ANNUAL PROGRESS REPORT

FISH RESEARCH PROJECT
OREGON

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

PROJECT NUMBER: F-163-R-08

PROJECT PERIOD: October 2002 through September 2003

Prepared by: R.K. Schroeder
K.R. Kenaston
R.B. Lindsay

Oregon Department of Fish and Wildlife
3406 Cherry Drive NE
Salem, Oregon 97303

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

CONTENTS

KEY FINDINGS

1. The number of wild spring chinook salmon in 2002 in the four rivers where we can estimate adult runs from otolith analysis was:
    - 3,428 (McKenzie above Leaburg Dam),
    - 536 (North Santiam above Bennett Dam),
    - 1,493 (Clackamas above North Fork Dam), and
    - 954 (Sandy above Marmot Dam).

2. The percentage of wild spring chinook incorporated into hatchery broodstocks in 2002 was:
    - 1.2% (McKenzie),
    - 0.6% (North Santiam),
    - 2.1% (South Santiam), and
    - 0.3% (Willamette).

   The general guideline in draft Hatchery Genetic Management Plans (HGMP) is 10%, although the HGMP for Willamette Hatchery identifies wild spring chinook as probably extinct in the Middle Fork Willamette.

3. We recovered a high number of wild spring chinook carcasses in 2002 in the South Santiam River (224), second only to the McKenzie (454).

4. Age 0 (subyearling) chinook salmon were found throughout the lower McKenzie, upper and lower Willamette, and Santiam rivers in late May–July, 2002 and 2003.

5. Using DNA microsatellite analysis, we found that 94% of the subyearling chinook salmon seined in 2002 in the Willamette River downstream of the Santiam River were spring chinook and 6% were introduced fall chinook. The racial composition did not change between June and July. The percentage of spring chinook in the lower Santiam River was 66%.

6. We documented that some subyearling chinook salmon (including some spring chinook) migrated past Willamette Falls in late spring to early summer. These fish were PIT-tagged in the Willamette, lower McKenzie, and Santiam rivers. Migration was higher for fish tagged in the lower Willamette and Santiam rivers.

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. A schematic of the study plan is shown in **APPENDIX A**.

We conducted work in the main-stem Willamette River at Willamette Falls, and in the Middle Fork Willamette, McKenzie, Calapooia, North Santiam, South Santiam, Molalla, Clackamas, and Sandy rivers in 2003. Basin descriptions and background information on management and fish runs can be found in subbasin plans developed by the Oregon Department of Fish and Wildlife (ODFW 1988, ODFW 1992a, ODFW 1992b, and ODFW 1996). Task headings below cross reference the study plan outlined in **APPENDIX A.** This report covers tasks that were worked on in late 2002 through early fall 2003.

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

Implementation of the Native Fish Conservation Policy (and the Wild Fish Management Policy that preceded it) requires 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 mark all hatchery chinook, less than 100% of the returning adults will have an external mark for several reasons. First, a percentage of hatchery releases do not receive a clip because finclipping personnel do not clip the adipose fin or clip only a portion of the fin, which then regenerates. For example, about 3% of hatchery fish were released without a clip in a sample of 76 release groups from the 1996–1999 broods. Second, fry and pre-smolts without fin clips have been released in the basin. Given the large numbers of hatchery fish released, even a small percentage of unmarked hatchery fish can bias estimates of wild spawners, especially because the number of wild fish in the basin is low. To help separate hatchery fish without fin clips 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 2003, 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 the 2005 run year, which will give us three brood years (1998–2000) to evaluate the proportion of hatchery and wild fish in the unclipped 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 hatchery fish released without a fin clip 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 2002 brood, hatchery spring chinook salmon in the Willamette and Sandy basins. Reference samples were collected at the hatcheries (Table 1) and will be analyzed for mark quality at the otolith laboratory operated by Washington Department of Fish and Wildlife (WDFW). Preliminary results indicated good quality marks at all hatcheries, final results will be reported in 2004.

Table 1. Data on thermal marking of spring chinook salmon in Willamette River hatcheries and collection of reference samples, 2002 brood. Reference samples consisted of 40–50 fry (35–50 mm) from each egg take.

Stock	Egg takes analyzed	Treatment (hrs on/off)	Temperature differential (°C) [a]	Cycles [b]	Comments
McKenzie	4	Chilled (24/72)	2.2–4.4	7 [c]	--
N. Santiam	3	Heated (48/48)	3.3–5.0	8	--
Willamette	3	Heated (48/48)	4.4–7.5	6	--
S. Santiam	3	Heated (48/48)	4.4–7.5	6	Marked at Willamette H.
Clackamas	2	Heated (48/48)	4.7–7.5	6	Marked at Willamette H.
Sandy	4	Heated (48/48)	4.7–7.5	6	Marked at Willamette H.

[a] *Difference between heated or chilled treatment and ambient incubation temperature.*
[b] *Number of treatment cycles for hatched fry, except where noted.*
[c] *4 cycles were administered to eggs and 3 cycles to hatched fry.*

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 2003 (**APPENDIX B**). Carcass surveys were conducted throughout the spawning period to collect otoliths from spring chinook salmon without fin clips. Otoliths were removed from carcasses and placed into individually numbered vials. In addition, we collected otoliths from adult hatchery fish 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**). We also collected otoliths from unclipped fish at the hatcheries. Otolith samples will be sent to WDFW for analysis and will be reported in 2004.

We estimated the proportion of naturally produced ("wild") fish on spawning grounds in the Willamette and Sandy basins from otoliths collected in 2002 (Table 2). Wild fish were determined by absence of a fin clip and absence of an induced thermal mark in the otoliths. Because we saw a significant difference between the distribution of redds and the distribution of carcasses recovered among survey areas within some watersheds (Figure 1), 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. We reasoned that variability in counting redds among survey areas was less than that in finding and recovering carcasses because spring chinook redds are in relatively shallow water and their visibility is less dependent on stream characteristics such as stream size or survey method (boat versus foot) than that of recovering carcasses.

Table 2. Number of otoliths collected from adult spring chinook in the Willamette and Sandy basins that were analyzed for presence of thermal marks, 2002.

Group, location	Number
Adipose fin not clipped	
McKenzie River	466
McKenzie Hatchery	114
North Santiam River	84
Minto Pond	11
South Santiam River	210
South Santiam Hatchery	45
Middle Fork Willamette River	58
Willamette Hatchery	58
Fall Creek	30
Molalla River	7
Clackamas River	115
Sandy River	96
Sandy River stock	97

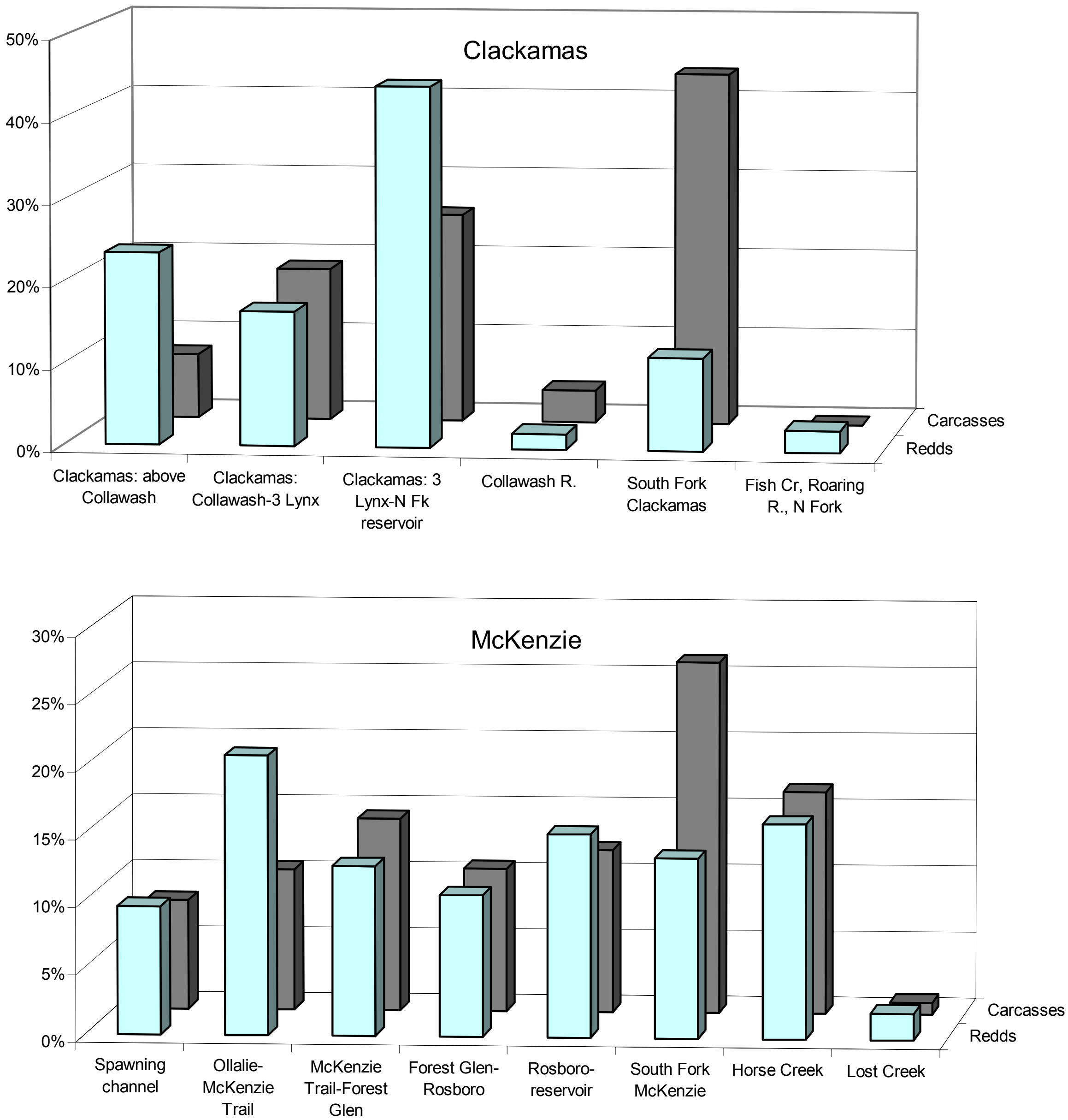

Figure 1. Distribution of redds and carcasses within the Clackamas and McKenzie watersheds, 2002.

We estimated the number of wild fish in the North Santiam, McKenzie, Clackamas, and Sandy rivers above dams from the proportion of wild and hatchery fish collected in spawning surveys above 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 fish without fin clips passing over dams, and T_{nc} is the percentage of non-clipped carcasses recovered above dams with thermal marks in their otoliths.

We also estimated the number of wild fish in the McKenzie and North Santiam rivers by using the percentage of 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. Because only fin-clipped fish are harvested in fisheries, we expanded the count of fin-clipped adults at the dams by 26%, the 1981–1995 average harvest rate in the lower Willamette River sport fishery (data from Foster and Boatner 2002).

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 unclipped carcasses and were not identified as "hatchery" samples.

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.

Results

Wild spring chinook composed the highest percentage of carcasses recovered in the Sandy, Clackamas, and McKenzie rivers and the lowest percentage in the Molalla and Middle Fork Willamette rivers in 2002 (Table 3). Of interest was the high number of wild carcasses recovered in the South Santiam River. The percentage of hatchery spring chinook was relatively high in the Clackamas River above North Fork Dam despite the removal of clipped hatchery fish at the dam (Table 3). Unclipped hatchery fish with coded wire tags (double-index groups) are released in the Clackamas River and some were likely released above the dam because unclipped fish were not scanned for the presence of a coded wire tag. The percentage of no clip hatchery fish was highest in the lower reaches of the Clackamas River immediately above reservoir, particularly in the South Fork Clackamas. They were also found late in the season; 92% of all carcasses in the South Fork Clackamas were found in October compared to 47% for the rest of the Clackamas basin above the dam. Clackamas Hatchery did not take unclipped fish and they were released back into the river throughout the run. Unclipped hatchery fish migrating above the dam would have difficulty correcting their course and may have been less likely to migrate very far above the reservoir. Unclipped fish were scanned for tags at the trap in 2003.

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. For comparison, the percentages of wild carcasses not weighted for redd distribution are also presented.

River (section), run year	Fin clipped	Not fin clipped[a]		Percent wild	
		Hatchery	Wild	Weighted	Not weighted
McKenzie (above Leaburg Dam)					
2001	62	50	265	70	69
2002	140	78	454	68	62
North Santiam (Minto–Bennett Dam[b])					
2000[c]	128	264	27	6	6
2001	385	43	56	12	6
2002	230	44	45	14	13
South Santiam (Foster–Waterloo)					
2002	1,604	37	224	12	12
Middle Fk Willamette (Dexter–Jasper[d])					
2002	167	151	15	5	5
Molalla (Copper Creek–Trout Creek)					
2002	94	5	3	3	2
Clackamas (above North Fork Dam)					
2002	e	31	70	69	59
Sandy (above Marmot Dam)					
2002	3[e]	26	121	81	81

[a] *The proportion of hatchery and wild fish were determined by presence or absence of thermal marks in otoliths.*
[b] *Including Little North Fork Santiam.*
[c] *About 95% of the 1995 brood (5-year-old) was released without an adipose fin clip.*
[d] *Including Fall Creek.*
[e] *Fish were sorted at the dams and all or most of clipped fish were removed.*

In the four rivers where we were able to estimate the number of wild spring chinook, the McKenzie River had the highest number and the North Santiam had the lowest number (Table 4). Wild and hatchery fish were more numerous in 2002 than in 2001, with a large increase of wild fish in the North Santiam River. The percentage of wild fish in the McKenzie River above Leaburg Dam decreased in 2002 (Table 4), at least in part because the number and percentage of clipped fish at Leaburg Dam increased from 20% in 2001 to 33% in 2002. In the Sandy River, an additional 157 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 97 otoliths sampled from these fish, 79% were wild.

Table 4. Estimated number of wild and hatchery adult spring chinook salmon in the McKenzie, North Santiam, Clackamas, and Sandy rivers above dams. Estimated from counts at the dams and from presence of induced thermal marks in otoliths of unclipped 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).

	At dam		No clip carcasses	Estimated number		
Run year	Not fin clipped	Fin clipped	with thermal marks (%)[a]	Wild	Hatchery	Percent wild
			McKenzie			
2001	3433	869	15.9	2887	1415	67
2002	4019	1949	14.7	3428	2540	57
			North Santiam			
2000[b]	1045	1241	90.7[b]	97	2189	4
2001	388	6398	43.4	220	6566	3
2002	1233	6407	56.5[c]	536	7104	7
			Clackamas			
2002	2154	d	30.7	1493	661	69
			Sandy			
2002	1159	d	17.7	954	205	82

[a] *Adjusted by distribution of redds among survey areas.*
[b] *Escapement at Bennett Dam was likely underestimated* (see *Schroeder et al. 2001).*
[c] *Average of adjusted spawning ground samples (49.4%) and samples from Minto Pond (63.6%).*
[d] *Fish were sorted at North Fork (Clackamas) and Marmot (Sandy) traps and only fish with no fin clips were allowed to pass.*

We also estimated the number of wild fish by using the percentage of juvenile hatchery fish released without a fin clip, and compared these to estimates based on analysis of otoliths in carcasses recovered without a fin clip. In general, estimates of wild spring chinook salmon calculated from the percentage of unclipped juveniles in hatchery releases were larger than those estimated from otoliths (Table 5). Possible reasons for the discrepancy are that partially-clipped adipose fins (classified as clipped at time of release) may regenerate, or the precision in classifying adipose fins as "clipped" is greater when juvenile fish are in hand than when adults are counted on video tape or netted and passed at dams. The exception was the 2001 run in the North Santiam River, which was composed of a large number of adults with fin clips and a small number without clips. Based on juvenile release data, we estimated no wild adults after adjusting for harvest difference because of selective fisheries on fin-clipped fish. For comparison, we estimated 220 wild fish in the North Santiam in 2001 based on otoliths from carcasses without fin clips (Table 5).

Table 5. Comparison of two methods of estimating the number of wild spring chinook salmon from adult counts at dams in the McKenzie and North Santiam rivers. The proportion of wild and hatchery adults is estimated either by the percentage of juvenile hatchery fish released without fin clips or by otoliths from carcasses recovered on spawning surveys.

River, run year	Number (% in run) of wild adults determined by— Release data	Otolith analysis
McKenzie, 2001	3368 (78%)	2887 (67%)
McKenzie, 2002	3806 (64%)	3428 (57%)
North Santiam, 2001	0 (0%)	220 (3%)
North Santiam, 2002	874 (11%)	536 (7%)

The WDFW otolith laboratory correctly identified a high percentage of adult hatchery spring chinook in the blind tests (Table 6). Additional tests are planned on the accuracy of identifying hatchery fish by presence of thermal marks in otoliths and identifying wild fish by absence of thermal marks.

Table 6. Accuracy of the WDFW otolith laboratory in identifying presence or absence of thermal marks in hatchery spring chinook salmon (blind tests), 2002.

Marking location, stock	Number	Classified— Correctly	Incorrectly	Percent correct
McKenzie Hatchery				
McKenzie	32	30	2	94
Marion Forks Hatchery				
North Santiam	29	29	0	100
Willamette Hatchery				
Middle Fork Willamette	22	22	0	100
South Santiam	22	22	0	100
Clackamas	25	24	1	96

The percentage of stray hatchery fish recovered in spawning surveys was much higher in the McKenzie and North Santiam rivers in 2002 (42% and 30%, respectively) than in 2001 (13% and 6%, respectively). The highest number of strays in the McKenzie and North Santiam rivers was from netpen and direct releases into the lower Willamette or Clackamas rivers (Table 7). Strays in the McKenzie River from releases into the Middle Fork Willamette and strays in the North Santiam from releases into the

Molalla were also high. The percentage of strays in other rivers ranged from 21% in the Molalla to 4% in the Middle Fork Willamette (Table 7). We collected 258 snouts from carcasses with adipose fin clips in 2003 (Table 8). Coded wire tags recovered from these fish will be read and reported in 2004.

Table 7. Origin of hatchery spring chinook salmon from recoveries of coded wire tags in spawning ground surveys, 2002. North Santiam data include recoveries in Little North Fork Santiam (2) and Middle Fork Willamette data include recoveries in Fall Creek (4).

		Origin of coded wire tags recovered							
River surveyed	n	Instream	Netpen[a]	Lower Willamette[b]	Molalla[c]	South Santiam	McKenzie	Middle Fork Willamette[d]	Youngs Bay[e]
Middle Fork Willamette	46	44	0	0	0	0	1		1
McKenzie	85	49	9	10	0	2		13	2
South Santiam	292	272	14	1	4	0	0	1	0
North Santiam	108	76	12	3	14	3	0	0	0
Molalla	28	22	3	2		0	0	0	1
Clackamas	14	13	0	1	0	0	0	0	0

[a] *McKenzie stock released in the lower Clackamas or Willamette rivers.*
[b] *McKenzie stock reared at Willamette Hatchery and released into the lower Willamette River.*
[c] *South Santiam stock.*
[d] *Includes releases in Fall Creek.*
[e] *Middle Fork Willamette stock released into netpens near mouth of Columbia River.*

Table 8. Number of snouts collected from carcasses of adult spring chinook salmon with adipose fin clips and a coded wire tag (determined with a hand-held detector), 2003.

River	Number of snouts
Middle Fork Willamette	4[a]
McKenzie	24[b]
South Santiam	103
North Santiam	48
Calapooia	2
Molalla	6
Clackamas	59[c]
Sandy	10[c]

[a] *Includes 3 collected in Fall Creek.*
[b] *Includes 5 collected below Leaburg Dam.*
[c] *5 each collected above North Fork and Marmot dams.*

TASK 1.3–DISTRIBUTION AND ABUNDANCE OF NATURAL SPAWNERS

We surveyed most of the major tributaries in the Willamette and Sandy basins in 2003 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.

The North Santiam River was regularly surveyed June 27–October 15 to recover carcasses and count redds. An unusually large return of spring chinook to the North Santiam River stimulated sports fisheries and prompted reports from anglers of large numbers of pre-spawning mortalities. We began surveys in late June to confirm those reports and to examine carcasses.

In 2003 we found that 72% of females died before spawning based on recovery of carcasses in spawning surveys (Table 9). Surveys in other years began later and estimates of pre-spawning mortality may be underestimated if mortality of chinook salmon begins in early summer, as in 2003 (Table 9). However, estimates of pre-spawning mortality may be high if conditions such as higher flow make it more difficult to recover carcasses later in the season when most of the carcasses would be spawners. Although dead male chinook salmon were also recovered throughout the summer, they are not included in the estimate of pre-spawning mortality because later in the spawning season we cannot accurately judge if they spawned. The number of all dead salmon found in August as a proportion of the Bennett Dam counts through August was slightly higher in 2003 (3.5%) than in previous years (Table 10). Although the mean daily flow in August was lower in 2003 than in other years, the maximum water temperature was similar to 2002 and lower than 2001 (Table 10). We did not include data from 1999 and 2000 because carcass surveys were not conducted in August in 1999, and the 2000 count at Bennett was likely underestimated (*see* Schroeder et al. 2001). More detailed data are in Appendix Table C-1, and the pre-spawning mortality of other rivers is in Appendix Table C-2.

Table 9. Season total percentage (through mid to late October) of chinook salmon females that died before spawning in the North Santiam River as assessed from recovery of carcasses.

Time period	2003	2002	2001	1998
late Jun–Oct	72	--	--	--
early Aug–Oct	56	52	--	23
mid Aug–Oct	45	51	75	23
late Aug–Oct	21	36	71	19

Table 10. Summary of spring chinook salmon counts through August, and number of carcasses recovered, water temperature, and flow in August in the North Santiam River, 1998, 2001–2003.

Year	Bennett count through August	Carcasses (start date, surveys)	Temperature (°C)[a]	Mean daily flow (cfs)
1998	2,120	17 (Aug 6, 2)	--	1,046
2001	6,886	113 (Aug 14, 5)	18.9	930
2002	7,669	210 (Aug 1, 8)	15.5	993
2003	12,451	439 (b, 6)	15.4	881

[a] *Mean daily maximum.*
[b] *Surveys began June 18, and 8 surveys were made before August 1.*

Redd digging was first observed on August 8 and peak spawning occurred in late September, similar to previous years. The redd density in 2003 was highest in the section immediately below Minto dam (55.5 redds/mi) and was almost four times that of 1996–2002 average (14.4 redds/mi, Table 11). Of the carcasses we recovered in the North Santiam in 2003, 86% had fin clips (Table 12), compared to 86% and 73% in 2001 and 2002, respectively.

Table 11. Summary of spawning surveys for spring chinook salmon in the North Santiam River, 2003, and comparison to redd densities in 1996–2002. Spawning in areas below Stayton may include some fall chinook.

Survey section	Length (mi)	Counts		Redds/mi							
		Carcass	Redd	2003	2002	2001	2000	1999	1998	1997	1996
Minto–Fishermen's Bend	10.0	528	555	55.5	16.2	17.9	23.0[a]	15.6	11.8	8.5	7.8
Fishermen's Bend–Mehama	6.5	209	42	6.5	9.4	5.7	5.8	3.1	4.3	2.5	3.5
Mehama–Stayton Is.	7.0	187	33	4.7	6.1	10.0	b	--	0.6	0.9	1.0
Stayton Is.–Stayton	3.3	145	12	3.6	3.0	6.7	b	--	10.0	3.6	2.0
Stayton–Greens Bridge	13.7	76	2	0.1	0.4	0.1	--	0.0	0.4	1.1	0.1
Greens Br.–mouth	3.0	2	5	1.7	4.7	--	--	--	4.7	9.7	--
Little North Santiam	17.0	46	31	1.8[d]	1.8[c]	1.1[a]	1.3[a]	1.0	2.3	0.5	0.0

[a] *Corrected number.*
[b] *Data was recorded for Mehama–Stayton; density for this section was 0.9 redds/mi.*
[c] *400 unclipped adult spring chinook were released into the Little North Fork Santiam on August 20 and 30, September 5 and 6, 2002.*
[d] *268 unclipped adult spring chinook were released into the Little North Fork Santiam in June (25th), July (9th, 15th, 22nd), August (25th), and September (2nd, 4th).*

Table 12. Composition of naturally spawning spring chinook salmon from carcasses recovered in the North Santiam River above Stayton Island, 2003.

Section	No fin clip[a]	Fin clipped
Minto–Fishermen's Bend	44	484
Fishermen's Bend–Mehama	32	177
Mehama–Stayton Island	19	168
Little North Fork Santiam	39	7
Total	134	836

[a] *Otoliths have not yet been read to determine the proportion of wild and hatchery fish.*

We calculated approximate fish/redd ratios for spring chinook salmon in the North Santiam basin above Bennett dams by estimating the number of potential spawners from estimates of chinook over the dams minus the number of fish removed at the Minto collection pond (e.g., fish spawned and fish transported above Detroit Dam) and those caught in the sport fishery (assuming a 20% exploitation rate). Adult chinook were transported from Minto to the Little North Fork Santiam in 2002 and 2003, and because we included redds in the Little North Fork, we did not subtract these fish from the Bennett counts. The fish/redd ratio was higher in 2003 (10.2) and 2001 (9.2) than in 2002 (6.9), which corresponds to the high pre-spawning mortality we saw in 2003 and 2001 (Table 9).

The McKenzie River was regularly surveyed August 7–October 13 to recover carcasses and count redds. Some redds were counted in August but active redd building began in early September, similar to previous years. Peak spawning occurred in late September to early October. More redds were counted in 2003 (1,187) than in 2002 (922) but relative redd densities in specific sections varied (Table 13). A large number of spring chinook were found in upper Horse and Lost creeks, areas not previously surveyed by our project. The percentage of fin-clipped carcasses in 2003 was higher above Leaburg Dam (32%) than in 2002 and 2001 (24% and 19%, respectively), but was similar below Leaburg Dam in 2003 (70%), 2002 (67%), and 2001 (72%) (Table 14). Water supply to McKenzie Hatchery was reduced in 2003 because of construction in the Leaburg Canal. Consequently, water temperature in the hatchery fish ladder was higher and likely resulted in lower effectiveness of attracting adult chinook salmon into the hatchery. McKenzie Hatchery is 3 km downstream of Leaburg Dam.

Table 13. Summary of chinook salmon spawning surveys in the McKenzie River, 2003, and comparison to redd densities (redds/mi, except redds/100 ft for spawning channel) in 1996–1998 and 2000–2002.

	Length			Redds/mi[a]						
Survey section	(mi)	Carcasses	Redds	2003	2002	2001	2000	1998	1997	1996
McKenzie River:										
Spawning channel	0.1	55	36	7.2	15.4	--	--	--	1.0	2.6
Olallie–McKenzie Trail	10.3	87	254	24.7	16.3	17.7	5.6	--	11.4	7.0
McKenzie Trail–Hamlin	9.9	42	40	4.0	5.2	4.9	1.6	--	--	2.1
Hamlin–S. Fork McKenzie	0.3	0	3	10.0	36.7	--	--	--	--	--
South Fork–Forest Glen	2.4	47	46	19.2	16.7	0.8	2.1	--	--	0.8
Forest Glen–Rosboro Br.	5.7	58	153	26.8	14.9	13.2	5.8	--	--	6.1
Rosboro Br.–Ben and Kay	6.5	19	48	7.4	16.2	6.3	3.2	--	--	4.9
Ben and Kay–Leaburg Lake	5.9	1	71	12.0	2.9	3.2	--	--	--	1.8
South Fork McKenzie:										
Cougar Dam–Road 19 br.	2.3	104	73	31.7	36.5	--	--	--	--	--
Road 19 bridge–mouth	2.1	11	12	5.7	11.4	8.1	7.6	--	--	2.9
Horse Creek:										
Pothole Cr.–Separation Cr.	2.8	30	52	18.6	--	--	--	--	--	--
Separation Cr.–mouth	10.7	62	145	13.6	12.1	7.4	--	--	--	5.3
Lost Creek:										
Spring–Limberlost	2.8	3	26	9.3	--	--	--	--	--	--
Limberlost–Hwy 126	2.0	3	42	21.0	--	--	--	--	--	--
Hwy 126–mouth	0.5	3	15	30.0	32.0	--	--	--	--	--
McKenzie River:										
Leaburg Dam–Leaburg Landing	6.0	61	171	28.5	19.2	12.3	--	15.3	19.8	10.3

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

Table 14. Composition of naturally spawning spring chinook salmon from carcasses recovered in the McKenzie River, 2003.

Section	No fin clip[a]	Fin clipped
McKenzie spawning channel	53	2
Olallie–Forest Glen	139	37
Forest Glen–Leaburg Lake	46	32
S Fork McKenzie	41	74
Horse Creek	90	2
Lost Creek	7	2
Total above Leaburg	322	149
Below Leaburg	24	55

[a] *Otoliths have not yet been read to determine the proportion of wild and hatchery fish.*

We regularly surveyed the Clackamas River basin above North Fork Dam August 20–October 20 to recover carcasses and count redds. Peak spawning generally occurred in early October, later than in previous years. A higher percentage of redds was counted above Cripple Creek in 2003 (73%) than in 1996–1999 (66%) (Table 15). Although the count of adult chinook passed at North Fork Dam was higher in 2003, our redd counts were lower and we accounted for a much lower percentage of the run (20%) than in previous years (49%) (Table 16). However, our recovery rate of chinook salmon passed at North Fork Dam (carcasses/dam count) was slightly higher in 2003 (5.3%) than in 2002 (4.7%), suggesting that pre-spawning mortality reduced the number of available spawners or that we did not count as many redds as should have been present. A higher percentage of the spring chinook run in the upper Clackamas River passed North Fork Dam in May–July in 2003 (77%) than in 1996–2002 (39%), which might increase the possibility of pre-spawning mortality in the early portion of the run. Of the female carcasses we processed above North Fork Dam, 27% died before spawning. Several factors may have affected our count of redds: (1) rain during early October discolored the main stem of the Clackamas where most redds are usually found; (2) large numbers of coho were in the upper Clackamas River (almost 1,500 passed the dam in September and early October) and were observed spawning in early October, which confounded our surveys of chinook redds; and (3) surveyors frequently encountered spawning gravels with large numbers of spawners and multiple redds in the upper Clackamas, which probably resulted in underestimated redd numbers.

The Clackamas River below River Mill Dam was surveyed July 24–October 7. We counted more redds in the upper reach of this section than in previous years (Table 15). Although fall chinook may be present below River Mill Dam, 77% of all the carcasses we processed had adipose fin clips indicating they were hatchery spring chinook. The remaining fish could be unclipped spring chinook salmon (hatchery and wild) or fall chinook. In previous years, the spring race composed 65% and 28% of the fish above and below Barton, respectively.

Table 15. Summary of spawning surveys for spring chinook salmon in the Clackamas River basin, 2003, and comparison to redd densities in 1996–1999 and 2002.

Survey section	Length (mi)	Carcasses	Redds	Redds/mi 2003	2002	1999	1998	1997	1996
Clackamas River:									
Sisi Creek–Forest Rd 4650	9.1	50	89	9.8	5.4	3.2	9.6	7.5	3.2
Forest Rd 4650–Collawash R.	8.0	21	44	5.5	4.8	4.1	7.0	5.9	4.1
Collawash R–Cripple Cr.	8.5	36	91	10.7	7.2	4.2	11.4	7.3	6.1
Cripple Cr.–South Fork	14.5	46	61	4.2	10.2	4.3	5.2	7.4	3.2
South Fork–Reservoir	1.0	7	10	10.0	15.0	1.0	7.0	17.0	--
South Fork Clackamas:									
Falls–mouth	0.6	0	11	18.3	70.0	16.7	5.0	11.7	--
Collawash River:									
Forest Rd 63–Hot Springs Fork	2.0	0	5	2.5	--	--	6.0	11.0	1.0
Hot Springs Fork–mouth	4.5	14	22	4.9	1.6	1.1	6.4	4.9	2.2
Fish Creek:									
Forest Rd 5430–mouth	4.5	1	3	0.7	0.4	--	1.7	2.6	1.1
Roaring River:									
Falls–mouth	2.0	1	3	1.5	2.5	--	1.5	3.0	3.0
North Fork Clackamas:									
Mouth area	0.2	0	3	15.0	15.0	--	0.0	0.0	0.0
Below Faraday Dam:									
Free-flowing stretch	1.5	23	1	0.7	0.0	--	--	--	--
Below River Mill Dam:									
McIver–Barton[a]	9.5	164[b]	109[b]	11.5	6.5	3.9	3.4	--	--
Barton–mouth	13.5	49[b]	8[b]	0.6	0.3	0.3	1.2	--	--

[a] *Additional 33 carcasses were processed in the 0.3 mi River Mill Dam–McIver section.*
[b] *Scales have not been read to separate spring chinook salmon from fall chinook salmon.*

Table 16. Counts of adult spring chinook salmon above North Fork Dam and the relationship to successful spawners above the dam, 1996–1999, 2002–2003.

Year	Counts: North Fork Dam[a]	Total Redds	Spawners[b]	Fish/redd[c]
1996	824	182	364	4.53
1997	1261	376	752	3.35
1998	1382	380	760	3.64
1999	818	212	424	3.86
2002	2168	370	740	5.86
2003	3338	342	684	9.76

[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.*

We regularly surveyed the Sandy River basin above Marmot Dam August 19–October 15 to recover carcasses and count redds (Table 17). Peak spawning generally occurred in late September to early October, similar to other years. Distribution of redds was similar to 2002, in that a lower percentage of redds in the basin was counted in the Salmon River in 2003 (68%) than in 1996–1999 (81%), and a higher percentage of redds was counted in Still Creek and the Zigzag River in 2003 (28%) than in previous years (16%). We accounted for a lower percentage of the spring chinook salmon run over Marmot Dam in 2003 (37%) than in 2002 (47%), and it was similar to that in 1999 (34%) (Table 18).

We surveyed the Sandy River below Marmot Dam in 2003 on September 24–25, and counted 183 redds (Table 17). Most of the chinook salmon found below Cedar Creek were not clipped (70%), whereas just 25% of the fish recovered between Cedar Creek and Marmot Dam were not clipped. Sandy Hatchery is located on Cedar Creek.

Table 17. Summary of spawning surveys for spring chinook salmon in the Sandy River basin, 2003, and comparisons to redd densities in 1996–1999, 2002.

Section	Length (mi)	Carcasses	Redds	Redds/mi 2003	2002	1999	1998	1997	1996
Salmon River:									
Final Falls–Forest Rd 2618	3.2	46	60	18.8	16.6	19.1	66.6	57.8	39.7
Forest Rd 2618–Bridge St.	3.6	17	11	3.1	9.2	9.4	15.3	12.2	19.7
Bridge St.–Highway 26	6.2	57	52	8.4	15.3	20.0	52.3	45.2	41.5
Below Highway 26[a]	0.3	1	4	13.3	15.0	--	15.0	--	--
Still Creek:									
Cool Creek– mouth	3.3	5	28	8.5	18.8	10.0	27.9	33.3	19.4
Zigzag River:									
Camp Creek– mouth	4.0	5	24	6.0	3.8	--	2.5	18.8	--
Lost Creek:									
Riley Campground–mouth	2.0	3	7	3.5	3.0	--	6.5	4.0	6.0
Camp Creek:									
Campground–mouth	2.0	0	0	0.0	0.5	--	4.5	6.0	3.0
Clear Fork Creek:									
Barrier–mouth	0.6	--	--	--	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	2.0
Sandy River:									
Marmot Dam–Cedar Creek	8.2	63[b]	155	18.9	--	--	--	--	--
Cedar Creek–Oxbow Park	9.9	20	28	2.0	--	--	--	--	--

[a] *Survey did not extend to the mouth as in other years.*
[b] *82 additional carcasses not processed.*

Table 18. Counts of adult spring chinook salmon at Marmot Dam and the relationship to successful spawners in the Sandy River basin above the dam, 1996–1999, 2002–2003.

	Counts				
Year	Marmot Dam[a]	Harvest[b]	Total Redds	Spawners[c]	Fish:redd[d]
1996	2461	78	569	1138	4.19
1997	3277	233	731	1462	4.16
1998	2606	185	744	1488	3.25
1999	1828	--	310	620	5.90
2002	1159	--	274	548	4.23
2003	969	--	181	362	5.35

[a] *Total from video counts (1996–1998) or fishway trap counts (1999, 2002) up to one week prior to last spawning survey*.
[b] *Sandy River above 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*.

Other rivers that were regularly surveyed in 2003 (Table 19) were South Santiam (7 dates, 14 July–21 October), Molalla (4 dates, 27 August–7 October), and Middle Fork Willamette (6 dates, 15 July–29 September). Active redd building began in early September in the South Santiam and in mid September in the Middle Fork Willamette. Peak spawning in both rivers was late September to early October. The percentage of fin-clipped carcasses was lower in the Middle Fork Willamette (54%) than in the North Santiam (86%), South Santiam (84%), and Molalla (79%) (Tables 12 and 19).

TASK 2.1– MORTALITY IN A CATCH AND RELEASE FISHERY

We conducted a study of hooking mortality of spring chinook salmon in the lower Willamette River sport fishery in 1998–2000. A manuscript describing this study was submitted and accepted for publication (Lindsay et al. in press). The paper is scheduled to be published in May 2004.

Table 19. Summary of chinook salmon spawning surveys in the Middle Fork Willamette, South Santiam, Santiam, Calapooia, Molalla rivers and tributaries, 2003.

River	Section	Length (mi)	Redds	Carcasses: No fin clip[a]	Carcasses: Fin clipped
Middle Fork Willamette	Dexter–Jasper	9.0	14	35	58
	Jasper–Coast Fork	8.0	0	0	0
	Fall Creek (above reservoir)	13.3	82	17	4
South Santiam	Foster–Pleasant Valley	4.5	594	159	845
	Pleasant Valley–Waterloo	10.5	16	20	128
	Lebanon–mouth	20.0	20	1	10
	Thomas Creek	7.6	9	10	3
Santiam	Confluence–I-5 bridge	5.0	11	0	0
	I-5 bridge–mouth	6.0	7	0	0
Molalla	Haybarn Cr– Bull Cr	2.3	1	0	0
	Bull Cr–Old Gawley bridge	3.9	9	4	12
	Old Gawley Cr bridge–Pine Cr bridge	5.3	5	1	7
Calapooia	Upstream of Bigs Cr	7.9	2	5	43

[a] *Otoliths have not yet been read to determine the proportion of wild and hatchery fish.*

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

In the 1970's, studies by Smith et al. (1985) found that trucking juvenile spring chinook salmon below Willamette Falls at Oregon City increased angler catch in the Clackamas and lower Willamette rivers by improving survival to adult return. Straying also increased. However, Specker and Schreck (1980) found that trucking smolts caused severe stress that tended to reduce survival compared to fish not trucked. Johnson et al. (1990) and Seiler (1989) suggested that stress from trucking could be reduced and survival increased by acclimating juveniles at a site for several weeks before release. Acclimation at lower river sites may increase angler harvest by improving survival of juveniles and by delaying migration to upriver areas.

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), Lindsay et al. (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 1995–1996 Brood Releases

Coded wire tags from experimental releases were primarily recovered 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 below Willamette Falls. Although some catch of spring chinook salmon occurs above Willamette Falls, these fisheries generally are not surveyed. Based on salmon catch card records, the fishery above Willamette Falls accounted for about 26% of the total basin harvest annually in 1981–1995 (calculated from Foster and Boatner 2002). Adult captures from 1992 through 1994 broods and conclusions based on these data are reported in Schroeder et al. 2002.

Adult captures from 1995 and 1996 broods are shown in Tables 20 and 21. 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. For 1995 and 1996 brood tag recoveries to date, two tentative conclusions can be reached. First, the conclusion in Schroeder et al. 2002 that smolt releases into the lower Willamette River do not increase sport catch appears to be holding true through 1996 brood recaptures. Sport catch below the falls of control fish released from McKenzie Hatchery was equal to or higher than catch of fish from groups acclimated or released directly into the lower main stem Willamette (Multnomah Channel for 1995 and 1996 broods). Second, for groups released into the Clackamas River in spring, those acclimated in Clackamas Cove appear to contribute more to sport fisheries in the Willamette and Clackamas rivers than groups released directly into the Cove or into the Clackamas River. However, for the 1995 brood, returns from acclimated groups in the Cove contributed less to the sport fishery than did the control.

Table 20. Capture of adult spring chinook salmon from the net pen evaluation of smolt releases into the lower Willamette River basin, 1995 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 2003.

		Smolts released into Multnomah Channel in—		Smolts released into the Clackamas River in—				
		Spring		Fall			Spring	
Capture location	McKenzie control	Acclimated	Direct	Cove, acclimated	Cove, direct	River, direct	Cove, acclimated	Cove, direct
Fisheries:								
Ocean	19	--	7	10	10	15	4	0
Columbia River	8	--	0	7	2	0	0	0
Willamette basin below the falls	102	--	29	63	83	132	43	0
(% in Clackamas River)	(0)	--	(0)	(35)	(39)	(31)	(9)	--
Hatcheries:								
McKenzie	183	--	10	2	3	29	0	0
Clackamas	0	--	0	17	44	31	18	7
Other	1	--	2	0	10	5	0	0
Spawning areas:								
McKenzie	16	--	2	0	0	0	0	0
Clackamas	0	--	0	0	0	0	0	0
Other	0	--	0	0	0	0	0	0
Leaburg Dam	39	--	3	0	0	0	0	0

Table 21. 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 2003. 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	68	35	32	20	46	47	23
Columbia River	87	34	21	27	84	41	20
Willamette basin							
below the falls	128	123	79	22	236	122	144
(% in Clackamas River)	(0)	(0)	(13)	(0)	(35)	(30)	(6)
Hatcheries[a]:							
McKenzie	236	15	11	22	3	1	1
Clackamas	0	2	6	3	77	36	14
Other	0	2	7	4	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

[a] *Counts are underestimated because adult returns have not yet been adjusted for sub-sampling at hatcheries in 2001.*

TASK 3.4– INCORPORATING WILD FISH INTO HATCHERY BROODSTOCKS

Otoliths were collected in 2002 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 highest percentage of wild fish in the unclipped portion of the broodstock was in South Santiam Hatchery, which also had the highest percentage of wild fish incorporated into their broodstock (Table 22).

Table 22. 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.

Hatchery	No clip		Clipped	Percent wild
	Wild	Hatchery	hatchery	in broodstock
McKenzie	13	101	933	1.2
North Santiam (Minto)	4	7	671	0.6
South Santiam	26	19	1,174	2.1
Willamette	5	53	1,602	0.3

TASK 4.1– MIGRATION TIMING OF WILD JUVENILE SPRING CHINOOK SALMON

We started field work in 1999–2000 under Objective 4 of our project study plan (**APPENDIX A**). Information collected under Objective 4 will allow managers to better understand spatial and temporal use of habitat by juvenile wild spring chinook in the Willamette basin and to better protect existing natural production areas. We initially began work on wild chinook in the McKenzie River where three life history types were defined at Leaburg Dam: (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. Initial work concentrated on determining juvenile migration timing of these three life history stages below Leaburg Dam in the McKenzie and Willamette rivers. In 2002 and 2003, our work expanded into the lower Willamette River and in the Santiam River basin where juvenile fall chinook salmon may be present.

In an effort to better define the distribution and migration timing of wild spring chinook, we began work in cooperation with NOAA Fisheries (Conservation Biology Division, Northwest Fisheries Science Center, Seattle) on use of DNA microsatellite analysis to identify the two races of chinook salmon. Fall chinook salmon were introduced above Willamette Falls in 1964 and about 5–12 million smolts were released each year until 1996 when the hatchery program was discontinued. Most fall chinook returned as age 3 (69%) or age 4 (18%) during the late 1990s (Foster and Boatner 2002). The average count at Willamette Falls in 1990–2000 (when the last age 4 fish from hatchery releases would have returned) was about 4,100 adults (Foster and Boatner 2002). The 2001–2003 count averaged 955 adults, with just 390 fish returning in 2003. In recent years, most of the fall chinook salmon have spawned in the lower Santiam River.

Methods

We used PIT tags (Prentice et al. 1990a, 1990b) to monitor migration of juvenile spring chinook salmon in the McKenzie and Willamette rivers. We injected fish with 134.2 kHz tags, and used a tag detector (Destron-Fearing® FS2001F), a laptop computer, and a computer program developed by Pacific States Marine Fisheries Commission (PSMFC) to enter data. All tagging data were loaded into a PIT tag database (PTAGIS) maintained by PSMFC.

Age 0 juvenile chinook salmon migrating in fall 2002 and yearling smolts migrating in spring 2003 were collected with a rotary screw trap installed in the Leaburg Dam bypass flume. 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 confined our sampling to the lower McKenzie and upper Willamette rivers downstream of spawning reaches to insure the juvenile chinook salmon we tagged had migrated. We also tagged a sample of hatchery fish that were released in the fall and spring from McKenzie Hatchery. In addition, we seined in sections of the Willamette River from Harrisburg to Newburg and in the Santiam River basin.

Migrating juvenile chinook salmon were scanned with a tag detector (Destron-Fearing® FS1001) at Willamette Falls in the bypass system 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). Additional tags were detected and reported by the National Marine Fisheries Service during their juvenile salmonid studies in the Columbia River estuary (Ledgerwood et al. 2000).

Because most of our tags were detected by passive interrogation, we did not measure growth between time of tagging and time of detection. We used fork lengths (FL) of individual fish at the time they were tagged to examine differences between the mean length of all tagged fish and the mean length of detected fish. We compared the difference in mean length by considering all tagged fish as a known population (N) and the detected fish as a sample (n) of N. We statistically analyzed differences in mean length by calculating a *t* value using the following equation:

$$\frac{(\overline{FL}_N - \overline{FL}_n)}{\sqrt{v_n(1-p)/n}}$$

where $\overline{FL}_N$ is the mean length of all juvenile fish given PIT tags, $\overline{FL}_n$ is the mean length at the time of tagging of fish that were later detected, v_n is the variance of the mean length of detected fish, and p is the detection rate of tagged fish (Willamette Falls and Columbia River). The square root of 1-p is the finite population correction (Snedecor and Cochran 1980).

Initial genetic analyses were conducted to investigate the feasibility of using DNA microsatellites to separate spring chinook and fall chinook. Samples in the initial analyses were tissues from frozen juvenile spring chinook that had been previously collected in the Clackamas, North Santiam, and McKenzie rivers for electrophoretic studies (Lindsay et al. 1997), and tissues from adult fall chinook collected at Willamette Falls in September 2002. We submitted additional reference samples in 2003 that included tissues collected in 2002 of adult hatchery spring chinook from Marion Forks (48) and McKenzie (48) hatcheries, and of wild spring chinook from spawning areas in the upper North Santiam (27) and McKenzie (48) rivers.

Tissues were collected from a sample of juvenile chinook captured by beach seine in the summer of 2002 (Schroeder et al. 2002) in anticipation that they could be identified by race using DNA microsatellite analyses. We collected tissues June 19–24 from juvenile chinook salmon in the Willamette River above and below the mouth of the Santiam River (15 and 64 samples, respectively), and in the lower Santiam River (71). We also collected tissues July 30–31 in the Willamette River below the Santiam River (37). These samples were analyzed by NOAA Fisheries.

Results

We tagged 6,578 wild spring chinook salmon in the McKenzie and Willamette rivers, 1,991 hatchery fish from McKenzie Hatchery, and 712 wild chinook salmon in the lower Willamette and Santiam rivers in June 2002–April 2003 (Table 23). In addition, we tagged over 3,800 age 0 wild chinook salmon in the lower McKenzie and upper Willamette rivers, and over 2,200 in the lower Willamette River and Santiam basin in spring and summer 2003 (Table 24).

Most of the detections of fish tagged in June 2002–April 2003 occurred at Willamette Falls (Table 23). Detection rates at Willamette Falls were generally low in 2002–2003 (Table 25). 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 amount of debris in the bypass system. In high flows, fewer fish migrate through the bypass system and the interrogator is more difficult to operate because of debris. In previous years, flows in November–January appeared to have the largest influence on the efficiency of the interrogator. However, flows in March appeared to have the greatest influence on tag recoveries this year. The average flow in March 2003 was 150% above the 1965–2002 average, and the interrogation system was fully operational less than 50% of the month (Appendix Table D-4). As an example, shortly after the first tagged hatchery fish from the spring release passed the falls on March 8,

Table 23. Detection of juvenile wild and hatchery spring chinook salmon given PIT tags and released in June 2002–April 2003. Tags were detected at the PGE Sullivan Plant at Willamette Falls unless noted.

	Leaburg Dam	Leaburg Dam	McKenzie & Upper Willamette R.	Lower Willamette & Santiam R.	McKenzie Hatchery	
	Nov 9 –Dec 20, 2002 (2422)	Feb 8 –Apr 22, 2003 (702)	Jun 18–Jul 25, 2002 (3,454)	Jun 20–Jul 22, 2002 (712)	Nov 6, 2002 (990)	Mar 3, 2003 (1001)
Month tag detected:						
June	--	--	0	4	--	--
July	--	--	2	12	--	--
September[a]	--	--	0	1	--	--
October	--	--	3	1	--	--
November	0	--	3	0	111	--
December	0	--	0	0	39	--
January	0	--	0	0	0	--
February	4	1	0	0	0	0
March	1	0	0	0	0	2
April	9	7	1	0	1	0
May	1	9[b]	0	0	0	0
June	0	1	0	0	0	0
Detection rate at Willamette Falls (%)	0.6	2.6	0.4	2.5	15.3	0.2
95% CI	0.3–0.9	1.4–3.7	0.1–0.4	1.4–3.7	13.0–17.5	0.0–0.5
Median days to Willamette Falls	116	49	107	9	11	11
Mean length (mm) at time of tagging for—						
Fish released	95.3	98.6	84.1	90.4	162.9	160.7
Fish detected	94.7	103.8	93.6	95.6	181.1	169.0

[a] *Sullivan Plant tag detector operated October 1, 2002 – September 30, 2003 with occasional shutdowns.*
[b] *Includes two fish detected in Columbia River estuary (rkm 76).*

the interrogator was shut down for several days and the flow increased to 64,000 cfs. Flows remained high through most of March and April, which has been a period of high migration in other years for chinook tagged in the previous summer and fall at age 0. An automatic brush-cleaning system was installed by PGE on the dewatering screen panels in summer 2003 to help keep the interrogator operational during periods of high debris.

Table 24. Number and mean fork length of wild spring chinook salmon (age 0) that were seined, PIT-tagged, and released in the McKenzie River below Hendricks Bridge (rkm 34), in the Willamette River above and below the Santiam River, and in the Santiam River watershed, 2000 (July–September), 2001 (July–August), 2002 (June–July), and 2003 (late May–mid July).

	Number tagged				Mean length (mm)			
River	2000[a]	2001	2002	2003	2000	2001	2002	2003
McKenzie	650	1897	1848	1949	109.1	94.8	84.8	78.6
Upper Willamette	796	937[b]	1606	1868	113.7	94.4	83.3	85.1
Lower Willamette			225	733			90.6	94.9
Santiam[c]			487	193			90.3	90.1
North Santiam				966				90.7
South Santiam				330				86.2

[a] *An additional 67 and 136 hatchery fish were seined and tagged in the McKenzie and Upper Willamette rivers, respectively.*
[b] *Does not include four hatchery fish*
[c] *From confluence of North and South Santiam to mouth.*

Table 25. Detection rate (%) at Willamette Falls of spring chinook salmon that were PIT-tagged and released in Willamette River basin in October 1999–April 2003.

	Summer				Fall		Spring	
Years	McKenzie River	Upper Willamette River	Lower Willamette River	Santiam River	McKenzie wild	McKenzie hatchery	McKenzie wild	McKenzie hatchery
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

Almost all the wild chinook salmon tagged as age 0 fish in summer 2002 migrated in the summer and fall, whereas all the wild fish tagged in fall 2002 migrated the following spring (Figure 2), similar to the migration of age 0 fish tagged in 2001 (Schroeder et al. 2002). In contrast, all age 0 fish tagged in 2000 migrated primarily in the spring (Schroeder et al. 2001). The migration of hatchery fish peaked at Willamette Falls shortly after their release (Figure 2), similar to previous years. The peak migration at Willamette Falls of chinook salmon smolts tagged in the spring was in April and May. The migration time for fish tagged in October 1999–April 2003 is presented in Table 26.

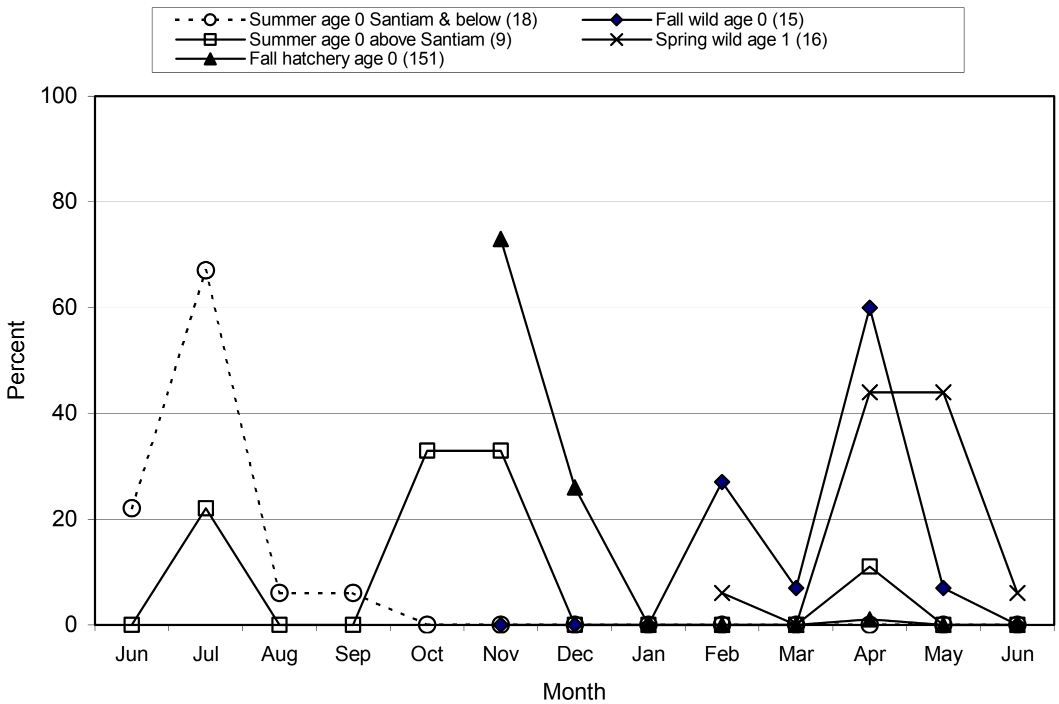

Figure 2. Migration timing of juvenile spring chinook salmon past Willamette Falls, 2002–2003. Based on detection of fish given PIT tags in the McKenzie, Willamette, and Santiam rivers. The number of detected tags is given in parentheses in the legend.

Table 26. Travel time (median days) to Willamette Falls of juvenile chinook salmon tagged and released in the Willamette River basin in October 1999–April 2003. Number of tag detections is in parentheses.

	Summer				Fall		Spring	
Years	McKenzie River	Upper Willamette River	Lower Willamette River	Santiam River	McKenzie wild	McKenzie hatchery	McKenzie wild	McKenzie hatchery
1999–2000					127 (39)	4 (19)		
2000–2001	191 (24)	217 (5)			129 (208)	25 (117)	46 (132)	
2001–2002	101 (28)	91 (7)			127 (27)	9 (94)	53 (86)	6 (24)
2002–2003	107 (7)	76 (2)	8 (3)	9 (15)	116 (15)	11 (151)	49 (16)	11 (2)

The mean fork length of juvenile chinook salmon tagged in 2002–2003 and later detected was generally larger than the mean fork length of all fish tagged and released (Table 23), but the difference was significant ($P < 0.05$) only for wild fish released in summer and for hatchery fish released in fall.

Age 0 chinook salmon were found throughout the lower McKenzie, upper and lower Willamette, and lower Santiam rivers. The catch of juvenile chinook salmon was higher in 2003 than in previous years (Table 27), in part, because we began sampling earlier in the year before some of the fish had migrated out of the Willamette and Santiam rivers. We documented an early summer migration of age 0 chinook salmon past Willamette Falls that were tagged in all areas of the Willamette, McKenzie, and Santiam rivers (Table 28). The migration of juvenile chinook was highest for fish tagged in the Santiam basin (Table 28), possibly because these are composed of a higher number of fall chinook than in other areas (*see* genetics results below). The mean fork length of the tagged juvenile chinook salmon that were later detected was larger than the mean fork length of all the fish that were tagged (Figure 3).

Table 27. Catch rate with a beach seine (fish/seine set) of juvenile chinook salmon in the Willamette, McKenzie, and Santiam rivers, 2000–2003.

	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

Table 28. Detection rate (%) and travel time (median days) of age 0 juvenile chinook salmon that were PIT-tagged and released in Willamette River basin in late May and June 2003, and detected at Willamette Falls in late May–late July 2003.

Location	Number tagged	Percent detected	Median days to Willamette Falls
McKenzie River	1,116	0.5	10.0
Willamette River:			
Above Santiam R.	995	2.9	16.5
Below Santiam R.	733	4.7	6.0
Santiam River:			
North	966	11.6	15.0
South	330	9.4	17.0
Mouth to confluence	193	11.4	7.0

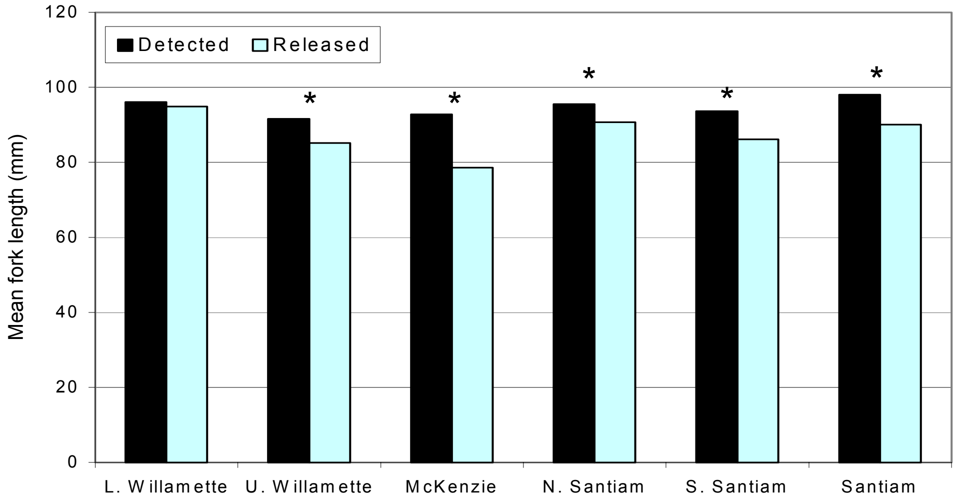

Figure 3. Comparison of the mean fork length (at time of tagging) of all age 0 juvenile chinook salmon that were PIT-tagged and released in Willamette River basin in late May and June 2003, and of those that were detected at Willamette Falls in late May–late July 2003. Asterisks indicate significant differences ($P < 0.01$).

The mean length of spring chinook salmon in the McKenzie and Willamette rivers tended to increase in 2003 from spring to early summer for fish sampled in similar areas (Figure 4). Comparisons of length between years generally showed that juvenile spring chinook were larger in 2000 and 2001 than in 2002 and 2003 (Figure 5).

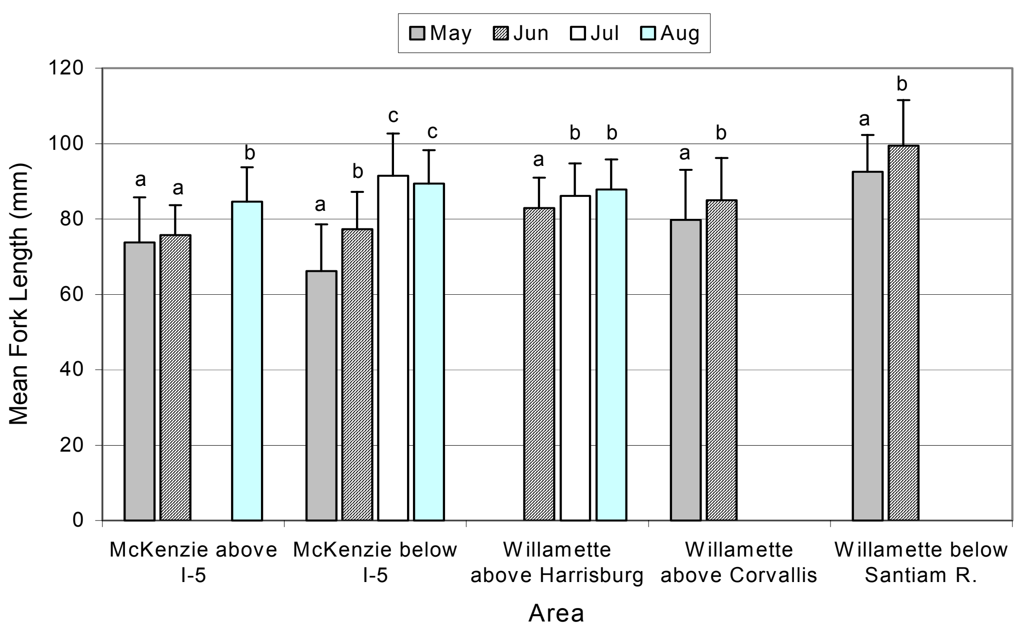

Figure 4. Mean fork length (± SD) of juvenile chinook salmon that were seined in the McKenzie and Willamette rivers, 2003. Columns with different letters within areas are significantly ($P < 0.05$) different.

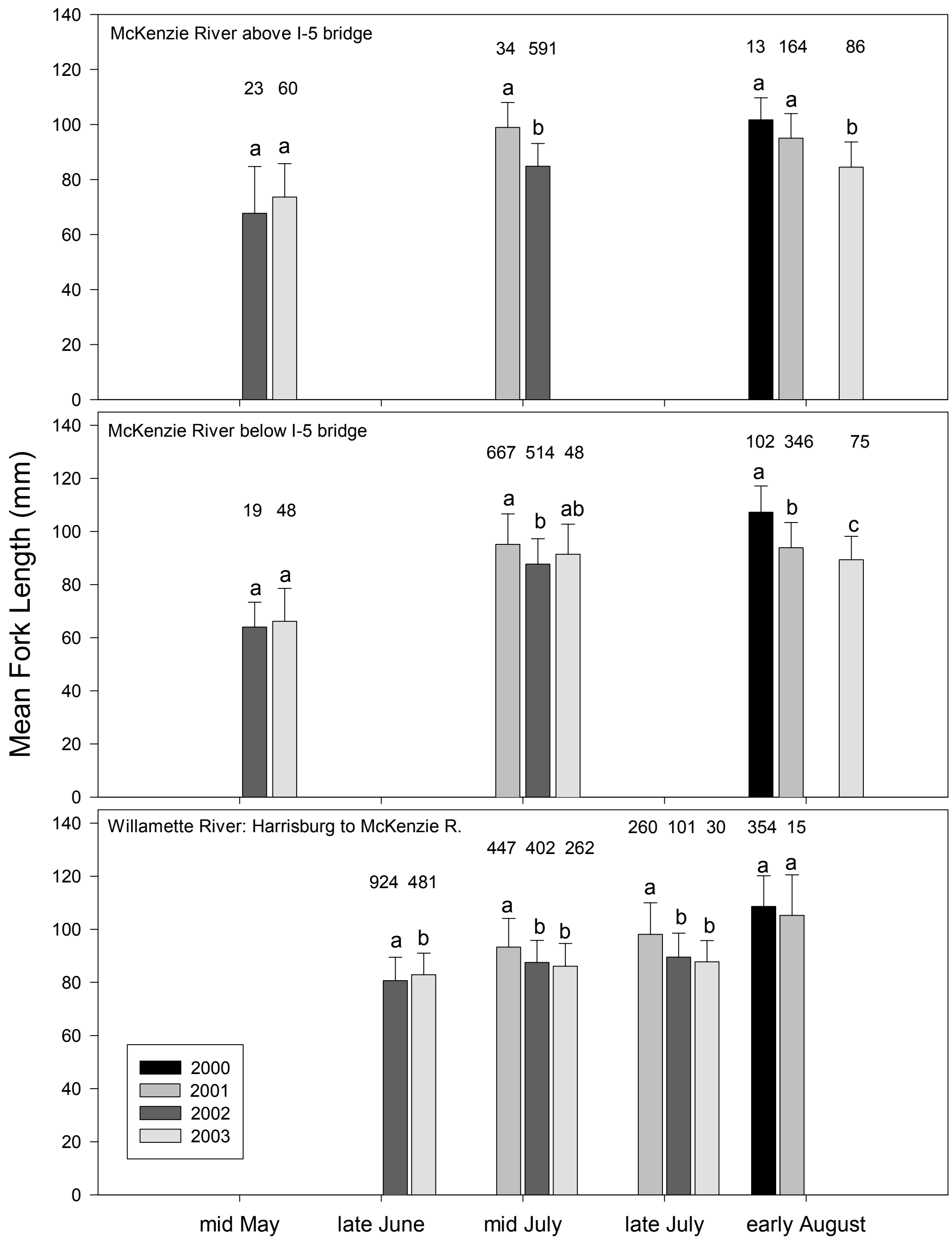

Figure 5. Mean fork length (± SD) of juvenile chinook salmon that were seined in similar locations and times of year in the McKenzie and Willamette rivers, 2000–2003. Columns with different letters within areas and times of year are significantly ($P < 0.05$) different; numbers above the bars are sample sizes.

Genetic analysis of tissue samples collected from chinook salmon of known stock origin in the Willamette basin showed distinct population groupings and demonstrated the feasibility of racial classification (Teel et al. 2002). Of 3,000 individuals that were simulated from allele frequency data, 96% were correctly classified into fall or spring chinook classifications.

Analyses of juvenile salmon of unknown run assigned most fish to spring or fall run with probabilities > 0.90 (Teel et al. 2002). About 14% of the unknown juveniles had assignment probabilities of about 0.50, which was likely because they were from populations that were insufficiently represented in the reference collections. All juvenile chinook salmon sampled in the Willamette above the Santiam River were spring chinook (Table 29). Of the 101 fish sampled in the Willamette River below the Santiam River, 94% were spring chinook. The percentage of spring chinook salmon in the lower Santiam River (66%) was lower than in the lower Willamette River (Table 29). Although the number of fall chinook counted at Willamette Falls has been low in recent years, most spawn in the lower Santiam River.

Table 29. Racial classification by DNA microsatellite analysis of juvenile chinook salmon collected by beach seine in the Willamette and Santiam rivers, 2002.

Month, general location (rkm)	Race[a] Fall	Race[a] Spring	Percent spring chinook
	Willamette River below Santiam River		
June			
Lambert Bar (107)–Wheatland (114)	5	18	78
Keizer (131)–Rickreall Cr. (138)	3	22	88
below Buena Vista (166)–Santiam R. (173)	3	11	79
July			
Jackson Bend (102)–Wheatland (114)	3	10	77
Keizer (133)–above Rickreall Cr. (142)	3	19	86
Independence (152) and above bridge (157)	0	2	100
	Santiam River		
June			
Railroad bridge (4)	24	46	66
	Above Santiam River		
June			
below Millersburg (181–182)	0	15	100

[a] *The genotype was unable to be determined for 2 samples collected in June in the lower Willamette and for 1 sample in the Santiam.*

Schools of juvenile chinook salmon (≥10 fish) sampled at five sites below the Santiam River were mixtures of spring and fall chinook. The average proportion of spring chinook was the same (82%) in three schools sampled in June and in two schools sampled in July. The mean fork length of spring chinook and fall chinook salmon was not significantly different ($P > 0.05$) in the June or July samples (Table 30).

Table 30. Mean fork length (FL [mm]) of juvenile spring and fall chinook salmon captured in the Willamette River, 2002. Race was identified by DNA analysis.

	late June			late July		
Race	FL	SD	*n*	FL	SD	*n*
Fall chinook	89.6	9.80	11	92.0	5.93	6
Spring chinook	86.5	11.39	66	95.5	7.65	31

Additional juvenile tissue samples were collected in summer 2003 in the Willamette River downstream of the Santiam River (Table 31). These samples will be analyzed in 2004 by NOAA Fisheries.

Table 31. Number of tissue samples collected from juvenile chinook salmon captured by beach seine or trap in the Willamette River below the Santiam River, 2003.

Date	Location (rkm)	Number captured	Tissues collected
	Beach seine		
Jun 25	mouth of Yamhill R. (86)	26	25
Jun 25	above San Salvadore (93)	4	4
May 27	below Jackson Bend (100)	96	30
May 28	above Wheatland (117)	91	30
May 28	Salem above Hwy 22 (136)	491	30
May 27	below Rickreall Cr (141)	217	25
May 27	below Rickreall Cr (142)	59	30
	Bypass trap		
Jun 24	PGE Sullivan Plant (43)	30	30

TASK 5.3–EFFORTS TO RE-ESTABLISH POPULATIONS

We reported the poor survival in 2002 of 400 unclipped adult spring chinook that were transported from the Minto collection facility on the North Santiam River and released into the Little North Fork Santiam (Schroeder et al. 2002). Few of these fish survived to spawn and the number of redds counted in 2002 (30) was only slightly higher than the 1997–2001 average (20). In 2003, we increased our efforts to monitor the outplantings of adult chinook salmon from some hatcheries.

Unclipped adult spring chinook, collected at Minto, were tagged with uniquely numbered Floy® tags and released at two locations in the Little North Fork Santiam River: Golf bridge (rkm 20) and Elkhorn bridge (rkm 27). A total of 268 fish were released on six dates from June 25 through September 4 (Table 32).

We examined 46 carcasses for fin clips and tags in nine surveys from July 10 to October 6, and collected otoliths and scales from unclipped fish. An additional 25 fish were decayed and we were unable to determine if they were clipped or tagged. The first spawned female was found on September 19. Of the 268 tagged fish released in the river, we recovered 32 tags and found 10 carcasses with a tag wound. Of the 15 tagged females recovered, 14 died prior to spawning. Half of the carcasses from the Elkhorn bridge releases were recovered in the same area and half were recovered downstream. Most of the carcasses from the Golf bridge releases were recovered in the same area (75%) and the rest were recovered upstream.

Table 32. Summary of adult chinook salmon released and recovered in the Little North Fork Santiam, 2003.

Release			Tag recoveries			
					Days to death	
Date	Number	Location	Number[a]	Percent	Range	Average
Jun 25	37	Elkhorn bridge	4	10.8	15–86	68
Jul 9	64	Golf bridge	6	9.4	8–72	26
Jul 16	31	Golf bridge	8	25.8	0–31	21
Jul 22	51	Golf bridge	7	13.7	14–37	21
Aug 25	54	Elkhorn bridge	2	3.7	25	25
Sep 4	31	Elkhorn bridge	5	16.1	15	15

[a] *10 additional fish were recovered with tag wounds but no tag.*

We counted 31 redds in the Little North Fork between Elkhorn bridge and the mouth, far fewer than expected from a release of 268 adults. However, recoveries of tagged female carcasses suggest that pre-spawning mortality was high (93%). In addition, only 8 of the 42 tagged carcasses we recovered were found after September

19, the date of first redd deposition, which suggests that only about 19% of the 268 adults (51 fish) might have survived to spawn.

On August 29, 135 adult chinook salmon with fin clips were transported from South Santiam Hatchery and released into the Calapooia River above Bigs Cr (rkm 93). Live chinook salmon counted at the release site decreased from over 100 fish on August 30 to 6 fish on September 12 (Table 33). The cumulative number of carcasses recovered in the river (3000 line bridge, rkm 95, to Bigs Cr) increased from 2 on August 30 to 49 on September 12. We collected 43 clipped chinook salmon, 5 unclipped fish, and 11 fish that were too decayed to process. The first redd was observed on September 25 in the section from McKinley Creek (rkm 98) to the 3000 line bridge, and we counted two redds through October 8 in this section, the only redds found in 7.6 mi we surveyed above Bigs Creek.

Table 33. Observations of chinook salmon in the Calapooia River, July–October 2003.

	Jul 29	Aug 30	Sep 2	Sep 12	Sep 25	Oct 7
Live adults: release site above Bigs Cr.	0	100+	53	6	0	0
Carcasses: 3000 line bridge to Bigs Cr.	0	2	16	31	1	0
Temperature: release site (°C)	17			17	16	

ACKNOWLEDGMENTS

Many individuals and groups helped with this study. We thank hatchery managers Terry Jones, Kurt Kremers, Gary Yeager, and their crews for conducting the otolith marking of chinook salmon in their hatcheries. We thank research biologists Mark Wade, Vince Tranquilli, Mike Hogansen, and Chad Helms for their help at the Leaburg bypass trap and assistance with collecting data in the McKenzie River. We thank Dan Domina with PGE who has been extremely helpful with making improvements and helping run the fish passage facilities at the Sullivan Power Plant at Willamette Falls in Oregon City. Dave Marvin and John Tenney of Pacific States Marine Fisheries Commission provided much appreciated technical expertise with the installation and operation of the PIT tag detection system at Willamette Falls. We thank Greg Taylor of the U. S. Army Corps of Engineers for conducting spawning ground surveys in Fall Creek. We thank Tim Downey of Eugene Water and Electric Board (EWEB) for providing assistance with the bypass trap at Leaburg Dam. Finally we want to recognize seasonal biologists Kevin Payne, Justin Mott, Ed Hughes, Greg Gilham, Lisa Riley, Jon Kluck, Rob Carlson, John Olson, and Norman Swanson who collected much of the field data during seining and spawning ground surveys.

REFERENCES

Foster, C.A., and J.R. Boatner. 2002. 2000 Willamette River spring chinook salmon run, fisheries, and passage at Willamette Falls. Oregon Department of Fish and Wildlife, Sport Fish Restoration Project Number F-119-R-16 and F-119-R-17, Portland.

Johnson, S.L., M.F. Solazzi, and T.E. Nickelson. 1990. Effects on survival and homing of trucked hatchery yearling coho salmon to release sites. North American Journal of Fisheries Management 10:427–433.

Ledgerwood, R.D., B.A. Ryan, E.P. Nunnallee, and J.W. Ferguson. 2000. Estuarine recovery of PIT-tagged juvenile salmonids from the Lower Granite Dam transportation study, 1998. National Marine Fisheries Service, Report to U. S. Army Corps of Engineers, Contract E8960100, Northwest Fisheries Science Center, Seattle.

Lindsay, R.B., K.R. Kenaston, R.K. Schroeder, J.T. Grimes, M. Wade, K. Homolka, and L. Borgerson. 1997. Spring chinook salmon in the Willamette and Sandy rivers. Oregon Department of Fish and Wildlife, Fish Research Report F-163-R-01, Annual Progress Report, Portland.

Lindsay, R.B., R.K. Schroeder, and K.R. Kenaston. 1998. Spring chinook salmon in the Willamette and Sandy rivers. Oregon Department of Fish and Wildlife, Fish Research Report F-163-R-03, Annual Progress Report, Portland.

Lindsay, R.B., R.K. Schroeder, and K.R. Kenaston. 2000. Spring chinook salmon in the Willamette and Sandy rivers. Oregon Department of Fish and Wildlife, Fish Research Report F-163-R-05, Annual Progress Report, Portland.

Lindsay, R.B., R.K. Schroeder, K.R. Kenaston, R. Toman, and M.A. Buckman. In press. Hooking Mortality by Anatomical Location and its Use in Estimating Mortality of Spring Chinook Salmon Caught and Released in a River Sport Fishery. North American Journal of Fisheries Management.

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

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

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

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

ODFW (Oregon Department of Fish and Wildlife). 2003a. Native Fish Conservation Policy. Oregon Department of Fish and Wildlife Administrative Rule No. 635-007-0502 through 635-007-0509, Salem.

ODFW (Oregon Department of Fish and Wildlife). 2003b. Fish Hatchery Management Policy. Oregon Department of Fish and Wildlife Administrative Rule No. 635-007-0542 through 635-007-0548, Salem.

Prentice, E.F., T.A. Flagg, and C.S. McCutcheon. 1990a. Feasibility of using implantable passive integrated transponder (PIT) tags in salmonids. American Fisheries Society Symposium 7:317–322.

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

Royer, D., T.D. Brush, and E.J. White. 2001. Fall 2000 evaluation of juvenile spring chinook salmon downstream migration at the Willamette Falls Project under two passage scenarios. Normandeau Associates, Final Report. (Available from Portland General Electric, Portland, OR).

Schroeder, R.K., K.R. Kenaston, and R.B. Lindsay. 1999. Spring chinook salmon in the Willamette and Sandy rivers. Oregon Department of Fish and Wildlife, Fish Research Report F-163-R-04, Annual Progress Report, Portland.

Schroeder, R.K., K.R. Kenaston, and R.B. Lindsay. 2001. Spring chinook salmon in the Willamette and Sandy rivers. Oregon Department of Fish and Wildlife, Fish Research Report F-163-R-06, Annual Progress Report, Portland.

Schroeder, R.K., K.R. Kenaston, and R.B. Lindsay. 2002. Spring chinook salmon in the Willamette and Sandy rivers. Oregon Department of Fish and Wildlife, Fish Research Report F-163-R-07, Annual Progress Report, Portland.

Seiler, D. 1989. Differential survival of Grays Harbor basin anadromous salmonids: water quality implications. Canadian Special Publication of Fisheries and Aquatic Sciences 105:123–135.

Smith, E.M., J.C. Zakel, and W.H. Day. 1985. Willamette River salmon studies. Oregon Department of Fish and Wildlife, Fish Research Projects F-102-R6 (as part of F-119-R) and DACW 57-74-C-0192, Annual Progress Report, Portland.

Snedecor, G.W., and W.G. Cochran. 1980. Statistical methods, 7th edition. Iowa State University Press, Ames.

Specker, J.L. and C.B. Schreck. 1980. Stress responses to transportation and fitness for marine survival in coho salmon (*Oncorhynchus kisutch*) smolts. Canadian Journal of Fisheries and Aquatic Sciences 37: 765–769.

Teel, D., P. Moran, T. Lundrigan, and K. Kenaston. 2002. Preliminary genetic analysis of Chinook salmon juveniles sampled in the upper Willamette River during the summer of 2002. National Marine Fisheries Service, Northwest Fisheries Science Center, Research Progress Report, Seattle.

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

Otoliths Collected from Adult Spring Chinook Salmon, 2003

Basin and location	Group	Number
Middle Fork Willamette:		
Dexter–Jasper	Not clipped	35
Fall Creek	Not clipped	17
Willamette Hatchery	AD clipped	31
Willamette Hatchery	Not clipped	64
McKenzie:		
Carmen-Smith spawning channel	Not clipped	53
Ollalie Boat Ramp–McKenzie Trail	Not clipped	80
McKenzie Trail–Forest Glen	Not clipped	59
Forest Glen–Ben and Kay Doris Park	Not clipped	46
Horse Creek	Not clipped	90
South Fork McKenzie below Cougar Reservoir	Not clipped	40
Lost Creek	Not clipped	9
Below Leaburg Dam	Not clipped	22
McKenzie Hatchery	AD clipped	50
McKenzie Hatchery	Not clipped	57
Calapooia River:		
Potts Creek–Mitchell	Not clipped	6
South Santiam:		
Foster–Pleasant Valley	Not clipped	161
Pleasant Valley–Waterloo	Not clipped	20
Lebanon–mouth	Not clipped	1
Thomas Creek	Not clipped	6
South Santiam Hatchery	AD clipped	31
South Santiam Hatchery	Not clipped	48
North Santiam:		
Minto–Fishermen's Bend	Not clipped	42
Fishermen's Bend–Mehama	Not clipped	31
Mehama–Stayton Island	Not clipped	21
Stayton Island–Stayton	Not clipped	17
Stayton–Greens Bridge	Not clipped	12
Little North Santiam	Not clipped	38
Minto collection pond	AD clipped	51
Minto collection pond	Not clipped	19
Molalla:		
Trout Creek–Copper Creek	Not clipped	5

Appendix B. Continued.

Basin and location	Group	Number
Clackamas:		
Sisi Creek–Collawash River	Not clipped	71
Collawash River–Cripple Creek	Not clipped	34
Cripple Creek–reservoir	Not clipped	50
South Fork Clackamas	Not clipped	0
Collawash River	Not clipped	14
Fish Creek and Roaring River	Not clipped	2
Below Faraday Dam	Not clipped	13
River Mill Dam–Barton	Not clipped	61
Barton–mouth	Not clipped	6
Clackamas Hatchery (Clackamas stock)	AD clipped	33
Clackamas Hatchery	Not clipped	5
Sandy:		
Final Falls–Road 2618 bridge	Not clipped	44
Road 2618 bridge–Bridge St. bridge	Not clipped	17
Bridge St. bridge–Highway 26 bridge	Not clipped	56
Highway 26 bridge–mouth	Not clipped	0
Still Creek	Not clipped	4
Zigzag River	Not clipped	4
Lost Creek	Not clipped	2
Clackamas Hatchery (Sandy stock)	Not clipped	110

APPENDIX C

Data on Pre-Spawning Mortality in the Willamette and Sandy Basins, 2001–2003

Appendix Table C-1. Summary of chinook salmon counts, pre-spawning mortalities, maximum water temperatures, and flows in the North Santiam River by two week periods, 2001–2003.

Data	2001	2002	2003
Bennett Dam count through Aug 31	6,886	7,669	12,451
Carcasses:			
Jun 16–30			96
Jul 1–15			117
Jul 16–31			189
Aug 1–15	37[a]	148	175
Aug 16–31	76	62	264
Max water temperature (°C) at Mehama:			
Jul 16–31	17.4	16.3	16.8
Aug 1–15	19.1	15.4	15.5
Aug 16–31	18.6	15.5	15.4
Flow (cfs) at Mehama:			
Jul 16–31	980	1,194	881
Aug 1–15	935	1,065	848
Aug 16–31	926	926	913

[a] Carcass sampling did not start until August 14 so this number underestimates the mortality in the first two weeks of August.

Appendix Table C-2. Number and percentage of carcasses of spring chinook salmon (females) in the Willamette and Sandy River basins that died before spawning and starting dates of spawning surveys, 2001–2003.

River	Starting date	Carcasses	Pre-spawn mortality	
			Number	Percent
		2001		
McKenzie	Aug 21	198	14	7
North Santiam	Aug 14	319	238	75
		2002		
Middle Fork Willamette	Aug 7	162	134	83
Fall Creek	Aug 27	36	21	58
McKenzie	Aug 15	509	41	8
South Santiam	Aug 6	794	204	26
North Santiam	Aug 1	229	120	52
Clackamas (below River Mill Dam)	Sep 11	50	25	50
		2003		
Middle Fork Willamette	Jul 15	49	49	100
Fall Creek	Aug 27	9	4	44
McKenzie	Aug 7	362	75	21
Calapooia	Jul 31	27	27	100
South Santiam	Jul 14	660	187	28
Thomas Creek	Aug 12	9	8	89
North Santiam	Jun 27	740	530	72
Little North Fork Santiam	Jul 10	27	22	81
Molalla	Aug 27	13	9	69
Clackamas (below River Mill Dam)	Jul 24	95	130	73
Clackamas (above North Fork Dam)	Aug 20	98	26	27
Sandy (below Marmot Dam)	Sep 24	21	13	62
Sandy (above Marmot Dam)	Aug 19	40	6	15

APPENDIX D

Migration and Rearing Data for McKenzie, Willamette, Calapooia, and Santiam Rivers, 2002

Appendix Table D-1. Fish species and numbers caught in seines in the McKenzie River (rkm 0–34), May 21–August 1, 2003

Species	Catch by date (seine sets in parentheses) May 21 (11)	Jun 10–12 (30)	Jul 1–8 (32)	Aug 1 (19)
Chinook salmon (wild)	1082	2124	1803	478
Rainbow trout	30	45	113	78
Cutthroat trout	19	278	140	102
Trout fry		2	2	1
Mountain whitefish		3	13	2
Rainbow trout (hatchery)			23	
Chinook salmon (adult)			1	
Redside shiner	31	324	98	227
Northern pikeminnow		45	39	293
Peamouth		8		
Chiselmouth				1
Dace	2	2	4	1
Largescale sucker	1	25	5	40
Sculpin	9	14	13	3
Three-spine stickleback	1	4	6	

Appendix Table D-2. Fish species and numbers caught in seines in the upper (rkm 173–282) and lower Willamette (rkm 88–173) River, May 22–July 28, 2003.

	Catch by location and date (seine sets in parentheses)				
	Upper Willamette River			Lower Willamette River	
Species	May 22 (13)	June 4–26 (87)	July 16–28 (29)	May 27–30 (26)	June 25 (12)
Chinook salmon (wild)	475	1837	369	1307	119
Rainbow trout	8	84	72	4	
Cutthroat trout	9	351	229	1	
Trout fry		90	7		
Mountain whitefish	19	450	28	37	147
Rainbow trout (hatchery)			1		
Chinook salmon (hatchery)		1			
Summer steelhead (adult)		3			
Chinook salmon (adult)		3			
Redside shiner	86	1208	115	272	290
Northern pikeminnow	36	929	681	75	151
Peamouth	1	57	14	76	15
Chiselmouth		65	66	73	31
Dace	25	159	5	87	35
Largescale sucker	10	157	44	67	67
Sculpin	7	27	6	19	
Sand roller		4			
Three-spine stickleback		3			
Bluegill	3	2			
Smallmouth bass				9	
Banded killifish				2	215

Appendix Table D-3. Fish species and numbers caught in seines in the Calapooia (rkm 1), Santiam (rkm 16), North Santiam (rkm 1–55), and South Santiam (rkm 5–53) rivers, May 22–June 24, 2003.

	Catch by location and date (seine sets in parentheses)			
Species	Calapooia May 22 (2)	Santiam June 3 (3)	N. Santiam June 5–9 (33)	S. Santiam June 3–24 (19)
Chinook salmon (wild)	9	202	1089	402
Rainbow trout			311	33
Cutthroat trout			8	30
Trout fry			1	
Mountain whitefish	3	1	3	15
Chinook salmon (hatchery)				7
Chinook salmon (adult)			1	
Redside shiner	3	3	124	
Northern pikeminnow		14	66	
Peamouth		3	1	
Dace	1		17	12
Largescale sucker		7	3	1
Sculpin	1	3	17	19
Sand roller		2		
Three-spine stickleback			1	

Appendix Table D-4. Dates the PIT tag interrogator in the PGE Sullivan Plant at Willamette Falls was operational September 2002–September 2003.

Month	Dates	Status	Comments
September	1–2	Shut down	Plant maintenance
	3–30	Operating	
October	1–31	Operating	
November	1–14	Operating	
	15	Shut down	High flows and debris
	16–30	Operating	2 days with screens partially opened
December	1–16	Operating	
	17–22	Shut down	High flows and debris
	23–31	Operating	2 days with screens partially opened
	27–31	Operating	
January	1	Operating	Screens partially opened
	2–8	Shut down	High flow and debris
	9–30	Operating	2 days with screens partially opened
	31	Shut down	Plant maintenance
February	5–28	Operating	
March	1–8	Operating	1 day with screens partially opened
	9–10	Shut down	High flow and debris, flows at Salem up to 70,000 cfs
	11–27	Operating	11 days with screens partially opened
	28	Shut down	High flows and debris
	29–31	Operating	2 days with screens partially opened
April	1–30	Operating	1 day with screens partially opened
May	1–31	Operating	
June	1–30	Operating	
July	1–27	Operating	
	28–31	Shut down	Plant maintenance
August	1–19	Shut down	Plant maintenance
	20–31	Operating	
September	1–30	Operating	