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

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CONTENTS

KEY FINDINGS

1. The number of wild spring Chinook salmon in 2003 in the four rivers where we can estimate adult runs from otolith analysis was:
   - 5,142 (McKenzie above Leaburg Dam), an increase of 43% from the 2002 run;
   - 271 (North Santiam above Bennett Dam), a decrease of 55%;
   - 2,617 (Clackamas above North Fork Dam), an increase of 74%; and
   - 856 (Sandy above Marmot Dam), a decrease of 10%.

2. The percentage of wild spring Chinook incorporated into hatchery broodstocks in 2003 as determined by otolith analysis was:
   - 1.4% (McKenzie),
   - 0.3% (North Santiam),
   - 2.3% (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 the 2003 run in the South Santiam River (151), second only to the McKenzie (351), and similar to that in the 2002 run.

4. Age 0 (subyearling) Chinook salmon were found throughout the lower McKenzie, upper and lower Willamette, and Santiam rivers in late May–July, 2002–2004.

5. Most juvenile spring Chinook tagged in spring and summer in the Willamette and Santiam rivers migrated in the summer, whereas over 50% of the fish tagged in the lower McKenzie River migrated in the fall and following spring. A higher percentage of wild Chinook salmon tagged in the lower McKenzie and Santiam rivers in spring and summer 2003 migrated during the summer compared to those tagged in 2002.

6. The percentage of wild adult Chinook recovered in 2002 and 2003 with an age 0 life history (subyearling smolt) ranged from 6–7% (Middle Fork Willamette and Sandy rivers) to 40–90% (North and South Santiam rivers). In the McKenzie and Clackamas rivers upstream of hatcheries, the percentage of wild adult Chinook with an age 0 life history was higher in the lower reaches of the basins (41 and 28%, respectively) than in the upper reaches (12% both 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, North Santiam, South Santiam, Molalla, Clackamas, and Sandy rivers in 2004. 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 2003 through early fall 2004.

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. First, a percentage of hatchery releases do not receive a clip because fin-clipping personnel do not clip the adipose fin or clip only a portion of the fin, which then regenerates. 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 2004, 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 hatchery spring Chinook salmon in the 2003 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 and 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, 2003 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	6	Chilled (24/72)	2.8–6.7	7-8 [c]	--
N. Santiam	3	Heated (48/48) [d]	4.4–5.0	8	--
Willamette	8	Heated (48/48)	4.7–8.3	6	--
S. Santiam	4	Heated (48/48)	4.4–8.3	6	Marked at Willamette H.
Clackamas	2	Heated (48/48)	6.1–8.1	6	Marked at Willamette H.
Sandy	4	Heated (48/48)	6.1–8.1	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 3-4 cycles to hatched fry.*
[d] *Power outages increased time between cycles to 96 hrs after cycle 1 and 240 hrs after cycle 2.*

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 2004 (**APPENDIX B**). Carcass surveys were conducted throughout the spawning period to collect otoliths from Chinook salmon without fin clips. Otoliths were removed from carcasses and placed into individually numbered vials. 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**); and from unclipped fish at the hatcheries. Otolith samples will be sent to WDFW for analysis and will be reported in 2005.

We estimated the proportion of naturally produced ("wild") fish on spawning grounds in the Willamette and Sandy basins from otoliths collected in 2003 (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. 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, 2003.

Group, location	Number
Adipose fin not clipped	
McKenzie River	334
McKenzie Hatchery	56
North Santiam River	147
Minto Pond	19
South Santiam River	186
South Santiam Hatchery	48
Middle Fork Willamette River	34
Willamette Hatchery	64
Fall Creek	17
Molalla River	5
Calapooia River	6
Clackamas River	159
Clackamas Hatchery	5
Sandy River	133
Sandy River broodstock	107

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 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. 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 (*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 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 were tagging fish during either trapping in the Leaburg bypass or seining 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.

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, North Santiam, and Middle Fork Willamette rivers in 2003 (Table 3). We continued to find high numbers of wild carcasses in the South Santiam River. The percentage of hatchery spring Chinook in the Clackamas River above North Fork Dam was lower in 2003 than in 2002 (Table 3) because more unclipped fish were scanned for presence of a coded wire tag to detect unclipped hatchery fish with coded wire tags (double-index groups). The percentage of no clip hatchery fish was highest in the lower reaches of the Clackamas River immediately above reservoir.

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). 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] Hatchery	Not fin clipped[a] Wild	Percent wild Weighted	Percent wild Not weighted
McKenzie (above Leaburg Dam)					
2001	62	50	265	70	69
2002	140	78	454	68	62
2003	130	44	351	67	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
2003	855	89	27	3	4
South Santiam (Foster–Waterloo)					
2002	1,604	37	224	12	12
2003	970	31	151	13	13
Middle Fk Willamette (Dexter–Jasper[d])					
2002	167	151	15	--	5
2003	62	48	4	--	4
Molalla (Copper Creek–Trout Creek)					
2002	94	5	3	3	2
2003	17	6	1	4	4
Clackamas (above North Fork Dam)					
2002	e	31	70	69	59
2003	5[e]	40	145	76	79
Sandy (above Marmot Dam)					
2002	3[e]	26	121	81	81
2003	9[e]	14	106	82	80

[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). Spring Chinook were more numerous in 2003 than in previous years. The number of wild fish in the McKenzie River increased 43% from 2002 to 2003, but because the number of hatchery fish increased almost 70%, the percentage of wild fish above Leaburg Dam decreased from previous years. Leaburg Canal, which supplies some water to McKenzie Hatchery, was kept at minimal flow because of construction, thus the water temperature was higher than normal and may have resulted in decreased attraction of returning adults to the hatchery. Wild fish also increased in the Clackamas River (Table 4). The number of wild fish in 2003 in the North Santiam River was less than half that in 2002 and the number of hatchery fish increased almost 80% (Table 4). In the Sandy River, wild fish decreased slightly and an additional 155 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 107 otoliths sampled from these fish, 94% 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	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
			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
			Clackamas			
2002	2,168	**d**	30.7	1,502	666	69
2003	3,338	**d**	21.6	2,617	721	78
			Sandy			
2002	1,159	**d**	17.7	954	205	82
2003	969	**d**	11.7	856	113	88

[a] *Adjusted by distribution of redds among survey areas.*
[b] *Escapement at Bennett Dam 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 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.

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.

	Number (% in run) of wild adults determined by—	
River, run year	Release data	Otolith analysis
McKenzie, 2001	3,365 (78%)	2,887 (67%)
McKenzie, 2002	4,016 (66%)	3,602 (59%)
McKenzie, 2003	5,337 (57%)	5,142 (55%)
North Santiam, 2001	0 (0%)	220 (3%)
North Santiam, 2002	874 (11%)	604 (8%)
North Santiam, 2003	485 (4%)	271 (2%)

The WDFW otolith laboratory correctly identified a high percentage of adult hatchery spring Chinook in the blind tests (Table 6), and identified 99% of known wild juvenile Chinook in a blind test conducted with wild and known juvenile hatchery Chinook.

Table 6. Accuracy of the WDFW otolith laboratory in identifying presence or absence of thermal marks in spring Chinook salmon (blind tests), 2003.

Marking location, stock	Number	Classified— Correctly	Incorrectly	Percent correct
McKenzie Hatchery				
McKenzie	23	23	0	100
Marion Forks Hatchery				
North Santiam	32	31	1	97
Willamette Hatchery				
Middle Fork Willamette	16	16	0	100
South Santiam	20	20	0	100
Clackamas[a]	19	18	1	95

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

The percentage of hatchery fish recovered in spawning surveys in the McKenzie River that strayed from their point of release was over 50% in 2004 and over 40% in 2003, compared to 42% in 2002 and 13% in 2001. However, most of these strays were from netpen and direct releases of McKenzie hatchery fish into the lower Willamette or Clackamas rivers. Stray hatchery fish in the North Santiam composed a higher percentage of the run in 2004 (64%) than in 2003 (37%), 2002 (30%), or 2001 (6%). In comparison, the percentage of stray hatchery fish in the South Santiam was lower in 2004 (25%) than in 2003 (43%), but both years were higher than that in 2002 (7%). The highest number of strays in these rivers was from netpen and direct releases into the lower Willamette River, followed by netpen and direct releases into the lower Clackamas River and releases into the Molalla River (Tables 7 and 8).

Table 7. Origin of release (from coded wire tags) for hatchery spring Chinook salmon recovered in spawning ground surveys, 2003.

River surveyed	n	Origin of release: Local	Netpen[a]	Lower Willamette[b]	Molalla[c]	North Santiam	South Santiam	McKenzie	Youngs Bay[e]	Washougal River
Middle Fork Willamette	1	1	0	0	0	0	0	0	0	0
McKenzie	21	12	1	7	0	1	0	--	0	0
Calapooia	2	0	0	0	0	0	2	0	0	0
S. Santiam	93	53	11	24	4	0	--	0	1	0
N. Santiam	46	29	2	8	4	--	1	1	1	0
Molalla	5	5	0	0	--	0	0	0	0	0
Clackamas	30	26	0	4	0	0	0	0	0	0
Sandy	4	1	0	0	0	0	1	0	0	2

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

Table 8. Origin of release (from coded wire tags) for hatchery spring Chinook salmon recovered in spawning ground surveys, 2004. Data are preliminary.

River surveyed	n	Origin of release: Local	Netpen[a]	Lower Willamette[b]	Molalla[c]	South Santiam
Middle Fork Willamette	5	5	0	0	0	0
McKenzie	19	9	2	7	0	1
S. Santiam	121	91	5	23	2	--
N. Santiam	28	10	1	9	5	3
Molalla	2	1	0	1	--	0
Clackamas	77	73	0	3	0	1

[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 and McKenzie stocks.*

TASK 1.3–DISTRIBUTION AND ABUNDANCE OF NATURAL SPAWNERS

We surveyed most of the major tributaries in the Willamette and Sandy basins in 2004 by boat and on foot to count spring Chinook salmon carcasses and redds. With the exception of the Clackamas and Sandy rivers, 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. In the Clackamas and Sandy rivers, we counted redds throughout the season and used the cumulative count of redds as the total number.

The North Santiam River was regularly surveyed June 17–October 14 to recover carcasses and count redds. Although the estimated number of Chinook salmon above upper and lower Bennett dams was the highest on record, the number of redds counted upstream was about half the number counted in 2003, and was similar to redds counted in 2000–2002 when counts were 20–60% that of the 2004 count. The fish/redd ratio upstream of Bennett dams was calculated using methods in Schroeder et al. (2003), and was much higher in 2004 (23.2) than the 2001–2003 average (8.8 fish/redd). In 2004, we found that 77% of the female carcasses recovered had not spawned (Table 9). Although these data suggest a low spawning success, the number of all dead salmon found through August as a percentage of the Bennett count through August was lower in 2004 than in 2003, and was probably similar or lower than in 2001 and 2002 when surveys began later (Table 10). Surveys in 2001 and 2002 likely underestimated pre-spawning mortality if mortality of Chinook salmon began in early summer, as in 2003 and 2004 (Table 9). As a percentage of the total Bennett count, the total number of carcasses recovered in 2004 (4.3%) was less than half the average of previous years

(9.8%). 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 would be completed spawners. Flow in the North Santiam at Mehama increased in late August and in mid September, and flow in the reach downstream of Minto Dam increased in early to mid September, which could have increased the difficulty in recovering carcasses. Increased flows also may have decreased the visibility of redds. More detailed data for the North Santiam are in Appendix Table C-1, and the pre-spawning mortality in 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, 1998 and 2001–2004.

Time period	2004	2003	2002	2001	1998
late Jun–Oct	77	72	--	--	--
early Aug–Oct	63	56	52	--	23
mid Aug–Oct	61	45	51	75	23
late Aug–Oct	53	21	36	71	19

Table 10. Summary of spring Chinook salmon counts and carcasses recovered through August, and water temperature and flow in August in the North Santiam River, 1998 and 2001–2004.

Year	Bennett count	Carcasses (% of Bennett count)	Start date (surveys)	Temperature (°C)[a]	Mean daily flow (cfs)
1998	2,122	17 (0.8)	Aug 6 (2)	--	1,046
2001	6,726	113 (1.6)	Aug 14 (5)	18.9	930
2002	7,669	210 (2.7)	Aug 1 (8)	15.5	993
2003	12,437	841 (6.8)	Jun 18 (14)	15.4	881
2004	13,780[b]	353 (2.6)	Jun 17 (4)	16.1	1,242

[a] *Mean daily maximum.*
[b] *Estimated count. Trapping at upper Bennett Dam ended July 16, prior to the end of the spring Chinook migration. Count is estimated from timing of the 2003 run, which had similar timing and a similar number of fish through mid July as the 2004 run.*

Redd digging was first observed on August 27 and peak spawning occurred in late September, similar to previous years. The redd density in 2004 was highest in the section immediately below Minto dam (Table 11), and was similar to the 1999–2002 average (18.2 redds/mi), but was much lower than in 2003. Of the carcasses we recovered in the North Santiam in 2004, 82% had fin clips (Table 12), similar to the 2001–2003 average.

Table 11. Summary of spawning surveys for spring Chinook salmon in the North Santiam River, 2004, and comparison to redd densities in 1996–2003. Spawning in areas below Stayton may include some fall Chinook.

Survey section	Length (mi)	Counts		Redds/mi								
		Carcass	Redd	2004	2003	2002	2001	2000	1999	1998	1997	1996
Minto–Fishermen's Bend	10.0	204	177	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	71	18	2.8	6.5	9.4	5.7	5.8	3.1	4.3	2.5	3.5
Mehama–Stayton Is.	7.0	101	88	12.6	4.7	6.1	10.0	**b**	--	0.6	0.9	1.0
Stayton Is.–Stayton	3.3	30	26	7.9	3.6	3.0	6.7	**b**	--	10.0	3.6	2.0
Stayton–Greens Bridge	13.7	50	3	0.2	0.1	0.4	0.1	--	0.0	0.4	1.1	0.1
Greens Br.–mouth	3.0	1	0	0.0	1.7	4.7	--	--	--	4.7	9.7	--
Little North Santiam	17.0	15	51	3.0[e]	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 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.*

Table 12. Composition of naturally spawning spring Chinook salmon from carcasses recovered in the North Santiam River above Stayton Island, 2004.

Section	No fin clip[a]	Fin clipped
Minto–Fishermen's Bend	22	184
Fishermen's Bend–Mehama	13	56
Mehama–Stayton Island	25	80
Little North Fork Santiam	12	3
Total	72	323

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

The McKenzie River was regularly surveyed August 18–October 12 to recover carcasses and count redds. A redd was counted in August but active redd building began in early September, similar to previous years. Peak spawning occurred in late September to early October. The total number of redds was slightly lower in 2004 (1,129) than in 2003 (1,187) but was higher than in 2002 (845). Redd densities in 2004 were highest in the South Fork McKenzie, upper McKenzie, and in the Forest Glen–Rosboro Bridge section (Table 13). In 2004, 67% of all redds occurred in the upper basin above Forest Glen (including South Fork McKenzie) compared to 62% in 2002 and 2003 (Figure 1). The percentage of redds below Leaburg Dam decreased from 14% in 2002–2003 to 9% in 2004.

Table 13. Summary of Chinook salmon spawning surveys in the McKenzie River, 2004, and comparison to redd densities (redds/mi, except redds/100 ft for spawning channel) in 1996–1998 and 2000–2003.

Survey section	Length (mi)	Carcass	Redds	Redds/mi[a]							
				2004	2003	2002	2001	2000	1998	1997	1996
McKenzie River:											
Spawning channel	0.1	52	93	18.6	7.2	15.4	--	--	--	1.0	2.6
Olallie–McKenzie Trail	10.3	62	228	22.1	24.7	16.3	17.7	5.6	--	11.4	7.0
McKenzie Trail–Hamlin	9.9	29	93	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	19.2	16.7	0.8	2.1	--	--	0.8
Forest Glen–Rosboro Br.	5.7	110	206	36.1	26.8	14.9	13.2	5.8	--	--	6.1
Rosboro Br.–Ben and Kay	6.5	26	67	10.3	7.4	16.2	6.3	3.2	--	--	4.9
Ben and Kay–Leaburg Lake	5.9	2	--	--	12.0	2.9	3.2	--	--	--	1.8
South Fork McKenzie:											
Cougar Dam–Road 19 Br.	2.3	94	113	49.1	31.7	36.5	--	--	--	--	--
Road 19 bridge–mouth	2.1	9	29	13.8	5.7	11.4	8.1	7.6	--	--	2.9
Horse Creek:											
Pothole Cr.–Separation Cr.	2.8	0	15	5.4	18.6	--	--	--	--	--	--
Separation Cr.–mouth	10.7	80	110	10.3	13.6	12.1	7.4	--	--	--	5.3
Lost Creek:											
Spring–Limberlost	2.8	0	18	6.4	9.3	--	--	--	--	--	--
Limberlost–Hwy 126	2.0	3	27	13.5	21.0	--	--	--	--	--	--
Hwy 126–mouth	0.5	0	2	4.0	30.0	32.0	--	--	--	--	--
McKenzie River:											
Leaburg Dam–Leaburg Landing	6.0	57	99	16.5	28.5	19.2	12.3	--	15.3	19.8	10.3

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

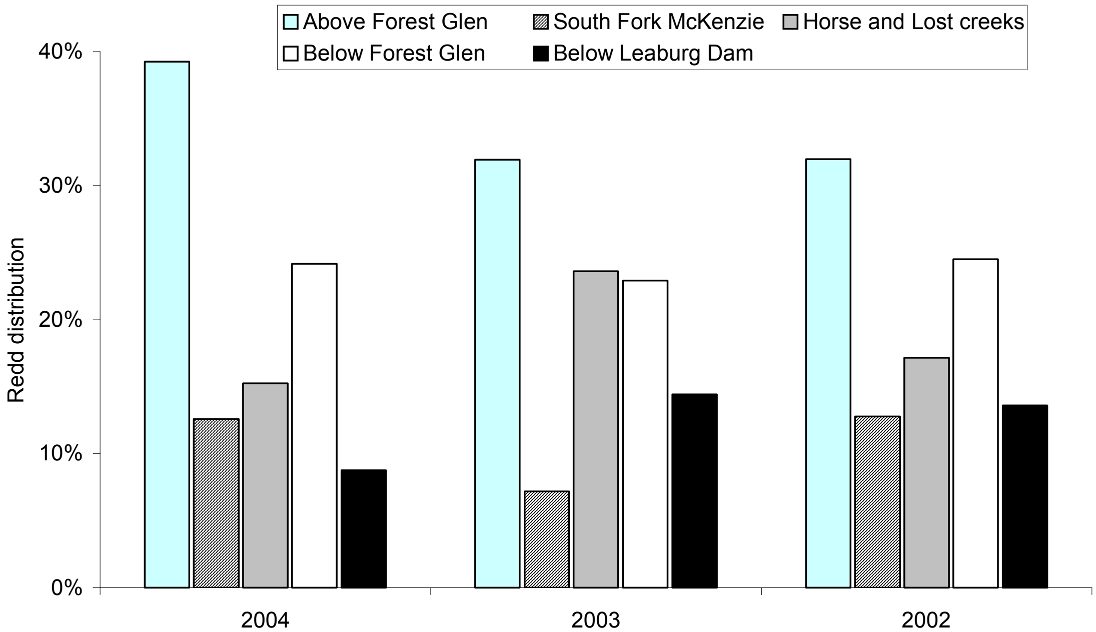

Figure 1. Distribution of spring Chinook salmon redds in the McKenzie River basin, 2002–2004.

We estimated fish/redd ratios for the McKenzie River basin upstream of Leaburg Dam from counts of spring Chinook at the dam and redds upstream. The ratio was slightly lower in 2004 (8.8) than in 2003 (9.2) and was slightly higher than in 2002 (8.3). Spring Chinook salmon are known to fall back after passing the dam and most of these are clipped fish (M. Hogansen, ODFW, personal communication), but it is not known how many remain downstream of the dam or ascend the fishway multiple times. The dam counts are from video tapes and therefore likely overestimate the number of fish upstream of the dam. A trap was operated during a portion of the migration in 2002–2003 and 26% of the clipped fish were removed and transported 2.5 mi downstream to McKenzie Hatchery. Because of construction at the dam in 2004, the trap was operated very briefly and just 9 clipped fish were removed. However, the percentage of fin-clipped carcasses above Leaburg Dam (Table 14) was similar in 2004 (34%) and 2003 (32%), which was higher than in 2002 (24%) or 2001 (19%). A higher percentage of carcasses below Leaburg Dam were fin-clipped in 2004 (85%) than in 2001– 2003 (70%).

Table 14. Composition of naturally spawning spring Chinook salmon from carcasses recovered in the McKenzie River, 2004.

Section	No fin clip[a]	Fin clipped
McKenzie spawning channel	50	2
Olallie–Forest Glen	88	10
Forest Glen–Leaburg Lake	58	80
S Fork McKenzie	39	64
Horse Creek	75	5
Lost Creek	3	0
Total above Leaburg	313	161
Below Leaburg	9	52

[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 19–October 20 to recover carcasses and count redds (Table 15). Peak spawning generally occurred in late September to early October. A higher percentage of redds was counted in the Collawash and Roaring rivers and in Fish Creek in 2004 than in 2002–2003, and fewer redds were counted in the Clackamas River. The count of adult Chinook passed at North Fork Dam was higher in 2004 than in previous years and our redd counts increased substantially. We accounted for a higher percentage of the run in our surveys in 2004 (40%) than in 2002–2003 (27%), although it was lower than in 1996–1999 (53%) (Table 16). Because we felt that redds were underestimated in 2003, we changed our survey technique to count redds throughout the season rather than once or twice near peak spawning. A higher percentage of the spring Chinook run in the upper Clackamas River passed North Fork Dam in May–July in 2003 and 2004 (75%) than in 1996–2002 (39%), which might increase the possibility of pre-spawning mortality in the early portion of the run. However, in 2004 only 9% of the female carcasses we processed above North Fork Dam died before spawning compared to 27% in 2003. Rainfall in August and September increased flows in the basin and allowed broad distribution of adult spring Chinook, especially into tributaries.

Although fall Chinook may be present below River Mill Dam, 72% 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.

Table 15. Summary of spawning surveys for spring Chinook salmon in the Clackamas River basin, 2004, and comparison to redd densities in 1996–1999 and 2002–2003.

Survey section	Length (mi)	Counts: Carcass	Counts: Redd	Redds/mi: 2004	2003	2002	1999	1998	1997	1996
Clackamas River:										
Sisi Creek–Forest Rd 4650	9.1	20	172	18.9	9.8	5.4	3.2	9.6	7.5	3.2
Forest Rd 4650–Collawash R.	8.0	7	106	13.2	5.5	4.8	4.1	7.0	5.9	4.1
Collawash R–Cripple Cr.	8.5	57	265	31.2	10.7	7.2	4.2	11.4	7.3	6.1
Cripple Cr.–South Fork	14.5	72	247	17.0	4.2	10.2	4.3	5.2	7.4	3.2
South Fork–Reservoir	1.0	11	42	42.0	10.0	15.0	1.0	7.0	17.0	--
South Fork Clackamas:										
Falls–mouth	0.6	59	57	95.0	18.3	70.0	16.7	5.0	11.7	--
Collawash River:										
Forest Rd 63–Hot Sprs. Fork	2.0	12	5	2.5	2.5	--	--	6.0	11.0	1.0
Hot Sprs. Fork–mouth	4.5	27	55	12.2	4.9	1.6	1.1	6.4	4.9	2.2
Fish Creek:										
Forest Rd 5430–mouth	4.5	13	54	12.0	0.7	0.4	--	1.7	2.6	1.1
Roaring River:										
Falls–mouth	2.0	3	21	10.5	1.5	2.5	--	1.5	3.0	3.0
North Fork Clackamas:										
Mouth area	0.2	2	4	20.0	15.0	15.0	--	0.0	0.0	0.0
Below Faraday Dam:										
Free-flowing stretch	1.5	7	44	29.3	0.7	0.0	--	--	--	--
Below River Mill Dam:										
McIver–Barton[a]	9.5	242[b]	c	--	11.5	6.5	3.9	3.4	--	--
Barton–mouth	13.5	60[b]	c	--	0.6	0.3	0.3	1.2	--	--

[a] *24 additional carcasses were processed in the 0.3 mi River Mill Dam–McIver section.*
[b] *Some fall Chinook salmon could spawn in this area.*
[c] *Redds were not counted in 2004.*

Table 16. Counts of adult spring Chinook salmon above North Fork Dam and the relationship to successful spawners above the dam, 1996–1999, 2002–2004.

Year	Counts: North Fork Dam[a]	Counts: Total Redds	Counts: 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

[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 18–October 21 to recover carcasses and count redds (Table 17). Peak spawning generally occurred in late September, similar to other years. Distribution of redds in 2004 was similar to the 1996–1998 distribution, with about 75% of redds occurring in the Salmon River and 13% in Still Creek. In 2002 and 2003, 67% of the redds occurred in the Salmon River and almost 20% were in Still Creek. We accounted for a higher percentage of the spring Chinook salmon run over Marmot Dam in 2004 (64%) than in 2002–2003 (42%) (Table 18). The change in survey technique from peak redd counts to cumulative redd counts may have resulted in more redds being counted. Additional surveyors were provided by the U.S. Forest Service, which increased the frequency of redd surveys. In addition, rainfall in August and September increased flow in the basin, which may have increased survival.

We surveyed the Sandy River below Marmot Dam several times in 2004 from August 24 to October 12 and counted 292 redds (Table 17). Most of the Chinook salmon were clipped (67%).

Table 17. Summary of spawning surveys for spring Chinook salmon in the Sandy River basin, 2004, and comparisons to redd densities in 1996–1999, 2002–2003.

	Length	Counts		Redds/mi						
Section	(mi)	Carcass	Redd	2004	2003	2002	1999	1998	1997	1996
Salmon River:										
Final Falls–Forest Rd 2618[a]	3.2	47	233	72.8	18.8	16.6	19.1	66.6	57.8	39.7
Forest Rd 2618–Bridge St.	3.6	5	57	15.8	3.1	9.2	9.4	15.3	12.2	19.7
Bridge St.–Highway 26	6.2	96	310	50.0	8.4	15.3	20.0	52.3	45.2	41.5
Still Creek:										
Cool Creek– mouth	3.3	60	108	32.7	8.5	18.8	10.0	27.9	33.3	19.4
Zigzag River:										
Camp Creek– mouth	4.0	8	54	13.5	6.0	3.8	--	2.5	18.8	--
Lost Creek:										
Riley Campground–mouth	2.0	1	20	10.0	3.5	3.0	--	6.5	4.0	6.0
Camp Creek:										
Campground–mouth	2.0	0	19	9.5	0.0	0.5	--	4.5	6.0	3.0
Clear Fork Creek:										
Barrier–mouth	0.6	0	0	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	2.0
Sandy River:										
Marmot Dam–Revenue Br.	6.2	52	186	30.0	14.2	--	--	--	--	--
Revenue Br.–Oxbow Park	11.9	18	106	8.9	8.0	--	--	--	--	--

[a] *Includes 3 redds at mouth of South Fork Salmon River.*
[b] *38 additional clipped hatchery 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, 2002–2004.

Year	Counts				Fish:redd[d]
	Marmot Dam[a]	Harvest[b]	Total Redds	Spawners[c]	
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

[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 2004 (Table 19) were South Santiam (10 dates, 20 July–11 October) and Middle Fork Willamette (3 dates, 24 August–16 September). Active redd building began in late August in the South Santiam and early September in the Middle Fork Willamette. Peak spawning in both rivers was mid to late September. Generally, fewer redds were counted in both rivers in 2004 than in 2002 and 2003, although the number of redds in Fall Creek in 2004 was similar to 2002. The Santiam and Molalla rivers were surveyed once in 2004 (Table 19).

Table 19. Summary of Chinook salmon spawning surveys in the Middle Fork Willamette, South Santiam, Santiam, and Molalla rivers, 2004.

River, section	Length (mi)	Carcasses: No fin clip[a]	Carcasses: Fin clipped	Redds	Redds/mi: 2004	Redds/mi: 2003	Redds/mi: 2002	Redds/mi: 1998
Middle Fk Willamette								
Dexter–Jasper	9.0	29	110	9	1.0	1.5	7.1	1.1
Fall Creek (above reservoir)	13.3	16	8	172	12.9	6.1	12.9	--
South Santiam								
Foster–Pleasant Valley	4.5	73	535	338	75.1	132.0	194.4	36.0
Pleasant Valley–Waterloo	10.5	41	304	35	3.3	1.5	1.8	1.8
Lebanon–mouth	20.0	0	4	4	0.2	1.0	3.4	2.9
Santiam								
Confluence–I-5 bridge	5.0	--	--	16	3.2	2.2	10.2	4.2
I-5 bridge–mouth	6.0	--	--	13	2.2	1.2	7.7	3.2
Molalla								
Haybarn Cr–Trout Cr[b]	16.1	4	4	44	2.7	1.3	3.2	--

[a] *Otoliths have not yet been read to determine the proportion of wild and hatchery fish.*
[b] *Length surveyed in 2003 and 2002 was 11.5 mi and 16.3 mi, respectively.*

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 paper describing this study and titled "Hooking Mortality by Anatomical Location and its Use in Estimating Mortality of Spring Chinook Salmon Caught and Released in a River Sport Fishery" was published in the May 2004 issue of the North American Journal of Fisheries Management in (Lindsay et al. 2004).

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

Acclimation of hatchery spring Chinook salmon at sites below Willamette Falls 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 1996–1998 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 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). 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 1996–1998 broods are shown in Tables 20–22. 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 1996–1998 brood tag recoveries to date, several tentative conclusions can be reached. First, the conclusion in Schroeder et al. 2002 that smolt releases into the lower Willamette River (Multnomah Channel) generally do not increase sport catch appears to be holding true through 1998 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. However, preliminary returns from the 1998 brood showed a higher catch for the fall release group that was acclimated in Multnomah Channel. Second, fish released into the lower Willamette River tended to stray into the Clackamas and most other spawning tributaries. Third, based on recoveries at hatcheries, fish released into Clackamette Cove returned mainly to the Clackamas River. Finally, 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, although preliminary returns from the 1998 brood showed roughly equal catch of the acclimated and direct river releases. In general, the acclimated release in the Cove contributed equally or more to the sport fishery than did returns from control groups released at McKenzie Hatchery.

Table 20. 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 2004.

		Smolts released into Multnomah Channel in—			Smolts released in spring into—		
		Fall		Spring	Clackamas Cove		Clackamas River
Capture location	McKenzie 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

Table 21. 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, November 2004. 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	33	0	0	12	21	0	0
Columbia River	111	22	36	5	72	7	13
Willamette basin							
below the falls	87	22	11	21	72	12	15
(% in Clackamas River)	(0)	(0)	(0)	(0)	(51)	(0)	(100)
Hatcheries:							
McKenzie	469	5	0	0	0	0	4
Clackamas	0	0	4	4	17	1	0
Other	0	0	13	0	1	0	1
Spawning areas:							
McKenzie River	9	0	0	0	0	0	0
Clackamas River	0	0	0	0	1	0	0
Other	0	2	4	0	3	0	0
Leaburg Dam	5	0	0	0	0	0	0

Table 22. 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, November 2004. 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	129	183
Columbia River	172	140	59	37	283	104	208
Willamette basin							
below the falls	251	445	89	31	676	229	688
(% in Clackamas River)	(0)	(6)	(0)	(0)	(33)	(35)	(9)
Hatcheries:							
McKenzie	831	37	28	16	0	4	19
Clackamas	2	18	12	1	222	113	101
Other	2	20	12	8	3	4	11
Spawning areas:							
McKenzie River	18	8	7	1	0	0	3
Clackamas River	0	0	2	0	7	4	6
Other	0	19	6	11	4	6	18
Other	0	2[a]	0	0	1[a]	0	4[b]

[a] *Mortalities found below Willamette Falls.*
[b] *3 mortalities below Willamette Falls and 1 reported in Umatilla River.*

TASK 3.4– INCORPORATING WILD FISH INTO HATCHERY BROODSTOCKS

Otoliths were collected in 2003 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 23).

Table 23. 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, 2003.

	No clip		Clipped	Percent wild
Hatchery	Wild	Hatchery	hatchery	in broodstock
McKenzie	14	42	953	1.4
North Santiam (Minto)	2	17	599	0.3
South Santiam	25	23	1,048	2.3
Willamette	5	59	1,465	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

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 2002–2004, our work expanded into the lower Willamette River and in the Santiam River basin where juvenile fall Chinook salmon may be present.

Methods

We used PIT tags (Prentice et al. 1990a, 1990b) to monitor migration of juvenile spring Chinook salmon in the McKenzie, Willamette, and Santiam 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 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 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 tag migrants in 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 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). Tags also were detected and reported by the NOAA Fisheries during their juvenile salmonid studies in the Columbia River estuary (Ledgerwood et al. 2000).

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. Additional methods are in Schroeder et al. (2003).

Results

We tagged 3,817 wild spring Chinook salmon in the McKenzie and Willamette rivers, 1,008 hatchery fish from McKenzie Hatchery, and 2,741 wild Chinook salmon in the lower Willamette and Santiam rivers in May 2003–March 2004 (Table 24). In addition, we tagged over 2,800 age 0 wild Chinook salmon in the lower McKenzie and upper Willamette rivers, and over 1,000 in the lower Willamette River and Santiam basin in spring and summer 2004 (Table 25).

Most of the detections of fish tagged in May 2003–March 2004 occurred at Willamette Falls (Table 24). Detection rates at Willamette Falls were generally high in 2003–2004 (Table 26) because most of the fish were tagged and migrated in the late spring and early summer. 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.

Table 24. Detection of juvenile wild and hatchery spring Chinook salmon given PIT tags and released in June 2003–April 2004. Tags were detected at the PGE Sullivan Plant at Willamette Falls unless noted.

	McKenzie R.	U. Willamette R.	L. Willamette R.	Santiam R.	S. Santiam R.	N. Santiam R.	McKenzie Hatchery
	Jun 10–Jul 1, 2003 (1,949)	Jun 4 –Jul 16, 2003 (1,868)	May 28–Jun 25, 2003 (733)	Jun 20–Jul 22, 2003 (712)	Jun 3–24, 2003 (330)	Jun 5–19, 2003 (966)	Mar 3, 2004 (1,008)
Month tag detected:							
May	0	0	2	0	0	0	--
June	6	26[a]	31[b]	22[c]	31[d]	108	--
July	0	4	2	0	2	4	--
August	0	0	0	0	0	0	
September	0	0	0	0	0	0	--
October	0	0	0	1	0	1	--
November	4	1	0	0	1	2	--
December	0	0	0	0	0	0	--
January	0	0	0	0	0	0	--
February	0	0	0	0	0	0	--
March	1	0	0	0	1	1	12
April	2[e]	0	0	0	0	0	9
May	0	0	0	0	0	0	0
June	0	0	0	0	0	0	0
Detection rate at Willamette Falls (%)	0.7	1.7	4.8	11.9	10.6	12.0	2.1
95% CI	0.3–1.0	1.1–2.2	3.2–6.3	7.4–16.5	7.3–13.9	10.1–14.1	1.2–3.0
Median days to Willamette Falls	146	10	6	7	17	15	27
Mean length (mm) at time of tagging for—							
Fish released	78.6	85.1	94.9	90.1	86.2	90.7	156.7
Fish detected	85.8	91.4	96.1	96.9	92.2	94.8	137.6

[a] *Includes one fish detected in Columbia River estuary (rm 47).*
[b] *Includes one fish detected in Columbia River estuary; does not include one estuary detection detected at Willamette Falls 15 days earlier.*
[c] *Does not include one fish detected in estuary that was also detected at Willamette Falls 6 days earlier.*
[d] *Includes two fish detected in Columbia River estuary.*
[e] *Does not include one fish detected in estuary that was also detected at Willamette Falls 4 days earlier.*

Table 25. 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 (rm 21), in the Willamette River above and below the Santiam River, and in the Santiam River watershed, 2002 (June–July), 2003 (late May–mid July), and 2004 (mid May–mid July).

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

[a] *Does not include 52 hatchery fish that were tagged.*
[b] *From confluence of North and South Santiam to mouth.*

Table 26. Detection rate (%) at Willamette Falls of spring Chinook salmon that were PIT-tagged and released in Willamette River basin in October 1999–March 2004.

	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
2003–2004	0.7	1.7	4.8	11.6	--	--	--	2.1

A higher percentage of wild Chinook salmon tagged in the lower McKenzie and Santiam rivers as age 0 fish in summer 2003 migrated that summer compared to those tagged in 2002 (Figure 2). We began tagging fish two to four weeks earlier in 2003 (starting dates: May 28–June 10) than in 2002 (June 18–July 8). 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 2). The migration time for fish tagged in October 1999–March 2004 is presented in Table 27.

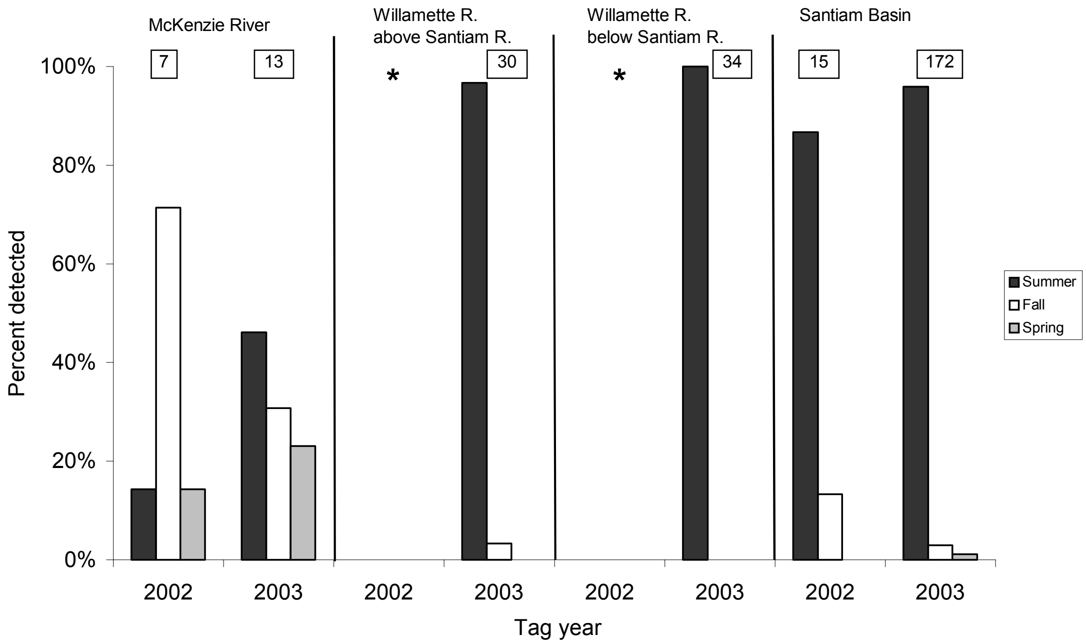

Figure 2. Migration timing of juvenile spring Chinook salmon past Willamette Falls, summer 2002–spring 2004. Based on detection of fish given PIT tags in the McKenzie, Willamette, and Santiam rivers in 2002 and 2003. Number of tag detections is given in boxes above the bars; asterisks indicate detection of < 5 fish.

Table 27. Travel time (median days) to Willamette Falls of juvenile Chinook salmon tagged and released in the Willamette River basin in October 1999–March 2004. 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)
2003–2004	146 (13)	10 (30)	6 (34)	15 (172)	--	--	--	27 (21)

The mean fork length of wild Chinook salmon tagged in summer 2003 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 (Table 24). In contrast, the mean length of the hatchery fish that were detected at the falls was significantly smaller than the mean length of all hatchery fish that were tagged.

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 was lower in 2004 than in 2003 (Table 28). As in 2003, 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 in 2004 (Table 29). The percentage and time of migration was highest for juvenile Chinook tagged in the lower Santiam River (Table 29), possibly because these are composed of a higher number of fall Chinook than in other areas (Schroeder et al. 2003). NOAA Fisheries reported detections of 10 age 0 fish that had been tagged and released in the Willamette and Santiam rivers (Table 30). Based on efficiency estimates of the trawl sampler (R.D. Ledgerwood, NOAA Fisheries, personal communication), we estimated that 20–50% of the age 0 Chinook we tagged and released in the Willamette and lower Santiam rivers migrated to the estuary with an average travel rate of 13 mi/d (Table 30). Age 0 Chinook tagged and released in the North and South Santiam and McKenzie rivers were not detected in the trawl.

Table 28. Catch rate with a beach seine (fish/seine set) of juvenile Chinook salmon in the Willamette, McKenzie, and Santiam rivers, 2000–2004.

	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

Table 29. 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–June 7, 2004, and detected in the PGE bypass detector at Willamette Falls in late May–June 14, 2004. The PGE Sullivan Plant was shut down on June 14.

Location	Number tagged	Percent detected	Median days to Willamette Falls
McKenzie River	270	1.1	17.0
Willamette River:			
Above Santiam R.	452	4.9	8.5
Below Santiam R.	343	2.6	9.0
Santiam River:			
Mouth to confluence	224	7.6	6.0

Table 30. Detections of subyearling spring Chinook salmon in Lower Columbia River trawl samples (rm 47) that were PIT-tagged and released in the Willamette and Santiam rivers, 2004.

River, general location	Number Tagged	Number Detected	Migration rate (mi/day)
L. Willamette, Salem	370	2	9.1
U. Willamette, Corvallis	911	5	13.9
Santiam, below I-5 bridge	224	3	14.3

The mean length of spring Chinook salmon in the McKenzie River increased from spring to early summer in 2004 (Figure 3). In general, the mean length of subyearling spring Chinook in the McKenzie River was greater in 2000 and 2001 than in 2002–2004 (Figure 4). In addition, the mean length of fish sampled in late June was greater in 2003 than in 2004, but was not significantly different in the May or mid July samples. In the upper Willamette River (above Harrisburg), the mean length of subyearling spring Chinook was greater in 2001 than in 2002–2004, and fish sampled in 2004 were generally smaller than in previous years (Figure 4). In contrast to the McKenzie and upper Willamette samples, subyearling spring Chinook seined in the Willamette River downstream of Harrisburg showed an increase in length from 2003 to 2004, with the exception of fish sampled in the Willamette River downstream of the Santiam River in late June (Figure 5). These differences may reflect real differences in growth between years, but other factors such as the number and size of fish migrating into and out of the sample areas may affect the size of fish we sampled. Additional data collected during field activities are in Appendix Tables D-1–D-4.

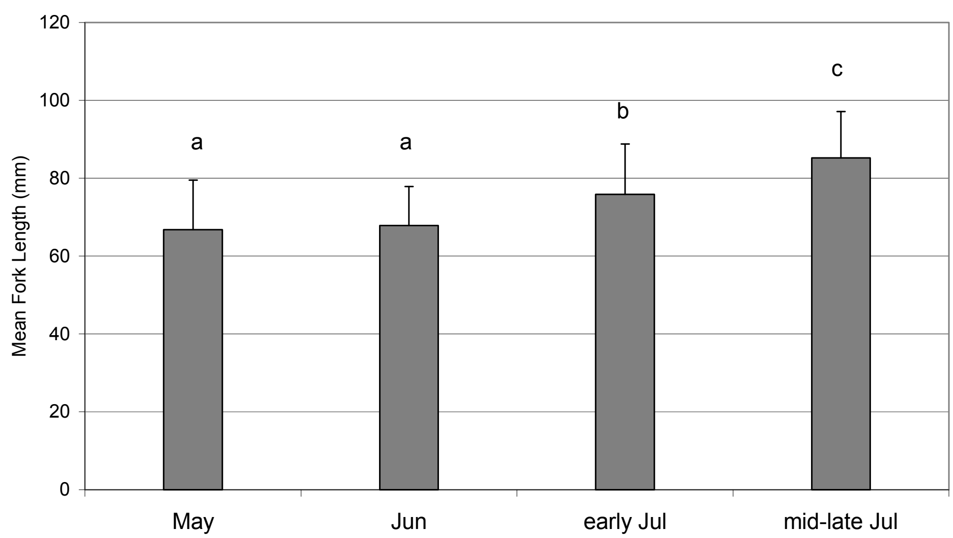

Figure 3. Mean fork length (± SD) of juvenile Chinook salmon that were seined in the McKenzie Rivers, 2004. Columns with different letters are significantly different (P < 0.05).

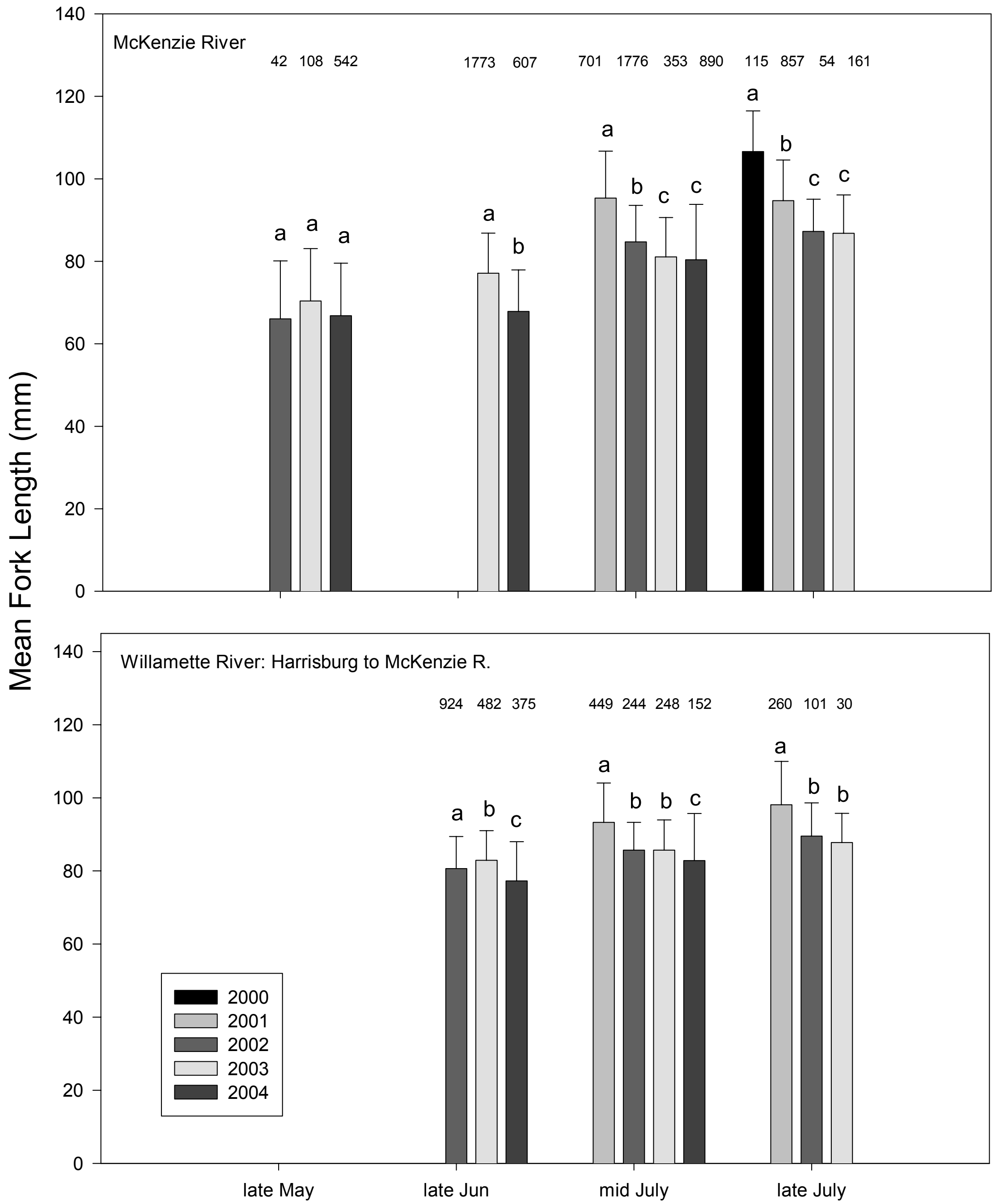

Figure 4. Mean fork length (± SD) of juvenile Chinook salmon that were seined in similar locations and times of year in the McKenzie and Willamette rivers, 2000–2004. Columns with different letters within areas and times of year are significantly different (*P* < 0.05). Numbers above the bars are sample sizes.

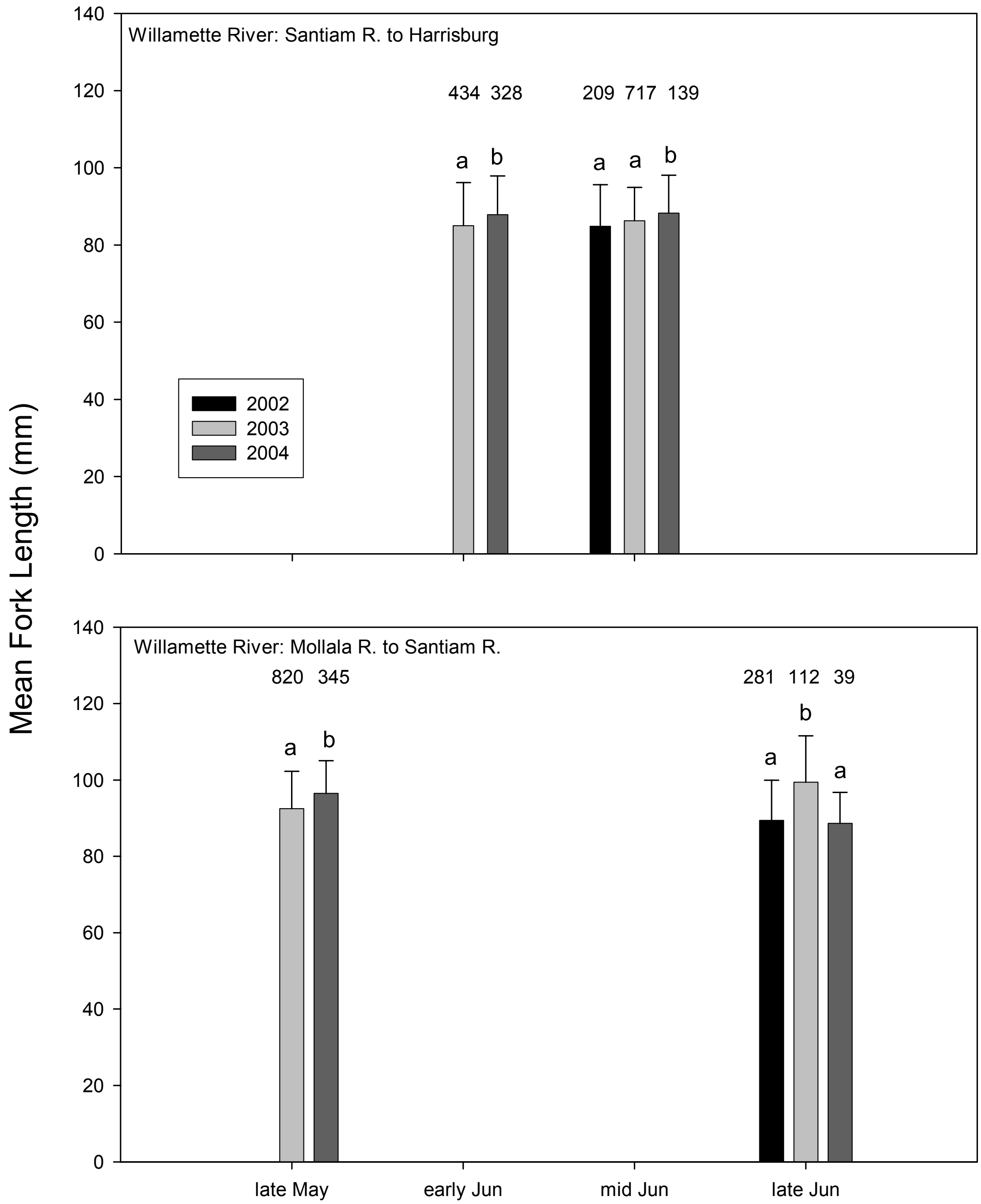

Figure 5. Mean fork length (± SD) of juvenile Chinook salmon that were seined in similar locations and times of year in the Willamette River downstream of Harrisburg, 2000–2004. Columns with different letters within areas and times of year are significantly different ($P < 0.05$). Numbers above the bars are sample sizes.

Life Histories—Scales

In some of our previous reports we used scales to classify adult Chinook salmon as spring or fall race based on the assumption that most spring Chinook were age 1 (yearling) smolts and most fall Chinook were age 0 (subyearling) smolts (e.g., Lindsay et al. 1998). 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 unclipped adult Chinook recovered in spawning areas. We used otoliths to identify and exclude scales collected from unclipped hatchery fish. Scales were analyzed to determine the freshwater age of smolts and the total age of adults in some years (Appendix Tables D-5–D-9).

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, and the percentage of 0-age Chinook in the adult returns varied between years (Figure 6). We will analyze 0-age life history by brood year when all scales have been read to determine the total age of adult fish.

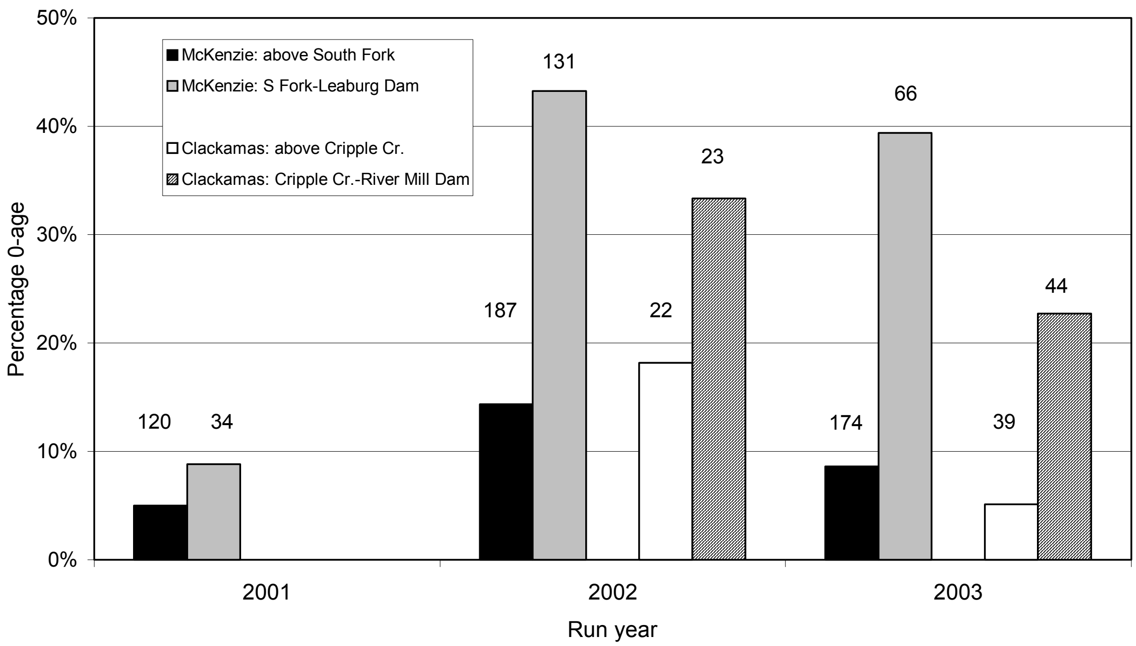

Figure 6. Percentage of the adult spring Chinook recovered in spawning areas in the Clackamas and McKenzie rivers upstream of hatcheries that had a 0-age life history, 2001–2003 run years. Numbers above bars are sample sizes.

The percentage of subyearling smolts in adult Chinook recovered in 2002 and 2003 varied between basins and between years (Table 31). Chinook in the South and North Santiam basins showed the highest percentage of 0-age life history. Future work may include genetic analysis to determine if fall Chinook or past introgression of fall Chinook might explain the high percentage of subyearling smolts.

Table 31. 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.

	Run year	
Basin	2002	2003
Middle Fork Willamette	5.6 (18)	
McKenzie	26.0 (339)	17.3 (243)
South Santiam	79.6 (186)	90.7 (140)
North Santiam	52.4 (42)	40.0 (35)
Clackamas	32.3 (62)	14.5 (83)
Sandy	6.8 (73)	

Winter Habitat Use by Juvenile Chinook

Floodplain

A Benton County farmer contacted us in March 2004 because he had seen juvenile salmon in a pool above a water control dam on his floodplain land. The Kenagy farm is adjacent to the Willamette River in Benton County 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 (Appendix Figure D-1). We installed two traps in the drainage channel: one in the upper channel at a water control dam where a notched stoplog concentrated the overflow, and the other in the lower channel where water flowed over a farm road. Trapping began in mid March and extended through mid May. The lower trap was operated for two weeks before water stopped flowing over the road. Another trap was installed at the same site for a week in mid May to sample the channel downstream of the road culvert. On May 18 and June 17, we used a ¼” mesh seine to sample a pond immediately upstream of the road culvert.

We captured 56 Chinook fry in the upper trap and 7 fry in the lower trap, along with 11 other fish species (Appendix Tables D-10 and D-11). We seined 47 Chinook fry in the pond on May 18 and released them into the drainage channel downstream of the road culvert. No Chinook were captured in the pond on June 17 when water temperature was very high and the water level in the pond was very low. The Willamette River flooded into the drainage channel on two occasions between May 18 and June 17, which could have allowed Chinook to evacuate the pond.

Although sample sizes are small, Chinook fry migrating out of floodplain ponds showed a continued increase in length from mid March to late April (Figure 7), with their average fork length increasing 35 mm in 44 days. The mean length of fish seined in the lower floodplain pond in mid May was slightly lower than that of fish captured in the drainage channels in late April or mid May (Figure 7). Water temperature varied diurnally and weekly during the time we sampled fish (Appendix Figure D-2), and the maximum temperature never exceeded 65°F (Appendix Table D-12).

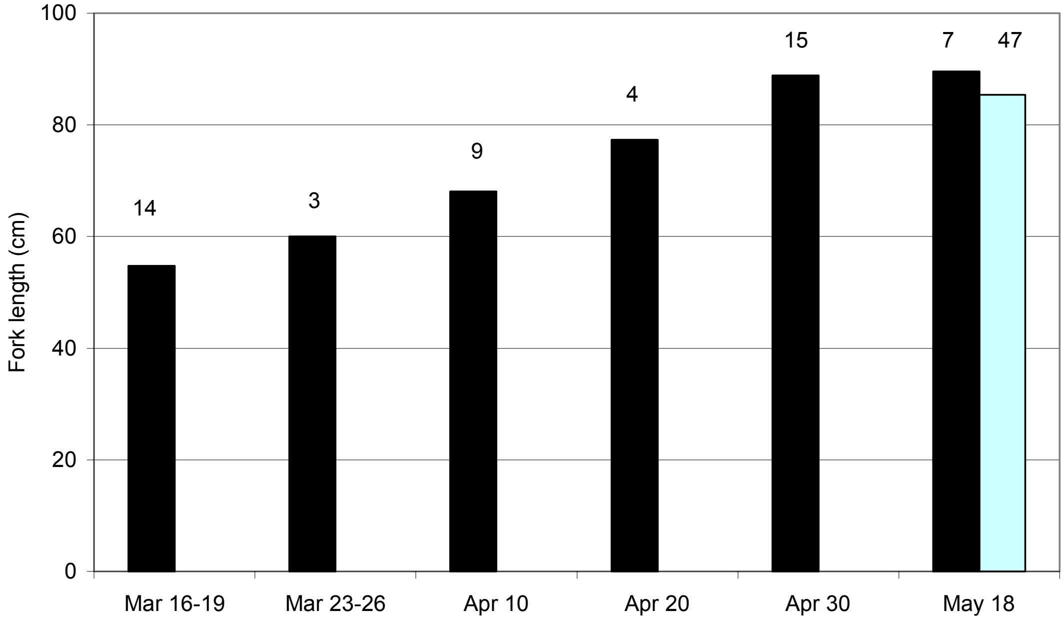

Figure 7. Mean fork length (cm) of Chinook fry captured by traps in drainage channels (solid) or by seine in a floodplain pond (shaded) of the Kenagy farm, 2004. Numbers above the bars are sample sizes.

Non-natal Tributaries

We compiled information on the capture of juvenile Chinook salmon in mid Willamette Valley tributaries where adult salmon are not known to spawn. Most of these tributaries drain the Coast Range from the west. Information on use of non-natal tributaries by juvenile salmon came from sampling records of ODFW District biologists, who were sampling for cutthroat trout. Sampling was primarily by traps, with limited sampling by electrofishing.

Some juvenile Chinook were encountered from October to April in most of the tributaries that were sampled. Most of the fish were in the size range of yearling Chinook (>90 mm), but a few fry were also captured (Table 32). Some of the juvenile Chinook were captured 7–20 mi from the Willamette River (Table 33). If these fish migrated during a flood event that inundated the lower reaches of tributaries, the actual distance they would have had to migrate upstream in the tributary may have been reduced. However, the distances these fish were found from the Willamette indicate juvenile Chinook do make a directed upstream migration into non-natal tributaries during the fall and winter. Additional data are in Appendix Table D-13.

Table 32. Number and fork length of juvenile Chinook salmon captured in tributaries where adult salmon are not known to spawn (non-natal tributaries), 1995–2004. Data are compiled from records of ODFW District biologists during sampling for cutthroat trout.

		Fry		Juvenile	
Stream	Date(s)	Number	Length	Number[a]	Length
North Yamhill	Mar 1996	5	60–70	4	90–150
McCall[b]	Mar 1997	2	52, 54	2	128, 138
Rickreall Cr.	Nov 1995, 1996			15 (2)	123–150
Rickreall Cr.	Feb–Mar 1996, 1997			7 (2)	134–175
Ash Cr.	Mar 1999	2	58, 61	1	134
Ash Cr.	2000			19	**c**
Cox Cr.	Dec 2000			1	100
Cox Cr.	Jan–Feb 2002			4	95–133
Periwinkle Cr.	Dec 2000			1	110
Periwinkle Cr.	Jan–Feb 2002			5 (4)	90–120
Periwinkle Cr.	Mar 2004	3	40–45		
Frazier Cr.	Jan–Apr 1999	5	60–85	13 (1)	120–170
Frazier Cr.	2000			8	**c**
Mt. View Cr.	Dec 1994–Jan 1995			9	94–135
Jackson Cr.	1999			2	115, 138
Beaver Cr.	Dec 1990–Feb 1991			3	112–131

[a] *Number of additional clipped hatchery fish is in parentheses.*
[b] *Small tributary to Willamette River in the Newberg area.*
[c] *No lengths were recorded.*

Table 33. Distance from Willamette River that juvenile Chinook salmon were captured in non-natal tributaries in October–April, 1995–2004. Data are compiled from records of ODFW District biologists during sampling for cutthroat trout.

Stream	Tributary of—	Proximity	Distance from Willamette R (mi)
Corral Cr.	Willamette R.	Wilsonville	0.6
King Cr.	Spring Valley Cr.	Wheatland	1.3
Rickreall Cr.	Willamette R.	Salem	8.3
Ash Cr.	Willamette R.	Independence	2.0
Parker Cr.	Luckiamute R.	Buena Vista	8.4
Soap Cr.	Luckiamute R.	Buena Vista	7.7
Cox Cr.	Willamette R.	Albany	0.3
Periwinkle Cr.	Willamette R.	Albany	0.3
Frazier Cr.	Willamette R.	Corvallis	1.2
Mt. View Cr.	Frazier Cr.	Corvallis	4.3
Jackson Cr.	Willamette R.	Corvallis	6.8
Oak Cr.	Marys R.	Corvallis	1.7
Marys R.	Willamette R.	Philomath	12.1
Newton Cr.	Marys R.	Philomath	10.4
Beaver Cr.	Muddy Cr. (Marys R.)	Greenberry	19.9
Long Tom R.	Willamette R.	Monroe	7.6

TASK 5.3–EFFORTS TO RE-ESTABLISH POPULATIONS

Unclipped adult spring Chinook, collected at Minto, were tagged with uniquely numbered Floy® tags and released at the Golf bridge (rm 12.5) in the Little North Fork Santiam River. In 2004, 377 fish were released on four dates (Table 34), compared to Chinook releases of 268 in 2003 and 400 in 2002.

Table 34. Number of male and female unclipped spring Chinook released in the Little North Fork Santiam at the Golf bridge (rm 12.5), 2004.

	9 July	19 Aug	27 Aug	9 Sept	Total
Male	26	111	49	74	260
Female	18	56	24	19	117

We examined 15 carcasses for fin clips and tags in four surveys from July 14 to September 28, and collected otoliths and scales from unclipped fish. An additional 16 fish were decayed and we were unable to determined if they were tagged or fin-clipped. We recovered six tags in the Little North Fork Santiam, five upstream of the release site and one downstream. An additional seven tags were recovered in the North Santiam River upstream of the confluence with the Little North Fork, of which four returned to the Minto trap, about 28 mi from the release location. Tag numbers were not recorded at the Minto trap, either at the time of tagging or at recapture, which precluded evaluation of differential redistribution of the transported adults.

Rain in late August and mid September substantially increased flow in the Little North Fork Santiam (Figure 8), which allowed more opportunity for transported fish to disperse. Maximum water temperature decreased by about 9°C in late August and by an additional 3°C in mid September after the flows increased (Figure 8). The number of redds counted in 2004 (51) was greater than the 2003–2003 average (31) when adult Chinook were also transported, and larger than the 1996–2001 average (17). We recovered too few tagged females to estimate pre-spawning mortality from the Minto releases. Of the 8 females recovered in 2004 in the Little North Fork Santiam (fin-clipped and unclipped), 4 had died before spawning. By comparison, we estimated that 80–90% of fish died before spawning in 2003 (Schroeder et al. 2003).

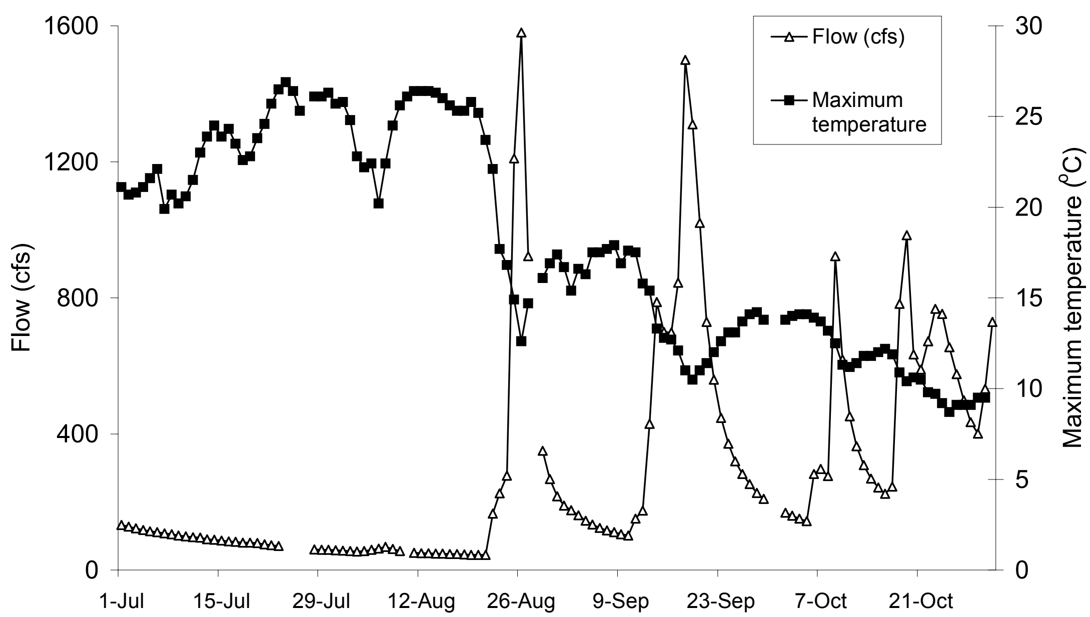

Figure 8. Flow (cfs) and maximum temperature (°C) in the Little North Fork Santiam River, July–October 2004.

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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.

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. N. Toman, and M. A. Buckman. 2004. 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 24:367–378.

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.

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, 2004

Basin and location	Group	Number
Middle Fork Willamette:		
Dexter–Jasper	Not clipped	27
Fall Creek	Not clipped	23
Willamette Hatchery	Coded wire tagged	40
Willamette Hatchery	Not clipped	44
McKenzie:		
Carmen-Smith spawning channel	Not clipped	50
Ollalie Boat Ramp–McKenzie Trail	Not clipped	55
McKenzie Trail–Forest Glen	Not clipped	33
Forest Glen–Ben and Kay Doris Park	Not clipped	57
Horse Creek	Not clipped	40
South Fork McKenzie below Cougar Reservoir	Not clipped	42
Lost Creek	Not clipped	3
Below Leaburg Dam	Not clipped	10
McKenzie Hatchery	Coded wire tagged	65
McKenzie Hatchery	Not clipped	131
South Santiam:		
Foster–Pleasant Valley	Not clipped	76
Pleasant Valley–Waterloo	Not clipped	41
Thomas Creek	Not clipped	1
South Santiam Hatchery	Coded wire tagged	41
South Santiam Hatchery	Not clipped	96
North Santiam:		
Minto–Fishermen's Bend	Not clipped	25
Fishermen's Bend–Mehama	Not clipped	13
Mehama–Stayton Island	Not clipped	21
Stayton Island–Stayton	Not clipped	3
Stayton–Greens Bridge	Not clipped	2
Little North Santiam	Not clipped	11
Minto collection pond	Coded wire tagged	49
Minto collection pond	Not clipped	27
Molalla:		
Trout Creek–Copper Creek	Not clipped	4

Appendix B. Continued.

Basin and location	Group	Number
Clackamas:		
Sisi Creek–Collawash River	Not clipped	35
Collawash River–Cripple Creek	Not clipped	51
Cripple Creek–reservoir	Not clipped	63
South Fork Clackamas	Not clipped	38
Collawash River	Not clipped	37
Fish Creek	Not clipped	13
Roaring River	Not clipped	3
Below Faraday Dam	Not clipped	5
River Mill Dam–Barton	Not clipped	73
Barton–mouth	Not clipped	21
Clackamas Hatchery (Clackamas stock)	Coded wire tagged	42
Clackamas Hatchery	Not clipped	1
Sandy:		
Final Falls–Road 2618 bridge	Not clipped	54
Road 2618 bridge–Arrah Wanna	Not clipped	29
Arrah Wanna–Highway 26 bridge	Not clipped	61
Still Creek	Not clipped	59
Zigzag River	Not clipped	7
Lost and Camp creeks	Not clipped	3
Clackamas Hatchery (Sandy stock)	Not clipped	80

APPENDIX C

Data on Pre-Spawning Mortality in the Willamette and Sandy Basins, 2001–2004

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, 2001–2004.

Data	2001	2002	2003	2004
Bennett Dam count through Aug 31	6,886	7,669	12,451	13,112
Carcasses:				
Jun 16–30			96	15
Jul 1–15			117	82
Jul 16–31			189	134
Aug 1–15	37[a]	148	175	26
Aug 16–31	76	62	264	96
Average daily maximum water temperature (°C) at Mehama:				
Jul 16–31	17.4	16.3	16.8	16.9
Aug 1–15	19.1	15.4	15.5	16.4
Aug 16–31	18.6	15.5	15.4	15.7
Flow (cfs) at Mehama:				
Jul 16–31	980	1,194	881	1,120
Aug 1–15	935	1,065	848	1,032
Aug 16–31	926	926	913	1,451

[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, 2001–2004.

River	Starting date	Carcasses	Pre-spawn mortality Number	Pre-spawn mortality 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
		2004		
Fall Creek	May 27	14	8	57
McKenzie	Aug 18	343	59	17
South Santiam	July 20	557	399	72
North Santiam	Jun 17	287	222	77
Little North Fork Santiam	Jul 14	8	4	50
Clackamas (above North Fork Dam)	Aug 19	149	13	9
Clackamas (below North Fork Dam)[a]	Aug 2	47	35	74
Sandy (below Marmot Dam)	Sep 2	17	11	65
Sandy (above Marmot Dam)	Aug 18	96	10	10

[a] *Additional carcasses were recovered below River Mill Dam, but these data are not included because surveys primarily occurred before peak spawning (July 23–September 21) and would be biased toward unspawned fish.*

APPENDIX D

Migration Timing, Life Histories, and Habitat Use Data for McKenzie, Willamette, and Santiam Rivers, 2004

Appendix Table D-1. Fish species and numbers caught in seines in the McKenzie River (rm 0–21), May 20–July 22, 2004

	Catch by date (seine sets in parentheses)			
Species	May 20-21 (25)	Jun 15–16 (9)	Jul 1–6 (26)	Jul 12-22 (28)
Chinook salmon (wild)	545	620	536	380
Rainbow trout	11	4	18	36
Cutthroat trout	72	5	31	57
Trout fry	0	0	12	12
Mountain whitefish	8	0	0	3
Steelhead (wild)	4	0	0	0
Redside shiner	120	0	51	23
Northern pikeminnow	38	0	13	4
Peamouth	11	0	2	0
Dace	2	1	5	8
Largescale sucker	1	0	4	1
Sculpin	32	15	11	0
Three-spine stickleback	16	0	1	0

Appendix Table D-2. Fish species and numbers caught in seines in two sections of the Willamette River above Willamette Falls, May 19–July 13, 2004. Upper section = Santiam River–McKenzie River (rm 107–175); lower section = Yamhill River–Santiam River (rm 55–107).

	Catch by location and date (seine sets in parentheses)				
	Upper section			Lower section	
Species	May 19 (9)	June 2–25 (69)	July 13 (17)	May 26–28 (31)	June 22–23 (30)
Chinook salmon (wild)	141	1,364	163	352	45
Rainbow trout		26	21	1	4
Cutthroat trout	6	228	86	1	
Trout fry		1	22		
Mountain whitefish	52	473	70	353	309
Steelhead (wild)	2	4			
Steelhead (hatchery)	2				
Summer steelhead (adult)		7	1	4	10
Redside shiner	815	963	174	546	650
Northern pikeminnow	439	1,541	239	270	758
Peamouth		187	4	154	435
Chiselmouth		24		6	88
Dace	1	81	47	88	105
Largescale sucker	80	424	6	209	569
Sculpin	1	7	8	22	8
Sand roller		1			
Three-spine stickleback	10	1		1	
Yellow perch		2			
Bluegill		1		7	1
Largemouth bass		1		6	2
Smallmouth bass				5	6
Banded killifish				200	140
Green sunfish				3	

Appendix Table D-3. Fish species and numbers caught in seines in the Middle Fork Willamette (rm 2–5), Santiam (rm 1–12), North Santiam (rm 0–11), and South Santiam (rm 1–11) rivers, June 1–30, 2004.

	Catch by location and date (seine sets in parentheses)			
	MF Willamette	Santiam	N. Santiam	S. Santiam
	June 11	June 1–30	June 29–30	June 3–8
Species	(14)	(22)	(25)	(28)
Chinook salmon (wild)	28	249	287	182
Rainbow trout	9	17	108	10
Cutthroat trout	10	3	2	10
Trout fry			64	
Mountain whitefish	3	55	13	116
Summer steelhead (adult)	1		1	6
Chinook salmon (hatchery)			1	1
Redside shiner		183	33	7
Northern pikeminnow	2	154	20	7
Peamouth	2	1		5
Coho salmon		2		
Dace	2	47	27	9
Largescale sucker	7	23	3	32
Sculpin	9	16	16	26
Three-spine stickleback		1	1	

Appendix Table D-4. Dates the PIT tag interrogator in the PGE Sullivan Plant at Willamette Falls was operational August 2003–September 2004.

Month	Dates	Status	Comments
August	20–31	Operating	Plant maintenance
September	1–30	Operating	
October	1–31	Operating	2 days with screens partially opened
November	1–4	Operating	
	5–6	Shut down	Plant closure for debris removal and repairs
	6–16	Operating	
	17–18	Shut down	High flows and debris
	19–30	Operating	2 days with screens partially opened
December	1–2	Shut down	High flows and debris
	3–8	Operating	3 days with screens partially opened
	8–9	Shut down	High flows and debris
	10–14	Operating	4 days with screens partially opened
	15–31	Shut down	Several plant closures for debris
January	1–19	Shut down	Several plant closures for debris and repairs
	20–29	Operating	
	30–31	Shut down	High flows and debris
February	1–10	Shut down	High flows and debris
	11–29	Operating	
March	1–31	Operating	
April	1–30	Operating	
May	1–31	Operating	
June	1–13	Operating	
June	14	Shut down	Plant closure for construction in forebay

Appendix Table D-5. Number by freshwater smolt age and the percentage of age 0 smolts among wild adult spring Chinook recovered in spawning areas of the Willamette River basin, 2003.

	Freshwater age of smolts		
Area	0	1	Percent age 0
McKenzie River:			
Spawning channel	1	30	3.2
Ollalie–McKenzie Trail	6	67	8.2
Lost Creek	0	7	0.0
Horse Creek	3	26	10.3
South Fork McKenzie	11	15[a]	42.3
McKenzie Trail–Forest Glen	5	29	14.7
Forest Glen–Ben&Kay Doris Park	15	25	37.5
Below Leaburg Dam	1	2	33.3
Total	42	201	26.0
South Santiam:			
Foster–Pleasant Valley	117	9	92.9
Pleasant Valley–McDowell	6	4	60.0
McDowell–Waterloo	4	0	100.0
Total	127	13	90.7
North Santiam:			
Minto–Fishermen's Bend	6	4	60.0
Fishermen's Bend–Mehama	2	7	22.2
Mehama–Stayton Island	3	3	50.0
Stayton Island–Stayton	3	2	60.0
Little North Fork	0	5	0.0
Total	14	21	40.0
Clackamas:			
Pinhead–Collawash	1	25[a]	3.8
Collawash–Cripple Cr	1	12	7.7
Cripple Cr–Fish Cr	2	13	13.3
Fish Cr–reservoir	0	3	0.0
Faraday Dam–McIver	0	3	0.0
McIver–Barton	8	15	34.8
Total	12	70	14.6

[a] *Two fish (McKenzie) and one fish (Clackamas) with age 2 smolt pattern.*

Appendix Table D-6. Number by freshwater smolt age and the percentage of age 0 smolts among wild adult spring Chinook recovered in spawning areas of the Willamette and Sandy river basins, 2002.

Area	Freshwater age of smolts 0	1	Percent age 0
Middle Fork Willamette:			
Dexter–Pengra	0	8	0.0
Pengra–Jasper	1	2	33.3
Fall Cr	0	3	0.0
hatchery	0	4	0.0
Total	1	17	5.6
McKenzie River:			
Spawning channel	3	31	8.8
Ollalie–McKenzie Trail	7	50	12.3
Lost Creek	0	4	0.0
Horse Creek	3	47	6.0
South Fork McKenzie	18	30	37.5
McKenzie Trail–Forest Glen	17	47	26.6
Forest Glen–Ben&Kay Doris Park	27	29	48.2
Below Leaburg Dam	13	13	50.0
Total	88	251	26.0
South Santiam:			
Foster–Pleasant Valley	120	17	87.6
Pleasant Valley–McDowell	12	8	60.0
McDowell–Waterloo	2	0	100.0
below Lebanon	2	1	66.7
Thomas Cr	0	2	0.0
hatchery	12	10	54.5
Total	148	38	79.6
North Santiam:			
Minto–Fishermen's Bend	11	9	55.0
Fishermen's Bend–Mehama	2	3	40.0
Mehama–Stayton Island	1	3	25.0
Stayton Island–Stayton	4	1	80.0
Little North Fork	2	2	50.0
hatchery	2	2	50.0
Total	22	20	52.4
Santiam R:			
Mouth–North Santiam	6	0	100.0
Molalla:			
Bull Cr–MF Molalla	0	1	0.0
Gawley–Turner	0	3	0.0
Total	0	4	0.0

Appendix Table D-6. Continued.

Area	Freshwater age of smolts 0	1	Percent age 0
Clackamas:			
Pinhead–Collawash	0	7	0.0
Collawash–Cripple Cr	4	11	26.7
Cripple Cr–Fish Cr	1	3	25.0
Fish Cr–SF Clackamas	3	2	60.0
SF Clackamas	3	7	30.0
Faraday Dam–McIver	0	2	0.0
McIver–Barton	9	10	47.4
Total	20	42	32.3
Sandy:			
Final Falls–Fly Bridge	1	11	8.3
Fly Br–Arrah Wanna	1	13	7.1
Arrah Wanna–Hwy 26	1	24	4.0
Hwy 26–mouth	1	3	25.0
Lost Cr	0	3	0.0
Still Cr	1	14	6.7
Total	5	68	6.8

Appendix Table D-7. Number by freshwater smolt age and the percentage of age 0 smolts among wild adult spring Chinook recovered in spawning areas of the McKenzie and North Santiam rivers, 2001.

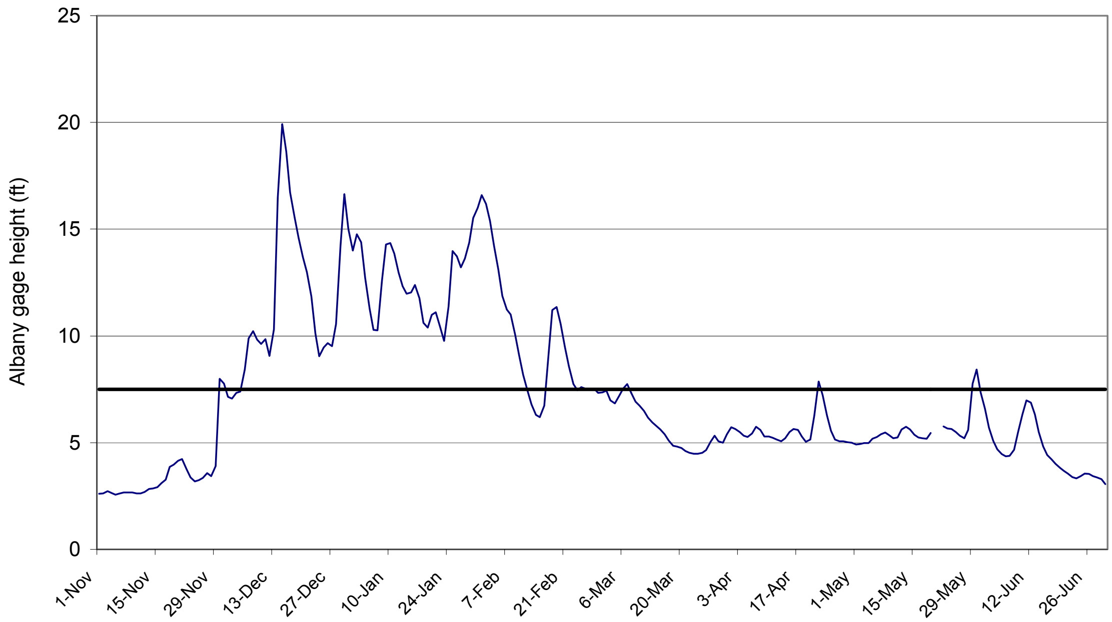
Area	Freshwater age of smolts 0	1	Percent age 0
McKenzie River:			
Spawning channel	1	24	4.0
Ollalie–McKenzie Trail	2	63	3.1
Horse Creek	0	13	0.0
South Fork McKenzie	1	11	8.3
McKenzie Trail–Forest Glen	3	14	17.6
Forest Glen–Ben&Kay Doris Park	2	20	9.1
Total	9	145	5.8
North Santiam:			
Minto–Fishermen's Bend	9	5	64.3
Fishermen's Bend–Mehama	2	3	40.0
Mehama–Stayton Island	1	2	33.3
Little North Fork	1	2	33.3
Total	13	12	52.0

Appendix Table D-8. Number by total age and smolt age of wild adult spring Chinook recovered in spawning areas of the Willamette River basin, 2003. Age designations follow Gilbert-Rich notation.

Area	3_1	4_1	4_2	5_1	5_2	6_1	6_2	6_3
McKenzie River:								
Spawning channel		1			30			
Ollalie–McKenzie Trail		3	2	3	61		4	
Lost Creek			2		5			
Horse Creek		2	2	1	24			
South Fork McKenzie		9	4	2	9			2
McKenzie Trail–Forest Glen	1	4	4	3	37			
Forest Glen–Ben&Kay Doris Park		11	4	1	9			
Below Leaburg Dam		1			2			
Total	1	31	18	10	177		4	2
South Santiam:								
Foster–Pleasant Valley	1	88	1	27	8	1		
Pleasant Valley–McDowell		3		3	4			
McDowell–Waterloo	0	4						
Total	1	95	1	30	12	1		
North Santiam:								
Minto–Fishermen's Bend		2		4	4			
Fishermen's Bend–Mehama		1	2	1	4		1	
Mehama–Stayton Island		1		2	3			
Stayton Island–Stayton		1		2	1		1	
Little North Fork					5			
Total		5	2	9	17		2	
Clackamas:								
Pinhead–Collawash		1	2		21		1	1
Collawash–Cripple Cr			2	1	10			
Cripple Cr–Fish Cr		1	1	1	12			
Fish Cr–reservoir			3					
Faraday Dam–McIver			1		2			
McIver–Barton		2	3	6	10		2	
Total		4	12	8	55		3	1

Appendix Table D-9. Number by total age and smolt age of wild adult spring Chinook recovered in spawning areas of the McKenzie and North Santiam rivers, 2001. Age designations follow Gilbert-Rich notation.

Area	3_1	4_1	4_2	5_1	5_2	6_2
McKenzie River:						
Spawning channel		1	3		19	2
Ollalie–McKenzie Trail		2	16		47	
Horse Creek					13	
South Fork McKenzie		1			10	1
McKenzie Trail–Forest Glen	1	2	1		13	
Forest Glen–Ben&Kay Doris Park		1		1	20	
Total	1	7	20	1	122	3
North Santiam:						
Minto–Fishermen's Bend	1	6	1	2	4	
Fishermen's Bend–Mehama	1	1	2		1	
Mehama–Stayton Island	1				2	
Little North Fork		1	1		1	
Total	3	8	4	2	8	



Appendix Figure D-1. Gage height of the Willamette River at Albany (USGS), November 1, 2003 through June 30, 2004. Kenagy farm drainage channels are flooded from Willamette River at gage heights >7.5 ft.

Appendix Table D-10. Fish caught in the upper trap on the Kenagy farm, March–May, 2004.

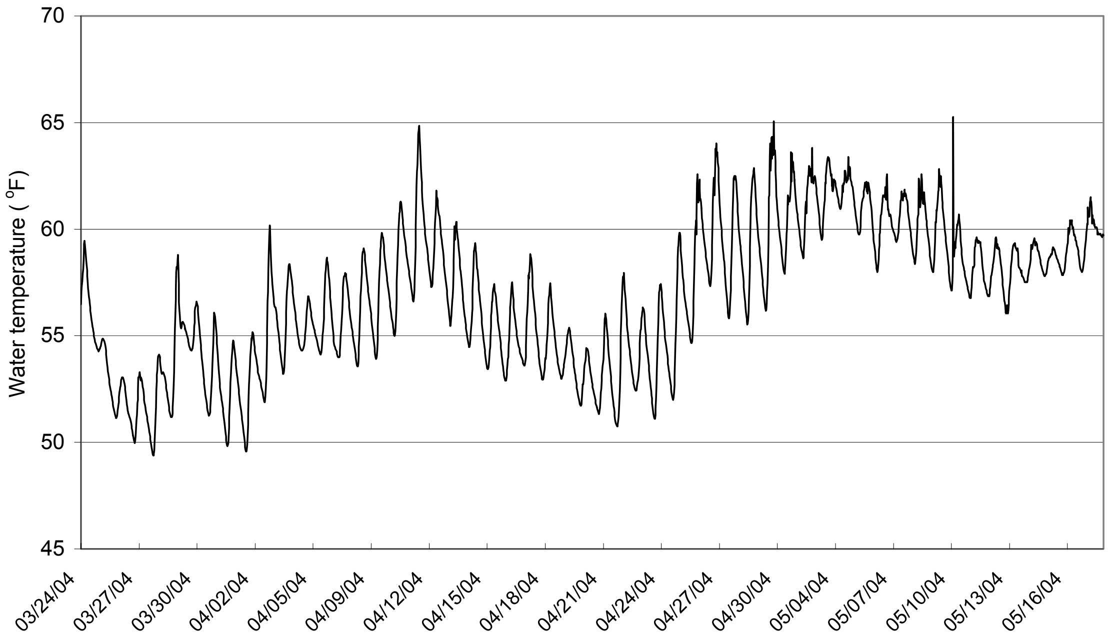
Date	Lunar phase	Nights	Chinook salmon	Redside shiner	Northern pikeminnow	Largescale sucker	Bluegill	Three-spine stickleback	Other
16-Mar	25	1	2	4	2	1		1	
17-Mar	26	1	2	15		1	1	1	
18-Mar	27	1	1	2					1[a]
19-Mar	28	1	1	2					
22-Mar	2	3		6		1			
23-Mar	3	1	2	3	1		1	2	
24-Mar	4	1							2[b]
26-Mar	6	2	1	1		1			
28-Mar	8	2	1	1					
31-Mar	11	3		1				2	
5-Apr	16	5		1			1	1	
10-Apr	21	5	3	6	1		4		
15-Apr	26	5	16	1		1	2		1[c]
20-Apr	1	5	4	1			5		
26-Apr	7	6	6	2			8	1	
30-Apr	11	4	15	1	4		12		
4-May	15	4	2	1			1	2	
9-May	20	5		4				16	
10-May	21	1						22	
11-May	22	1						1	
12-May	23	1						8	
18-May									

[a] *1 mosquitofish*.
[b] *1 mosquitofish and 1 largemouth bass*.
[c] *1 black crappie*.

Appendix Table D-11. Fish caught in the lower trap on the Kenagy Farm, March–May 2004.

Date	Nights	Chinook salmon	Redside shiner	Northern pikeminnow	Largescale sucker	Three-spine stickleback	Sculpin	Dace	Mosquito-fish	Other
16-Mar	1	3		7	6	2	1			1[c]
17-Mar	1	1	40		2			2		1[d]
18-Mar	1		3			1				
19-Mar	1		2							
22-Mar	3									
23-Mar	1		2			2			2	
24-Mar	1		24	4	4	7		1	2	
26-Mar	2	1	6		4	2		0		
28-Mar[a]	2								1	
10-May[b]	1	2	8				2			
11-May	1		2				1			
12-May	1		1							1[d]
18-May	6									

[a] *Flow blocked by roadbed. Trapping discontinued*.
[b] *New trap installed in drainage channel below road crossing*.
[c] *1 Pacific lamprey.*
[d] *1 bluegill.*



Appendix Figure D-2. Maximum water temperatures (°F) recorded at the upper trap site on the Kenagy Farm, March–May 2004.

Appendix Table D-12. Water temperatures (°F) recorded at the upper trap site on the Kenagy farm, March–May 2004.

	Water temperature (°F)			
Date	Maximum	Minimum	Average	Range
24 Mar	59.4	55.9	57.7	3.6
25 Mar	55.7	52.7	54.4	3.0
26 Mar	53.0	51.1	52.1	1.9
27 Mar	53.3	50.0	51.6	3.3
28 Mar	54.1	49.4	51.9	4.7
29 Mar	58.8	51.2	54.3	7.6
30 Mar	56.6	53.6	55.1	3.0
31 Mar	56.1	51.2	53.1	4.8
1 Apr	54.8	49.8	52.3	5.0
2 Apr	55.2	49.6	52.5	5.6
3 Apr	60.2	51.9	55.2	8.3
4 Apr	58.4	53.2	55.8	5.2
5 Apr	56.9	54.3	55.4	2.6
6 Apr	58.7	54.1	55.9	4.5
7 Apr	57.9	54.0	55.8	3.9
8 Apr	59.1	53.6	56.2	5.5
9 Apr	59.8	53.9	56.9	5.9
10 Apr	61.3	55.0	58.1	6.3
11 Apr	64.8	56.6	60.0	8.2
12 Apr	61.8	57.3	59.3	4.5
13 Apr	60.3	55.5	57.9	4.9
14 Apr	59.4	54.5	56.6	4.9
15 Apr	57.4	53.4	55.4	4.0
16 Apr	57.5	52.9	54.9	4.6
17 Apr	58.8	53.6	55.7	5.2
18 Apr	57.5	52.9	54.8	4.5
19 Apr	55.4	53.0	54.1	2.4
20 Apr	54.4	51.7	53.1	2.7
21 Apr	56.0	51.3	53.2	4.7
22 Apr	57.9	50.8	53.8	7.2
23 Apr	56.3	52.4	54.1	3.9
24 Apr	57.4	51.1	54.2	6.3
25 Apr	59.8	52.0	55.6	7.8
26 Apr	62.6	54.6	58.2	7.9
27 Apr	64.0	57.3	60.3	6.7
28 Apr	62.5	55.8	59.1	6.7
29 Apr	62.9	55.5	59.1	7.4
30 Apr	65.1	56.2	60.2	8.9

Appendix Table D-12. Continued.

Date	Water temperature (°F)			
	Maximum	Minimum	Average	Range
1 May	63.6	57.9	60.6	5.7
2 May	63.8	58.6	61.0	5.2
3 May	63.4	59.5	61.6	3.9
4 May	63.4	60.9	62.0	2.4
5 May	62.2	59.7	61.2	2.5
6 May	62.6	58.0	60.3	4.6
7 May	61.8	59.4	60.6	2.4
8 May	62.6	58.4	60.3	4.2
9 May	62.8	58.0	60.2	4.9
10 May	65.3	57.1	59.0	8.2
11 May	59.6	56.8	58.3	2.8
12 May	59.6	56.9	58.1	2.8
13 May	59.4	56.0	57.8	3.3
14 May	59.6	57.5	58.4	2.1
15 May	59.1	57.8	58.5	1.3
16 May	60.4	57.9	59.0	2.6
17 May	61.5	58.0	59.5	3.5
18 May	60.4	59.6	59.9	0.8

Appendix Table D-13. Number and fork length of juvenile Chinook salmon captured in non-natal tributaries, 1995–2004. Data are compiled from records of ODFW District biologists during sampling for cutthroat trout.

		Fry		Juvenile	
Stream	Date(s)	Number	Length	Number[a]	Length
North Yamhill	17 Mar 1996	5	60–70	4	90–150
McCall[b]	23 Mar 1997	2	52, 54	2	128, 138
Rickreall Cr.	17 Nov 1995			5	133–143
Rickreall Cr.	16–17 Nov 1996			10 (2)	123–150
Rickreall Cr.	18 Mar 1996			3 (2)	137–150
Rickreall Cr.	16–20 Feb 1997			2	158, 175
Rickreall Cr.	26–30 Mar 1997			2	134, 136
Rickreall Cr.	14 Oct 199?			1	82
Ash Cr.	24 Mar 1999	2	58, 61	1	134
Ash Cr.	2000			19	**c**
Cox Cr.	26 Dec 2000			1	100
Cox Cr.	15 Jan 2002			2	95, 100
Cox Cr.	6 Feb 2002			2	110, 133
Periwinkle Cr.	22 Dec 2000			1	110
Periwinkle Cr.	10 Jan 2002			3	100–120
Periwinkle Cr.	5–15 Feb 2002			2 (4)	90,103
Periwinkle Cr.	24 Mar 2004	3	40–45		
Frazier Cr.	12, 31 Jan 1999			5	120–140
Frazier Cr.	17 Feb 1999			1	140
Frazier Cr.	9–25 Mar 1999			7	130–170
Frazier Cr.	Apr 1999	5	60–85		
Frazier Cr.	2000			8	**c**
Mt. View Cr.	19–28 Dec 1994			2	123, 127
Mt. View Cr.	5–28 Jan 1995			7	94–135
Jackson Cr.	1999			2	115, 138
Beaver Cr.	6–10 Dec 1990			2	115, 131
Beaver Cr.	15 Feb 1991			1	112

[a] *Number of additional clipped hatchery fish is in parentheses.*
[b] *Small tributary to Willamette in Newberg area.*
[c] *No lengths were recorded.*