River basin, 1997–1998 and 2002–2005.

Section	1997	1998	2002	2003	2004	2005
Salmon R.: Final Falls–Rd 2618	25.8	29.1	19.3	32.3	30.9	18.2
Salmon R.: Rd 2618–Bridge St.	6.1	7.5	12.0	5.9	7.6	6.7
Salmon R.: Bridge St.–Hwy 26	39.7	44.2	38.0	30.1	41.2	44.3
Still Creek	15.4	12.6	22.6	15.1	14.3	17.1
Zigzag River	10.5	1.4	5.5	12.9	0.8	9.5
Lost Creek	1.1	1.8	2.2	3.8	2.7	2.4
Camp Creek	1.7	1.2	0.4	0	2.5	1.7
Clear and Clear Fork creeks	0.3	2.3	0	0	0	0

Appendix Table C-13. Density (redds/mi) of spring Chinook salmon redds in the Clackamas River basin, 1997–1998 and 2002–2005.

Section	1997	1998	2002	2003	2004	2005
Salmon R.: Final Falls–Rd 2618	57.8	66.6	16.6	18.8	72.8	26.3
Salmon R.: Rd 2618–Bridge St.	12.2	15.3	9.2	3.1	15.8	8.6
Salmon R.: Bridge St.–Hwy 26	45.2	52.3	16.8	9.0	50.0	32.9
Still Creek	33.3	27.9	18.8	8.5	32.7	23.9
Zigzag River	18.8	2.5	3.8	6.0	1.5	11.0
Lost Creek	4.0	6.5	3.0	3.5	10.0	5.5
Camp Creek	6.0	4.5	0.5	0	9.5	4.0
Clear and Clear Fork creeks	1.0	8.1	0	0	0	0

Appendix Table C-14. Passage by month (%) of adult spring Chinook salmon at Marmot Dam on the Sandy River, 1996–2005.

Month	1996	1997	1998	1999	2002	2003	2004	2005
May	0	2	1	0	0	4	1	4
Jun	13	20	14	6	10	14	12	12
Jul	37	30	38	40	28	23	24	30
Aug	15	20	9	27	26	14	29	19
Sep	23	25	34	22	31	32	33	25
Oct	12	4	3	5	4	12	2	9

Appendix Table C-15. Spring Chinook salmon redds counted in seven areas of the Willamette River basin, 2002–2005.

Area (section)	2002	2003	2004	2005
Middle Fork Willamette (Dexter–Jasper)	64	14	9	9
Fall Creek	171	82	172	130
Calapooia	16	2	--	--
South Santiam (Foster–Pleasant Valley)	875	594	338	507
South Santiam (Pleasant Valley–Waterloo)	19	16	35	23
Thomas Creek	18	9	--	--
Molalla	52	15	44	25

Appendix Table C-16. Spring Chinook salmon redds counted in six watersheds of the Willamette River basin, 2002–2005.

Watershed	2002	2003	2004	2005
Middle Fork Willamette[a]	235	96	181	139
McKenzie	922	1,187	1,129	1,147
Calapooia	16	2	--	--
South Santiam[b]	914	619	373	530
North Santiam	306	673	360	325
Molalla	52	15	44	25

[a] *Includes Fall Creek.*
[b] *Includes Thomas Creek.*

Appendix Table C-17. Difference between counts of spring Chinook salmon redds made on consecutive days by different surveyors for four categories of streams that differed in size and survey method (boating or walking), 2005.

Stream (section)	Difference		Redd density
	Number	Percent	(redd/mi)
	Large (boating)		
North Santiam (Minto–Gates)	10	17	21.1
North Santiam (Gates–Mill City)	4	8	13.7
South Santiam (Foster–Pleasant Valley)	135	39	76.9
	Medium-large (boating)		
Clackamas (Fish Cr–S Fork Clackamas)	7	7	7.9
McKenzie (Olallie–Belknap)	90	45	36.7
McKenzie (Belknap–Paradise)	11	14	29.6
McKenzie (Paradise–McKenzie Trail)	17	45	18.1
	Medium (walking)		
Collawash (Hot Spring Fork–mouth)	8	36	4.9
S Fork McKenzie (Cougar Dam–Bridge 19 Rd)	21	41	22.2
S Fork McKenzie (Bridge 19 Rd–mouth)	8	23	16.7
	Small (walking)		
Still Creek (Road 200 bridge–mouth)	7	16	26.9
S Fork Clackamas (Falls–mouth)	5	17	50.0
Horse Creek (Bridge–mouth)	29	33	36.3
Horse Creek (Bridge–mouth)	6	9	26.7

Appendix Table C-18. Number of spring Chinook salmon that successfully spawned in the North Santiam River basin from estimates of potential and successful spawners and from recovery of female carcasses, 2001–2005.

		Spawners			Female carcasses	
Year	Bennett count	potential[a]	successful[b]	Redds	spawned	not spawned
2001	7,003	2,551	669	304	79	236
2002	7,793	1,826	651	296	102	530
2003	12,832	6,227	1,454	661	210	530
2004	13,531	7,380	735	334	65	222
2005	4,883	2,534	662	301	87	91

[a] *Bennett dams count minus estimated harvest and removed at Minto collection pond (spawned, died, or outplanted).*

[b] *From redd counts, assuming 1 female and 1.2 males per redd, based on sex ratio at Minto pond.*

Appendix Table C-19. Number of female spring Chinook salmon that spawned and that died before spawning through October for eight survey season lengths using progressively later starting periods (from mid June to early September), 2003 and 2004.

	2003		2004	
Starting period	spawned	not spawned	spawned	not spawned
mid Jun	210	530	65	222
early Jul	210	454	65	218
mid Jul	--	--	65	201
late Jul	210	387	65	177
early Aug	210	268	65	112
mid Aug	210	169	65	100
late Aug	210	121	65	80
early Sep	209	55	65	59

Appendix Table C-20. Number of spring Chinook salmon that successfully spawned in the McKenzie River basin upstream of Leaburg Dam, from estimates of potential and successful spawners and from recovery of female carcasses, 2001–2005.

Year	Spawners		Redds	Female carcasses	
	potential[a]	successful[b]		spawned	not spawned
2001	4,428	1,417	644[c]	184	14
2002	6.105	1,775	807	396	27
2003	9,442	2,235	1,016	265	51
2004	9,061	2,266	1,030	267	33
2005	3,108	2,358	1,072	160	30

[a] *From Leaburg Dam counts.*
[b] *From redd counts, assuming 1 female and 1.2 males per redd.*
[c] *Expanded from partial counts based on redd distribution in full surveys in 2002–2005.*

Appendix Table C-21. Number of spring Chinook salmon that successfully spawned in the Clackamas and Sandy basins upstream of North Fork and Marmot Dam, respectively, 1996–1998 and 2003–2005. Estimated from recovery of female carcasses.

Year	Clackamas			Sandy		
	date[a]	spawned	not spawned	date[a]	spawned	not spawned
1996	Aug 26	9	2	Sep 3	223	11
1997	Aug 26	46	1	Aug 28	77	0
1998	Aug 27	40	4	Aug 27	79	2
2003	Aug 20	75	21	Aug 19	37	7
2004	Aug 19	136	13	Aug 18	86	10
2005	Aug 22	92	33	Aug 23	104	11

[a] *Starting date of spawning surveys.*

APPENDIX D

Evaluation of Net Pens in Lower Willamette River

Appendix Table D-1. Capture of adult spring Chinook salmon from the net pen evaluation of smolt releases into the lower Willamette River basin, 1996 brood. Numbers were adjusted to a standard release of 100,000 smolts. Data were obtained from the coded wire tag database of the Pacific States Marine Fisheries Commission, November 2005.

		Smolts released into Multnomah Channel in—			Smolts released in spring into—		
	McKenzie	Fall		Spring	Clackamas Cove		Clackamas River
Capture location	control	Acclimated	Direct	Direct	Acclimated	Direct	Direct
Fisheries:							
Ocean	68	35	32	20	46	47	23
Columbia River	87	34	21	27	96	41	20
Willamette basin below the falls	131	134	80	22	238	123	144
(% in Clackamas River)	(0)	(0)	(13)	(0)	(35)	(29)	(6)
Hatcheries:							
McKenzie	436	15	11	30	3	1	1
Clackamas	0	2	6	3	77	36	14
Other	0	2	7	7	2	0	0
Spawning areas:							
McKenzie River	11	3	2	0	0	0	0
Clackamas River	0	0	0	0	1	0	0
Other	0	2	0	10	0	0	0
Leaburg Dam	13	5	0	1	0	0	0
Other	4[a]	0	0	1[b]	0	0	0

[a] *Lewis River.*
[b] *Umpqua River.*

Appendix Table D-2. Capture of adult spring Chinook salmon from the net pen evaluation of smolt releases into the lower Willamette River basin, 1997 brood. Numbers were adjusted to a standard release of 100,000 smolts. Data were obtained from the coded wire tag database of the Pacific States Marine Fisheries Commission, April 2006.

Capture location	McKenzie control	Smolts released into Multnomah Channel in— Fall Acclimated	Smolts released into Multnomah Channel in— Fall Direct	Smolts released into Multnomah Channel in— Spring Direct	Smolts released in spring into— Clackamas Cove Acclimated	Smolts released in spring into— Clackamas Cove Direct	Smolts released in spring into— Clackamas River Direct
Fisheries:							
Ocean	33	0	0	12	21	0	0
Columbia River	201	104	64	5	184	7	13
Willamette basin below the falls	87	22	11	21	79	12	15
(% in Clackamas River)	(0)	(0)	(0)	(0)	(47)	(0)	(100)
Hatcheries:							
McKenzie	746	5	5	0	0	0	4
Clackamas	0	0	5	4	17	1	0
Other	0	0	13	0	1	0	1
Spawning areas:							
McKenzie River	10	0	0	0	0	0	0
Clackamas River	0	0	0	0	1	0	0
Other	0	2	4	0	3	0	1
Leaburg Dam	5	0	0	0	0	0	0

Appendix Table D-3. Capture of adult spring Chinook salmon from the net pen evaluation of smolt releases into the lower Willamette River basin, 1998 brood. Numbers were adjusted to a standard release of 100,000 smolts. Data were obtained from the coded wire tag database of the Pacific States Marine Fisheries Commission, April 2006. Data are preliminary.

		Smolts released into Multnomah Channel in—			Smolts released in spring into—		
	McKenzie	Fall		Spring	Clackamas Cove		Clackamas River
Capture location	control	Acclimated	Direct	Direct	Acclimated	Direct	Direct
Fisheries:							
Ocean	248	77	66	34	228	109	183
Columbia River	170	138	58	38	298	113	207
Willamette basin							
below the falls	251	445	89	32	676	236	688
(% in Clackamas River)	(0)	(6)	(0)	(0)	(33)	(34)	(9)
Hatcheries:							
McKenzie	1,369	41	32	27	0	4	22
Clackamas	2	18	14	3	241	131	116
Other	2	22	13	8	3	4	10
Spawning areas:							
McKenzie River	20	8	7	1	0	0	3
Clackamas River	0	0	2	1	7	4	6
Other	0	19	6	11	4	6	18
Other	0	2[a]	0	0	1[a]	0	5[b]

[a] *Mortalities found downstream of Willamette Falls.*
[b] *4 mortalities downstream of Willamette Falls and 1 reported in the Umatilla River.*

Appendix Table D-4. Capture of adult spring Chinook salmon from the net pen evaluation of smolt releases into the lower Willamette River basin, 1999 brood. Numbers were adjusted to a standard release of 100,000 smolts. Data were obtained from the coded wire tag database of the Pacific States Marine Fisheries Commission, April 2006. Data are preliminary.

		Smolts released into Multnomah Channel in—			Smolts released in spring into—		
	McKenzie	Fall		Spring	Clackamas Cove		Clackamas River
Capture location	control	Acclimated	Direct	Direct	Acclimated	Direct	Direct
Fisheries:							
Ocean	56	217	189	327	193	204	125
Columbia River	336	400	422	710	512	536	360
Willamette basin							
below the falls	48	177	119	184	211	269	250
(% in Clackamas River)	(0)	(0)	(0)	(6)	(6)	(47)	(7)
Hatcheries:							
McKenzie	365	121	18	167	5	5	15
Clackamas	0	69	39	74	272	238	130
Other	0	49	89	315	6	11	7
Spawning areas:							
McKenzie River	3	8	2	7	0	1	3
Clackamas River	0	2	3	1	8	8	6
Other	0	28	18	42	2	5	4
Other	3[a]	8[b]	2[c]	7[c]	0	0	0

[a] *Caught in McKenzie River sport fisheries.*
[b] *6 caught in South Santiam River and 2 caught in McKenzie River sport fisheries.*
[c] *Caught in South Santiam River sport fisheries.*

APPENDIX E

Migration Timing and Life Histories of Juvenile Spring Chinook Salmon

Appendix Table E-1. Number of juvenile spring Chinook salmon with PIT tags detected at Willamette Falls in summer 2002–spring 2005, from fish seined and tagged in the McKenzie, Willamette, and Santiam rivers, 2002–2004.

River, year	Dates tagged	Number tagged	Number detected in–– Summer	Fall	Spring
McKenzie River					
2002	Jul 8-25	1,848	1	5	1
2003	Jun 10-Jul 1	1,949	6	4	3
2004	May 20-Jul 22	1,337	3	1	6
Willamette above Santiam R.					
2002	Jun 18-Jul 25	1,606	1	1	0
2003	Jun 4-Jul 17	1,868	29	1	0
2004	May 19-Jul 13	1,511	22	0	0
Willamette below Santiam R.					
2002	Jun 20-Jul 2	225	3	0	0
2003	May 28-Jun 25	733	34	0	0
2004	May 26-Jun 23	377	11	0	0
Santiam Basin					
2002	Jun 25-Jul 22	487	13	2	0
2003	Jun 3-24	1,489	165	5	2
2004	Jun 1-Jun 30	643	18	0	1

Appendix Table E-2. Number of adult spring Chinook salmon recovered in spawning areas in the McKenzie and Clackamas rivers upstream of hatcheries that had a 0-age life history, 2001–2004 run years.

	2001		2002		2003		2004	
	0-age	total	0-age	total	0-age	total	0-age	total
McKenzie River:								
above South Fork	6	120	24	179	15	174	3	142
S Fork-Leaburg Dam	3	34	54	128	26	66	8	73
Clackamas River:								
above Cripple Cr			4	21	2	39	3	88
Cripple Cr.-River Mill Dam			8	20	10	44	0	76

Appendix Table E-3. Fish species and numbers caught in seines in two sections of the Willamette River upstream of Willamette Falls, May 25–July 28, 2005. Lower section = Yamhill River–Santiam River (rm 55–107), Upper section = Santiam River–McKenzie River (rm 107–175).

	Catch by location and date (seine sets in parenthesis)				
	Lower section		Upper section		
Species	May 25 (5)	June 15–20 (48)	May 26–31 (42)	June 1–27 (103)	July 28 (11)
Chinook salmon (wild)	18	553	1090	2127	91
Rainbow trout		7	8	47	
Cutthroat trout			24	253	7
Trout fry			2	19	2
Northern pikeminnow	1	130	78	219	174
Mountain whitefish	79	209	473	1106	
redside shiner		984	190	1029	119
Largescale sucker	3	145	78	476	7
Dace		4	40	256	43
Sculpin	1	13	15	97	22
Chiselmouth		4	2	28	
Peamouth		52	6	76	16
Smallmouth bass		19			
Bluegill	2			12	
Sand roller				2	
Steelhead (wild)			12	2	
Steelhead (hatchery)				1	
Three spine stickleback				40	
Summer steelhead (adult)		6		3	
Largemouth bass				11	
Banded killifish	57	201			
Coho salmon (wild)		2			
Chinook salmon (adult)			1	1	
Carp				2	

Appendix Table E-4. Fish species and numbers caught in the McKenzie (rm 0–21), Santiam (rm 0–10), North Santiam (rm 0–9), and South Santiam rivers (rm 4–16), June 9–July 21, 2005.

	Catch by location and date (seine sets in parenthesis)					
	McKenzie		Santiam		North Santiam	South Santiam
Species	June 9–30 (35)	July 5–21 (75)	June 6 (17)	July 7 (17)	July 12–13 (18)	July 14–18 (13)
Chinook salmon (wild)	1530	812	401	26	190	11
Rainbow trout	21	109	7	32	159	22
Cutthroat trout	38	249	6		8	2
Trout fry	1	6			155	
Northern pikeminnow	1	41	15	25	35	1
Mountain whitefish	1	5	173	135	13	13
Redside shiner	50	93	2	74	20	8
Largescale sucker	1	4	49	6		
Dace	12	64	6	25	12	16
Sculpin	14	34	4	5	5	8
Chiselmouth				2		
Peamouth		11	20	4	3	
Sand roller		1				
Steelhead (wild)				1		
Steelhead (hatchery)						
Three spine stickleback	6	1		1		
Summer steelhead (adult)				2		
Coho salmon (wild)					3	
Brown bullhead	1					
Chinook salmon (hatchery)			1			

Appendix Table E-5. Dates the PIT tag interrogator in the PGE Sullivan Plant at Willamette Falls was operational October 2004–September 2005.

Month	Dates	Status	Comments
June	1–14	operating	
June	14–30	shutdown	plant closed for construction in forebay
July–September		shutdown	plant closed for construction in forebay
October	1–28	shutdown	plant closed for construction in forebay
October	29-31	bypass mode	plant restarted after summer construction
November	1	bypass mode	
November	2-30	operating	
December	1-22	operating	flow and debris levels high mid December
December	22-31	operating	flow and debris levels low
January	1-31	operating	
February	1-7	operating	debris clogs on 5th & 7th, but still sampling
February	7-28	operating	
March	1-2	operating	
March	2-3	shutdown	plant closure for fish salvage behind entraining wall
March	3-31	operating	debris clogs on 14th, 18th, 21st, 28th; still sampling
April	1-30	operating	
May	1-31	operating	
June	1-30	operating	
July	1-11	operating	
July	11-13	shutdown	new PIT tag antenna installation
July	13-31	operating	
August	1-31	operating	
September	1-9	operating	
September	9-30	bypass mode	limited sampling, dependent on new antenna

APPENDIX F

Re-establish Spring Chinook Salmon Populations

Appendix Table F-1. Spring Chinook carcasses recovered, redds counted, and redd density (redds/mi) in the Little North Fork Santiam River, before (1996–2001) and after (2002–2005) the transport and release of non fin-clipped fish collected at Minto Pond. Survey area was 17 mi in all years except 1999 when 10.7 mi was surveyed.

	Counts			
Year	carcass	redd	Redds/mi	Number transported
1996	2	0	0.0	
1997	10	10	0.6	
1998	8	38	2.2	
1999	8	11	1.0	
2000	18	22	1.3	
2001	7	18	1.1	
2002	16	30	1.8	400
2003	46	31	1.8	268
2004	15	51	3.0	377
2005	81	61	3.6	329

Appendix Table F-2. Recovery of female spring Chinook salmon in the Little North Fork Santiam River that were tagged (transported and released from Minto Pond) or not tagged; spawned or not spawned; and count of redds, 2002–2005.

		Spawned females		Redds		Fish	Female carcasses	
Year	Released	tagged	not tagged	total	transport[a]	per redd	spawned	not spawned
2002	400	2	5	30	9	44.4		
2003	268	1	4	31	6	44.7	5	22
2004	377	2	2	51	26	14.5	4	4
2005	329	20	10	61	41	8.0	30	17

[a] *Attributed to transported and released fish by the percentage of spawned females recovered with tags.*

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