Work Completed for Compliance With the Biological Opinion for Hatchery Programs in the Willamette Basin, USACE funding: 2004

J. Firman, M. Buckman, R. Schroeder, and K. Kenaston,
M. Hogansen, B. Cannon

Task Order: NWP-OP-FH-02-01

February 2005

TABLE OF CONTENTS

Tables and Figures

Introduction

The National Marine Fisheries Service (NMFS) has listed spring chinook salmon (*Oncorhynchus tshawytscha*) and winter steelhead (*O. mykiss*) in the Upper Willamette River Evolutionarily Significant Unit (ESU) as threatened under the Endangered Species Act (ESA; 64 FRN 14308; 64 FRN 14517). Concomitant with this listing, any actions taken or funded by a federal agency must be evaluated to assess whether these actions are likely to jeopardize the continued existence of threatened and endangered species, or result in the destruction or impairment of critical habitat. Several fish hatcheries operate within the ESU and may impact wild populations of listed species. Although all of the artificial propagation programs that potentially affect listed salmonids in the Upper Willamette River ESUs are operated by the Oregon Department of Fish and Wildlife (ODFW), 90% of the funding for these operations comes from the U.S. Army Corps of Engineers (COE).

Possible risks of artificial propagation programs have been well documented. Hazards include disease transfer, competition for food and spawning sites, increased predation, increased incidental mortality from harvest, loss of genetic variability, genetic drift, and domestication (Steward and Bjornn 1990; Hard *et al*. 1992; Cuenco *et al*. 1993; Busack and Currens 1995; NRC 1996; and Waples 1999). Hatcheries can also play a positive role for wild salmonids by bolstering populations, especially those on the verge of extirpation, providing a genetic reserve in the case of extirpation, and providing opportunities for nutrient enrichment of streams (Steward and Bjornn 1990; Cuenco *et al*. 1993). The objective of this project is to evaluate the potential effects of hatchery programs on naturally spawning populations of spring chinook and winter steelhead within the Upper Willamette River ESU. The project employs four types of activities to achieve this goal: sampling of returns to hatcheries, creels to assess fisheries, monitoring of adult and juvenile migration through the use of traps and video observations, and monitoring natural production through spawning ground surveys.

Approach

Hatchery Broodstock
Hatcheries conventionally include some naturally produced spring chinook in their broodstock, however, naturally produced fish in the broodstock should constitute no more than 10% of wild fish that spawn naturally. Data were collected on all spring chinook spawned at hatcheries in the upper Willamette to determine their origin.

Creels
Statistical creels were conducted on the North and South Santiam Rivers, the McKenzie River, the Middle Fork Willamette, and Foster Reservoir. Expanded catch statistics from the river creels are used to estimate the number of naturally produced adult chinook and steelhead in the bycatch, and to estimate the number of marked fish that were removed from the run. The Foster creel was designed to evaluate the number of winter steelhead smolts that are caught in the trout fishery. The creel on the McKenzie River also provides samples of stomach content from hatchery-reared trout that are released in the vicinity. Stomach content samples are used to determine if the consumption of wild juvenile chinook by artificially produced trout is a common occurrence.

Adult and Juvenile Migration
Viewing stations are available at the Willamette Falls fish ladder on the lower Willamette River and at the Leaburg Dam fish ladder on the McKenzie River. Video cameras are in place at both locations, and the species and mark status of all fish that passed the ladders was recorded. Adult traps are available at the Leaburg Dam fish ladder and at the ladders over Upper and Lower Bennett Dams on the North Santiam River.

Spawning Ground Surveys
Spawning surveys were conducted for both summer steelhead and spring chinook. Foot and boat surveys were conducted to make visual counts of spawners, redds and to evaluate pre-spawning mortality.

Spring Chinook Passage

Willamette Falls

Passage of migrating salmon and steelhead is monitored at the Willamette Falls Fishway. The falls and fishway are situated in the lower reaches of the Willamette River near Oregon City. In 2004, 95,643 adult chinook salmon and 755 jacks passed Willamette Falls (Table 1). Spring chinook first appeared at the falls in March, with peak passage occurring in May, and the bulk of the run passing during April, May and tailing off in June (Table 1, Figure 1). Small numbers of chinook continued to pass the falls through mid August. This pattern falls within the average timing observed in the previous three years, but passage was later in 2004, and the peak was more compressed (Figure 2). The spring chinook run in 2004 was the largest in the 58 years on record, continuing a trend of strong runs over the last three years (Table 2, Figure 3).

Table 1. Spring chinook passage at Willamette Falls: 2004.

Month	Adults	Jacks	Total
March	313		313
April	34,261	90	34,351
May	47,264	442	47,706
June	11,498	180	11,678
Jul	2,134	32	2,166
Aug	173	11	184
Season	**95,643**	**755**	**96,398**

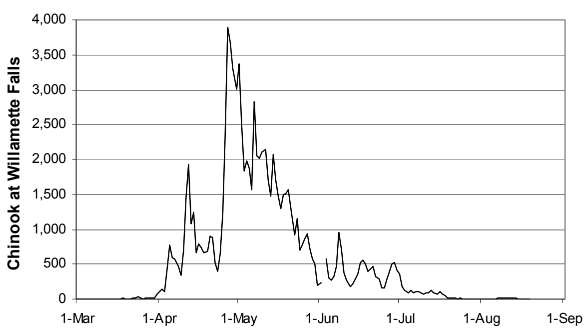

Figure 1. Chinook Run-timing at Willamette Falls: 2004.

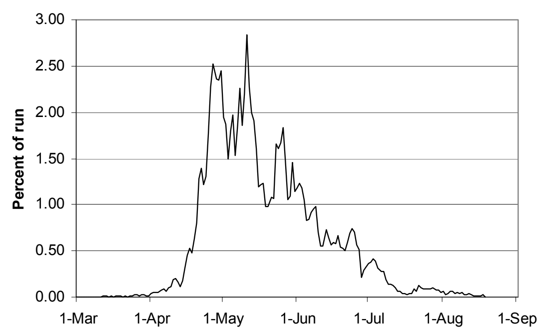

Figure 2. Chinook run-timing, Willamette Falls: 01-03.

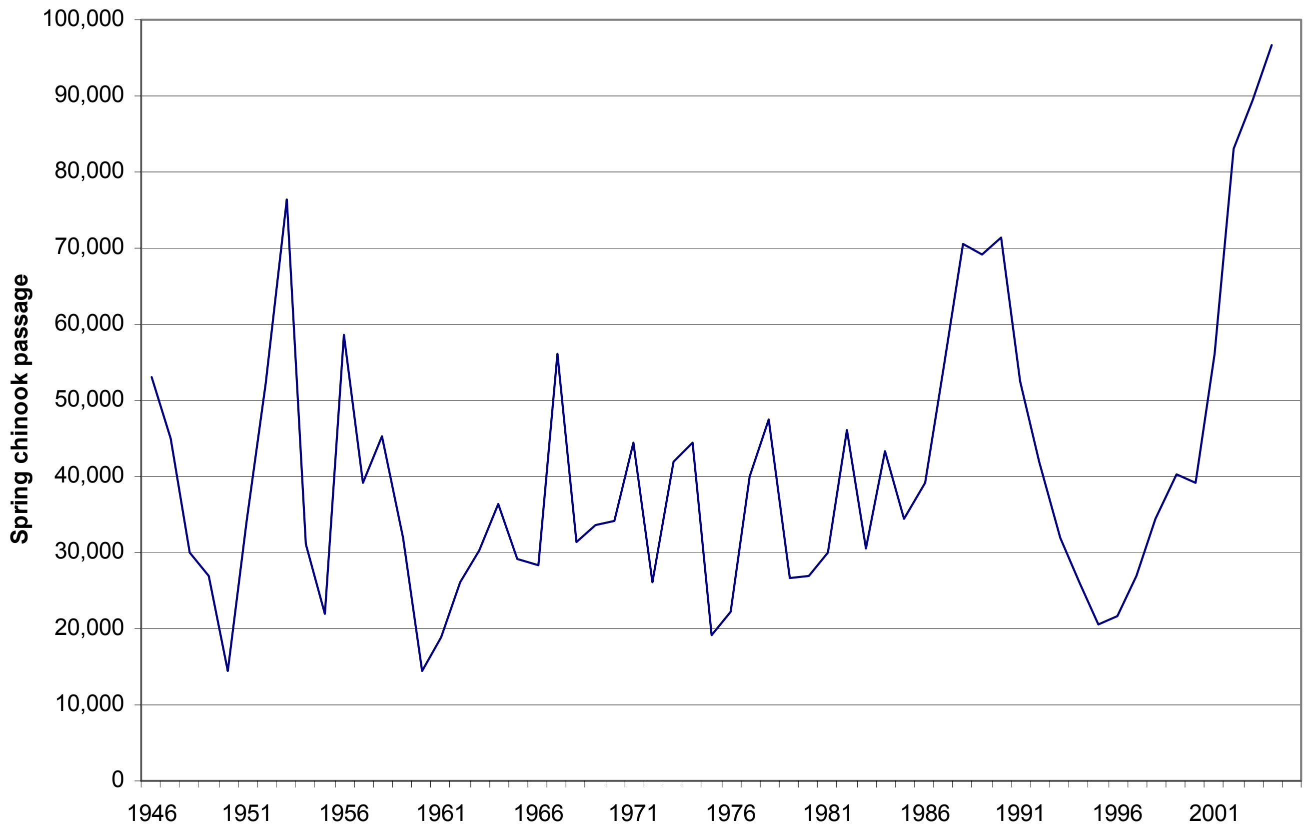

Figure 3. Chinook passage at Willamette Falls: 1946-2004.

Table 2. Spring Chinook passage at Willamette Falls: 1946-2004.

Year	Adults	Jacks	Total
1946			53,000
1947			45,000
1948			30,000
1949			27,000
1950			14,500
1951			34,300
1952			52,200
1953	72,300	4,146	76,446
1954	29,300	1,827	31,127
1955	20,500	1,500	22,000
1956	58,000	600	58,600
1957	37,107	2,193	39,300
1958	42,850	2,350	45,200
1959	29,600	2,300	31,900
1960	13,000	1,400	14,400
1961	17,200	1,700	18,900
1962	22,200	3,800	26,000
1963	29,000	1,300	30,300
1964	31,747	4,543	36,290
1965	26,623	2,439	29,062
1966	25,607	2,623	28,230
1967	53,689	2,510	56,199
1968	29,075	2,394	31,469
1969	31,160	2,554	33,714
1970	33,410	770	34,180
1971	43,936	633	44,569
1972	25,339	815	26,154
1973	40, 495	1,465	41,960
1974	44,090	440	44,530
1975	17,844	1,235	19,079
1976	21,031	1,123	22,154
1977	38,509	1,503	40,012
1978	45,711	1,801	47,512
1979	25,492	1,131	26,623
1980	26,364	609	26,973
1981	28,640	1,417	30,057
1982	45,107	1,088	46,195
1983	28,692	1,897	30,589
1984	42,363	1,089	43,452
1985	33,095	1,438	34,533
1986	37,300	1,855	39,155
1987	52,797	2,035	54,832
1988	68,723	1,728	70,451
1989	65,866	3,314	69,180
1990	69,128	2,145	71,273
1991	48,696	3,820	52,516
1992	39,657	2,347	42,004
1993	29,721	2,245	31,966
1994	25,460	642	26,102
1995	19,343	1,249	20,592
1996	20,394	1,211	21,605
1997	26,248	637	26,885
1998	33,073	1,388	34,461
1999	38,948	1,462	40,410
2000	37,594	1,479	39,073
2001	52,685	1,288	53,973
2002	82,111	1,025	83,136
2003	87,660	1,851	89,511
2004	95,968	757	96,725

Bennett Dams, Stayton Island, North Santiam River

Abundance and migration timing of adult spring chinook were monitored at upper and lower Bennett dams in 2004 (Table 3 and Figure 4) with methods similar to previous years. Adjusted totals reflect rates of otolith marks in unclipped chinook carcasses recovered from the spawning grounds from 2001 to 2003 (see Table 22). Passage estimates have also been adjusted to account for fallback over the dam, and to compensate for construction in the latter part of the season. Approximately 13,000 spring chinook passed Upper and Lower Bennett Dams in 2004, rivaling the run in 2003, which was the largest run on record. Roughly 11% of these were un-clipped fish. If a similar proportion of unclipped fish have otolith marks as has been observed in the past, then as a preliminary estimate, roughly 6% of the chinook passing Bennett Dams were naturally produced. When otolith results for 2004 are available, this estimate will be finalized.

Table 3. Spring chinook passage estimates at Bennett Dams, N. Santiam River: 2004.

Month	Unmarked	Marked	Adults	Jacks	Total
April	33	165	198	0	198
May	793	5,870	6,662	0	6,925
June	447	4,351	4,798	0	4,910
Jul	90	866	957	263	996
Aug	10	67	76	112	83
Sep	23	71	94	39	98
Oct	11	0	11	7	16
Season	**1,407**	**11,388**	**12,795**	**430**	**13,225**
Construction adj.*	***1,457***	***12,099***	***13,556***	***445***	***14,001***
Fallback adj.**	***1,383***	***11,488***	***12,871***	***423***	***13,294***
Otolith adj.***	***705***	***12,166***	***12,871***	***423***	***13,294***

**Passage through July 16 expanded based on % run passed by this point in 2003 (92.5%).*
***Passage has been adjusted for a 5% fallback rate.*
**** Numbers of unmarked fish have been adjusted using the average otolith mark rate observed in unmarked fish from 2001-2003 (49%; see Table 22)*

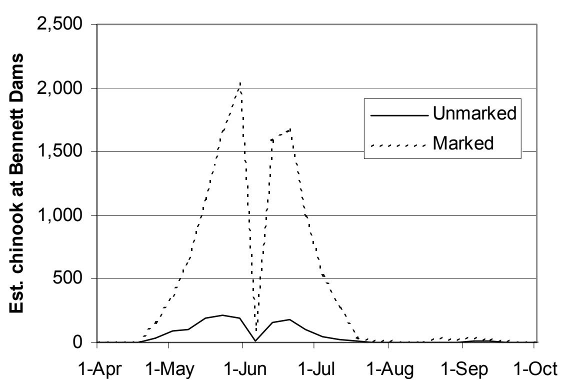

Figure 4. Chinook run-timing at Bennett Dams: 2004.

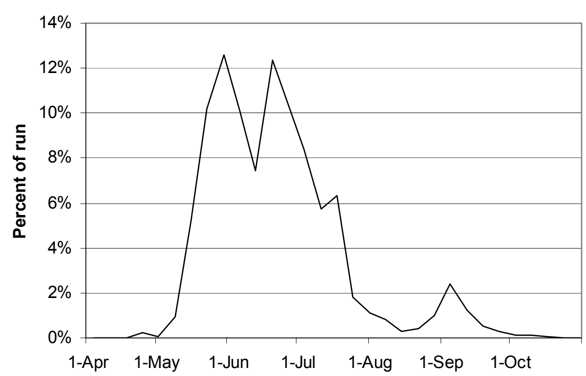

Figure 5. Chinook run-timing, Bennett Dams: 1998-2003.

Construction at the upper Bennett Dam prevented fish from passing the existing ladder beginning July 16, 2004. The ladder was out of commission for the remainder of the spring chinook run. The lower Bennett ladder was still operating during this time, but most chinook pass using the upper Bennett ladder. A temporary steep pass ladder was installed at upper Bennett Dam to provide passage during the construction. We were not able to monitor the number of fish using this ladder, as it could not be configured to allow trapping. Most chinook passage had occurred prior to the decommissioning of the Upper Bennett ladder, but it is still important to obtain an accurate estimate of the total number of chinook that passed the dams during the 2004 season. We have employed two approaches to estimate passage during this time period. The most straightforward approach is to compare the run-timing curve to previous years and adjust the estimate assuming that a similar percent of total fish passage occurred during the same time period. Passage in 2003 was very similar to 2004 in both run size and timing (Figure 6), so data from 2003 were used to correct 2004 estimates. In 2003, 92.5% of the spring chinook run had passed by July 16. Expanding the 2004 counts through July 16 by 7.5% gives a total estimate of 12,871 spring chinook (Table 3). This statistic has been used to compare spring chinook passage among different years.

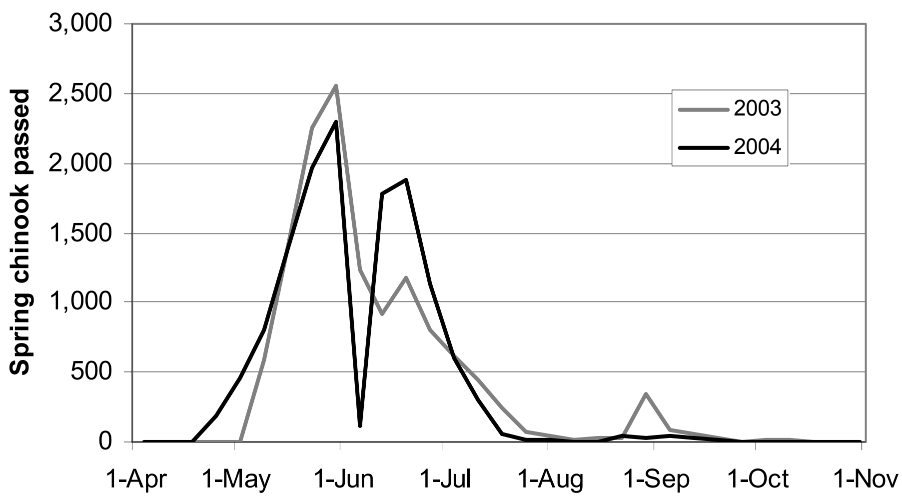

Figure 6. Spring chinook passage at Bennett Dams in 2003 and 2004.

Mark-Recapture methods for spring chinook

A mark recapture method was used as a second approach. Clipped adult spring chinook were marked with a numbered floy tag as they passed the Bennett Dams, and tags were recovered as fish were handled at the Minto Ponds hatchery facilities, and on spawning ground surveys. Mark recapture methods were employed in both 2003 and 2004 to provide a comparison of methods during a year when trapping took place over the entire season. Fish were double tagged to monitor tag loss rate, and very few tags were lost (4.6%). Population estimates and 95% Confidence Intervals were calculated using the following equations:

$$N = (C+1)(M+1)(1-(P/R)^2)/(R+1)$$

$$C.I. = (N^2*(C-R)/((C+1)*(R+2)))^{0.5}*1.96$$

Where:
N = Total population
C = Number handled during recovery
M = Number marked
R = Number of tags recovered
P = R*0.05

In 2003, 5,889 marked spring chinook were handled at the Bennett traps, and 610 were tagged (10.4%). Tags were recovered from 24 of 1,026 spring chinook carcasses sampled on spawning surveys (2.3%), and from 41 of 4,002 fish handled at the Minto trap (1.0%). These results yield estimates of chinook passage past Stayton Island of 59,506 ± 9,025 using the recoveries at Minto, 26,081 ± 5,050 using the recoveries from spawning surveys, and 47,155 ± 5,721 using the combined recoveries. These estimates are considerably larger than the estimate of 11,570 chinook made by expanding trap catches at the Bennett traps. Spawning surveys started two months before regular trapping began at Minto, and the fact that there was a higher percentage of tagged fish recovered from spawning surveys than at Minto suggests that there may have been a higher rate of pre-spawning mortality among tagged fish than in untagged fish. This hypothesis is further supported by most of the tags recovered from fish on the spawning grounds being found before fish started spawning in mid-August. Between 6-18-2003 and 8-18-2003, 441 carcasses were recovered, including 20 tagged fish. This yields a population estimate of 12,556 ± 2,606 spring chinook, only 8.5% higher than the trap estimate. We believe that this is the most accurate estimate yielded by the mark-recapture data.

In 2004, 5,665 marked adult spring chinook were handled at the Bennett traps, and 579 were tagged (10.2%). Tags were recovered from 86 of the 3,518 chinook handled at the Minto trap (2.6%), and 6 tags were recovered from 130 chinook carcasses sampled on spawning surveys (4.6%). These results yield estimates of 23,622 ± 2,326 chinook based on the Minto recoveries, 12,633 ± 4,343 chinook based on recoveries from spawning surveys, and 21,992 ± 2,190 based on combined recoveries. Again, we believe that the recoveries from spawning surveys give the most accurate estimate of the chinook population above Stayton Island due to the possibility that tagging stress may increase the rate of pre-spawning mortality in tagged fish (the estimate based on recoveries on spawning surveys is 10% larger than the trap estimate). We have reason to suspect that estimates based on trap expansions may be somewhat negatively biased. We spent a large amount of time observing fish at Upper Bennett Dam in the evenings during July of 2004 to monitor whether fish were using the temporary steep pass ladder that was installed during construction. During these observations, a small number of chinook were observed to successfully jump the dam. Also, there has been a question for some time that more fish may move through the ladders during the weekends when the traps are disabled and fish can move freely. The 10% increase in estimates based on mark-recapture data seems reasonable considering these factors. The fact that we obtained very similar results in the two years sampled also increases our confidence in the results obtained using this method. However, we have used the estimate based on run-timing in 2003 to compare 2004 to previous years, as that approach more closely recreates the methods that have been used to make estimates in the past.

The spring chinook run in 2004 paralleled the run in 2003, and was the largest in the seven years on record (Table 4, Figure 7). However, the percentage of naturally produced fish remains very low (5.6%).

Table 4. Spring Chinook passage at Bennett Dams, North Santiam River: 2001-2004.

Year	Total Adults	Marked Adults*	Unmarked Adults*	Jacks	% Unmarked
1998	2,252				
1999	2,527			191	
2000	2,286			282	
2001	6,786			258	
2002*	7,793	7,185	608	153	7.8
2003*	12,832	12,561	271	406	4.4
2004**	12,871	12,166	705	423	5.6

**Estimates for marked and unmarked fish have been adj. for unmarked fish with otolith marks (Table 22).*

** *Numbers of unmarked fish have been adjusted using the average otolith mark rate observed from 2001-2003 (49%; see Table 22)*

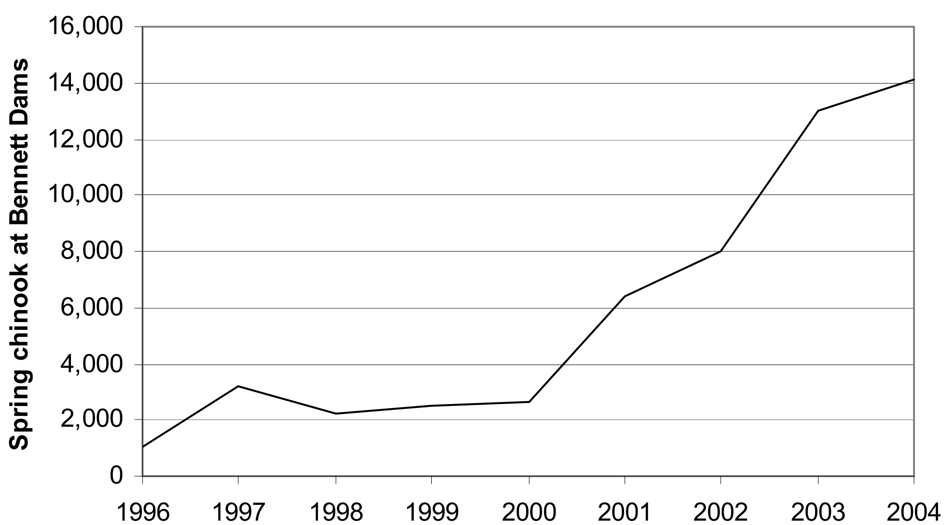

Figure 7. Spring chinook passage at the Bennett Dams, North Santiam River, 1998-2004.

Leaburg Dam, McKenzie River

The results of trapping at Leaburg Dam in 2004 are presented in Table 5. Adjusted totals reflect rates of otolith marks in unclipped fish from 2001 to 2003 (see Table 22). Roughly 55% of the chinook passing Leaburg Dam consisted of hatchery fish. We were unable to trap fish at the old left bank ladder for most of the 2004 passage season due to construction. Consequently, only 9 marked chinook were removed. Chinook were able to pass freely through the new right bank ladder, and passage was monitored by video.

Table 5. Spring chinook at Leaburg Dam, McKenzie River: 2004.

Month	Unmarked	Marked	Adults	Jacks	Total
May	1,412	638	2,050	4	2,054
June	2,416	1,800	4,215	6	4,221
Jul	794	971	1,765	8	1,773
Aug	89	367	456	0	456
Sep	73	475	548	0	548
Oct	3	4	7	0	7
Nov	1	0	1	0	1
Season	**4,788**	**4,255***	**9,043**	**18**	**9,061**
Adjusted*	***4,070***	***4,973***	***9,043***	***18***	***9,061***

**Nine marked fish were removed and did not pass Leaburg Dam.*

***Numbers of unmarked fish have been adjusted using the average otolith mark rate observed from 2001-2003 (15%; see Table 22)*

Chinook began appearing at Leaburg Dam in May of 2004, with peak passage occurring in two distinct peaks: one in late May and early June, and the second in late June and early July. A similar bi-modal pattern was seen at the Bennett Dams on the North Santiam. A small tertiary peak of marked chinook occurred in September (Figure 8). Overall run timing was similar to the 20-year average (Figure 9).

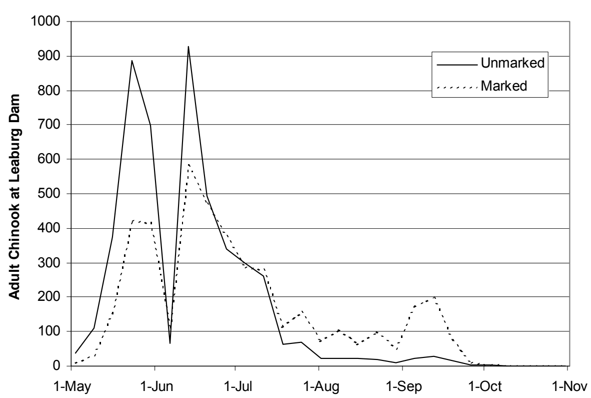

Figure 8. Chinook run-timing at Leaburg Dam: 2004.

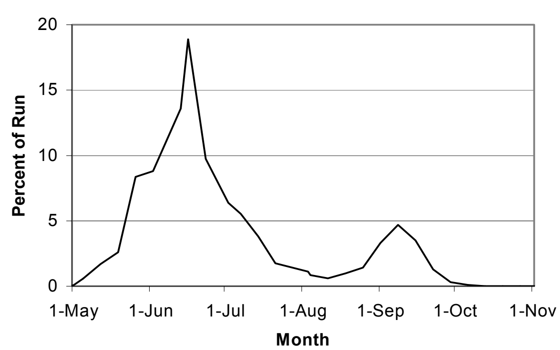

Figure 9. Chinook run-timing, Leaburg Dam: 1980-2001.

Although the run of spring chinook to the upper McKenzie was smaller than that in 2003, it is still the second largest return in the 24 years on record, and continues a string of three years of strong returns (Table 6, Figure 10). Adult to Adult ratios are based on the dominant five year life cycle.

Table 6. Spring Chinook at Leaburg Dam, McKenzie River: 1981-2004.

Year	Total	Marked	Unmarked	Jacks	% Unmarked	Adult/Adult
1981	1,087			42		
1982	1,706			62		
1983	1,405			38		
1984	921			31		
1985	808			25		
1986	1,736			68		1.60
1987	2,933			97		1.72
1988	6,613			165		4.71
1989	3,852			126		4.18
1990	6,988			238		8.65
1991	4,287			130		2.47
1992	3,679			141		1.25
1993	3,554			78		0.54
1994	1,507			84		0.39
1995	1,577			39		0.23
1996	1,432			15		0.33
1997	1,110			2		0.30
1998	1,848			9		0.52
1999	1,862					1.24
2000	2,533			12		1.61
2001	4,428					3.09
2002	6,774	2,551	4,223	38	62%	6.10
2003	10,524	4,740	5,784	115	55%	5.69
2004	9,043	4,255	4,788	18	53%	4.86

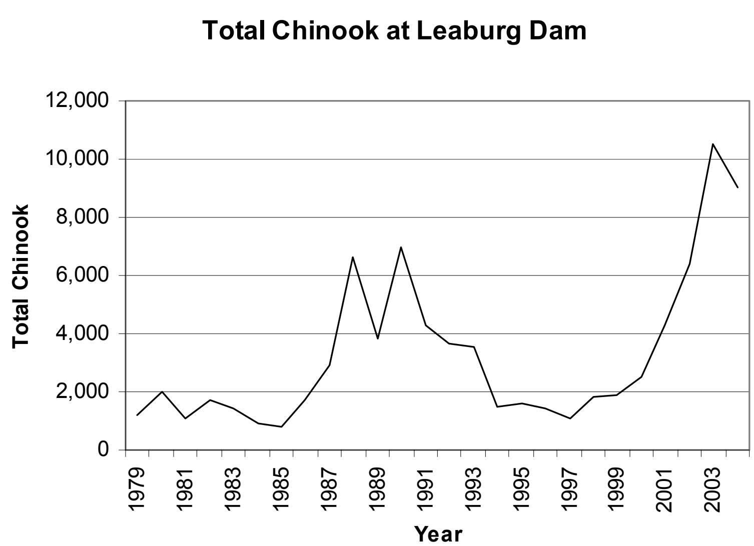

Figure 10. Chinook passage at Leaburg Dam, McKenzie River: 1980-2004.

Chinook spawning surveys

We surveyed most of the major tributaries in the Willamette Basin above Willamette Falls in 2004 by boat and on foot to count spring chinook salmon carcasses and redds. We counted redds during peak times of spawning based on data from past surveys. Carcasses were examined for adipose fin clips to determine the proportion of hatchery fish on spawning grounds. Otoliths were also collected from carcasses without fin clips to sort out unclipped hatchery fish from those produced naturally (*see* Otolith Sampling below). We used hand-held electronic tag detectors manufactured by Northwest Marine Technology, Inc. to determine if carcasses with adipose fin clips had a coded wire tag. We collected the snouts of fish with a tag, which were then put into plastic bags along with a unique identification number.

Spawning Ground Surveys

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 7). 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 8). 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 7). 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.

Table 7. 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 & 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 8. 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	7,329	210 (2.9)	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 construction 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 9), 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 10), similar to the 2001–2003 average.

Table 9. Summary of spawning surveys for spring chinook salmon in the North Santiam River, 2004, and comparison to redd densities in 1996–2003. Spawning below Stayton may include some fall chinook.

Survey section	Length (mi)	Counts: Carcass	Counts: Redd	Redds/mi: 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 10. 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 11). 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 11). The percentage of redds below Leaburg Dam decreased from 14% in 2002–2003 to 9% in 2004.

Table 11. 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.*

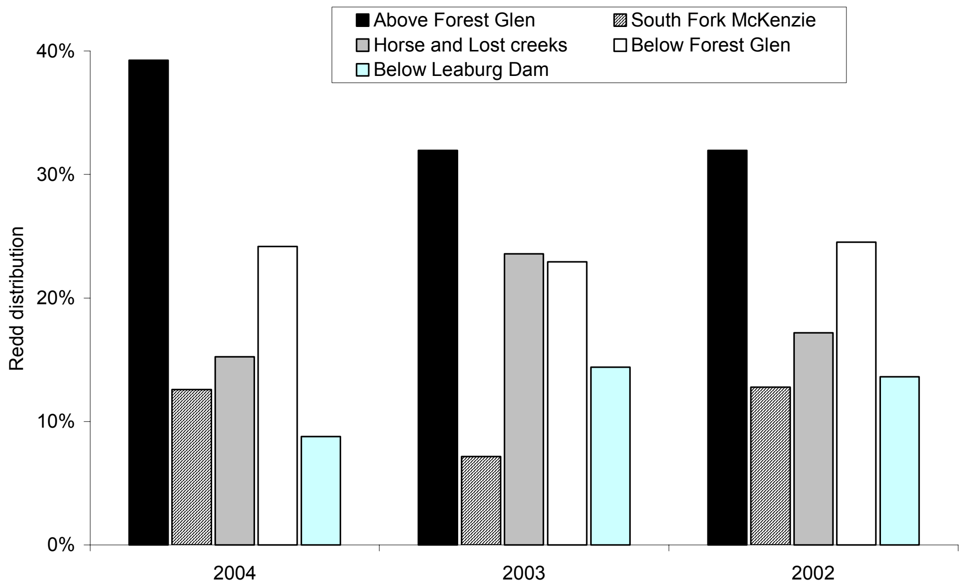

Figure 11. Distribution of spring chinook salmon redds in the McKenzie River basin, 2002–2004.

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, but it is not known how many remain below the dam or ascend the fishway multiple times. The dam counts are from video tapes and therefore are likely overestimates of the number of clipped fish above 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 12) 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 12. 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.*

Other rivers that were regularly surveyed in 2004 (Table 13) 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 13). The percentage of fin-clipped carcasses was lowest in the McKenzie above Leaburg Dam (34%, Table 12) and in the Molalla (50%), although sample size was small (Table 13). A high percentage of fin-clipped fish were recovered in the Middle Fork Willamette (72%), the North Santiam (82%), South Santiam (88%), and the McKenzie below Leaburg Dam (85%) (Tables 10 and 13).

Table 13. Summary of chinook salmon spawning surveys in the Middle Fork Willamette, South Santiam, Santiam, and Molalla rivers, 2004.

		Carcasses			Redds/mi			
River, section	Length (mi)	No fin clip[a]	Fin clipped	Redds	2004	2003	2002	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.*

The pre-spawning mortality of spring chinook salmon (based on examination of female carcasses) is in Table 14.

Table 14. Number and percentage of carcasses of spring chinook salmon (females) in the Willamette River basin that died before spawning and starting dates of spawning surveys, 2001–2004.

River	Starting date	Carcasses	Pre-spawn mortality Number	Percent
		2001		
McKenzie	Aug 21	198	14	7
North Santiam	Aug 14	319	238	75
		2002		
Middle Fork Willamette	Aug 7	162	134	83
Fall Creek	Aug 27	36	21	58
McKenzie	Aug 15	509	41	8
South Santiam	Aug 6	794	204	26
North Santiam	Aug 1	229	120	52
		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
		2004		
Middle Fork Willamette	Aug 24[a]	76	75	99
McKenzie	Aug 18	343	59	17
South Santiam	Jul 20	557	399	72
North Santiam	Jun 17	287	222	77
Little North Fork Santiam	Jul 14	8	4	50

[a] *No surveys were conducted after September 16.*

Mortality of spring chinook carcasses (females) recovered in 2004.

River	Pre-spawn clipped	Pre-spawn not clipped	Spawned clipped	Spawned not clipped
N. Santiam	186 (77%)	36 (80%)	56	9
S. Santiam	351 (70%)	48 (83%)	148	10
McKenzie	38 (26%)	21 (11%)	109	175

Coded wire tags from carcasses recovered in 2003 were processed in 2004 and results are in Table 15. Preliminary tag data from carcasses recovered in 2004 are in Table 16. The percentage of stray hatchery fish recovered in spawning surveys in the McKenzie River in 2003 (Table 15) was similar to that in 2002 (42%) and higher than in 2001 (13%), and strays composed over 50% of hatchery recoveries in 2004 (Table 16). Stray hatchery fish in the North Santiam was higher in 2003 and 2004 (37 and 64%, respectively) than in 2002 (30%) and 2001 (6%). In the South Santiam a higher percentage of stray hatchery fish were recovered in 2003 (43%) and 2004 (25%) than in 2002 (7%). The highest number of strays in these rivers was from net pen 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 15 and 16).

Table 15. Origin of hatchery spring chinook salmon from recoveries of coded wire tags in spawning ground surveys, 2003.

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

[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 16. Origin of hatchery spring chinook salmon from recoveries of coded wire tags in spawning ground surveys, 2004. Data are preliminary.

River surveyed	n	Origin of coded wire tags recovered: 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

[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.*

Efforts to Re-Establish Populations

We previously reported on the poor survival of unclipped adult spring chinook that were transported from the Minto collection facility on the North Santiam River and released into the Little North Fork Santiam (Firman et al. 2004). Few of these fish survived to spawn and the number of redds counted in the Little North Santiam River in 2002 (30) and 2003 (31) was only slightly higher than the 1997–2001 average (20).

In 2004, unclipped adult spring chinook, collected at Minto, were tagged with Floy® tags and released at the Golf bridge (rm 12.5) in the Little North Fork Santiam River. A total of 377 fish were released on four dates from July 9 through September 9 (Table 17).

Table 17. Number of male and female unclipped spring chinook released in the Little North Fork Santiam at the Golf Bridge (rm 12.5), July-September, 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. We recovered six tags in the Little North Fork Santiam, five upstream of the release site and one downstream. 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. Rain in late August and mid September 2004 increased the flow in the Little North Fork Santiam (Figure 12), which allowed more opportunity for transported fish to disperse. We recovered too few tagged females to estimate pre-spawning mortality from the release. Of the 8 females recovered (fin-clipped and unclipped), 4 had died before spawning.

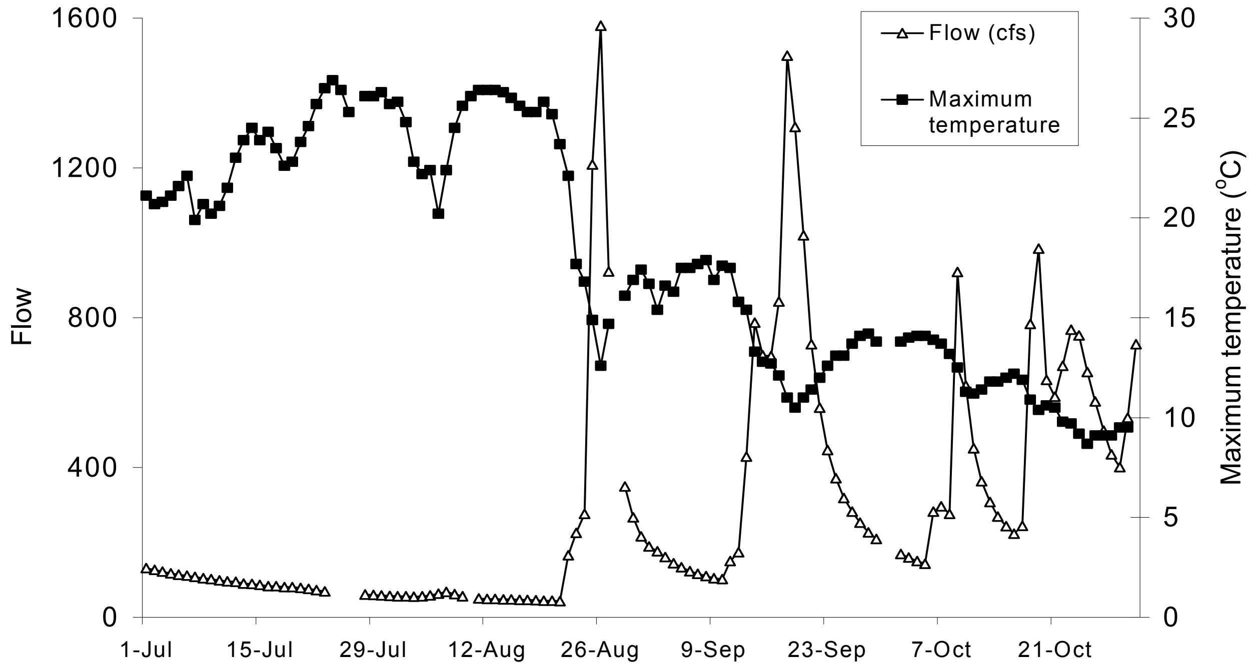

Figure 12. Flow (cfs) and maximum temperature (°C) in the Little North Fork Santiam River, July–October 2004.

The rain in 2004 increased flow and allowed a broad distribution of transported adults, and likely contributed to increased survival of these fish to spawning. As a result of the rain and increased flow, maximum water temperature decreased by about 9°C in late August, and by another 3°C in mid September (Figure 12). The number of redds counted in 2004 (51) was larger than the 2002–2003 average (31) when adult chinook were also transported, and larger than the 1996–2001 average (17).

Otolith Sampling

Restoration of spring chinook salmon under the Endangered Species Act and the implementation of ODFW's Native Fish Conservation Policy require information on hatchery and wild fish in spawning populations. In response to this need and to implement a selective fishery, all hatchery spring chinook salmon in the Willamette basin, beginning with the 1997 brood, were marked with adipose fin clips. Although the intention is to externally mark all juvenile hatchery fish, some are missed during marking. To help separate returning hatchery fish without fin clips from wild fish, otoliths have been thermally marked on all hatchery spring chinook released into the Willamette basin 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 for 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 2003 brood, hatchery spring chinook salmon in the Willamette basin. Reference samples were collected at the hatcheries (Table 18) and were analyzed for mark quality at the otolith laboratory operated by Washington Department of Fish and Wildlife (WDFW). Results indicated good quality marks at all hatcheries that should be identifiable in returning adults.

Table 18. 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 spring chinook without fin clips on spawning grounds and at hatcheries in most of the major tributaries in the Willamette Basin in 2004 (Table 19). Otoliths were removed from carcasses without fin clips and placed into individually numbered vials. We also collected otoliths from adult hatchery fish at Minto (North Santiam River), South Santiam, McKenzie, and Willamette hatcheries to serve as reference samples for blind tests of accuracy in identifying thermal marks (Table 19). These samples will be sent to WDFW for analysis and will be reported in 2005.

Table 19. Otoliths collected from adult spring chinook salmon during spawning ground surveys and at hatcheries, 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

We estimated the proportion of naturally produced ("wild") fish on spawning grounds in the Willamette basin from otoliths collected in 2003 (Table 20). 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 (Firman et al. 2004). 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 20. Otoliths collected from adult spring chinook in the Willamette River basin 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

We estimated the number of wild fish in the North Santiam and McKenzie rivers above dams in 2003 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 Bennett Dam (North Santiam) or Leaburg Dam (McKenzie), and T_{nc} is the percentage of non-clipped carcasses on spawning grounds of the North Santiam or McKenzie rivers with thermal marks in their otoliths.

We also estimated the number of wild fish in the McKenzie and North Santiam rivers by using the percentage of hatchery fish released without clips and the number of fin-clipped adults counted at dams to estimate the number of additional hatchery fish without a clip. Because only fin-clipped fish are harvested in fisheries, we expanded the count of fin-clipped adults at the dams by 26%, the 1981–1995 average in the lower Willamette River sport fishery (data from Foster and Boatner 2002).

We tested the accuracy of identifying induced thermal marks by submitting otoliths 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.

Results

Wild spring chinook composed the highest percentage of carcasses recovered in the McKenzie River and the lowest percentage in the Molalla, North Santiam, and Middle Fork Willamette rivers in 2003 (Table 21). We continued to find higher than expected numbers of wild carcasses in the South Santiam River.

Table 21. Composition of spring chinook salmon in the Willamette River basin based on carcasses recovered, adjusted for distribution of redds among survey areas within a watershed. For comparison, the percentages of wild carcasses unadjusted for redd distribution are also presented.

		Not fin clipped[a]		Percent wild	
River (section), run year	Fin clipped	Hatchery	Wild	Weighted	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

[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.*

The McKenzie River had the highest number of wild spring chinook and the North Santiam River had the lowest number (Table 22). 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 naturally-spawning 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. 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 22).

Table 22. Estimated number of wild and hatchery adult spring chinook salmon in the McKenzie and North Santiam 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) and expanded trap counts (North Santiam, from 4 d/wk counts).

Run year	At dam: Not fin clipped	At dam: Fin clipped	No clip carcasses with thermal marks (%)[a]	Estimated number: Wild	Estimated number: Hatchery	Estimated number: 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	1,231	6,409	51.0[c]	604	7,036	8
2003	1,262	11,570	78.5[c]	271	12,561	2

[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.*

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 otoliths from carcasses without a fin clip recovered on spawning grounds. 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 23). These data suggest that the percentage of hatchery fish released without a clip is underestimated possibly because 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 23. Comparison of two methods of estimating the number of wild spring chinook salmon from adult counts at dams in the McKenzie and North Santiam rivers.
The proportion of wild and hatchery adults is estimated either by the percentage of juvenile hatchery fish released without fin clips or by otoliths from carcasses recovered on spawning surveys.

River, run year	Number (% in run) of wild adults determined by— Release data	Otolith analysis
McKenzie, 2001	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 24), and identified 99% of known wild juvenile chinook in a blind test with juvenile hatchery chinook. Further tests are planned on the accuracy of identifying hatchery fish by presence of thermal marks in otoliths.

Table 24. Accuracy in blind tests of the WDFW otolith laboratory in identifying presence or absence of thermal marks in hatchery spring chinook salmon, 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

Marked and Unmarked Chinook in Hatcheries and Broodstock Collection Facilities

Table 25 gives details of the status of chinook that were captured at hatcheries and broodstock collection facilities. The released category includes both fish that were recycled, and fish that were released upstream of collection facilities. A total of 30,989 spring chinook entered hatcheries and broodstock collection facilities in 2004. Most of the salmon collected were released alive (22,124; 71.4%). Table 26 shows details of the locations and magnitude of releases.

Table 25. Fate of marked and unmarked spring chinook entering hatcheries & collection facilities: 2004.

Hatchery	Status	Marked Adults	Unmarked Adults	Total Adults	Marked Jacks	Unmarked Jacks	Total Chinook	% Unmk
Marion Forks	Released	2,778	434	3,212	36	0	3,248	13.36
	Spawned	507	59	566	0	0	566	10.42
	Other dead	233	5	238	0	0	238	2.10
	Total	*3,518*	*498*	*4,016*	*36*	*0*	*4,052*	*12.29*
S. Santiam	Released	7,123	1710	8,833	22	6	8,861	19.37
	Spawned	970	29	999	15	1	1,015	2.96
	Other dead	1,701	14	1,715	15	0	1,730	0.81
	Total	*9,794*	*1748*	*11,542*	*52*	*7*	*11,601*	*15.13*
Dexter	Released	6,069	110	6,179	130	2	6,311	1.77
	Spawned	2,462	26	2,488	11	0	2,499	1.04
	Other dead	2,516	0	2,516	49	0	2,565	0.00
	Total	*11,047*	*136*	*11,183*	*190*	*2*	*11,375*	*1.21*
Willamette	Spawned	1,825	26	1,851	0	0	1,851	1.40
	Other dead	637	0	637	11	0	648	0.00
	Total	*2,462*	*26*	*2,488*	*11*	*0*	*2,499*	*1.04*
McKenzie	Released	3,663	5	3,668	26	1	3,695	0.16
	Spawned	829	180	1,009	0	0	1,009	17.84
	Other dead	260	40	300	3	0	303	13.20
	Total	*1,217*	*225*	*1,442*	*10*	*1*	*1,453*	*15.55*
Leaburg Trap	Released	9		9	0	0	9	
	Total	*9*		*9*	*0*	*0*	*9*	
Grand Total		***28,047***	***2,633***	***30,680***	***299***	***10***	***30,989***	***8.53***

Table 26. Releases of spring chinook captured in hatcheries and collection facilities: 2004.

Hatchery	Release Location	Mk Adult	Unmk Adult	Mk Jack	Unmk Jack	Total Chinook	% Unmk
Marion Forks	ABOVE DETROIT	2,475	0	36	0	2,511	0.00
	ABOVE MINTO	87	57	0	0	144	39.58
	LITTLE N. FORK	0	377	0	0	377	100.00
	RECYCLED DOWN	216	0	0	0	216	0.00
	TOTAL	*2,778*	*434*	*36*	*0*	*3,248*	*13.36*
S. Santiam	SANTIAM R, S FK (downstream)	5,455	80	16	0	5,551	1.44
	SANTIAM R, S FK (above Foster)	944	1,630	0	6	2,580	63.41
	WILEY CR	242	0	5	0	247	0.00
	THOMAS CR	236	0	1	0	237	0.00
	CRABTREE CR	246	0	0	0	246	0.00
	TOTAL	*7,123*	*1,710*	*22*	*6*	*8,861*	*19.37*
Dexter	LOST CR	392	10	3	0	405	2.47
	WILLAMETTE R, MID FK	1,969	0	42	0	2,011	0.00
	SALT CR	1,144	26	22	0	1,192	2.18
	WILLAMETTE R, N FK MID FK	2,564	74	63	2	2,703	2.81
	TOTAL	*6,069*	*110*	*130*	*2*	*6,311*	*1.77*
McKenzie	MCKENZIE R	0	5	0	1	6	100.00
	MOHAWK R	137	0	0	0	137	0.00
	MCKENZIE R, S FK	3,406	0	24	0	3,430	0.00
	TRAIL BRIDGE RES	120	0	2	0	122	0.00
	TOTAL	*3,663*	*5*	*26*	*1*	*3,695*	*0.16*
Leaburg Trap	MCKENZIE R, UPSTREAM						
	MCKENZIE R, S FK	9	0	0	0	9	0
	TOTAL	*9*	*0*	*0*	*0*	*9*	*0*
Grand Total		***19,642***	***2,259***	***214***	***9***	***22,124***	***35***

In 2004, a total of 4,321 spring chinook were spawned at hatcheries in the Upper Willamette ESU. Of these, 93% were marked hatchery fish. Otoliths were collected from all unmarked fish in the broodstock to confirm their origin, and are currently being read. A breakdown of spawned fish by hatchery is presented in Table 27. The highest incidence of unmarked fish in the broodstock was at McKenzie Hatchery where 18.2% of the fish spawned were unmarked. In 2003, 75% of the unmarked chinook spawned at McKenzie hatchery had otolith marks that indicated that they were actually hatchery-reared fish (Table 31). Assuming a similar percentage of otolith marks in 2004, then 4.6% of the broodstock in 2004 was unmarked. At all other hatcheries, the number of unmarked fish in the broodstock was at or under 10%, and overall, 7% of the 2004 broodstock were unmarked.

Table 27. Spring Chinook spawned at hatcheries in the Upper Willamette ESU in 2004.

Hatchery	Males	Females	Jacks	Mk Adult	Unmk Adlt	Mk Jack	Unmk Jack	% UnMk
Marion Forks	283	283	0	507	59	0	0	10.42
S. Santiam	493	506	16	970	29	15	1	2.96
McKenzie	492	497	0	809	180	0	0	18.20
Willamette	1,006	845	0	1,810	41	0	0	2.22
Grand Total	***2,274***	***2,131***	***16***	***4,096***	***309***	***15***	***1***	***7.01***

The 'Dead' category in Table 25 includes mortalities, fish that were killed to retrieve coded wire tags, fish that were given to food banks, diseased fish that were culled, and excess fish. Spawned fish are not included in this category. Details can be found in Table 28.

Table 28. Spring Chinook captured in hatcheries and broodstock collection facilities that died or were killed: 2004. (Fish spawned are not included in these totals).

Hatchery	TYPE	Mk Adult	Unmk Adlt	Mk Jack	Unmk Jack	Total Chinook	% Unmk
Marion Forks	*CWT REC*	92	0	0	0	92	0.00
	MORTS	111	0	0	0	111	0.00
	BKD CULL	30	5	0	0	35	14.29
	TOTAL	*233*	*5*	*0*	*0*	*238*	*2.10*
S. Santiam	GIVE AWAY	1,431	1	8	0	1,440	0.07
	MORTS	239*	12*	7	0	258	4.65
	OTHER	31	1	0	0	32	3.13
	TOTAL	*1,701*	*14*	*15*	*0*	*1,730*	*0.81*
Dexter	*CWT REC-GIVE AWAY*	*2,516*	*0*	*49*	*0*	*2,565*	*0.00*
McKenzie	GIVE AWAY	1,217	0	10	0	1,227	0.00
	MORTS	260	40	3	0	303	13.20
	EXC/Tagkill	409	0	4	0	413	0.00
	TOTAL	*1,886*	*40*	*17*	*0*	*1,943*	*2.06*
Leaburg	*TOTAL*	*0*	*0*	*0*	*0*	*0*	
Willamette	*TOTAL*	*637*	*0*	*11*	*0*	*648*	*0.00*
Grand Total		***6,973***	***59***	***92***	***0***	***7,124***	***0.83***

** The mark status was recorded for only a portion of mortalities at South Santiam hatchery (mark was recorded for 16% of morts). The ratio of unmarked fish among mortalities with known mark was used to estimate the total number of marked and unmarked mortalities.*

Coded Wire Tag recoveries from hatcheries

Eighty five spring chinook with coded wire tags were recovered at Minto Ponds in 2004. Of these, 27 fish were strays from other hatcheries (31.8% of the returns). The greatest number of strays came from fish that had been raised at Willamette Hatchery and released in the Molalla River (16 = 59.3% of the strays). Five of these were from the 1999 brood, and the remainder were from the 2000 brood. Another 8 strays (29.6% of the strays at this location) were reared and released at South Santiam Hatchery. All were from the 2000 brood. Three strays had been raised at McKenzie Hatchery. All were from the 1999 brood. One had been released in the Clackamas River, and the other two were released in the Willamette River near Portland.

Forty nine of 388 coded wire tags recovered at South Santiam Hatchery were strays (12.6%). Most of these (38; 56.9%) were fish that had been raised at McKenzie Hatchery and released in the Willamette River near Portland (29) or in the Clackamas River (9). Another 10 fish (19.6% of the strays) were fish that had been raised at Willamette Hatchery and released in the Molalla River. A single fish had been raised at Willamette Hatchery and released from the Dexter Ponds on the Middle Fork Willamette. No strays were found among 106 coded wire tags recovered at McKenzie hatchery and 31 tags recovered at Willamette Hatchery of the Middle Fork Willamette.

Broodstock Biometrics

The number of spring chinook spawned, the sex ratio, and the mark rate are shown in Table 27. Length statistics for spring chinook spawned in hatcheries in the Upper Willamette ESU are presented in Table 29 and Figure 13. Length data were collected for 4,642 adult spring chinook. Jacks were defined as those having a fork length less than 600 mm. Jacks made up a very small proportion of the broodstock (24 of 4,666), and were excluded from this analysis.

Lengths ranged between 600 and 1,135 mm, with an overall average length of 788.6 ± 2.1 mm. Mean lengths among hatcheries were compared using a Kruskal-Wallis One-Way ANOVA on ranks followed by Dunn's pairwise multiple comparison method. There were significant differences in fork length among all hatcheries except between South Santiam and McKenzie hatcheries ($p<0.05$ for all comparisons). Mean lengths of marked and unmarked chinook were also significantly different (Mann-Whitney Rank Sum Test, $p<0.05$). Among hatcheries, mean fork length was greatest at the Minto collection facility (811.6 mm) and least at Willamette hatchery (773.0 mm; Table 29, Figure 14). Mean fork length was greater for unmarked fish (820.5 mm) than for marked fish (787 mm; Table 29, Figure 15).

Table 29. Fork Length statistics from Upper Willamette hatchery broodstock, 2004.

Hatchery	Mark	Count	Min. (mm)	Max. (mm)	Mean (mm)	95% C.I.
McKenzie	Unmk	121	600	1,100	814.6	13.8
McKenzie	Marked	973	610	1,030	794.7	4.4
Minto	Unmk	22	709	935	819.6	28.8
Minto	Marked	464	615	1,010	811.2	6.9
S. Santiam	Unmk	30	680	950	808.2	28.5
S. Santiam	Marked	1,003	600	1,135	796.4	4.4
Willamette	Unmk	41	660	1,040	847.3	26.1
Willamette	Marked	1,800	600	1,040	771.3	3.0
McKenzie	All	1,094	600	1,100	796.9	4.2
Minto	All	486	615	1,010	811.6	6.7
S. Santiam	All	1,033	600	1,135	796.7	4.4
Willamette	All	1,841	600	1,040	773.0	3.1
All	Unmk	214	600	1,100	820.5	10.6
All	Marked	4,240	600	1,135	787.0	2.1

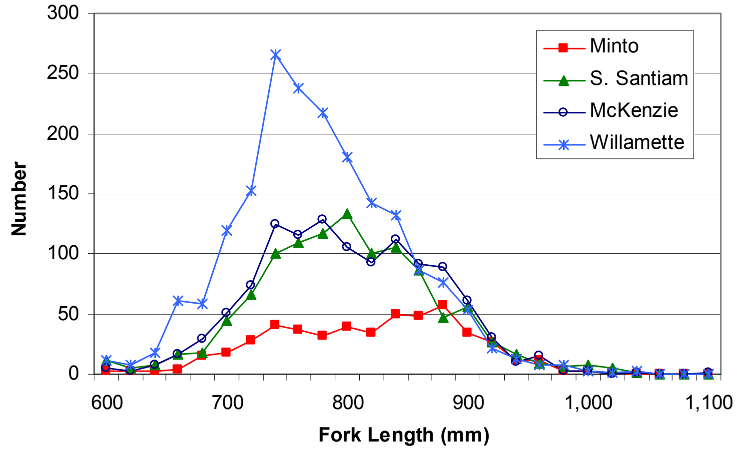

Figure 13. Length frequency distributions of hatchery broodstock, 2004.

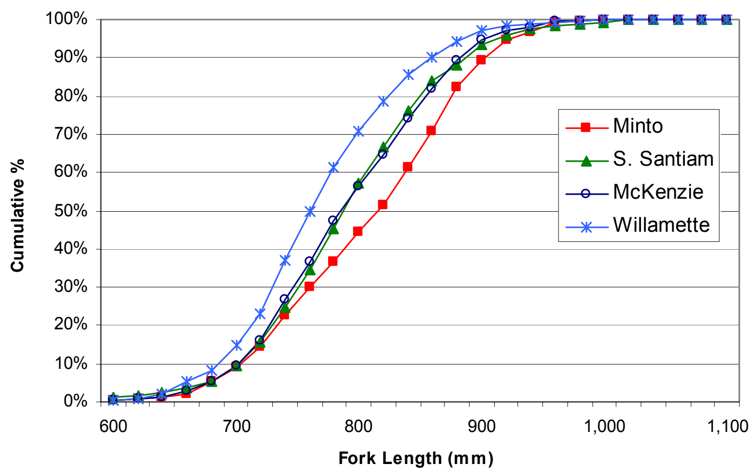

Figure 14. Cumulative frequency distributions of fork length for spring chinook broodstock: comparison among hatcheries.

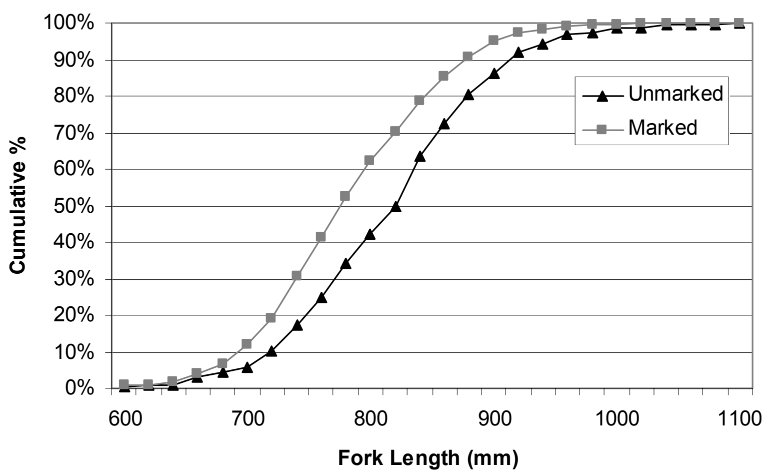

Figure 15. Cumulative frequency distributions of fork length for spring chinook broodstock: marked vs. unmarked fish.

Number and Percentage of Natural-Origin (unmarked) Spring Chinook Run Taken for Broodstock

The size of the natural-origin (unmarked) spring chinook run can be estimated using a combination of passage data from ladders at Stayton Island on the North Santiam River and at Leaburg Dam on the McKenzie River, data from Chinook spawning ground surveys below the dams, and hatchery collection data (Table 30). In these calculations, the total reported for hatchery collection excludes fish that were recycled downstream and thus could appear as carcasses in spawning surveys. This is likely an underestimate since not all fish released would appear in one of those two counts. The total reported for natural spawners includes only carcasses and redd expansions from areas that are below fish passage monitoring facilities. Generally, only a small proportion of naturally spawning fish are recovered as carcasses, so this gives a very conservative minimum estimate of the number of unmarked spring chinook run. In all cases except Willamette Hatchery in the Middle Fork Willamette, the number of unmarked Chinook spawned falls well within 10% of even this conservative minimum estimate (Table 30). However, examination of the otoliths of unmarked chinook collected at Willamette Hatchery last year show that 92.2% of them were actually hatchery fish (Table 31).

Table 30. Estimates of the total natural-origin spring chinook run, 2004.

Basin	Passage at Dams	Natural [a] Spawners	Out-plants [b]	Hatchery Morts	Hatchery Brood	Total	10% of Total
North Santiam	1,383	74			59	1,457[c]	146
South Santiam		114	1,630	14	30	1,788	179
McKenzie River	4,788	131		40	180	5,139	514
Middle Fork Willamette		29	110		41	180	18
Total	**6,171**	**348**	**1,740**	**54**	**251[c]**	**8,564**	**857**

[a] *carcasses or redd expansions from areas below fish passage monitoring facilities only.*
[b] *excludes fish that were recycled downstream and fish that had been counted by other means.*
[c] *excludes fish captured at Minto as these are already accounted for in the Bennett estimates.*

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 incorporated into 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 31).

Table 31. 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.

Hatchery	Thermal mark— Absent	Thermal mark— Present	Percent wild fish	Total fish spawned	Percent wild in broodstock
McKenzie	14	42	25.0	1,009	1.4
North Santiam (Minto)	2	17	10.5	618	0.3
South Santiam	25	23	52.1	1,096	2.3
Willamette	5	59	7.8	1,529	0.3

Spring Chinook Fishery

2004
Analysis of creel data for 2004 is ongoing. Results will be published at a later date.

2003
Creel Methods
Surveys were divided into early and late shifts. The start and end times of these shifts varied with day length in order to encompass the entire daylight period. Early shifts began at dawn and spanned a 10-hour period. Late shifts began 10 hours before dusk and continued until dusk. Angler surveys were conducted on two randomly selected days during the week, and on both days during the weekend. The time of the shift (early vs. late) was also randomly assigned. Data and analysis were stratified by day type (weekend/weekday), angler type (boat, bank), river, fishing location, and month.

Effort counts were conducted three times within a shift at 3-hour intervals. During effort counts, surveyors tallied numbers of anglers and vehicles while driving along the entire survey area. The effort count is intended as an instantaneous count of the number of anglers on the river. Between effort counts, surveyors interviewed groups of anglers, recording catch, time spent fishing, fishing location, and angling gear. Catch was identified by species, maturity and fin mark. Angler interviews were classified as complete if they were finished fishing, or incomplete if they were still fishing. Total angler hours of effort were estimated as the average of total daily angler hours of effort multiplied by the number of days in the stratum. Average daily angler hours of effort was estimated by calculating the area under the curve (AUC) formed by the average angler or boat count at different times of the day. Effort was assumed to be zero at the legal start and end of the fishing day. The catch rate was estimated from the angler interviews by summing sampled catch by species, fin mark and maturity and dividing by sampled angler hours. Total catch was estimated by multiplying the catch rate by the estimated hours of effort. Angler trips were estimated by dividing the estimated hours of effort by the average trip length from completed trips.

South Santiam Chinook Creel

The angler creel survey on the South Santiam River began on April 1, 2003 and ended October 31, 2003. It is estimated that anglers spent a total of 146,245 hours fishing on the South Santiam during this time period in 2003 (Table 32, Figure 16). Bank anglers contributed the bulk of the effort with 87,807 hours fished, and boat anglers made up the remainder (58,438 hours). An estimated 4,731 spring chinook were caught, 3,265 by bank anglers and 1,466 by boat anglers (Table 32, Figure 17). Bank anglers were more successful with a catch rate of 0.037 fish per hour fished (Table 32, Figure 18). Boat anglers brought in 0.025 fish per hour, giving a average catch rate of 0.032 fish per hour fished. Catch rate was highest in September when there were few hours fished, but more fish caught than in the previous month. Both effort and catch were highest in May and June.

Table 32. Effort, catch, and catch rate for spring chinook salmon in the South Santiam fishery, 2003.

Month	Effort			Catch			Catch Rate		
	Bank	Boat	*Total*	Bank	Boat	*Total*	Bank	Boat	*Average*
April	7,681	4,737	*12,418*	24	20	*44*	0.0031	0.0042	*0.0035*
May	26,084	27,194	*53,278*	985	625	*1,610*	0.0378	0.0230	*0.0302*
June	26,646	19,637	*46,283*	1,147	675	*1,822*	0.0430	0.0344	*0.0394*
July	16,649	5,605	*22,254*	475	135	*610*	0.0285	0.0241	*0.0274*
Aug	6,288	997	*7,285*	240	11	*251*	0.0382	0.0110	*0.0345*
Sept	3,270	96	*3,366*	391	0	*391*	0.1196	0.0000	*0.1162*
Oct	1,189	172	*1,361*	3	0	*3*	0.0025	0.0000	*0.0022*
Season	**87,807**	**58,438**	***146,245***	**3,265**	**1,466**	***4,731***	**0.0372**	**0.0251**	***0.0323***

A total estimate of 3,297 marked chinook were harvested from the South Santiam in 2003 (Table 33). Of these, 2,035 were caught by bank anglers and 1,262 by boat anglers. Another 784 marked chinook were caught and released. The mortality rate for chinook that are caught and released has been estimated at 12.5% (Lindsay et al., 2000). Based on this rate, it is estimated that another 98 hatchery fish died after release, for a total of 3,395 marked fish that were removed by the fishery. Bank anglers were far more likely to release marked fish (26.7% of marked fish caught were released) than were boat anglers (3.2% of marked fish caught were released).

Roughly 14% of the spring chinook caught were unmarked (Table 33). A total of 650 unmarked spring chinook were caught over the course of the season. It is estimated that 10 were kept illegally. Assuming a 12.5% hooking mortality rate (Lindsay et al., 2000), it is estimated that the fishery on the South Santiam had a take of 90 unmarked spring chinook in 2003.

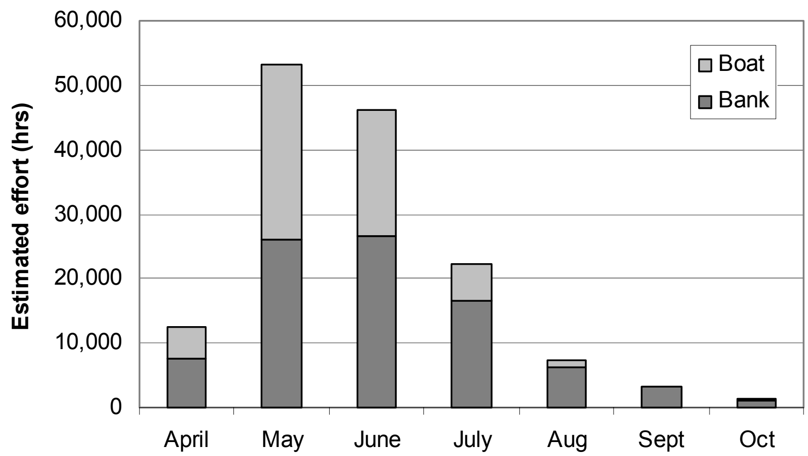

Figure 16. Estimated hours effort in South Santiam fishery, 2003.

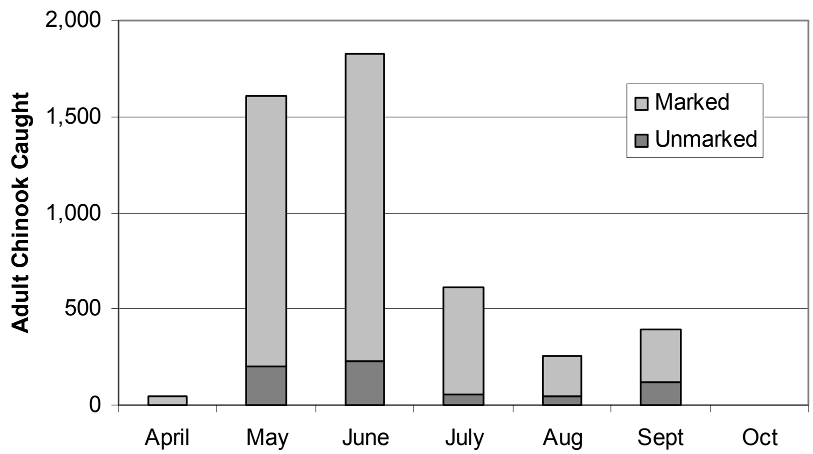

Figure 17. Catch of spring chinook in the South Santiam, 2003.

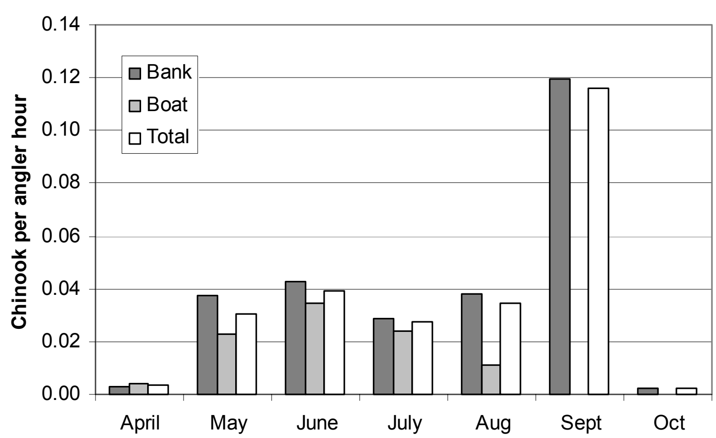

Figure 18. Catch rate for spring chinook in the South Santiam, 2003.

Table 33. Spring chinook harvested and released in the South Santiam fishery, 2003.

Kept

	Bank		Boat						
	Unmk	Mark	Unmk	Mark	Unmarked	Marked	Bank	Boat	**Total**
April	0	24	0	20	0	44	24	20	**44**
May	0	840	0	531	0	1,371	840	531	**1,371**
June	0	836	0	607	0	1,443	836	607	**1,443**
July	10	260	0	99	10	359	270	99	**369**
Aug	0	75	0	5	0	80	75	5	**80**
Sept	0	0	0	0	0	0	0	0	**0**
Oct	0	0	0	0	0	0	0	0	**0**
Season	*10*	*2,035*	*0*	*1,262*	*10*	*3,297*	*2,045*	*1,262*	***3,307***

Released

	Bank		Boat						
	Unmk	Mark	Unmk	Mark	Unmarked	Marked	Bank	Boat	**Total**
April	0	0	0	0	0	0	0	0	**0**
May	128	17	76	18	204	35	145	94	**239**
June	163	148	68	0	231	148	311	68	**379**
July	32	173	12	24	44	197	205	36	**241**
Aug	36	129	6	0	42	129	165	6	**171**
Sept	116	275	0	0	116	275	391	0	**391**
Oct	3	0	0	0	3	0	3	0	**3**
Season	*478*	*742*	*162*	*42*	*640*	*784*	*1,220*	*204*	***1,424***

McKenzie River Chinook Creel

The angler creel survey on the McKenzie River began on April 1, 2003 and ended November 30, 2003. It is estimated that anglers spent a total of 78,160 hours fishing on the McKenzie during this time period in 2003 (Table 34, Figure 19). Boat anglers contributed the greatest effort with 59,367 hours fished, while bank anglers made up the remainder (18,793 hours). An estimated 1,987 spring chinook were caught, 430 by bank anglers and 1,557 by boat anglers (Table 34, Figure 20). Boat anglers and bank anglers had similar catch rates with 0.026 and 0.022 fish caught per hour (Table 34, Figure 21). The overall catch rate was 0.025 fish per hour fished. Effort, catch and catch rate were all highest in June.

Table 34. Effort, catch, and catch rate for spring chinook salmon in the McKenzie fishery, 2003.

	Hours Effort			Chinook					
				Catch			Catch Rate		
Month	Bank	Boat	*Total*	Bank	Boat	*Total*	Bank	Boat	*Average*
April	807	2,702	*3,509*	0	0	*0*	0.0000	0.0000	*0.0000*
May	5,029	16,990	*22,019*	24	492	*516*	0.0048	0.0290	*0.0234*
June	6,023	21,611	*27,634*	274	773	*1,047*	0.0455	0.0358	*0.0379*
July	3,152	8,071	*11,223*	101	220	*321*	0.0320	0.0273	*0.0286*
Aug	1,936	4968	*6,904*	22	59	*81*	0.0114	0.0119	*0.0117*
Sept	967	2562	*3,529*	7	13	*20*	0.0072	0.0051	*0.0057*
Oct	680	2241	*2,921*	2	0	*2*	0.0029	0.0000	*0.0007*
Nov	199	222	*421*	0	0	*0*	0.0000	0.0000	*0.0000*
Season	**18,793**	**59,367**	***78,160***	**430**	**1,557**	***1,987***	**0.0229**	**0.0262**	***0.0254***

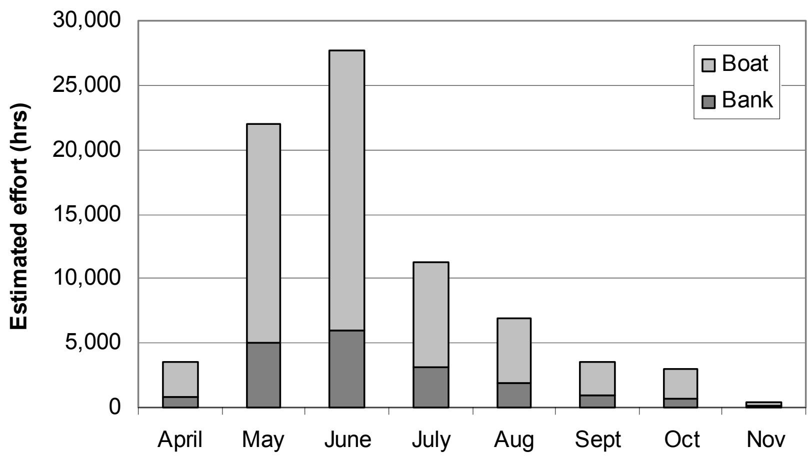

Figure 19. Estimated hours effort in the McKenzie River fishery, 2003.

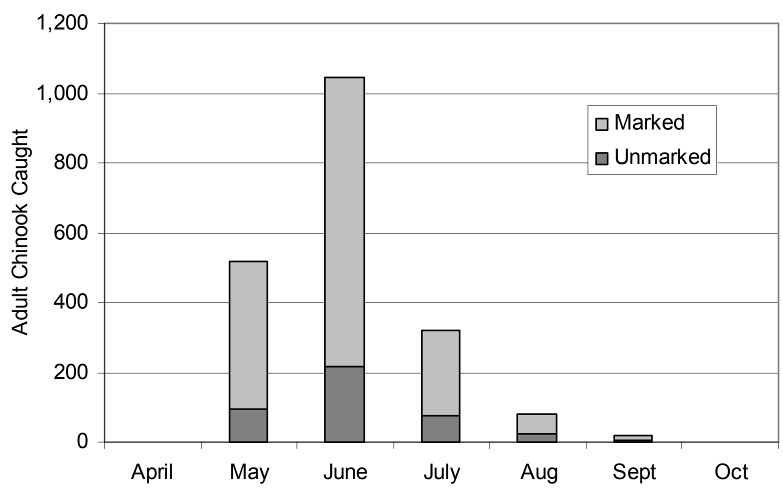

Figure 20. Catch of spring chinook in the McKenzie River, 2003.

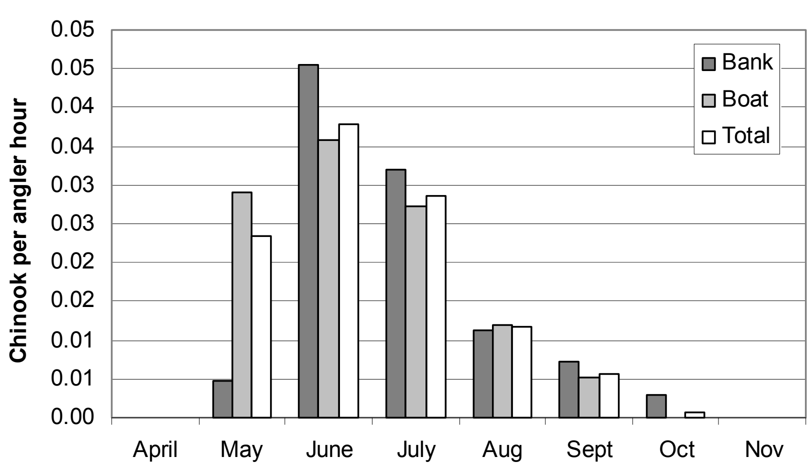

Figure 21. Catch rate for spring chinook in the McKenzie River, 2003.

A total of 1,517 marked chinook were harvested from the McKenzie in 2003 (Table 35). Bank anglers caught 247 of these, and boat anglers caught the remaining 1,270. Another 97 marked chinook were caught and released. Assuming a 12.5% hooking mortality rate on released fish (Lindsay et al., 2000), another 12 hatchery fish died after release, for a total of 1,529 marked fish removed by the fishery. Bank anglers were far more likely to release marked fish (16.8% of marked fish caught were released) than were boat anglers (3.7% of marked fish caught were released).

Approximately 21% of the spring chinook caught were unmarked (Table 35). A total of 417 unmarked spring chinook were caught over the course of the season. It is estimated that 42 were kept illegally. Assuming a 12.5% hooking mortality rate (Lindsay et al., 2000), it is estimated that the fishery on the McKenzie had a take of 94 unmarked spring chinook in 2003.

Table 35. Spring chinook harvested and released in the McKenzie fishery, 2003.

Kept

	Bank		Boat						
	Unmk	Mark	Unmk	Mark	Unmarked	Marked	Bank	Boat	**Total**
April	0	0	0	0	0	0	0	0	**0**
May	0	16	0	401	0	417	16	401	**417**
June	0	177	42	598	42	775	177	640	**817**
July	0	44	0	186	0	230	44	186	**230**
Aug	0	10	0	43	0	53	10	43	**53**
Sept	0	0	0	0	0	0	0	0	**0**
Oct	0	0	0	0	0	0	0	0	**0**
Season	*0*	*247*	*42*	*1,228*	*42*	*1,475*	*247*	*1,270*	***1,517***

Released

	Bank		Boat						
	Unmk	Mark	Unmk	Mark	Unmarked	Marked	Bank	Boat	**Total**
April	0	0	0	0	0	0	0	0	**0**
May	4	4	91	0	95	4	8	91	**99**
June	76	21	100	33	176	54	97	133	**230**
July	42	15	34	0	76	15	57	34	**91**
Aug	6	6	16	0	22	6	12	16	**28**
Sept	3	4	0	13	3	17	7	13	**20**
Oct	2	0	0	0	2	0	2	0	**2**
Season	*133*	*50*	*242*	*47*	*375*	*97*	*183*	*289*	***472***

Middle Fork Willamette Chinook Creel
The angler creel survey on the Middle Fork Willamette River began on April 1, 2003 and ended July 31, 2003. It is estimated that anglers spent a total of 100,585 hours fishing on the Middle Fork during this time period in 2003 (Table 36, Figure 22). Bank anglers contributed 63% of the effort with 63,194 hours fished. Boat anglers spent a total of 37,391 hours fishing. It is estimated that 2,782 spring chinook were caught, 2,265 by bank anglers and 517 by boat anglers (Table 36, Figure 23). Bank anglers were much more successful than boat anglers with a catch rate of 0.036 fish per hour fished compared to 0.014 fish per hour for boat anglers (Table 36, Figure 24). The overall catch rate was 0.028 fish per hour fished. Effort was highest in May, catch was highest in June, and the catch rate was highest in July.

Table 36. Effort, catch, and catch rate in the Middle Fork Willamette fishery, 2003.

				Chinook					
	Hours Effort			Catch			Catch Rate		
Month	Bank	Boat	*Total*	Bank	Boat	*Total*	Bank	Boat	*Average*
April	8,839	4,355	*13,194*	23	6	*29*	0.0026	0.0014	*0.0022*
May	21,872	17,748	*39,620*	525	201	*726*	0.0240	0.0113	*0.0183*
June	21,734	11,589	*33,323*	1,050	237	*1,287*	0.0483	0.0205	*0.0386*
July	10,749	3,699	*14,448*	667	73	*740*	0.0621	0.0197	*0.0512*
Season	**63,194**	**37,391**	**100,585**	**2,265**	**517**	**2,782**	**0.0358**	**0.0138**	***0.0277***

It is estimated that a total of 1,583 marked chinook were harvested from the Middle Fork in 2003 (Table 37). Of these, 1,245 were caught by bank anglers and 338 by boat anglers. Another 366 marked chinook were caught and released. Assuming a hooking mortality rate of 12.5% (Lindsay *et al*., 2000), it is estimated that another 46 hatchery fish died after release, for a total of 1,629 marked fish that were removed by the fishery. Bank anglers were more likely to release marked fish (21.6% of marked fish caught were released) than were boat anglers (6.4% of marked fish caught were released).

Almost 30% of the spring chinook caught were unmarked (Table 37). This seems unlikely as only 1.2% of the chinook trapped at Dexter Dam were unmarked. At the time of the surveys, the surveyors suspected that some anglers were inflating numbers of fish released, especially unmarked fish. A suspiciously high percentage of unmarked steelhead were also reported to have been released. We are currently working to remove questionable interviews from the data used to make expansions. Our preliminary estimate is that a total of 833 unmarked spring chinook were caught over the course of the season. Assuming a 12.5% hooking mortality rate (Lindsay et al., 2000), it is estimated that the fishery on the Middle Fork Willamette had a take of 104 unmarked spring chinook in 2003.

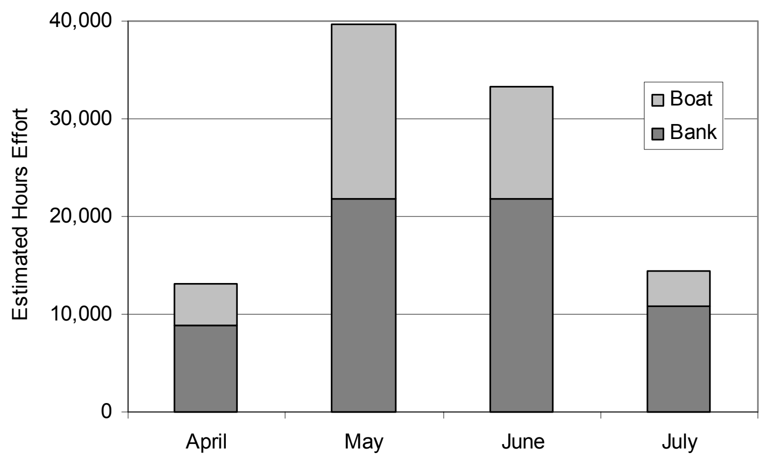

Figure 22. Estimated hours effort in the Middle Fork Willamette fishery, 2003.

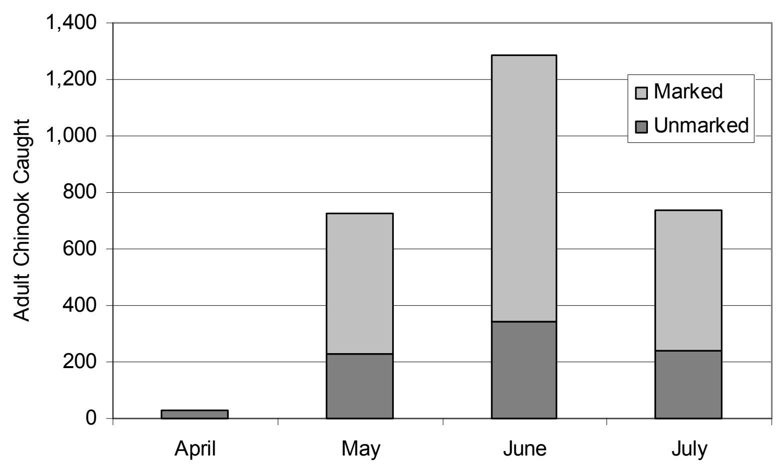

Figure 23. Catch of spring chinook in the Middle Fork Willamette, 2003.

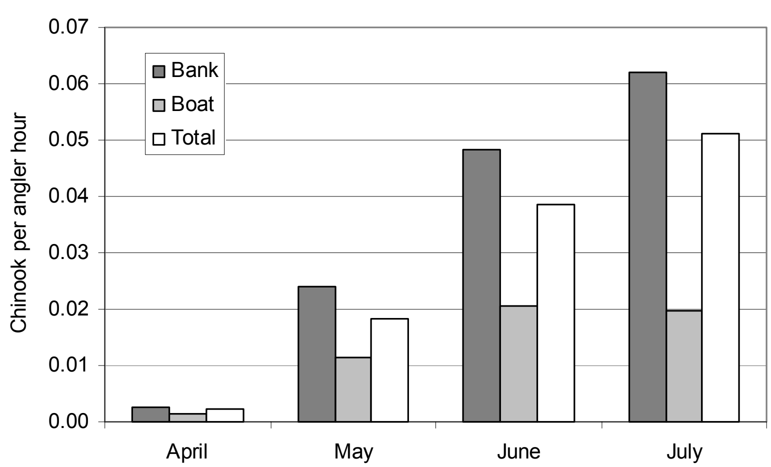

Figure 24. Catch rate for spring chinook in the Middle Fork Willamette, 2003.

Table 37. Spring chinook harvested and released in the Middle Fork fishery, 2003.

Kept

	Bank		Boat						
	Unmk	Mark	Unmk	Mark	Unmarked	Marked	Bank	Boat	**Total**
April	0	0	0	3	0	3	0	3	**3**
May	0	307	0	122	0	429	307	122	**429**
June	0	626	0	154	0	780	626	154	**780**
July	0	312	0	59	0	371	312	59	**371**
Season	*0*	*1,245*	*0*	*338*	*0*	*1,583*	*1,245*	*338*	***1,583***

Released

	Bank		Boat						
	Unmk	Mark	Unmk	Mark	Unmarked	Marked	Bank	Boat	**Total**
April	23	0	3	0	26	0	23	3	**26**
May	156	62	70	9	226	71	218	79	**297**
June	260	164	83	0	343	164	424	83	**507**
July	238	117	0	14	238	131	355	14	**369**
Season	*677*	*343*	*156*	*23*	*833*	*366*	*1,020*	*179*	***1,199***

Steelhead Passage

Willamette Falls

Winter steelhead began arriving at Willamette Falls in November of 2003, and continued to pass through May of 2004 (Table 38, Figure 25). During the 2003-2004 season, a total of 11,842 winter steelhead passed Willamette Falls. The run timing was similar to that seen over the last three years (Figure 26), and the run size was similar to the 33 year average of 12,200 (Table 39, Figure 27). Summer steelhead began arriving at Willamette Falls in March of 2004 (Table 38, Figure 25). Peak passage occurred in May and June, and the run continued through October. Run timing was similar to the previous three years (Figure 26). The run size (32,832) was one of the highest on record (Table 38, Figure 25).

Table 38. Willamette Falls steelhead passage: 2004.

Month	Winter	Summer
Nov	150	
Dec	723	
Jan	1,761	
Feb	2,730	
March	3,284	1,130
April	2,747	5,789
May	447	12,415
June		9,243
Jul		3,130
Aug		528
Sept		444
Oct		153
Season	**11,842**	**32,832**

Table 39. Steelhead passage at Willamette Falls: 1950-2004

	Winter			Summer
Year	**Early**	**Late**	**Total**	**Total**
1950	2,200			
1951	1,200			
1952	3,400			
1953	1,200			
1954	5,200			
1955	2,100			
1956	3,800			
1957	7,500			
1958	5,500			
1959	3,700			
1960	2,200			
1961	6,500			
1962	5,900			
1963	1,000			
1964	900			
1965	1,500			
1966	14,700			
1967	14,600			
1968	6,400			
1969	8,400			
1970	4,700			146
1971	8,152	18,495	26,647	2,310
1972	6,572	16,685	23,257	690
1973	6,389	11,511	17,900	1,686
1974	5,733	9,091	14,824	4,858
1975	3,096	3,034	6,130	2,910
1976	4,204	5,194	9,398	3,876
1977	5,327	8,277	13,604	9,244
1978	8,599	8,270	16,869	15,172
1979	2,861	5,865	8,726	7,638
1980	6,258	16,097	22,356	11,222
1981	7,662	9,004	16,666	15,224
1982	6,117	6,894	13,011	12,571
1983	4,596	4,702	9,298	5,301
1984	6,664	10,720	17,384	25,002
1985	4,549	16,043	20,592	22,223
1986	8,475	12,776	21,251	40,719
1987	8,543	8,222	16,765	23,742
1988	8,371	15,007	23,378	36,940
1989	4,211	5,361	9,572	6,841
1990	1,878	9,229	11,107	23,428
1991	2,221	2,722	4,943	6,360
1992	1,717	3,679	5,396	11,697
1993	843	2,725	3,568	12,920
1994	1,025	4,275	5,300	11,819
1995	1,991	2,702	4,693	12,704
1996	479	1,322	1,801	6,346
1997	619	3,925	4,544	14,907
1998	757	2,921	3,678	12,931
1999	1,207	5,697	6,904	10,935
2000	1,402	3,359	4,761	12,518
2001	1,773	10,752	12,525	26,418
2002			16,658	34,291
2003			9,046	15,170
2004			11,842	32,832

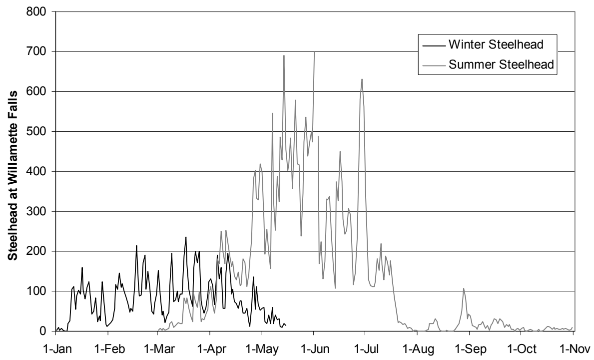

Figure 25. Steelhead Run-timing at Willamette Falls: 04.

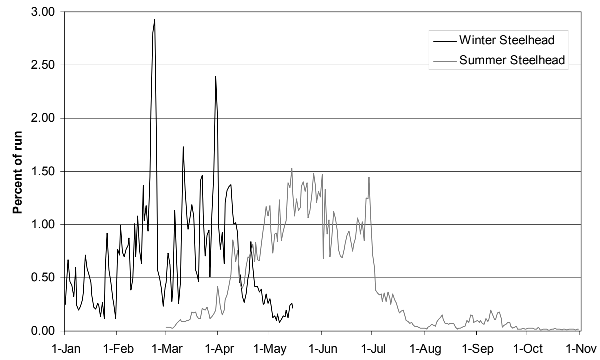

Figure 26. Steelhead run-timing, Willamette Falls: 01-03.

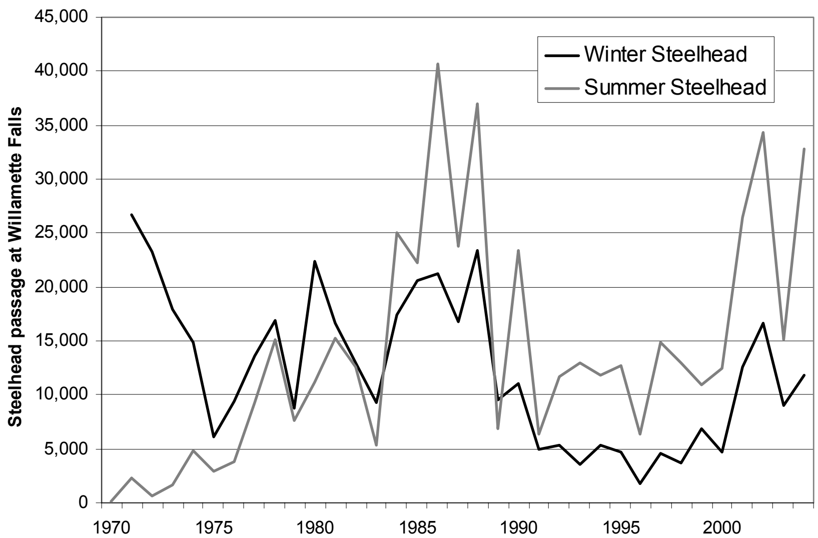

Figure 27. Steelhead passage at Willamette Falls: 1970-2004.

Bennett Dams, Stayton Island, North Santiam River

Abundance and migration timing of steelhead were monitored at upper and lower Bennett dams (Table 40 and Figure 28). Totals have been adjusted to account for fallback over the dams. The traps at the Bennett Dams are inoperable in high flows, so we are unable to trap during the entirety of the winter steelhead run. The counts presented here represent only a portion of the run. It appears that most of the winter steelhead run in 2004 was sampled. Almost 3,000 winter steelhead passed Upper and Lower Bennett Dams in 2004. Winter steelhead were present when the traps were put in service on March 2nd, and peak passage occurred in March and April. Winter steelhead were not seen in the traps after June.

Summer steelhead also began appearing as soon as the traps began operating in late February. Peak passage occurred in May and June, with passage tailing off in July. We estimate that 8,600 summer steelhead passed Stayton Island in 2004. Run timing for both winter steelhead and summer steelhead in 2004 were similar to the pattern observed over the previous 6 years (Figure 29)

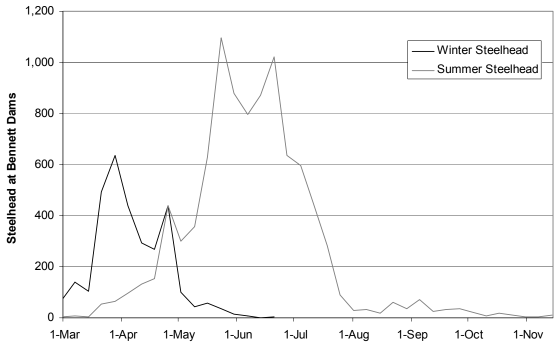

Figure 28. Steelhead run-timing at Bennett Dams: 2004.

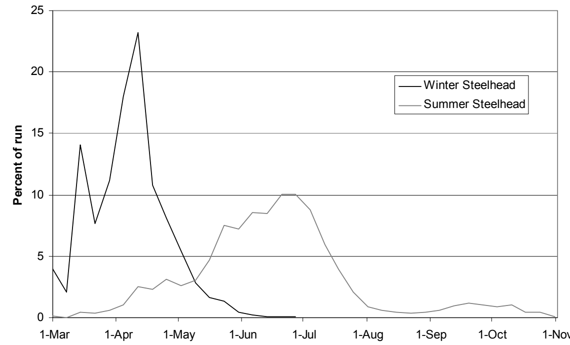

Figure 29. Steelhead run-timing, Bennett Dams: 1998-2003.

Table 40. Steelhead passage estimates at Bennett Dams, N. Santiam: 2004.

	Winter Steelhead			Summer Steelhead		
Month	**Adults**	**1-Salts**	**Total**	**Adults**	**1-Salts**	**Total**
March	1,437	7	1,444	128	7	135
April	1,439	2	1,440	816	7	823
May	251	0	251	3,264	0	3,264
June	12	0	12	3,326	0	3,326
Jul	0	0	0	1,416	2	1,418
Aug	0	0	0	176	0	176
Sep	0	0	0	165	2	167
Oct	0	0	0	65	0	65
Nov	0	0	0	14	0	14
Season	**3,138**	**9**	**3,147**	**9,370**	**18**	**9,388**
Const. adj.*	***3,138***	***9***	***3,147***	***9,924***	***19***	***9,943***
Fallback adj.**	***2,931***	***8***	***2,939***	***8,584***	***16***	***8,600***

**Passage through July 16 expanded based on 86.4% run passed by this point in 2003.*

***Winter Steelhead passage has been adjusted for a 6.6% fallback rate. Summer Steelhead passage has been adjusted for a 13.5% fallback rate.*

We collected scales from unmarked summer steelhead at both Upper and Lower Bennett fishways on the North Santiam River in 2001 (n = 175), 2002 (n = 152) and 2003 (n = 70). Scales were read to verify origin as hatchery or naturally produced. Scale analyses of unmarked summer steelhead in 2001, 2002, and 2003 indicated that 82%, 85% and 76%, respectively were naturally produced. Another 7 scale samples were collected from unmarked summer steelhead at Foster trap on the South Santiam River in 2001, and 10 scale samples in 2002. Scale analyses indicated that 79% were hatchery reared in 2001 and 100% were naturally produced in 2002. However, sample sizes were very small at Foster trap.

Construction at the upper Bennett Dam prevented fish from passing the existing ladder beginning July 16, 2004. The ladder was out of commission for the remainder of the summer steelhead run. The lower Bennett ladder was still operating during this time, and most steelhead pass using the lower Bennett ladder. A temporary steep pass ladder was installed at upper Bennett Dam to provide passage during the construction. We were not able to monitor the number of fish using this ladder, as it could not be configured to allow trapping. Most steelhead passage had occurred prior to the decommissioning of the Upper Bennett ladder, but fairly large numbers of fish were still passing in July, and it is important to obtain an accurate estimate of the total number of summer steelhead that passed the dams during the 2004 season. We have employed two approaches to estimate passage during this time period. The most straightforward approach is to compare the run-timing curve to previous years and adjust the estimate assuming that a similar percent of total fish passage occurred during the same time period. Although the run size in 2003 was much smaller than in 2004, the run timing is the most similar among the runs over the past six years (Figure 30), so data from 2003 were used to correct 2004 estimates. In 2003, 86.4% of the summer steelhead run had passed by July 16. Expanding the 2004 counts through July 16 by 13.6% gives a total estimate of 9,924 summer steelhead. Correcting for fallback gives an estimate of 8,584 summer steelhead. This statistic has been used to compare 2004 to previous years.

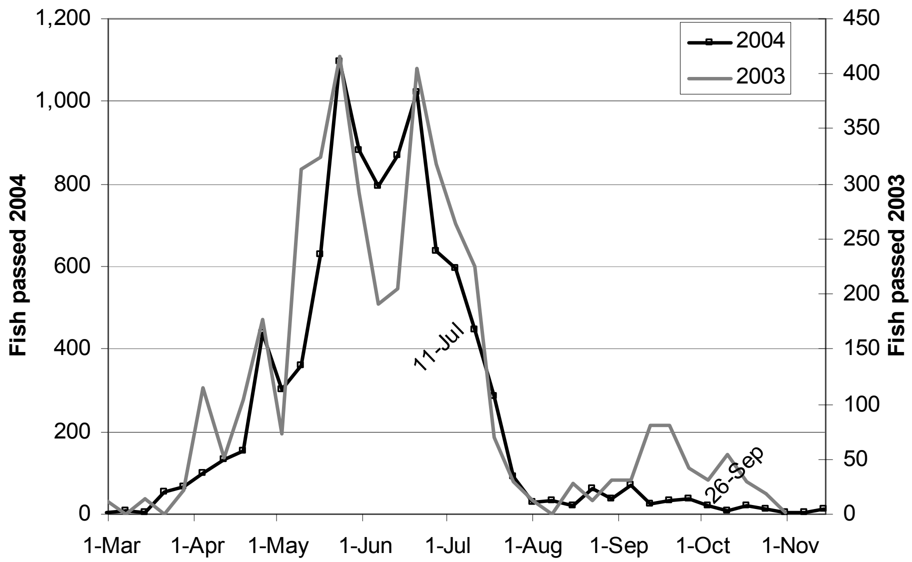

Figure 30. Summer Steelhead passage at Bennett Dams in 2003 and 2004.

Mark-Recapture methods for summer steelhead

A mark recapture method was used as a second approach. Clipped adult summer steelhead were marked with a numbered floy tag as they passed the Bennett Dams, and tags were recovered as fish were handled at the Minto Ponds hatchery facilities. Mark recapture methods were employed in both 2003 and 2004 in order to provide a comparison of methods during a year when trapping took place over the entire season. Fish were double tagged to monitor tag loss rate, and very few tags were lost (4.12%). Population estimates and 95% Confidence Intervals were calculated using the following equations:

$$N = (C+1)(M+1)(1-(P/R)^2)/(R+1)$$

$$C.I. = (N^2*(C-R)/((C+1)*(R+2)))^{0.5}*1.96$$

Where:
N = Total population
C = Number handled during recovery
M = Number marked
R = Number of tags recovered
P = R*0.05

In 2003, 2,070 marked adult summer steelhead were handled at the Bennett traps, and 202 were tagged (9.8%). Tags were recovered from 89 of 3,289 fish handled at the Minto trap (2.7%). These results yield estimates of summer steelhead passage past Stayton Island of 7,486 ± 772, 184% of the trap estimate of 4,073. In 2003, 1,751 summer steelhead were removed by the fishery in the North Santiam. If half of these were caught above Stayton Island, then that would leave 3,198 summer steelhead available to be caught at Minto. The number caught at Minto was actually higher than this (3,289), and we know that the capture rate at Minto was not 100% since some marked summer steelhead were observed spawning naturally in the upper North Santiam in 2003 (Firman et al., 2004). Thus is appears that the trap expansions underestimate the number of steelhead passing the Bennett Dams on Stayton Island. There has been a question for some time that more fish may move through the ladders during the weekends when the traps are disabled and fish can move freely.

In 2004, 4,708 marked adult summer steelhead were handled at the Bennett traps, and 495 were tagged (10.5%). Tags were recovered from 148 of the 5,717 summer steelhead handled at the Minto trap (2.6%). These results yield an estimate of 18,329 ± 1,444 summer steelhead, 214% of the trap estimate of 8,584. The fact that we obtained very similar results in the two years sampled increases our confidence in the results obtained using this method, however, the large discrepancies between estimates based on trap expansion and estimates based on mark recapture are concerning.

The power canal just upstream of Lower Bennett Dam was recently deepened to provide greater flow to the powerhouse. A result of this is that there is now consistent flow through the overflow channel that makes the ladder there passable throughout the year. Fish using this ladder would be able to bypass the trap at Lower Bennett. Most steelhead use the north channel around Stayton island, and would be able to pass by way of the overflow channel whenever there was adequate flow. This ladder must be passable whenever there is water flowing through the channel. Attempts have been made to trap this ladder in the past, but persistent vandalism thwarted these efforts.

There were strong runs of both winter and summer steelhead at the Bennett Dams in 2004 (Table 41, Figure 31). The run of winter steelhead was the second largest observed during the past seven years, and the run of summer steelhead was the largest observed in the seven year record.

Table 41. Steelhead passage at Bennett Dams, N. Santiam: 2001-04

Year	Winter	Summer
1998	1,409	3,777
1999	1,111	3,151
2000	1,448	2,523
2001	3,639	5,460
2002	2,694	6,211
2003	1,261	4,073
2004	2,939	8,584

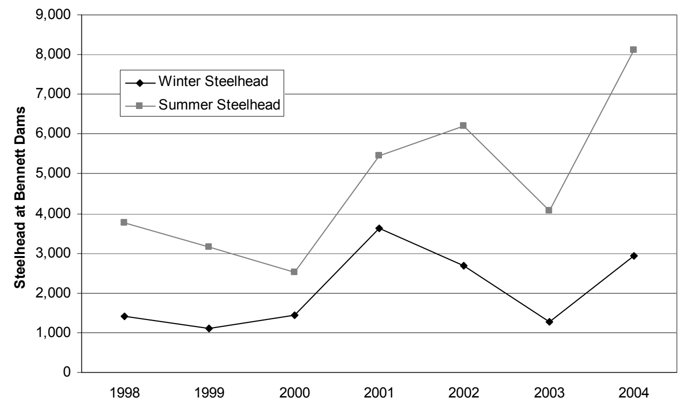

Figure 31. Steelhead passage at Bennett Dams: 98-04.

Leaburg Dam, McKenzie River

The results of trapping at Leaburg Dam in 2004 are presented in Table 42 and Figure 32. Construction on the old left bank ladder prevented removal of steelhead at Leaburg Dam. The trap will be operational again for the 2005 season. Fish were able to pass the dam using the new right bank ladder, and passage was monitored by video. A total of 2,540 marked and 78 unmarked steelhead passed Leaburg Dam in 2004 (Table 42).

Table 42. Steelhead at Leaburg Dam: 2004.

Month	Unmarked	Marked	Total
Jan	3	1	4
Feb	1	1	2
Mar	1	0	1
April	2	50	52
May	5	344	349
June	21	835	856
Jul	28	812	840
Aug	6	226	232
Sep	6	162	168
Oct	2	101	103
Nov	3	3	6
Dec	0	8	8
Season	**78**	**2,543**	**2,621**

Steelhead began appearing at Leaburg Dam in April of 2004, with peak passage occurring in June and July (Table 42, Figure 32). There was a very sharp peak in passage in mid July, but otherwise run-timing was similar to the 20-year average (Figure 33).

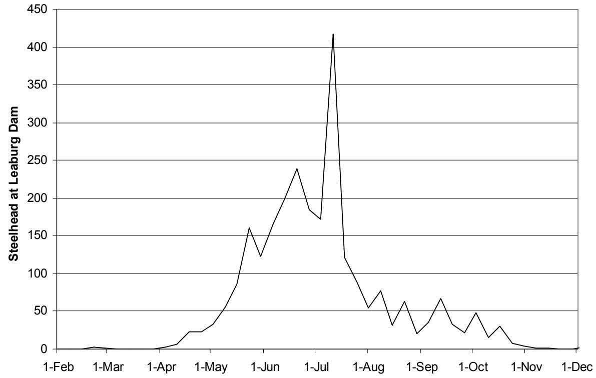

Figure 32. Steelhead run-timing at Leaburg Dam: 2004.

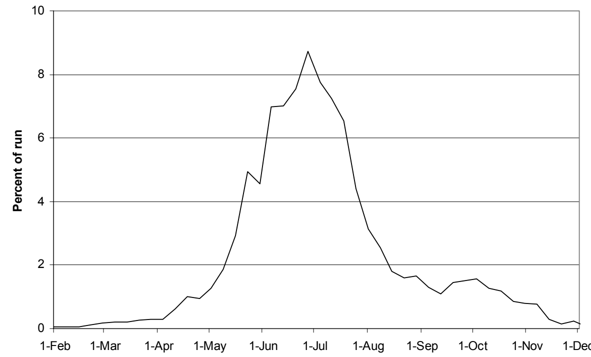

Figure 33. Steelhead run-timing, Leaburg Dam: 1980-2001.

The run of summer steelhead at Leaburg Dam in 2004 was the largest in the 24 year record, 34% higher than the second largest run (Table 43, Figure 34).

Table 43. Steelhead at Leaburg Dam: 1981-2004.

Year	Total
1981	1,512
1982	730
1983	328
1984	656
1985	705
1986	411
1987	636
1988	1,953
1989	212
1990	1,162
1991	343
1992	815
1993	684
1994	535
1995	666
1996	227
1997	837
1998	609
1999	1,151
2000	879
2001	1,310
2002	998
2003	777
2004	2,613

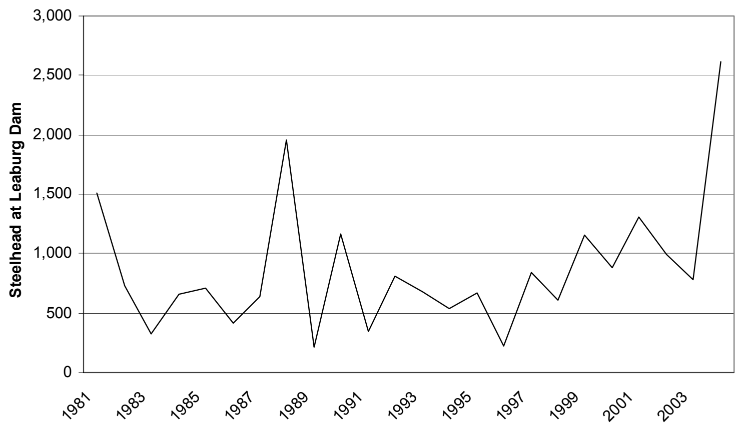

Figure 34. Steelhead passage at Leaburg Dam: 1980-2004.

Summer Steelhead Spawning Surveys

A statistical survey to estimate spawning by summer steelhead strays in the Upper Willamette ESU was conducted in the winter and early spring of 2004. Surveys were conducted on foot and by boat throughout the supposed spawning distribution of summer steelhead. Also, some surveys were conducted in areas of the winter steelhead spawning distribution that were believed to be outside of the regions where summer steelhead might spawn. Surveys were conducted at bi-weekly intervals. The number of adult steelhead and new redds were recorded on each visit. When possible, the mark status of adult steelhead was also ascertained. Additional details of survey methods can be found in Susac and Jacobs, 1998.

Flow Conditions

Stream flow conditions influence the success of spawning surveys. Exceptionally low flows can prevent fish from accessing spawning areas, high flows can redistribute gravel making redds less obvious, and high turbid flows interfere with visual counts. Flows are generally high during the period when summer steelhead spawn (winter and early spring). Unsuitably high flows sustained by dam releases are a particular problem for the mainstem float surveys. Figure 35 illustrates the flow conditions for the 2004 spawning season along with the 95th and 5th percentile of mean daily flows. Sustained high flows from early January to mid February made it difficult to obtain counts of steelhead redds during a large portion of the season.

Spawn timing

Estimates of spawn timing were made based on the observation of fresh redds and spawning adults in survey areas. Figure 36 shows estimates of spawning timing for summer steelhead in the Middle Willamette Monitoring Area (Molalla, North Santiam, and South Santiam Rivers) and the Upper Willamette Monitoring Area (McKenzie, Middle Fork Willamette and Coast Fork Willamette Rivers). Small numbers of adult fish were observed throughout the season. We used these observations to confirm that we were identifying steelhead redds correctly. Steelhead spawners first appeared in the Middle Willamette in early January, just after the first small freshet of the season.

Numbers of new steelhead redds in the Upper Willamette Monitoring Area peaked in mid January and late February (Figure 36). Redd counts in the Mid Willamette Monitoring Area were up and down throughout January and February, but rose sharply in mid March. Winter steelhead passage at the Bennett Dams on the North Santiam increased sharply in mid March as well (Figure 36). Consequently, we excluded all counts after March 11, 2004 when making estimates of spawning by summer steelhead.

Estimates of Abundance

Estimates of the abundance of summer steelhead redds are provided in Table 44. In 2004 an estimated 1,582 ± 763 summer steelhead spawned in the Upper Willamette ESU, compared to 3,528 ± 1,686 in 2003 (Firman et al., 2004). The 2004 estimate for the Mid Willamette Monitoring Area is only slightly less than the 2003 estimate, but the estimate for the Upper Willamette Monitoring Area is almost an order of magnitude lower than the previous year. The difference in escapement is not surprising considering the differences in run size in 2002 and 2003. In 2002, 34,291 summer steelhead passed Willamette Falls (these fish spawned in early 2003). In 2003, only 15,170 summer steelhead passed the falls.

There was another strong run of summer steelhead in 2004. Spawning surveys are currently underway to determine if the number and distribution of spawners is similar to that seen in 2003.

Table 44. Population estimates for summer steelhead redds in the Upper Willamette ESU.

Monitoring Area	2003			2004		
	Estimate	C.I.	C.I. %	Estimate	C.I.	C.I. %
Mid Willamette Monitoring Area	1,480	836	56.5	1,035	542	52.4
Upper Willamette Monitoring Area	2,048	1,464	71.5	547	536	98.0
Upper Willamette ESU	3,528	1,686	47.8	1,582	763	48.2

Comparison to traditional winter steelhead surveys

Surveys for summer steelhead redds were conducted at 8 sites in the North Santiam and South Santiam Rivers that are traditionally surveyed to count winter steelhead redds. Summer steelhead spawning was observed in four of these surveys (Table 45).

Table 45. Comparison of summer steelhead (StS) and winter steelhead (StW) redd counts in 2004 on traditional surveys. Average and maximum values for winter steelhead are based on 17 to 30 years of data.

Subbasin	Stream	StS Redds	Avg StW Redds	Max StW Redds	n
N Santiam River	Rock Cr.	0	6	16	26
N Santiam River	Mad Cr.	4	40	77	18
N Santiam River	Elkhorn Cr.	1	9	31	16
N Santiam River	Sinker Cr.	4	24	63	30
S Santiam River	Wiley Cr, upper	0	4	11	24
S Santiam River	Wiley Cr, lower	0	10	26	24
S Santiam River	Crabtree Cr.	0	27	93	17
S Santiam River	Thomas Cr.	2	17	35	18

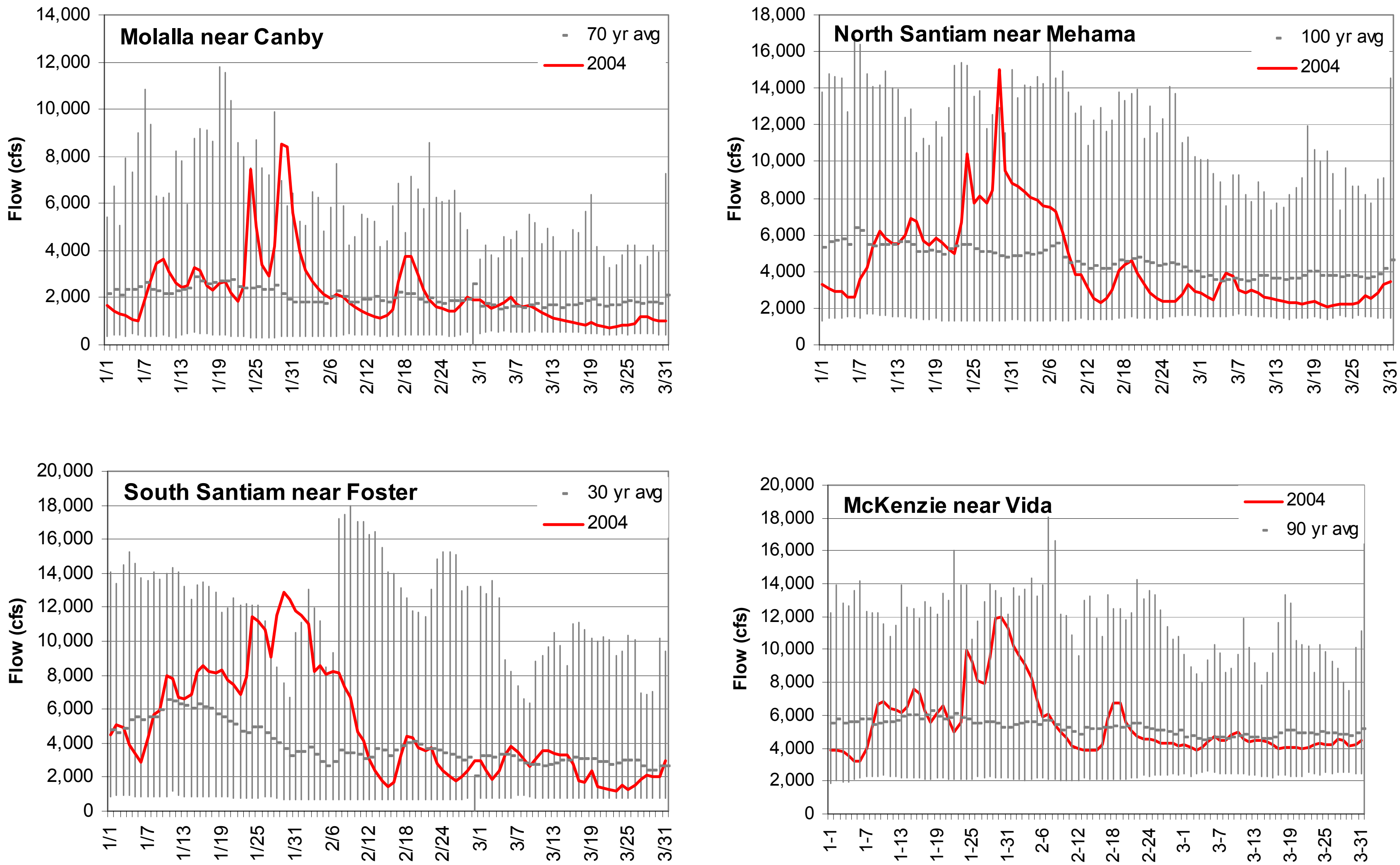

Figure 35. Daily mean river discharge in cubic feet per second for four surface water stations. Vertical bars represent the 95th and 5th percentiles of mean daily flows for the period of record. Data obtained at http://water.usgs.gov/.

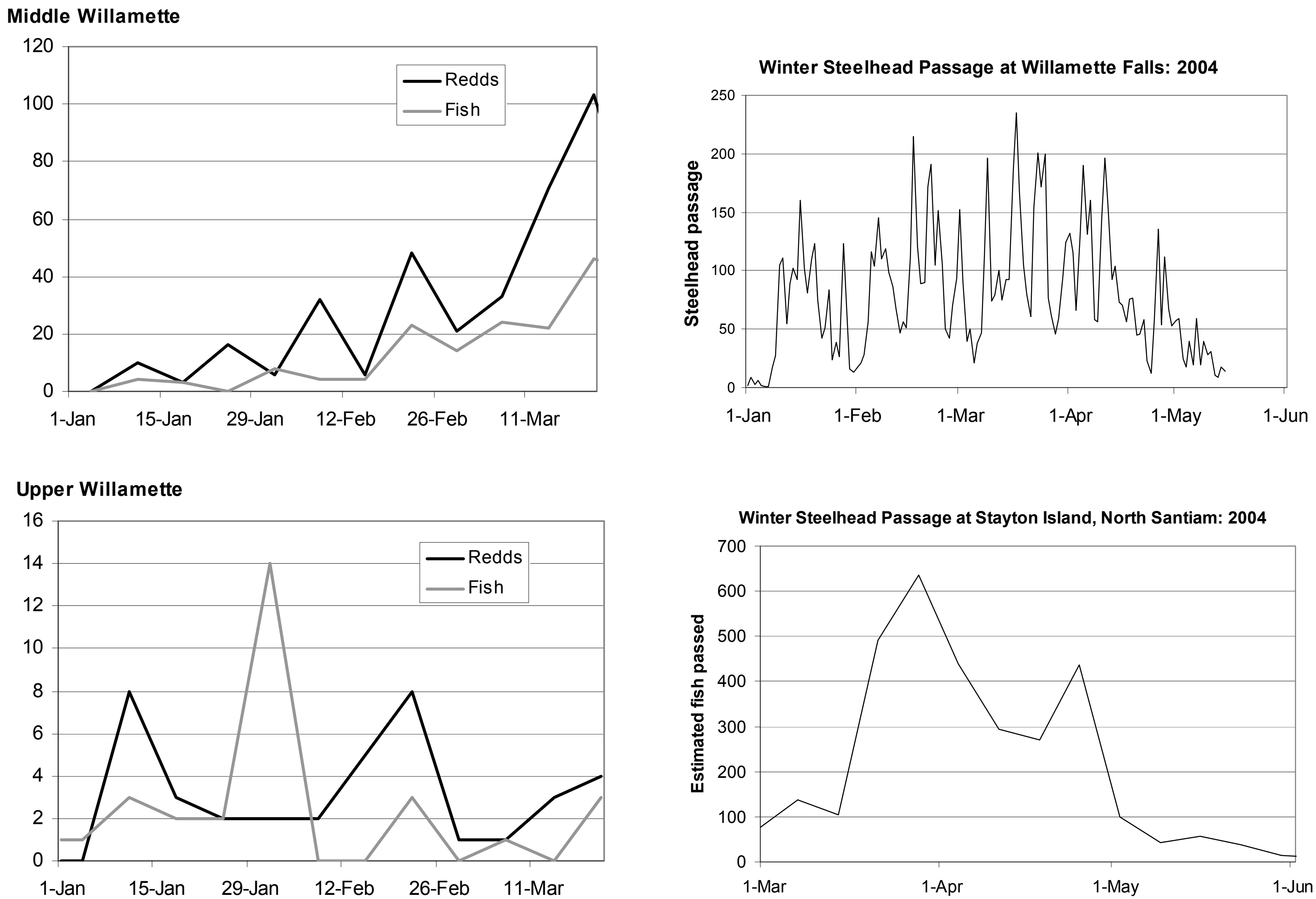

Figure 36. Summer steelhead spawn timing, and winter steelhead run timing in the Upper Willamette ESU. The Middle Willamette Monitoring Area includes the Molalla, North Santiam, South Santiam and Calapooia. The Upper Willamette Monitoring Area includes the McKenzie, Middle Fork Willamette and Coast Fork Willamette.

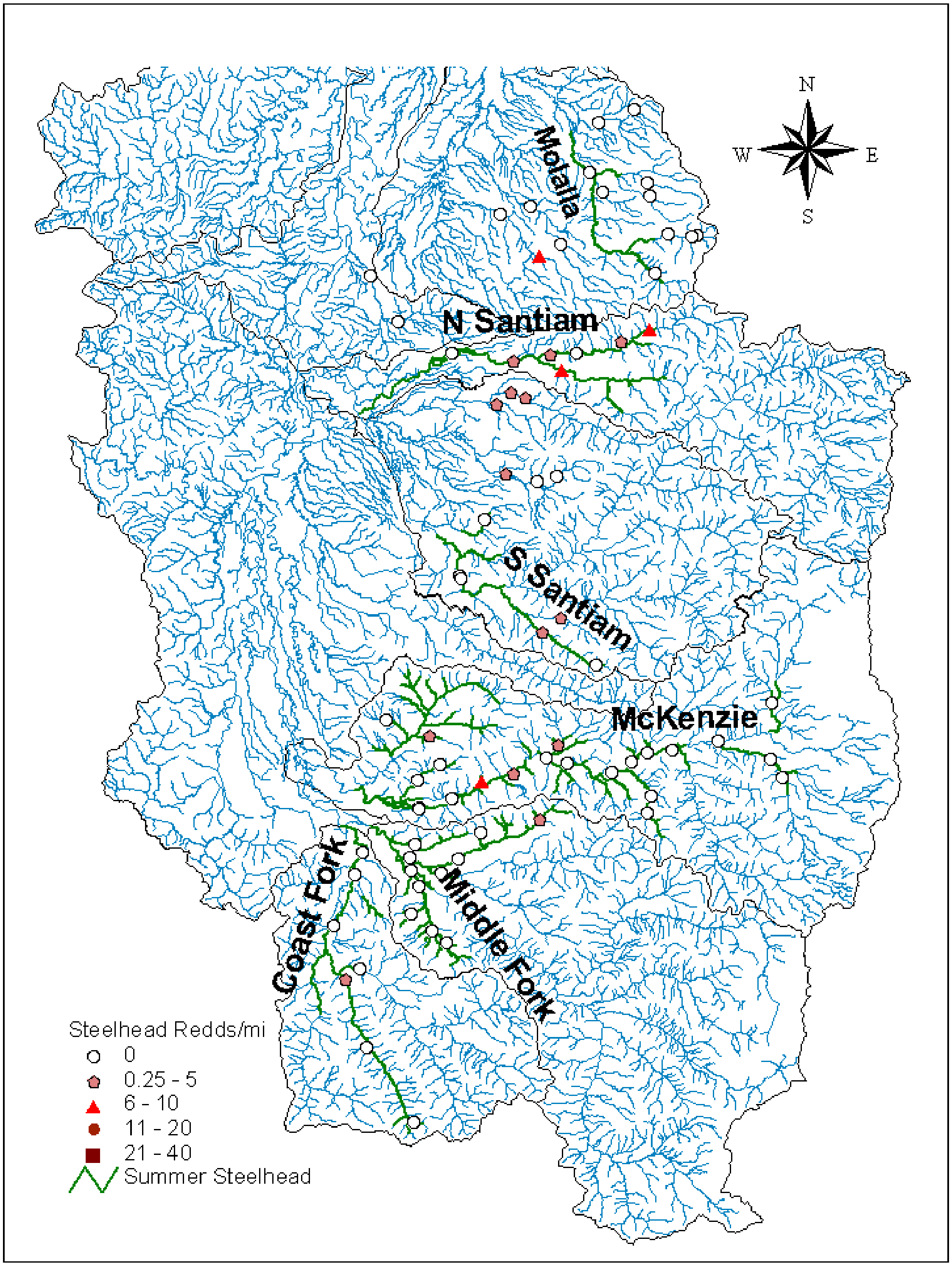

Figure 37. Summer steelhead redd densities in randomly selected surveys and traditional winter steelhead surveys in the Upper Willamette ESU, 2004.

Spawner Distribution

Spawning summer steelhead were widely distributed in the areas surveyed, however, no fish or redds were observed on most surveys. Densities ranged from 0 to 10 redds per mile, with an average density of 0.3 redds per mile (Figure 37; Table 46). The map in Figure 37 shows the number of redds/mile in both randomly selected and traditional surveys. Randomly selected surveys are designed to provide a representative sample of the occurrence of spawners in a variety of habitats. Consequently, they provide us with a means to monitor the status and trends of spawner populations and distribution. Redd densities in surveys that are traditionally surveyed for winter steelhead tended to be higher (0.4 redds/mi) than the average seen in random surveys (0.3 redds/mi).

Table 46. Redd densities on randomly selected summer steelhead spawning surveys, 2004.

Subbasin	Reach ID	Seg	Survey	Redds/mi
Molalla River	31360.00	20	Butte Creek	1.2
Molalla River	31364.30	1	Fall Creek	0.0
Molalla River	31390.00	1	Abiqua Creek	0.0
Molalla River	31398.00	2	Abiqua Creek	0.0
Molalla River	31457.00	1	Milk Creek	0.0
Molalla River	31471.00	1	Milk Creek	0.0
Molalla River	31480.00	1.1	Molalla River	0.3
Molalla River	31486.00	1	Lukens Creek	0.0
Molalla River	31488.00	1	Cougar Creek	0.0
Molalla River	31491.00	3	Trout Creek	0.0
Molalla River	31515.00	1	Table Rock Fork Molalla Ri	1.0
Molalla River	31522.00	1	Lost Creek	0.0
Molalla River	31522.00	2	Lost Creek	0.0
Molalla River	31536.00	1	Molalla River	0.0
Mid Willamette	31794.00	6	Mill Creek	0.0
Mid Willamette	31820.00	1	Mill Creek	0.0
S Santiam River	31959.00	1	Neal Creek	3.0
S Santiam River	31964.00	2	Thomas Creek	0.3
S Santiam River	31964.00	2	Thomas Creek	0.3
S Santiam River	31978.00	6	Crabtree Creek	2.2
S Santiam River	31982.00	1	Crabtree Creek	0.0
S Santiam River	31992.00	4	Crabtree Creek	0.0
S Santiam River	32000.00	2	Hamilton Creek	0.0
S Santiam River	32010.00	1	McDowell Creek	0.0
S Santiam River	32021.00	2	South Santiam River	0.0
S Santiam River	32027.00	5	Little Wiley Creek	3.1
S Santiam River	32028.00	3	Wiley Creek	9.7
S Santiam River	32028.00	9	Wiley Creek	0.0
N Santiam River	32159.00	1	North Santiam River	0.2
N Santiam River	32163.00	6	North Santiam River	0.0
N Santiam River	32173.00	1.1	North Santiam River	0.5
N Santiam River	32174.00	1	Little North Santiam River	1.9
N Santiam River	32182.00	1.1	Little North Santiam River	0.4

Table 46. (cont.)

Subbasin	Reach ID	Seg	Survey	Redds/mi
N Santiam River	32201.00	1	Sinker Creek	5.7
N Santiam River	32218.00	2.1	Little North Santiam River	5.8
N Santiam River	32231.00	4	North Santiam River	7.9
Mohawk River	32666.00	2	Parsons Creek	0.0
Mohawk River	32668.00	3	Cartwright Creek	1.3
Mohawk River	32682.00	2	Cash Creek	0.0
Mohawk River	32685.00	1	Mohawk River	0.0
Mohawk River	32695.00	1	Mohawk River	0.0
Mohawk River	32695.00	2	Mohawk River	0.0
McKenzie River	32697.00	6	Cedar Flat Creek	0.0
McKenzie River	32698.00	1	McKenzie River	0.0
McKenzie River	32698.00	4.1	McKenzie River	0.0
McKenzie River	32699.00	2	Camp Creek	0.0
McKenzie River	32700.00	1	Wegner Creek	0.0
McKenzie River	32704.00	1	McKenzie Side Channel	0.0
McKenzie River	32708.00	1	McKenzie River	0.0
McKenzie River	32711.00	1	Holden Creek	10.0
McKenzie River	32712.00	1	McKenzie River	0.0
McKenzie River	32718.00	1	McKenzie River	1.4
McKenzie River	32731.00	1	North Fork Gate Creek	3.3
McKenzie River	32736.00	1	McKenzie River	0.0
McKenzie River	32742.00	1	McKenzie River	0.0
McKenzie River	32750.00	1	McKenzie River	0.0
McKenzie River	32757.00	1	Quartz Creek	0.0
McKenzie River	32761.00	1	Quartz Creek	0.0
McKenzie River	32766.00	1	McKenzie River	0.0
S Fk McKenzie	32800.00	1	McKenzie River	0.0
S Fk McKenzie	32801.00	1	South Fork McKenzie River	0.0
McKenzie River	32864.30	1	East Fork Horse Creek	0.0
McKenzie River	32870.00	1	Horse Creek	0.0
McKenzie River	32878.00	1	Horse Creek	0.0
McKenzie River	32897.00	1	McKenzie River	0.0
Mosby Creek	32929.00	1	Coast Fork Willamette River	0.0
Mosby Creek	32935.00	2	Coast Fork Willamette River	0.0
Mosby Creek	32941.00	1	Coast Fork Willamette River	0.0
Mosby Creek	32943.00	2	Mosby Creek	1.1
Mosby Creek	32949.00	1	Mosby Creek	0.0
Mosby Creek	32975.00	1	East Fork Mosby Creek	0.0
Mosby Creek	32976.00	1	Row River	0.0
Mosby Creek	33022.00	1	Coast Fork Willamette River	0.0
M Fk Willamette	33052.00	1	Hills Creek	0.0
M Fk Willamette	33062.00	1	Fall Creek	0.0
M Fk Willamette	33063.00	5	Little Fall Creek	0.0

Table 46. (cont.)

Subbasin	Reach ID	Seg	Survey	Redds/mi
M Fk Willamette	33064.00	2	Norton Creek	0.0
M Fk Willamette	33069.00	5	Little Fall Creek	1.1
M Fk Willamette	33069.00	6	Little Fall Creek	0.0
M Fk Willamette	33070.00	1	Fall Creek	0.0
M Fk Willamette	33158.00	1	Middle Fork Willamette River	0.0
M Fk Willamette	33159.00	3	Lost Creek	0.0
M Fk Willamette	33162.30	1	Dexter Creek	0.0
M Fk Willamette	33168.00	1	Gosage Creek	0.0
M Fk Willamette	33173.00	3	Lost Creek	0.0

Most surveys had low densities of summer steelhead redds. In randomly selected surveys, 75% of sites had no summer steelhead redds, and over 90% of the sites surveyed had fewer than 5 redds per mile surveyed (Figure 38). In traditional surveys, 75% of surveys had fewer than 5 redds, and at the 90th percentile there were 5 redds per mile surveyed. This result is not surprising considering that traditional surveys are located in areas believed to have the best winter steelhead spawning habitat. Since summer steelhead are likely to select similar spawning habitats to winter steelhead, we would expect to see more summer steelhead in areas with good winter steelhead spawning habitat.

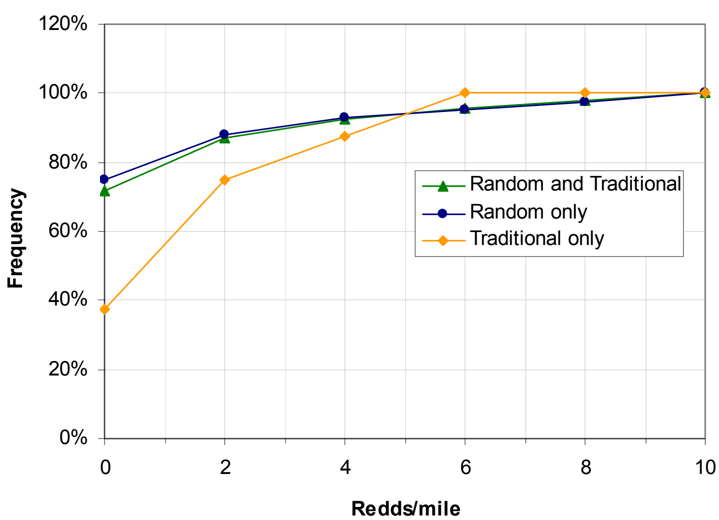

Figure 38. Cumulative frequency distribution of summer steelhead redds in 2004.

Estimates of the number of natural-origin steelhead smolts migrating past Leaburg Dam.

The bypass channel was not operational until July of 2004 due to construction on the right bank ladder. Juvenile steelhead move downstream in April and May, so were not able to capture juvenile steelhead during the 2004 season. We are currently trapping for the 2005 season.

Predation on Juvenile Chinook by Hatchery Rainbow Trout and Steelhead Smolts

Hatchery stocking of juvenile steelhead and rainbow can have a direct impact on native populations of spring chinook by preying on chinook juveniles. To assess this impact, we sampled stomach contents of hatchery-produced rainbow trout and steelhead smolts released in the McKenzie River in 2004. Samples were obtained by examining fish retained in the fishery, seining, and angling.

Approximately 113,000 summer steelhead smolts were released from Leaburg hatchery between April 5, 2004 and April 6, 2004. A total of 949 steelhead were sampled between April 7, 2004 and May 9, 2004. By the middle of May it became difficult to catch steelhead smolts in the McKenzie. The majority of the samples (60%) were collected using a 40' seine within a few hundred meters of the hatchery the remaining 40% were captured by angling and creel. The most common prey found in the gut samples was aquatic insects at 72%. Stomachs were empty in 24% of the steelhead smolts sampled. Only two fish (both chinook) were found in the stomach contents of steelhead smolts sampled (0.001% of smolt gut contents contained chinook, Figure 39).

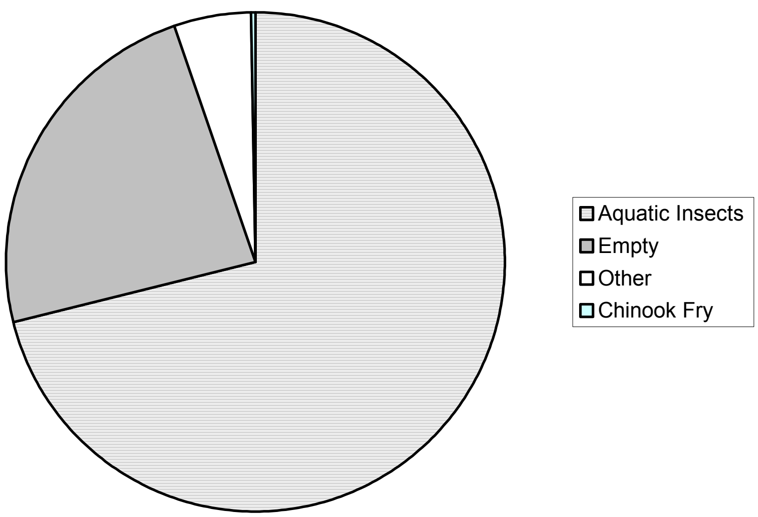

Figure 39. Stomach contents of steelhead smolts.

Approximately 142,973 hatchery rainbow were stocked in the McKenzie between April 23, 2004 and September 15, 2004. A total of 1,414 trout were sampled between April 15, 2004 and October 28, 2004. The most common prey found in the gut samples were aquatic insects at 87%. A total of 15 fish were found in the rainbow gut samples (Figure 40). Of the 15 fish, only one was identified as a chinook, the remaining 14 were unidentified. All fish samples were preserved in alcohol. We are exploring other means to identify the remaining unidentified fish. The last fish found in the stomach contents was caught on October 11th. Seining conducted by the Willamette Spring Chinook project showed that juvenile chinook made up 76% of all species caught in the lower McKenzie (Below Hayden Bridge in a wild trout managed area, Figure 41). In 2003 we sampled with the Spring Chinook project in the upper McKenzie and found hatchery rainbow co-occurring with juvenile chinook. While seining in 2003 we also found a fish in the stomach contents of a hatchery rainbow. We have only made expansions using the identifiable chinook in stomach contents of rainbow trout. If 76% of all of fish found in the stomach contents were actually chinook, our estimate would be considerably larger.

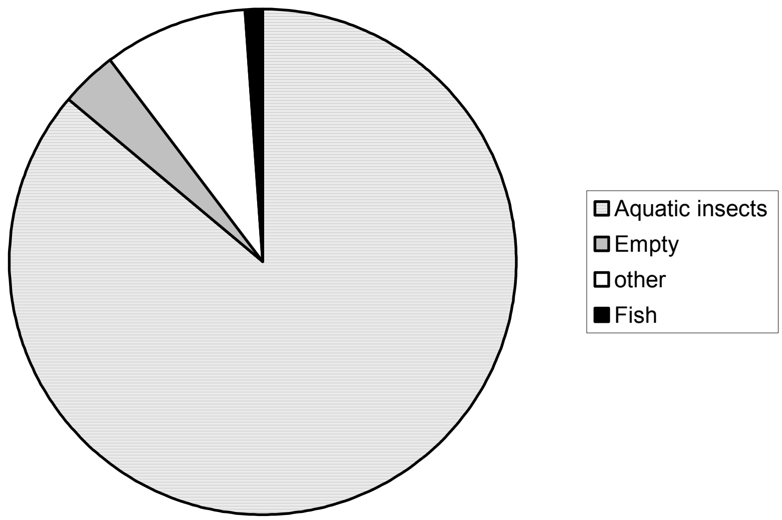

Figure 40. Stomach contents of hatchery rainbow trout.

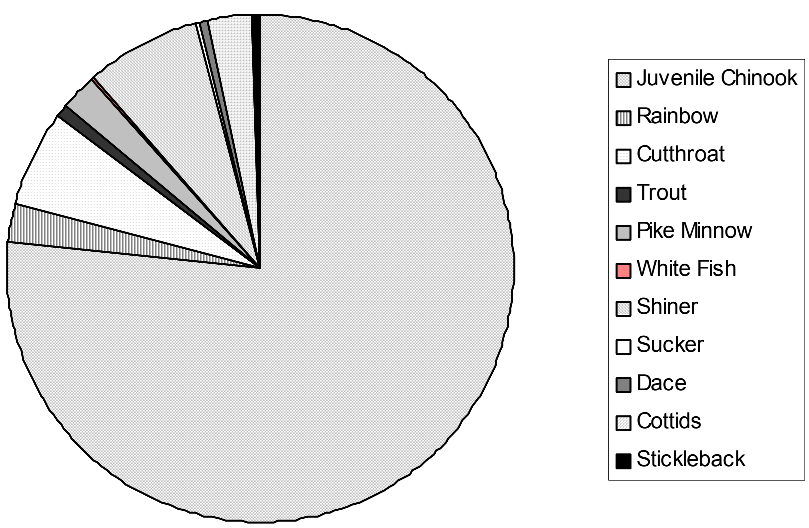

Figure 41. Species composition of seine catch in the lower McKenzie River, 2003.

Controlled studies were used to determine the average gut residence time a chinook fry would be apparent in the stomach of hatchery rainbow and juvenile summer steelhead. Forty cape cod rainbow and forty Skamania summer steelhead were placed in separate 500 gallon Canadian troughs. The Canadian troughs were fed with McKenzie river water. Both species were starved for three days to duplicate the conditions for their release to the McKenzie. One hundred to 300 fry were introduced into each trough for one to two hours. At the end of this time, remaining fry were removed. Chinook fry sizes were chosen to simulate wild fry in the McKenzie. Steelhead and rainbow were removed and had their stomachs flushed one to two hours after the fry were originally introduced. Steelhead and rainbow were checked on an hourly basis until no identifiable fry were found. The control for rainbow starting on 4/9/04 was run once a month for three months. A single controlled experiment was conducted for steelhead on 4/9/04. Controls on the rainbow would have been run through September of 2004, but repairs at Leaburg hatchery required us to dewater the system.

The limiting factor in this control study was that it was difficult to get the fish to eat just one fry. One fish had consumed 17 fry, making it impossible to determine if the fish digested one fish out of the 17 consumed. If the fish stomach was flushed and it produced no identifiable fry but it did have gut contents, this was recorded as digested. Many fish had unidentifiable fry and what appeared to be parts of digested fish. These were not considered digested.

Steelhead smolts took 3-7 hours to digest one Chinook fry at 7.2 degrees Celsius. By seven hours there were no identifiable fry to be found in the steelhead smolts, and 50% of the steelhead had completely digested the fry.

On 4/9/04, rainbow trout took 2-6 hours to digest one chinook fry at 7.2 degrees Celsius. By six to eight hours 60% of the rainbow trout sampled completely digested their food. On 5/10/04, it took rainbow trout 3-8 hours to digest one chinook fry at 8.8 degrees Celsius. By six to eight hours no identifiable fry were found, and 85% of the rainbow trout completely digested their food. Rainbow trout on 6/28/2004 took 1-7 hours to digest one chinook fry at 10.0 degrees Celsius. No identifiable fry were ever found in this control group. By 5-7 hours, 50% of the rainbow trout sample had completely digested their food. Gut residence times of 2 to 8 hours were used to make expansions for rainbow trout.

Expanding stomach contents to make estimates of predation requires that we embrace several assumptions. Assumptions five and six are not applicable for steelhead smolts. The assumptions that we have made in our calculations are as follows:

1. Hatchery trout only fed on juvenile chinook for the 196 days between 4-15-2004 and 10-24-2004;
2. Hatchery steelhead smolts fed on juvenile chinook for 55 days between 4-7-2004 and 5-31-2004;
3. Predation rates were consistent throughout the period during which we are making expansions;
4. The average gut residence time was 2-8 hours for rainbow trout, and 3-7 hours for steelhead smolts;
5. Anglers removed 37% of the trout that were stocked (Hutchinson & Hooton 1990);
6. Harvest rates were consistent throughout the period during which we are making expansions;
7. There was no mortality of stocked trout or steelhead smolts; and
8. There were no hatchery trout or steelhead that held over from the previous year.

Predation estimates were made using the following equation:

T*P*24/G*D = total number chinook consumed

Where
T = the total number of trout present;
P = the percentage stomach content samples that contained chinook;
G = the gut residence time; and
D = the total number of days that trout fed on chinook.

Using this equation we estimate that between 36,111 and 161,933 juvenile chinook were consumed by hatchery rainbow trout in 2004. Another 24,469 to 57,095 were consumed by hatchery steelhead smolts in the McKenzie River. Hatchery rainbow trout and steelhead smolts combined consumed an estimated total of 60,580 to 219,028 juvenile chinook. In 2004 a total of 1,187 chinook redds were counted in the McKenzie River. An estimated fecundity of 4,350 eggs per female (10-year average at McKenzie Hatchery, Kurt Kremers, pers. comm.) and 15% egg mortality equates to approximately 4,388,933 fry in the McKenzie River in 2004. For both hatchery rainbow trout and steelhead smolts the estimated predation rate is 1-5% on natural produced juvenile chinook.

Using digital video data we observed a hatchery rainbow trout consume two small fish. Both of these fish were eaten near midnight. It is well known that juvenile chinook migrate at night. It could be that most predation on juvenile chinook happens at night, but nearly all of our stomach sampling in the field was done on an 8am to 4:30 pm schedule. With a 2 to 8 hour gut residence time, most of the fish eaten at night would not be visible the following day. This logic challenges our third assumption.

Steelhead Fishery

Methods

Creel survey methods are described under Spring Chinook Creels, page 39.

South Santiam Steelhead Creel

The angler creel survey on the South Santiam River began on April 1, 2003 and ended October 31, 2003. It is estimated that anglers spent a total of 146,245 hours fishing on the South Santiam during this time period in 2003 (Table 47, Figure 42). Bank anglers contributed the bulk of the effort with 87,807 hours fished, and boat anglers made up the remainder (58,438 hours). An estimated 6,084 summer steelhead were caught, 4,851 by bank anglers and 1,233 by boat anglers (Table 47, Figure 43). Bank anglers were more successful with a catch rate of 0.06 fish per hour fished (Table 47, Figure 44). Boat anglers brought in 0.021 fish per hour, giving an average catch rate of 0.042 fish per hour fished. Effort was highest in May, and catch was highest in June. The catch rate was highest in September and October when there were few hours fished.

Table 47. Effort, catch, and catch rate for steelhead in the South Santiam fishery, 2003.

Month	Effort			Catch			Catch Rate		
	Bank	Boat	*Total*	Bank	Boat	*Total*	Bank	Boat	*Average*
April	7,681	4,737	*12,418*	400	326	*726*	0.0521	0.0688	*0.0585*
May	26,084	27,194	*53,278*	943	459	*1,402*	0.0362	0.0169	*0.0263*
June	26,646	19,637	*46,283*	1,640	405	*2,045*	0.0615	0.0206	*0.0442*
July	16,649	5,605	*22,254*	1,231	28	*1,259*	0.0739	0.0050	*0.0566*
Aug	6,288	997	*7,285*	297	6	*303*	0.0472	0.0060	*0.0416*
Sept	3,270	96	*3,366*	251	0	*251*	0.0768	0.0000	*0.0746*
Oct	1,189	172	*1,361*	89	9	*98*	0.0749	0.0523	*0.0720*
Season	**87,807**	**58,438**	***146,245***	**4,851**	**1,233**	***6,084***	**0.0552**	**0.0211**	***0.0416***

A total estimate of 5,473 summer steelhead were harvested from the South Santiam in 2003 (Table 48). Of these, 4,441 were caught by bank anglers and 1,032 by boat anglers. Another 442 marked steelhead were caught and released. The mortality rate for steelhead that are caught and released has been estimated at 3.4% (Hooton, 1987). Based on this rate, it is estimated that another 15 hatchery fish died after release, for a total of 5,489 steelhead that were removed by the fishery. Bank anglers and boat anglers were equally likely to release marked fish (7.1% of marked fish caught were released by bank anglers, and 9.2% were released by boat anglers).

Roughly 3% of the steelhead caught were unmarked winter steelhead (Table 48). A total of 168 winter steelhead were caught over the course of the season. Assuming a 3.4% hooking mortality rate (Hooton, 1987), it is estimated that the fishery on the South Santiam had a take of 6 winter steelhead in 2003.

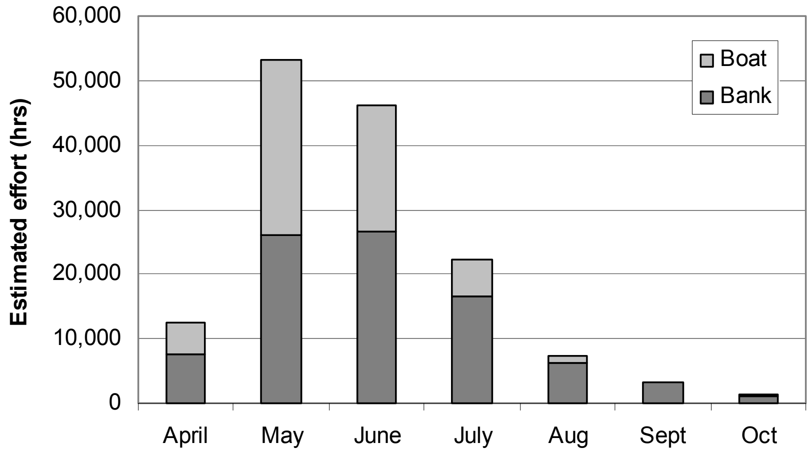

Figure 42. Estimated hours effort in South Santiam fishery, 2003.

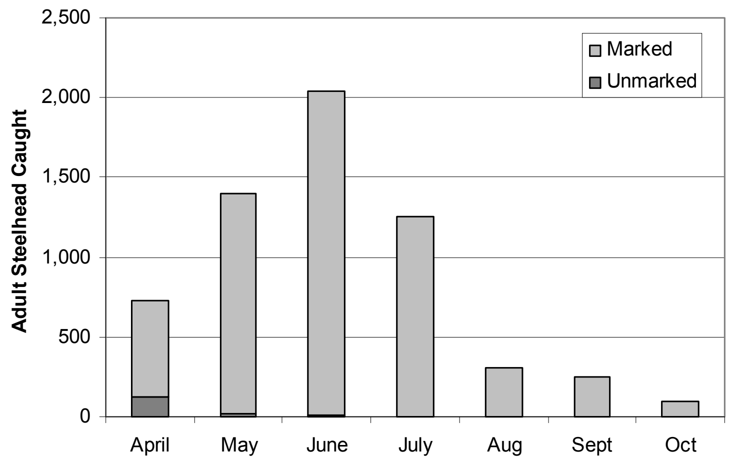

Figure 43. Catch of steelhead in the South Santiam, 2003.

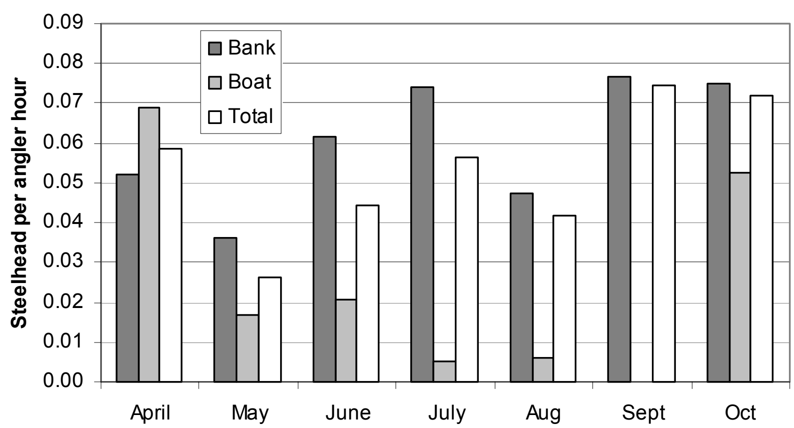

Figure 44. Catch rate for steelhead in the South Santiam, 2003.

Table 48. Steelhead harvested and released in the South Santiam fishery, 2003.

Kept

	Bank		Boat						
	Unmk	Mark	Unmk	Mark	Unmarked	Marked	Bank	Boat	**Total**
April	0	353	0	248	0	601	353	248	**601**
May	0	897	0	432	0	1,329	897	432	**1,329**
June	0	1,551	0	309	0	1,860	1,551	309	**1,860**
July	0	1,103	0	28	0	1,131	1,103	28	**1,131**
Aug	0	248	0	6	0	254	248	6	**254**
Sept	0	216	0	0	0	216	216	0	**216**
Oct	0	74	0	9	0	83	74	9	**83**
Season	*0*	*4,441*	*0*	*1,032*	*0*	*5,473*	*4,441*	*1,032*	***5,473***

Released

	Bank		Boat						
	Unmk	Mark	Unmk	Mark	Unmarked	Marked	Bank	Boat	**Total**
April	47	0	78	0	125	0	47	78	**125**
May	12	34	10	17	22	51	46	27	**73**
June	5	84	9	87	14	171	89	96	**185**
July	0	128	0	0	0	128	128	0	**128**
Aug	0	49	0	0	0	49	49	0	**49**
Sept	4	31	0	0	4	31	35	0	**35**
Oct	3	12	0	0	3	12	15	0	**15**
Season	*71*	*338*	*97*	*104*	*168*	*442*	*409*	*201*	***610***

McKenzie River Steelhead Creel

The angler creel survey on the McKenzie River began on April 1, 2003 and ended November 30, 2003. It is estimated that anglers spent a total of 78,160 hours fishing on the McKenzie during this time period in 2003 (Table 49, Figure 45). Boat anglers contributed the greatest effort with 59,367 hours fished, while bank anglers made up the remainder (18,793 hours). An estimated 1,367 were caught, 532 by bank anglers and 835 by boat anglers (Table 49, Figure 46). Bank anglers had a higher catch rate than boat anglers (0.028 vs. 0.012; Table 49, Figure 47). The overall catch rate was 0.018 fish per hour fished. Effort and catch were highest in June, but the highest catch occurred in November.

Table 49. Effort, catch, and catch rate for steelhead in the McKenzie fishery, 2003.

Month	Hours Effort			Catch			Catch Rate		
	Bank	Boat	*Total*	Bank	Boat	*Total*	Bank	Boat	*Average*
April	807	2,702	*3,509*	22	17	*39*	0.0273	0.0063	*0.0111*
May	5,029	16,990	*22,019*	163	172	*335*	0.0324	0.0101	*0.0152*
June	6,023	21,611	*27,634*	171	249	*420*	0.0284	0.0115	*0.0152*
July	3,152	8,071	*11,223*	30	99	*129*	0.0095	0.0123	*0.0115*
Aug	1,936	4968	*6,904*	15	16	*31*	0.0077	0.0032	*0.0045*
Sept	967	2562	*3,529*	47	52	*99*	0.0486	0.0203	*0.0281*
Oct	680	2241	*2,921*	72	181	*253*	0.1059	0.0808	*0.0866*
Nov	199	222	*421*	12	49	*61*	0.0603	0.2207	*0.1449*
Season	**18,793**	**59,367**	***78,160***	**532**	**835**	***1,367***	**0.0283**	**0.0141**	***0.0175***

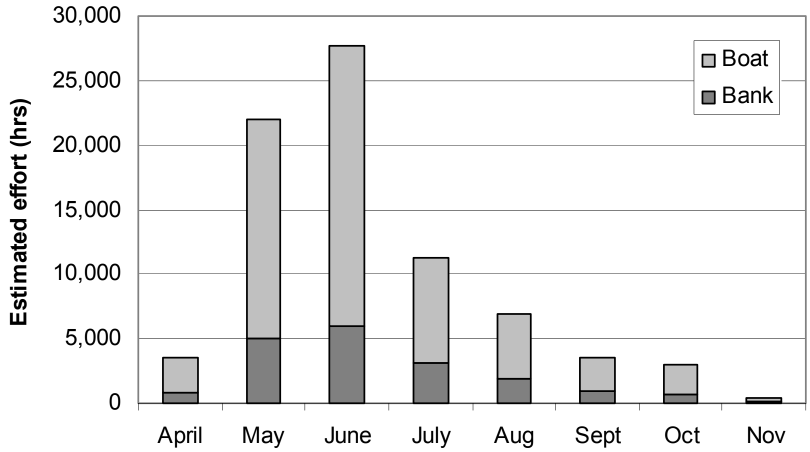

Figure 45. Estimated hours effort in the McKenzie River fishery, 2003.

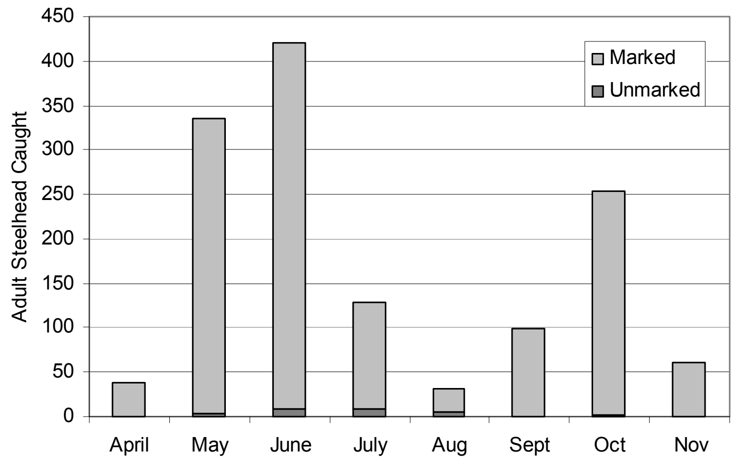

Figure 46. Catch of steelhead in the McKenzie River, 2003.

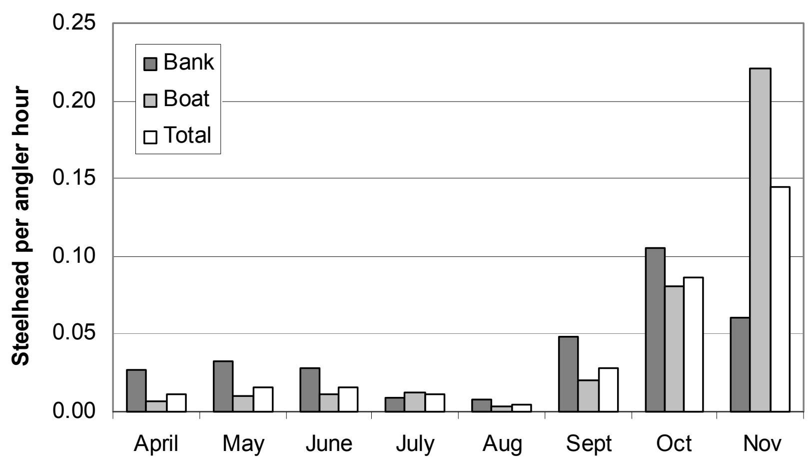

Figure 47. Catch rate for steelhead in the McKenzie River, 2003.

A total of 1,173 summer steelhead were harvested from the McKenzie in 2003 (Table 50). Bank anglers caught 438 of these, and boat anglers caught the remaining 735. Another 170 marked steelhead were caught and released. Assuming a 3.4% hooking mortality rate on released fish (Hooton, 1987), an additional 6 hatchery fish died after release, for a total of 1,179 marked fish removed by the fishery. Bank anglers were slightly more likely to release marked fish (16.1% of marked fish caught were released) than were boat anglers (10.5% of marked fish caught were released).

Approximately 2% of the steelhead caught were unmarked (Table 50). A total of 29 unmarked steelhead were caught over the course of the season. We would expect this number to be small since there is no native run of winter steelhead to the McKenzie River. Many if not all of these unmarked steelhead are probably hatchery fish. Assuming a 3.4% hooking mortality rate (Hooton, 1987), it is estimated that the fishery on the McKenzie had a take of 1 unmarked steelhead in 2003.

Table 50. Steelhead harvested and released in the McKenzie fishery, 2003.

Kept

	Bank		Boat						
	Unmk	Mark	Unmk	Mark	Unmarked	Marked	Bank	Boat	**Total**
April	0	20	0	17	0	37	20	17	**37**
May	0	159	0	172	0	331	159	172	**331**
June	0	150	0	207	0	357	150	207	**357**
July	0	26	0	85	0	111	26	85	**111**
Aug	0	9	0	16	0	25	9	16	**25**
Sept	0	30	0	52	0	82	30	52	**82**
Oct	0	35	0	136	0	171	35	136	**171**
Nov	0	8	0	49	0	57	8	49	**57**
Season	*0*	*438*	*0*	*735*	*0*	*1,173*	*438*	*735*	***1,173***

Released

	Bank		Boat						
	Unmk	Mark	Unmk	Mark	Unmarked	Marked	Bank	Boat	**Total**
April	0	2	0	0	0	2	2	0	**2**
May	4	0	0	0	4	0	4	0	**4**
June	0	21	8	34	8	55	21	42	**63**
July	2	2	7	7	9	9	4	14	**18**
Aug	6	0	0	0	6	0	6	0	**6**
Sept	0	17	0	0	0	17	17	0	**17**
Oct	1	36	0	45	1	81	37	45	**82**
Nov	0	4	0	0	0	4	4	0	**4**
Season	*14*	*84*	*15*	*86*	*29*	*170*	*98*	*101*	***199***

Middle Fork Willamette Steelhead Creel

The angler creel survey on the Middle Fork Willamette River began on April 1, 2003 and ended July 31, 2003. It is estimated that anglers spent a total of 100,585 hours fishing on the Middle Fork during this time period in 2003 (Table 51, Figure 48). Bank anglers contributed 63% of the effort with 63,194 hours fished. Boat anglers spent a total of 37,391 hours fishing. It is estimated that 3,251 spring chinook were caught, 2,677 by bank anglers and 574 by boat anglers (Table 51, Figure 49). Bank anglers were much more successful than boat anglers with a catch rate of 0.042 fish per hour fished compared to 0.015 fish per hour for boat anglers (Table 51, Figure 50). The overall catch rate was 0.032 fish per hour fished. Effort was highest in May, catch was highest in June, and the catch rate was highest in June and July.

Table 51. Effort, catch, and catch rate in the Middle Fork Willamette fishery, 2003.

Month	Hours Effort			Catch			Catch Rate		
	Bank	Boat	*Total*	Bank	Boat	*Total*	Bank	Boat	*Average*
April	8,839	4,355	*13,194*	258	180	*438*	0.0292	0.0413	*0.0332*
May	21,872	17,748	*39,620*	742	169	*911*	0.0339	0.0095	*0.0230*
June	21,734	11,589	*33,323*	1,148	133	*1,281*	0.0528	0.0115	*0.0384*
July	10,749	3,699	*14,448*	529	92	*621*	0.0492	0.0249	*0.0430*
Season	**63,194**	**37,391**	**100,585**	**2,677**	**574**	**3,251**	**0.0424**	**0.0154**	***0.0323***

It is estimated that a total of 2,610 summer steelhead were harvested from the Middle Fork in 2003 (Table 52). Of these, 2,196 were caught by bank anglers and 414 by boat anglers. Another 239 marked steelhead were caught and released. Assuming a hooking mortality rate of 3.4% (Hooton, 1987), it is estimated that an additional 8 hatchery fish died after release, for a total of 2,601 marked fish that were removed by the fishery. Bank anglers and boat anglers were equally likely to release marked fish (8.6% vs. 7.5% of marked fish caught were released).

Roughly 15% of the steelhead caught in the Middle Fork fishery were unmarked (Table 52). This result seems unlikely considering that winter steelhead are not native to the Middle Fork Willamette, and a low proportion (2%) unmarked steelhead were caught in the McKenzie. At the time of the surveys, the surveyors conducting the interviews believed that some anglers were inflating numbers of fish released, especially unmarked fish. Anglers in the Middle Fork Willamette also reported a suspiciously high proportion of unmarked chinook released. We are currently working to remove questionable interviews from the data used for expansions. It is estimated that 17 unmarked steelhead were kept illegally. A preliminary estimate suggests that a total of 401 unmarked steelhead were caught over the course of the season. Assuming a 3.4% hooking mortality rate (Hooton, 1987), it is estimated that the fishery on the Middle Fork Willamette had a take of 31 unmarked steelhead in 2003.

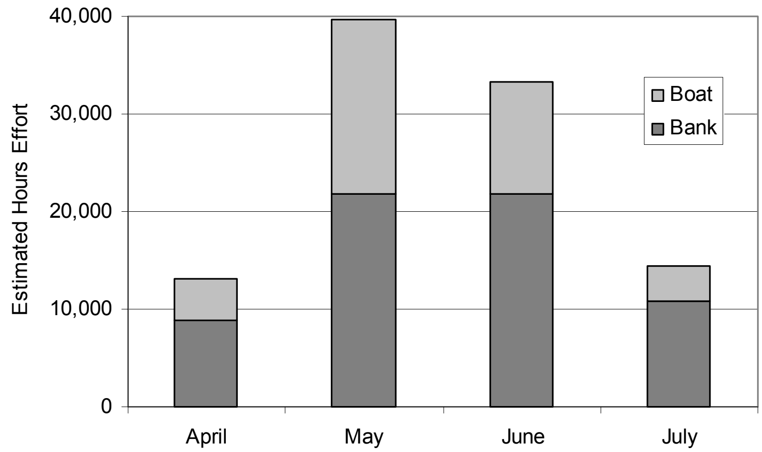

Figure 48. Estimated hours effort in the Middle Fork Willamette fishery, 2003.

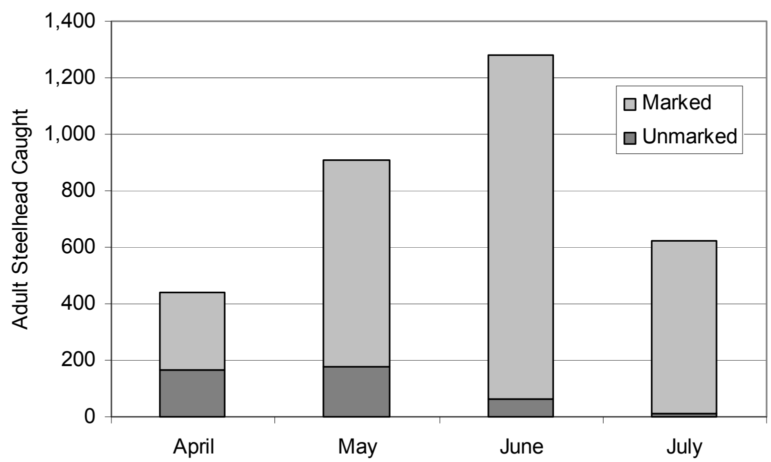

Figure 49. Catch of steelhead in the Middle Fork Willamette, 2003.

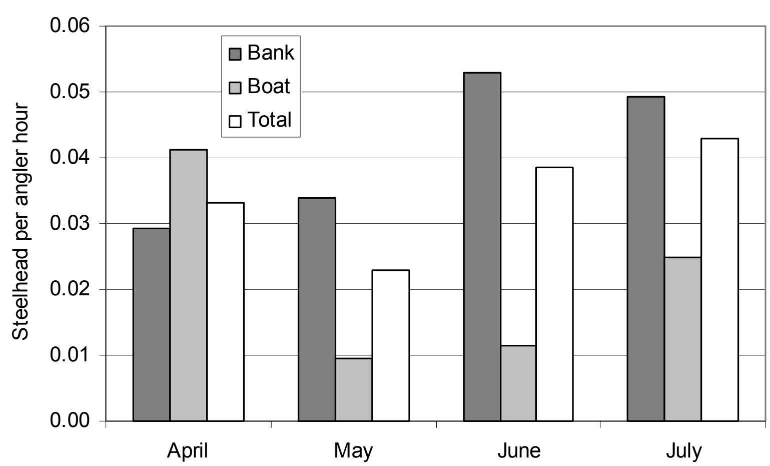

Figure 50. Catch rate for steelhead in the Middle Fork Willamette, 2003.

Table 52. Steelhead harvested and released in the Middle Fork Willamette fishery, 2003.

Kept

	Bank		Boat						
	Unmk	Mark	Unmk	Mark	Unmarked	Marked	Bank	Boat	**Total**
April	11	168	0	102	11	270	179	102	**281**
May	0	523	0	98	0	621	523	98	**621**
June	0	1,023	6	115	6	1,138	1,023	121	**1,144**
July	0	470	0	92	0	562	470	92	**562**
Season	*11*	*2,185*	*6*	*408*	*17*	*2,593*	*2,196*	*414*	***2,610***

Released

	Bank		Boat						
	Unmk	Mark	Unmk	Mark	Unmarked	Marked	Bank	Boat	**Total**
April	79	0	78	0	157	0	79	78	**157**
May	133	86	44	27	177	113	219	71	**290**
June	53	72	6	6	59	78	125	12	**137**
July	10	49	0	0	10	49	59	0	**59**
Season	*274*	*206*	*127*	*33*	*401*	*239*	*480*	*160*	***640***

Foster Reservoir Creel

The angler survey on Foster Reservoir began in November of 2002 and continued through the end of October 2003. An estimated 382 naturally produced steelhead smolts were retained in the Foster Reservoir fishery in 2003 (Table 53). Another 87 were caught and released. If we assume 20% mortality on released fish, then we estimate that the fishery resulted in a take of 400 steelhead smolts. A total of 19,477 marked hatchery trout were caught, and 19,102 of these were kept. Thus, steelhead smolts made up approximately 2% of the catch and the harvest in Foster Reservoir in 2003.

Most steelhead smolts were caught in the winter and early spring, with the greatest catch of steelhead smolts in January (Figure 51, D & E). Most hatchery trout were caught in May and June (Figure 51, B). Angler effort was greatest in June (Figure 51, A). The catch rate for unmarked smolts was highest in February, and in May for marked hatchery rainbow trout (Figure 51, C). The ratio of unmarked smolts to marked trout was greatest in February when 25 percent of the catch was made up of unmarked steelhead smolts (Figure 51, F).

We collected scales from juvenile winter steelhead smolts caught by anglers in Foster Reservoir to determine age (n = 41). Steelhead smolts ranged in age from 1^+ to 4 years and ranged in size from 220-340 mm (8.6-13.4 in.). Fifty-five percent of the smolts were 3 years old. Scale markings on winter steelhead smolts indicated that juveniles spent an extra year rearing within Foster Reservoir.

Table 53. Estimated angler effort ,catch and harvest of unmarked, naturally produced steelhead smolts (Unmk), and marked hatchery rainbow trout in Foster Reservoir, 2003.

Month	Effort (hrs)	Unmk, kept	Unmk, released	Marked, kept	Marked, released
November	2,183	44	10	642	258
December	1,645	52	13	721	87
January	1,404	79	3	252	8
February	1,359	58	12	196	0
March	3,774	41	0	218	35
April	2,485	33	13	1,128	389
May	6,853	0	3	3,964	1,412
June	11,135	13	23	4,921	886
July	6,410	0	0	2,107	204
August	4,107	20	0	1,302	265
September	3,332	16	0	1,481	156
October	4,264	26	10	2,170	175
2003	48,951	382	87	19,102	3,875

Estimating the number of steelhead smolts entering the reservoir to determine the proportion of smolts that are impacted by the fishery is more challenging. Three hundred ninety one female steelhead passed above Foster Dam. Buckley (1967) reported that the fecundity of Big Creek steelhead ranges from 1,827 to 3,996 eggs per female, with an average of 2,912 eggs per female. In Table 54 we present three scenarios of fecundity and survival used to estimate the number of steelhead smolts entering the reservoir. In the best-case scenario, we estimate fresh-water mortality at 90%, giving us an estimate of 156,000 smolts entering the reservoir. If freshwater mortality was as high as 98% and fecundity was at the lower limit observed by Buckley (1967), then we estimate that approximately 14,000 smolts would enter the reservoir. In the moderate scenario we have used the average fecundity reported by Buckley (1967) and a 95% freshwater mortality rate, giving us an estimate of approximately 57,000 steelhead smolts entering Foster Reservoir. Using these various scenarios, the impact of the Foster Reservoir trout fishery on naturally produced winter steelhead is roughly between 0.2% and 2%.

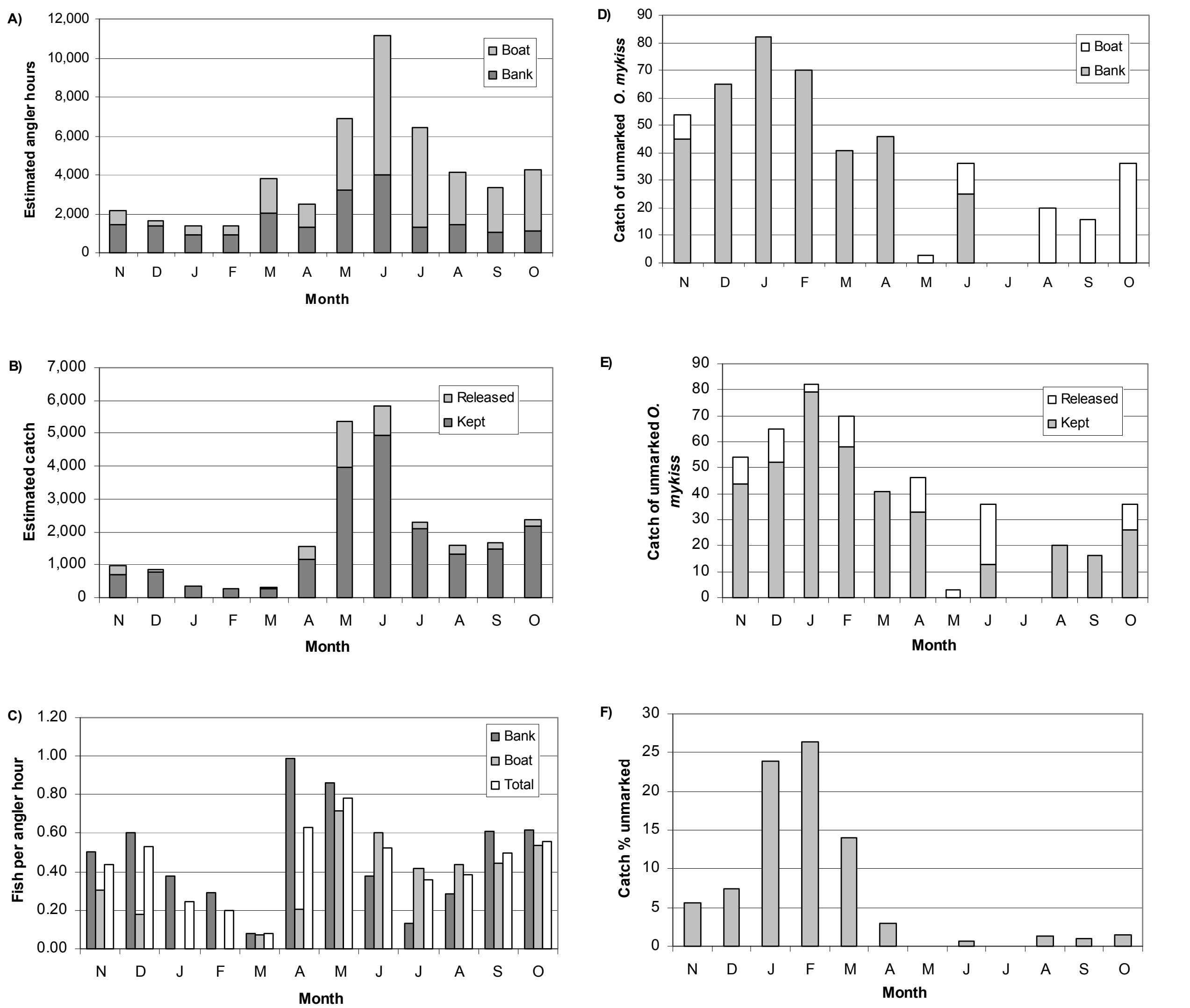

Figure 51. Results from Foster Reservoir angler survey by month, 2003. A) Estimated angler effort by month in hours fished. B) Fate of *O. mykiss* caught in the Foster Reservoir fishery. C) Catch rate in fish caught per hour. D) Catch of unmarked steelhead smolts by fishing method. E) Fate of unmarked steelhead smolts caught in the Foster Reservoir fishery. F) Percent of total catch that was made up of unmarked steelhead smolts.

Table 54. Estimates of impacts on naturally produced winter steelhead smolts entering Foster Reservoir:

Best	Worst	Moderate	
391	391	391	Number of female steelhead passed above Foster Dam
3,996	1,827	2,912	Fecundity. (from Buckley, 1967, Big Creek steelhead)
90.0%	98.0%	95.0%	Estimated freshwater mortality
156,244	14,287	56,920	Estimated smolts entering reservoir
382	382	382	Estimated harvest of smolts, Nov 2002 - Oct 2003
87	87	87	Estimated smolts released, Nov 2002 - Oct 2003 (20% mort)
17	17	17	20% Mort on released fish
399	399	399	Estimated Impact of fishery on smolts
0.20%	**2.19%**	**0.55%**	*Estimated impact (percent of run)*

Wild steelhead show up mainly in the spring and again in the fall, but there is considerable overlap in timing with current stocking schedules and catch of holdovers. Consequently, season manipulation is probably not a good protection option. There is also a great deal of size overlap between wild and hatchery O.mykiss (Figure 52), so size restrictions are not a practical option. Since this is a bait fishery, getting rid of bait is not a practical option. Changing the regulations to allow take of adipose clipped trout only may be the best conservation measure. Several reasons to propose this change are: consistency in regulations, saving take for other lower river fisheries, a small impact on allowable harvest (2% of harvest of trout), and providing a small but additional protection to wild fish.

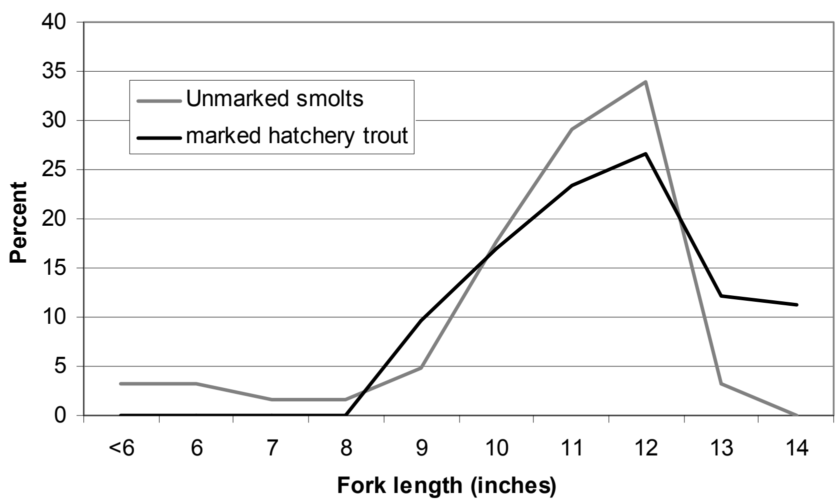

Figure 52. Length frequencies of stocked hatchery rainbow trout (marked) and naturally produced winter steelhead smolts (unmarked) retained in the Foster Reservoir angler survey, 2003.

Percentage of the Summer Steelhead Run Harvested and Number of Steelhead Potentially Spawning Naturally

In 2003, 15,170 summer steelhead passed Willamette Falls (Table 55). Counts at Bennett Dams on the North Santiam River and Foster Dam on the South Santiam River account for 57% of the number of summer steelhead that passed Willamette Falls. Another 5% were encountered at Leaburg Dam on the McKenzie River. Assuming a 3.4% hooking mortality (Hooton, 1987), a total of 9,326 marked steelhead were removed by fisheries in the South Santiam, McKenzie and Middle Fork Willamette. Another 1,702 summer steelhead were taken for broodstock. Spawning surveys yielded an estimate of 1,562 summer steelhead redds in the upper Willamette ESU. This gives a ratio of 2.65 fish per redd.

Table 55. Summer Steelhead in the Upper Willamette, 2003.

		Summer Steelhead	Marked kept	Marked released	Unmk released	Reference
Passage	Willamette Falls	15,170				I.J. website*
	North Santiam	4,073				Bennett count
	South Santiam	4,529				Bill Nyara‡
	McKenzie	777				Leaburg count
Harvest	South Santiam		5,473	442	168	Angler survey
	McKenzie		1,173	170	29	Angler survey
	M. Fk. Willamette		2,593	239	401**	Angler survey
Broodstock		1,702				Bill Nyara‡
Redds	Mid-Willamette	1,298				Spawn Surv.
	Upper Willamette	264				Spawn Surv.
	Total	1,562				Spawn Surv.

*Interjurisdictional Fisheries Management Program:
http://www.dfw.state.or.us/ODFWhtml/InfoCntrFish/Interfish/2002wfcounts.htm
**We are working to remove questionable interviews from the estimate for released unmarked fish.
‡South Santiam Hatchery Manager

In 2004, 32,382 passed Willamette Falls (Table 56). Approximately 54% of these were encountered at traps in the North Santiam, South Santiam and McKenzie Rivers. A total of 1,566 were taken for broodstock. Surveys are currently under way to estimate the number of redds constructed by straying summer steelhead from the 2004 run.

Table 56. Summer Steelhead in the Upper Willamette, 2004.

		Summer Steelhead	Reference
Passage &	Willamette Falls	32,382	I.J. website*
Trapping	North Santiam	8,584	Bennett count
	South Santiam	6,283	Bill Nyara‡
	McKenzie	2,618	Leaburg count
Broodstock		1,566	Bill Nyara‡

*Interjurisdictional Fisheries Management Program:
http://www.dfw.state.or.us/ODFWhtml/InfoCntrFish/Interfish/2002wfcounts.htm
‡South Santiam Hatchery Manager

Acknowledgements

This work would not have been possible without the efforts of many dedicated people. We would like to recognize the field crews who collected the data: Rob Carlson, Bart DeBow, Deanna Emig, Greg Gilham, Annie Hartle, Kevin Hood, Ed Hughes, Matt Johnson, April Lewis, Wendy MacLean, Tim McCabe, Matt Powell, Bob Pucillo, Brent Reed, Lisa Riley, Donna Sharp, and Jason Tavares. Hatchery Managers Terry Jones, Kurt Kremers, Gary Yeager, and Bill Nyara and their crews provided data on chinook captured at their hatcheries and conducted the otolith marking of chinook salmon in their hatcheries. Bill Nyara also provided information on summer steelhead spawned at the hatchery. Tom Nickelson provided significant administrative and editorial assistance.

Literature Cited

Busack, C.A. and K.P. Currens. 1995. Genetic Risks and Hazards in Hatchery Operations: Fundamental Concepts and Issues. American Fisheries Society Symposium 15:71-80.

Cuenco, M.L., T.W.H. Backman, and P.R. Mundy. 1993. The use of supplementation to aid in natural stock restoration. In, Genetic Conservation of Salmonid Fisheries, J.G. Cloud and G.H. Thorgaard, eds. Plenum Press, New York.

Efron, B., R. Tibshiani. 1986. Bootstrap Methods for Standard Errors, Confidence Intervals, and other Measures of Statistical Accuracy. Statistical Science. Vol. 1, No, 54-77

Firman, J., R. Schroeder, R. Lindsay, K. Kenaston, and M. Hogansen. 2004. Work Completed for Compliance With the Biological Opinion for Hatchery Programs in the Willamette Basin, USACE funding: 2003. Oregon Department of Fish and Wildlife, Task Order: NWP-OP-FH-02-01, Salem.

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.

Hard, J.J., R.P. Jones, M.R. Delarm, and R.S. Waples. 1992. Pacific salmon and aritificial propagation under the Endangered Species Act. NOAA Tech. Memo. NMFS F/NWC-2, 56p.

Hooton, R. S. 1987. Catch and release as a management strategy for steelhead in British Columbia. In R. Barnhart and T. Roelofs, editors, Proceedings of: Catch and Release Fishing - A Decade of Experience. Sept 30 - Oct 1, 1987. Humboldt State University, Arcata, California.

Hutchinson, J.M. and R.M. Hooton. 1990. McKenzie River Creel Survey, 1983. Oregon Department of Fish and Wildlife

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-04, Annual Progress Report, Portland.

NRC (National Research Council). 1996. Upstream: Salmon and Society in the Pacific Northwest. National Academy Press, Washington, D.C. 452 p.

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.

Schroeder, R. K., K. R. Kenaston, and R. B. Lindsay. 2003. Spring Chinook salmon in the Willamette and Sandy rivers. Oregon Department of Fish and Wildlife, Fish Research Report F-163-R-08, Annual Progress Report, Salem.

Solazzi, M.F., S.L. Johnson, B Miller, and T. Dalton 2003 Salmonid Life-Cycle Monitoring Project 2003 Monitoring Program Report Number OPSW-ODFW-2003-2, Oregon Department of Fish and Wildlife, Salem, Oregon

Steward, C.R. and T.C. Bjornn. 1990. Supplementation of salmon and steelhead stocks with hatchery fish: a synthesis of published literature. Tech, Rpt. 90-1. Idaho Cooperative Fish and Wildlife Research Unit. University of Idaho, Moscow, ID.

Susac, G. and S. Jacobs 1999. Evaluation of spawning ground surveys for indexing the abundance of adult winter steelhead in Oregon coastal basins. Annual Progress Report, Oregon Department of Fish and Wildlife, Portland, OR.

Waples, R.S. 1999. Dispelling some myths about hatcheries. Fisheries 24(2) 12-1.