Work Completed for Compliance With the Biological Opinion for Hatchery Programs in the Willamette Basin, USACE funding: 2003

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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.

Tasks and Activities

<u>Task 1.1</u> Remove hatchery-reared spring chinook at Leaburg Dam [RPA 1, c, iii], thus reducing the number of hatchery spring chinook spawning above Leaburg Dam on the McKenzie River.

The results of trapping at Leaburg Dam in 2003 are presented in Table 1. Adjusted totals reflect rates of otolith marks in unclipped fish in 2001 and 2002 (see Table 19). Over a thousand marked spring chinook were captured, removed, and transported to McKenzie hatchery or released in the South Fork McKenzie above Cougar Reservoir (Table 1, Figure 1). Four hundred ninety-five naturally-produced spring chinook were captured and passed above the trap. According to video counts, a total of 4,584 hatchery and 4,248 naturally-produced spring chinook passed the dam during the period when the trap was not operating in 2003. Thus, approximately 21% of the hatchery spring chinook that arrived at Leaburg dam were captured and removed from the naturally-spawning population, whereas only 10% of the naturally-produced fish were captured and released upstream. Roughly 55% of the chinook arriving at Leaburg Dam consisted of hatchery fish, and 49% of the chinook that passed the dam to reach the spawning grounds upstream were hatchery fish.

Table 1. Spring chinook at Leaburg Dam, 2003.

Month	Unmarked	Marked	Removed*	Passed*	Adults	Jacks	Total
May	1,784	655	50	605	2,439	6	2,445
June	2,982	1,754	0	1,754	4,736	40	4,776
Jul	504	671	112	559	1,175	24	1,198
Aug	100	168	101	67	268	7	274
Sep	402	1,476	918	558	1,878	9	1,887
Oct	12	16	16	0	28	30	29
Total	**5,784**	**4,740**	**1,197**	**3,543**	**10,524**	**115**	**10,639**
Adjusted*	***4,859***	***5,665***	***1,197***	***4,468***	***10,524***	***115***	***10,639***

*Chinook removed and passed are subsets of marked Chinook observed at the dam. Fish removed from the trap were transported to McKenzie Hatchery or outplanted in the South Fork McKenzie River upstream of Cougar Reservoir.
** Numbers of unmarked fish have been adjusted using the otolith mark rate observed in 2001 and 2002 (16%; see Table 19)

Chinook began appearing at Leaburg Dam in May of 2003, with peak passage occurring in late May and early June, and a secondary peak occurring in September (Figure 2). Overall run-timing was similar to the 20-year average (Figure 3) and 2002 (Figure 4), although the peak of chinook passage in 2003 occurred about two weeks earlier than average, and the leading edge of the curve was exceptionally steep. In the course of four days, daily counts of chinook passing Leaburg dam went from 0 to 527, and in the course of three weeks, weekly counts went from 0 to almost 2,000 fish. For four weeks, weekly totals rivaled or exceeded the total annual returns for 15 of the past 25 years.

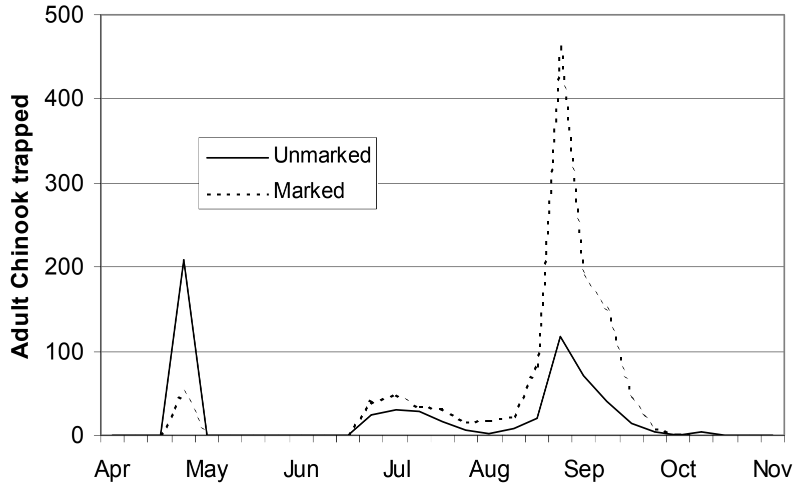


Figure 1. Chinook trapping at Leaburg Dam: 2003

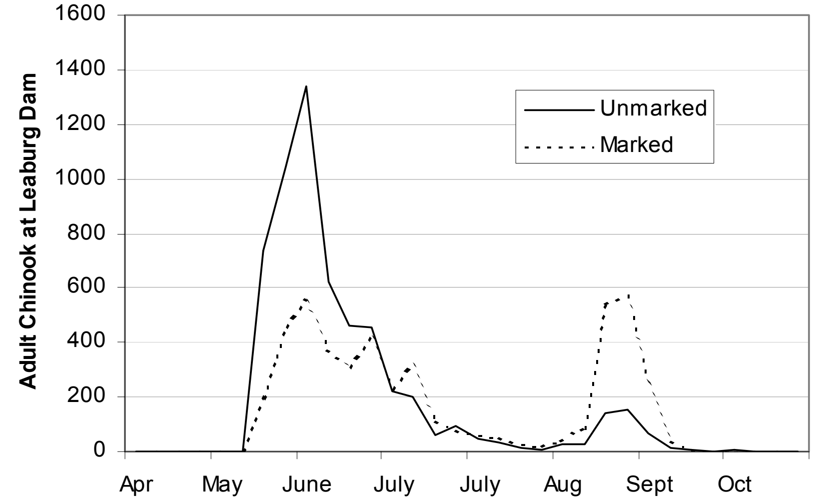


Figure 2. Chinook run-timing at Leaburg Dam: 2003.

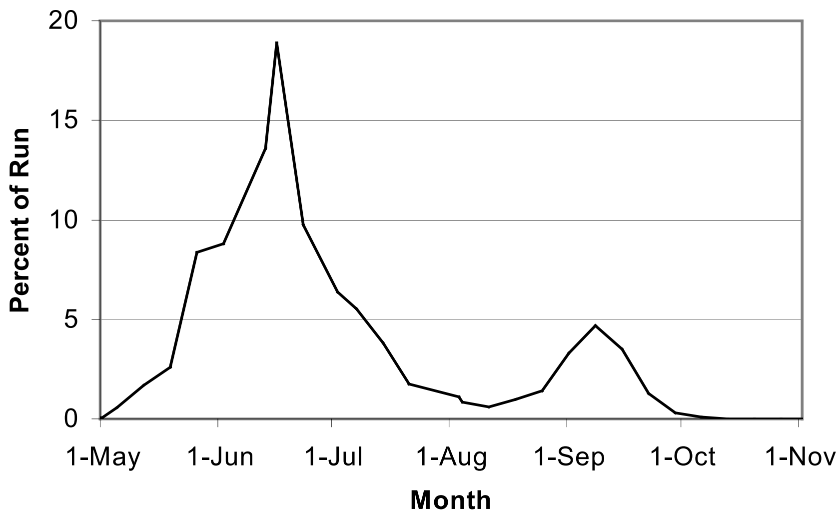


Figure 3. Chinook run-timing, Leaburg Dam: 1980-2001

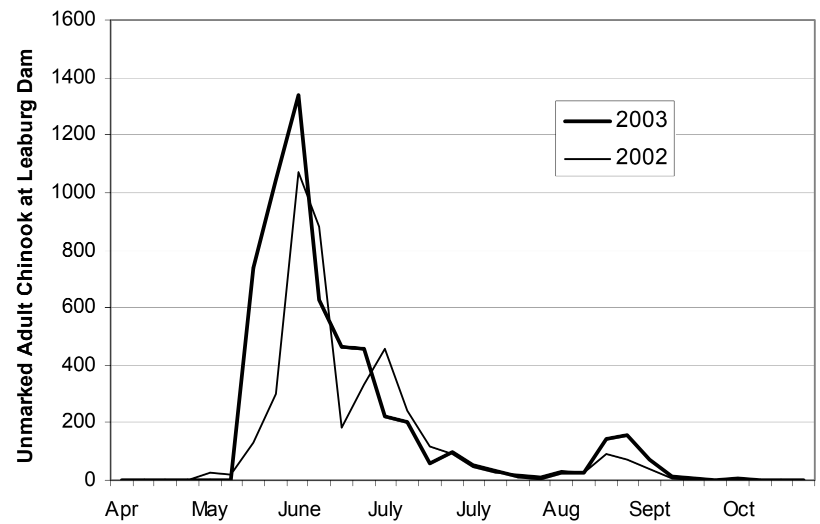


Figure 4. Unmarked Spring Chinook: 2002 vs. 2003.

The run of spring chinook in 2003 was the largest in 25 years of recorded fish passage at Leaburg Dam (Table 2, Figure 5). There has been a significant increasing trend over the last 5 years (R^2 = 0.92; Figure 6). Ocean conditions began shifting to a regime favoring salmon production in Oregon in 1998. Upwelling strengthened in 1998, but ocean productivity didn't increase until 1999. In 2001, the chinook run was two to four times as large as runs in the preceding 7 years (Table 2).

Table 2. Spring Chinook at Leaburg Dam: 1981-2003

Year	Total	Marked	Unmarked	Jacks	% Unmarked	Adult/Adult
1981	1087			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

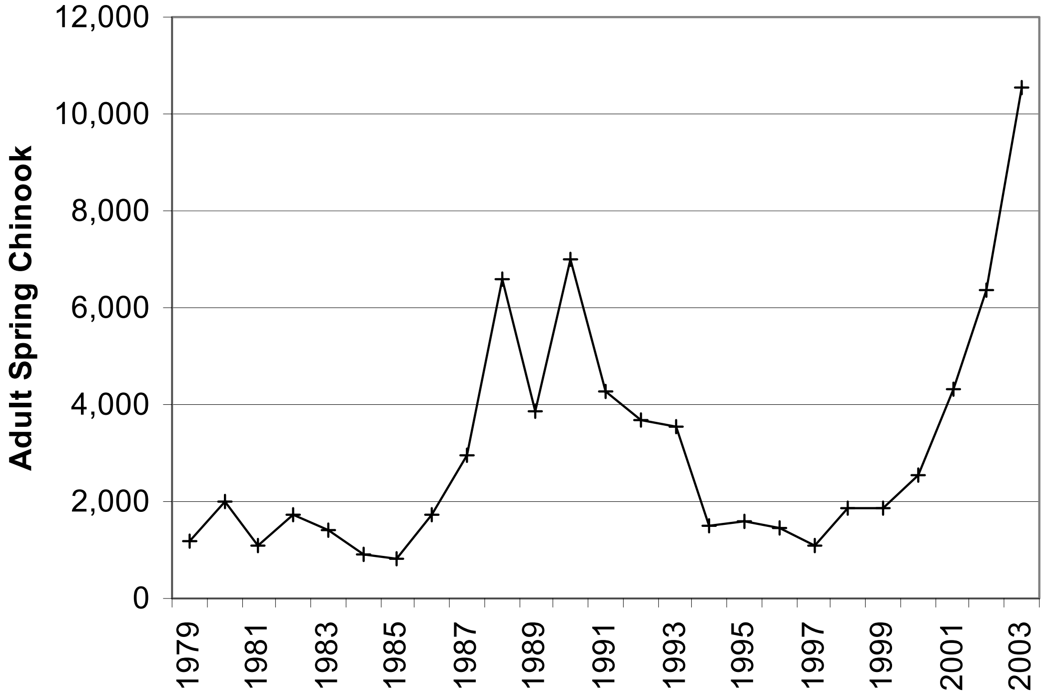


Figure 5. Chinook passage at Leaburg Dam: 1980-2002

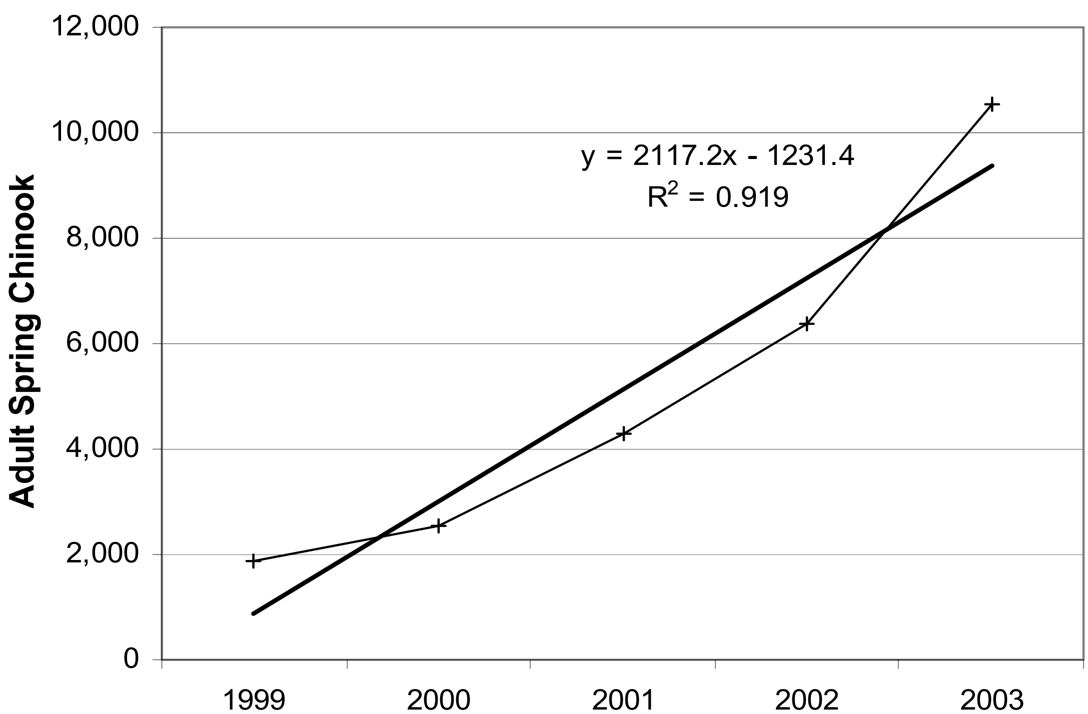


Figure 6. 5-year trend in Chinook Run Size at Leaburg.

<u>Task 1.2</u> Monitor straying of hatchery fish on natural spawning grounds: conduct annual spawning ground surveys. [RPM2,d]

Activity 1.2.1 Monitor the distribution and abundance of natural spawning spring chinook salmon in the Willamette Basin by counting redds.

We surveyed most of the major tributaries in the Willamette Basin above Willamette Falls in 2003 by boat and on foot to count spring chinook salmon carcasses and redds. We counted redds during peak times of spawning based on data from past surveys. 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 27–October 15 to recover carcasses and count redds. An unusually large return of spring chinook to the North Santiam River stimulated sports fisheries and prompted reports from anglers of large numbers of pre-spawning mortalities. We began surveys in late June to confirm those reports of mortalities and examine carcasses.

In 2003, we found that 72% of females died before spawning based on recovery of carcasses in spawning surveys (Table 3). Surveys in other years began later and estimates of pre-spawning mortality may be underestimated if mortality of chinook salmon begins in early summer, as in 2003 (Table 3). Estimates of pre-spawning mortality may be high if conditions such as higher flow make it more difficult to recover carcasses later in the season when most of the carcasses would be spawners. Although dead male chinook salmon were also recovered throughout the summer, they are not included in the estimate of pre-spawning mortality because later in the spawning season we cannot accurately judge if they spawned. The number of all dead salmon found in August as a proportion of the Bennett Dam counts through August was slightly higher in 2003 than in previous years (Table 4). Although the mean daily flow in August was lower in 2003 than in other years, the maximum water temperature was similar to 2002 and lower than 2001 (Table 4). We did not include data from 1999 and 2000 because carcass surveys were not conducted in August in 1999 and the 2000 count at Bennett was likely underestimated (*see* Schroeder et al. 2001).

Table 3. Season total percentage (through mid to late October) of females that died before spawning in the North Santiam River as assessed from recovery of carcasses.

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

Table 4. Summary of chinook salmon counts through August, and number of carcasses recovered, water temperature, and flow in August in the North Santiam River, 1998, 2001–2003.

Year	Bennett count through August	Carcasses (start date, surveys)	Carcasses as % of count	Temperature (°C)[a]	Mean daily flow (cfs)
1998	2,120	17 (Aug 6, 2)	0.8%		1,046
2001	6,886	113 (Aug 14, 5)	1.6%	18.9	930
2002	7,669	210 (Aug 1, 8)	2.7%	15.5	993
2003	12,451	439 (b, 6)	3.5%	15.4	881

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

We calculated approximate fish/redd ratios for spring chinook salmon in the North Santiam basin above Bennett dams by estimating the number of potential spawners from estimates of chinook over the dams minus the number of fish removed at the Minto collection pond (e.g., fish spawned and fish transported above Detroit Dam) and those caught in the sport fishery (assuming a 20% exploitation rate). Adult chinook were transported from Minto to the Little North Fork Santiam in 2002 and 2003, and because we included redds in the Little North Fork, we did not subtract these fish from the Bennett counts. The fish/redd ratio was higher in 2003 (10.2) and 2001 (9.2) than in 2002 (6.9), which corresponds to the high pre-spawning mortality we saw in 2003 and 2002 (Table 4).

Redd digging was first observed on August 8 and peak spawning occurred in late September, similar to previous years. The redd density in 2003 was highest in the section immediately below Minto dam (55.5 redds/mi) and was almost four times that of 1996–2002 average (14.4 redds/mi, Table 5).

Table 5. Summary of spawning surveys for spring chinook salmon in the North Santiam River, 2003, and comparison to redd densities in 1996–2002.
Spawning in areas below Stayton may include some fall chinook.

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

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

Activity 1.2.2 Estimate the number of marked and unmarked spring chinook salmon passing Bennett Dam near Stayton on the North Santiam River.

Abundance and migration timing of adult spring chinook were monitored at upper and lower Bennett dams in 2003 (Table 6 and Figure 7) with methods similar to previous years. Adjusted totals reflect rates of otolith marks in unclipped chinook carcasses recovered from the spawning grounds in 2001 and 2002 (see Table 19). Over 12,000 spring chinook passed Upper and Lower Bennett Dams in 2003, the largest run on record. Roughly 10% of these were un-clipped fish. If a similar proportion of unclipped fish have otolith marks as was observed in 2002, then as a preliminary estimate, roughly 5% of the chinook passing Bennett Dams were naturally produced. When otolith results for 2003 are available, this estimate will be finalized.

Table 6. Spring Chinook Passage Estimates at Bennett Dams, North Santiam, 2003.

Month	Marked	Unmarked	*% Fallback*	Corrected Mark [a]	Corrected Unmk [a]	Total
Mar	0	0	--	0	0	0
Apr	4	4	--	4	4	8
May	3,817	449	*0.00*	3,817	449	4,266
Jun	6,060	625	*1.39*	5,975	617	6,592
Jul	1,277	102	*5.71*	1,204	96	1,300
Aug	101	14	*0.00*	101	14	115
Sep	450	52	*8.22*	413	48	461
Oct	0	32	--	0	32	32
Nov	0	0	--	0	0	0
Total	11,708	1,278	*1.18*	**11,570**	**1,262**	**12,832**
Adjusted [b]	12,296	690		**12,151**	**681**	**12,832**

[a] *Passage estimates adjusted to account for fallbacks.*
[b] *Estimates adjusted using otolith mark rates observed in 2001 and 2002 (46%; see Table 19)*

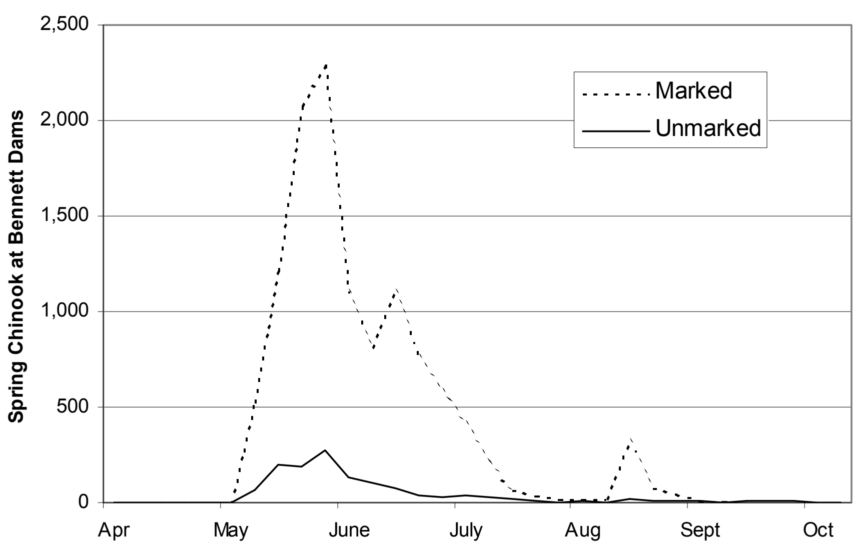


Figure 7. Spring Chinook Passage at Bennett Dams, North Santiam, 2003.

Activity 1.2.3 Determine the proportion of hatchery spawners in natural spawning population of spring chinook in the Willamette Basin.

Activity 1.2.4 Determine the percentage and origin of hatchery strays in spring chinook populations in the Willamette Basin.

Of the carcasses we recovered in the North Santiam in 2003, 86% had fin clips (Table 7), compared to 86% and 73% in 2001 and 2002, respectively.

Table 7. Composition of naturally spawning spring chinook salmon based on carcasses recovered in the North Santiam River above Stayton Island, 2003.

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

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

The McKenzie River was regularly surveyed August 7–October 13 to recover carcasses and count redds. Some redds were counted in August but active redd building began in early September, similar to previous years. Peak spawning occurred in late September to early October. More redds were counted in 2003 (1,187) than in 2002 (922) but relative redd densities in specific sections varied (Table 8). A large number of spring chinook were found in upper Horse and Lost creeks, areas not previously surveyed by our project. The percentage of fin-clipped carcasses in 2003 was higher above Leaburg Dam (32%) than in 2002 and 2001 (24% and 19%, respectively), but was similar below Leaburg Dam in 2003 (70%), 2002 (67%), and 2001 (72%) (Table 9).

Table 8. Summary of chinook salmon spawning surveys in the McKenzie River, 2003, and comparison to redd densities (redds/mi except redds/100 ft for spawning channel) in 1996–1998 and 2000–2002.

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

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

Table 9. Composition of naturally spawning spring chinook salmon based on carcasses recovered in the McKenzie River, 2003.

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

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

Other rivers that were regularly surveyed in 2003 were the South Santiam (7 dates, July 14–October 21), Molalla (4 dates, August 27—October 7), and Middle Fork Willamette (6 dates, July 15–September 29). Active redd building began in early September in the South Santiam and in mid September in the Middle Fork Willamette. Peak spawning in both rivers was late September to early October. The percentage of fin-clipped carcasses was lower in the Middle Fork Willamette (54%) than in the North Santiam (86%), South Santiam (84%), and Molalla (79%) (Tables 7 and 10). The pre-spawning mortality of spring chinook salmon (based on examination of female carcasses) is in Table 11.

Table 10. Summary of chinook salmon spawning surveys in the Middle Fork Willamette, South Santiam, Santiam, Calapooia, Molalla rivers and tributaries, 2003.

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

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

Table 11. 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, 2001–2003.

River	Starting date	Carcasses	Pre-spawn mortality Number	Pre-spawn mortality Percent
		2001		
McKenzie	Aug 21	198	14	7
North Santiam	Aug 14	319	238	75
		2002		
Middle Fork Willamette	Aug 7	162	134	83
Fall Creek	Aug 27	36	21	58
McKenzie	Aug 15	509	41	8
South Santiam	Aug 6	794	204	26
North Santiam	Aug 1	229	120	52
		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

The percentage of stray hatchery fish recovered in spawning surveys was much higher in the McKenzie and North Santiam rivers in 2002 (42% and 30%, respectively) than in 2001 (13% and 6%, respectively). The highest number of strays in the McKenzie and North Santiam rivers was from releases into the lower Willamette or Clackamas (netpen) rivers (Table 12). Strays in the McKenzie River from releases into the Middle Fork Willamette and strays in the North Santiam from releases into the Molalla were also high. The percentage of strays in other rivers ranged from 21% in the Molalla to 4% in the Middle Fork Willamette (Table 12). We collected 258 snouts from carcasses with adipose fin clips in 2003 (Table 13). Coded wire tags recovered from these fish will be read and reported in 2004.

Table 12. Origin of hatchery spring chinook salmon from recoveries of coded wire tags in spawning ground surveys, 2002.
North Santiam data include recoveries in Little North Fork Santiam (2) and Middle Fork Willamette data include recoveries in Fall Creek (4).

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

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

Table 13. Number of snouts collected from carcasses of adult spring chinook salmon with adipose fin clips and a coded wire tag (determined with a hand-held detector), 2003.

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

[a] *Includes 3 collected in Fall Creek.*
[b] *Includes 5 collected below Leaburg Dam.*

Efforts to Re-Establish Populations

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

Unclipped adult spring chinook, collected at Minto, were tagged with uniquely numbered Floy® tags and released at two locations in the Little North Fork Santiam River: Golf bridge (rkm 20) and Elkhorn bridge (rkm 27). A total of 268 fish were released on six dates from June 25 through September 4 (Table 14).

We surveyed the Little North Fork nine times beginning July 10 and ending October 6. We examined 46 dead chinook salmon for fin clips and tags, and collected otoliths and scales from unclipped fish. An additional 25 fish were decayed and we were unable to determine if they were clipped or tagged. The first spawned female was found on September 19. We recovered 32 of the 268 tags and found 10 more fish that had lost their tags, but had a tag wound. Of the 15 tagged females recovered, 14 died prior to spawning. Half of the carcasses from the Elkhorn bridge releases were recovered in the same area and half were recovered downstream. Most of the carcasses from the Golf bridge releases were recovered in the same area (75%) and the rest were recovered upstream.

Table 14. Summary of adult chinook salmon released and recovered in the Little North Fork Santiam, 2003.

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

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

We counted 31 redds in the Little North Fork between Elkhorn bridge and the mouth, far fewer than expected from a release of 268 adults. However, recoveries of tagged female carcasses suggest that pre-spawning mortality was high (93%). In addition, only 8 of the 42 tagged carcasses we recovered were found after September 19, the date of first redd deposition, which suggests that only about 19% of the 268 adults (51 fish) might have survived to spawn.

On August 29, 135 adult chinook salmon with fin clips were transported from South Santiam Hatchery and released into the Calapooia River above Biggs Cr (rkm 92.6). Live chinook salmon counted at the release site decreased from over 100 fish on August 30 to 6 fish on September 12 (Table 15). The cumulative number of carcasses recovered in the river (3000 line bridge, rkm 95, to Biggs Cr) increased from 2 on August 30 to 49 on September 12. We collected 43 clipped chinook salmon, 5 unclipped fish, and 11 fish that were too decayed to process. The first redd was observed on September 25 in the section from McKinley Creek (rkm 98) to the 3000 line bridge, and we counted two redds through October 8 in this section, the only redds found in 7.6 mi we surveyed above Biggs Creek.

Table 15. Observations of chinook salmon in the Calapooia River, July–October 2003.

	July 29	Aug 30	Sept 2	Sept 12	Sept 25	Oct 7
Live adults: release site above Biggs Cr.	0	100+	53	6	0	0
Carcasses:3000 line bridge to Biggs Cr.	0	2	16	31	1	0
Temperature: release site	17			17	16	

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 2003, all returning spring chinook salmon originating from Willamette basin hatcheries should be otolith marked. Analysis of otolith marks in returning adults is scheduled to continue through the 2005 run year, which will give us three brood years (1998–2000) to evaluate the proportion of hatchery and wild fish in the unclipped portion of the run. Otolith marking may be discontinued if analyses 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 2002 brood, hatchery spring chinook salmon in the Willamette basin. Reference samples were collected at the hatcheries (Table 16) and will be analyzed for mark quality at the otolith laboratory operated by Washington Department of Fish and Wildlife (WDFW). Preliminary results indicated good quality marks at all hatcheries, final results will be reported in 2004.

Table 16. Data on thermal marking of spring chinook salmon in Willamette River hatcheries and collection of reference samples, 2002 brood.
Reference samples consisted of 40–50 fry (35–50 mm) from each egg take.

Stock	Egg takes analyzed	Treatment (hrs on/off)	Temperature differential (°F) [a]	Cycles[b]	Comments
McKenzie	4	Chilled (24/72)	4.0–8.0	7[c]	--
N. Santiam	3	Heated (48/48)	6.0–9.0	8	--
Willamette	3	Heated (48/48)	8.0–13.5	6	--
S. Santiam	3	Heated (48/48)	8.0–13.5	6	Marked at Willamette H.
Clackamas	2	Heated (48/48)	8.5–13.5	6	Marked at Willamette H.
Sandy	4	Heated (48/48)	8.5–13.5	6	Marked at Willamette H.

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

Adults

We collected otoliths from adult spring chinook without fin clips on spawning grounds and at hatcheries in most of the major tributaries in the Willamette Basin in 2003 (Table 17). Otoliths were removed from carcasses and placed into individually numbered vials. In addition, we 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 17). These samples will be sent to WDFW for analysis and will be reported in 2004.

We estimated the proportion of naturally produced ("wild") fish on spawning grounds in the Willamette and Sandy basins from otoliths collected in 2002 (Table 18). Wild fish were determined by absence of a fin clip and absence of an induced thermal mark in the otoliths. Because we saw a significant difference between the distribution of redds and the distribution of carcasses recovered among survey areas within some watersheds (Figure 8), we used the distribution of redds among survey areas to adjust the number of no clip carcasses for all watersheds. 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 17. Otoliths collected from adult spring chinook salmon during spawning ground surveys and at hatcheries, 2003.

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

Table 18. Otoliths collected from unclipped adult spring chinook in the Willamette River basin that were analyzed for presence of thermal marks, 2002.

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

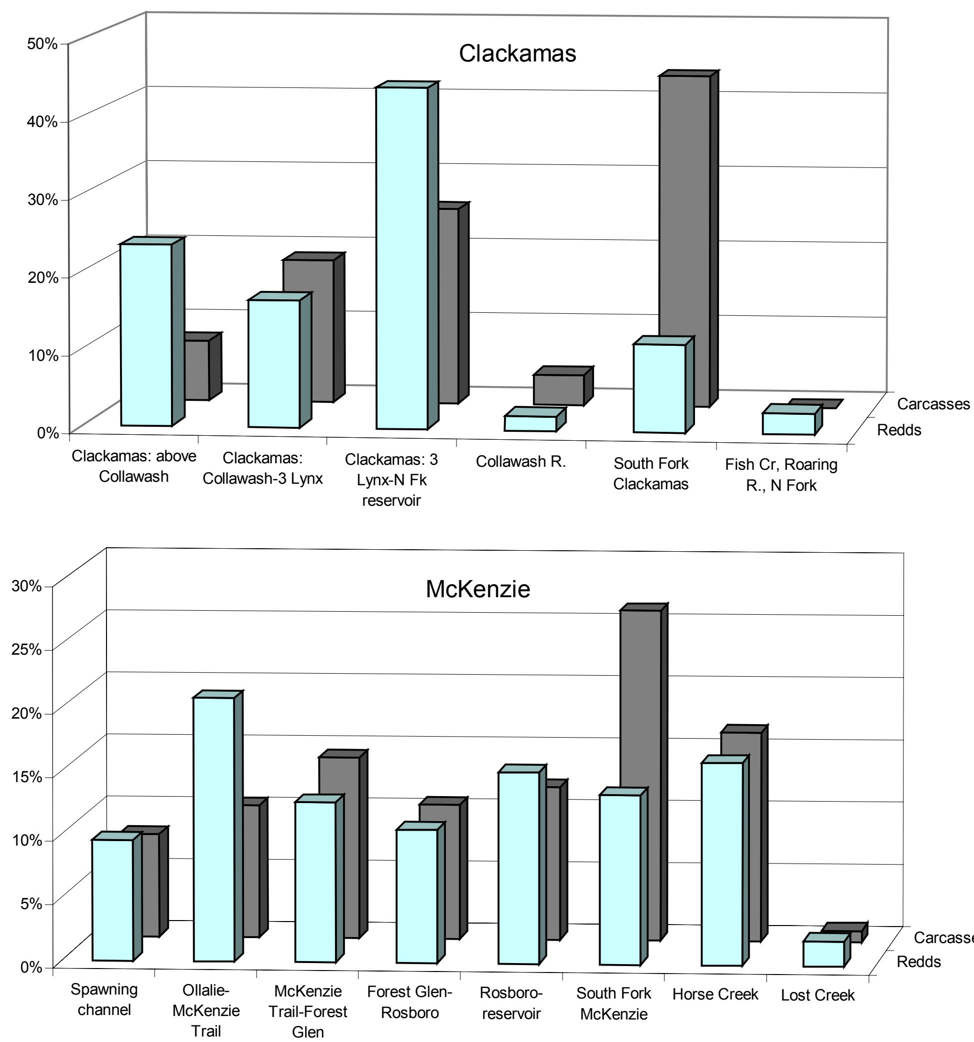


Figure 8. Distribution of redds and carcasses within the Clackamas and McKenzie watersheds, 2002.

We estimated the number of wild fish in the North Santiam and McKenzie rivers above dams in 2002 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 and Middle Fork Willamette rivers (Table 19). Of interest was the relatively high number of wild carcasses recovered in the South Santiam River.

Table 19. 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.

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

[a] *Proportions 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 had the lowest number (Table 20). Wild and hatchery fish were more numerous in 2002 than in 2001, with a large increase of wild fish in the North Santiam River. The percentage of wild fish in the McKenzie River above Leaburg Dam decreased in 2002 (Table 20), at least in part because the number and percentage of clipped fish at Leaburg Dam increased from 20% in 2001 to 33% in 2002.

Table 20. 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	Fin clipped	No clip carcasses with thermal marks (%)[a]	Estimated number Wild	Hatchery	Percent wild
			McKenzie			
2001	3,433	869	15.9	2,887	1,415	67
2002	4,019	1,949	14.7	3,428	2,540	57
			North Santiam			
2000[b]	1,045	1,241	90.7[b]	97	2,189	4
2001	388	6,398	43.4	220	6,566	3
2002	1,233	6,407	56.5[c]	536	7,104	7

[a] *Adjusted by distribution of redds among survey areas.*
[b] *Escapement at Bennett Dam was likely underestimated* (see *Schroeder et al. 2001).*
[c] *Average of adjusted spawning ground samples (49.4%) and samples from Minto Pond (63.6%).*

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 21). 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. Based on juvenile release data, we estimated no wild adults after adjusting for harvest difference because of selective fisheries on fin-clipped fish. For comparison, we estimated 220 wild fish in the North Santiam in 2001 based on otoliths from carcasses without fin clips (Table 21).

Table 21. Comparison of two methods of estimating the number of wild spring chinook salmon from adult counts at dams in the McKenzie and North Santiam rivers.
The proportion of wild and hatchery adults is estimated either by the percentage of juvenile hatchery fish released without fin clips or by otoliths from carcasses recovered on spawning surveys.

	Number (% in run) of wild adults determined by—	
River, run year	Release data	Otolith analysis
McKenzie, 2001	3,368 (78%)	2,887 (67%)
McKenzie, 2002	3,806 (64%)	3,428 (57%)
North Santiam, 2001	0 (0%)	220 (3%)
North Santiam, 2002	874 (11%)	536 (7%)

The WDFW otolith laboratory correctly identified a high percentage of adult hatchery spring chinook in the blind tests (Table 22). Additional tests are planned on the accuracy of identifying hatchery fish by presence of thermal marks in otoliths and identifying wild fish by absence of thermal marks.

Table 22. Accuracy in blind tests of the WDFW otolith laboratory in identifying presence or absence of thermal marks in hatchery spring chinook salmon, 2002.

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

<u>Task 2.1</u> Record the number of marked and unmarked fish that volitionally enter the hatcheries and broodstock collection facilities (McKenzie, Dexter, Minto and S. Santiam). [RPM 3,a]

Table 23 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 27,707 spring chinook entered hatcheries and broodstock collection facilities in 2003. Most of the salmon collected were released alive (16,491; 60%). Table 24 shows details of the locations and magnitude of releases.

Table 23. Fate of marked and unmarked spring chinook entering hatcheries and collection facilities.

Hatchery	Status	Marked Adults	Unmarked Adults	Total Adults	Marked Jacks	Unmarked Jacks	Total Chinook	% Unmk
Marion Forks	Released	3,079	378	3,457	30	0	3,487	10.8
	Spawned	599	19	618	0	0	618	3.1
	Other dead	324	12	336	0	0	336	3.6
	Total	*4,002*	*409*	*4,411*	*30*	*0*	*4,441*	*9.2*
S. Santiam	Released	3,942	401	4,343	38	4	4,385	9.2
	Spawned	1,044	32	1,076	20	0	1,096	2.9
	Other dead	844	12	856	49	0	905	1.3
	Total	*5,830*	*445*	*6,275*	*107*	*4*	*6,386*	*7.0*
Dexter	Released	3,339	106	3,445	380	1	3,826	2.8
	Willamette	2,211	6	2,217	11	0	2,228	0.3
	Dead	467	0	467	49	0	516	0.0
	Total	*6,017*	*112*	*6,129*	*440*	*1*	*6,570*	*1.7*
Willamette	Spawned	1,525	4	1,529	0	0	1,529	0.3
	Other dead	686	2	688	11	0	699	0.3
	Total	*2,211*	*6*	*2,217*	*11*	*0*	*2,228*	*0.3*
McKenzie	Released	3,067	33	3,100	55	0	3,155	1.0
	Spawned	846	51	897	0	0	846	6.0
	Other dead	2,086	88	2,174	34	0	2,208	4.0
	Total	*5,999*	*172*	*6,171*	*89*	*0*	*6,260*	*2.7*
Leaburg Trap	Released	1,015	603	1,618	14	6	1,638	37.2
	Spawned	112	0	112	0	0	112	0.0
	Dead	70	1	71	1	0	72	1.4
	Total	*1,197*	*604*	*1,801*	*15*	*6*	*1,822*	*33.5*
Grand Total		***25,256***	***1,748***	***27,004***	***692***	***11***	***27,707***	**6.3**

Table 24. Releases of spring chinook captured in hatcheries and collection facilities.

Hatchery	Release Location	Mk Adult	Unmk Adlt	Mk Jack	Unmk Jack	Total Chinook	% Unmk
Marion Forks	ABOVE DETROIT	2,884	0	30	0	2,914	0.0
	ABOVE MINTO	93	110	0	0	203	54.2
	LITTLE N. FORK	0	268	0	0	268	100.0
	RECYCLED DOWN	102	0	0	0	102	0.0
	TOTAL	*3,079*	*378*	*30*	*0*	*3,487*	*10.8*
S. Santiam	SANTIAM R, S FK (downstream)	3,228	0	30	0	3,258	0.0
	CALAPOOIA R	140	0	0	0	140	0.0
	SANTIAM R, S FK (above Foster)	151	401	0	4	556	72.8
	WILEY CR	97	0	4	0	101	0.0
	THOMAS CR	153	0	2	0	155	0.0
	CRABTREE CR	173	0	2	0	175	0.0
	TOTAL (includes 87 reruns)	*3,942*	*401*	*38*	*4*	*4,385*	*9.2*
Dexter	WILLAMETTE R, MID FK	1,346	0	152	0	1,498	0.0
	SALT CR	541	28	62	0	631	4.4
	WILLAMETTE R, N FK MID FK	1,452	78	166	1	1,697	4.7
	TOTAL	*3,339*	*106*	*380*	*1*	*3,826*	*2.8*
McKenzie	MCKENZIE R	0	33	0	0	33	100.0
	MCKENZIE R, S FK	2,930	0	51	0	2,981	0.0
	TRAIL BRIDGE RES	137	0	4	0	141	0.0
	TOTAL	*3,067*	*33*	*55*	*0*	*3,155*	*1.0*
Leaburg Trap	MCKENZIE R, UPSTREAM	*0*	603	0	*6*	609	100.0
	MOHAWK R	125	0	0	0	125	0.0
	MCKENZIE R, S FK	890	0	14	0	904	0.0
	TOTAL	*1,015*	*603*	*14*	*6*	1,638	37.2
Grand Total		***14,442***	***1,521***	***517***	***11***	***16,491***	***9.3***

In 2003, a total of 4,252 spring chinook were spawned at hatcheries in the Upper Willamette ESU. Of these, 97.5% 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 25. The highest incidence of unmarked fish in the broodstock was at Marion Forks Hatchery where 3.1% of the fish spawned were unmarked, well under the 10% cap. The ‘Dead’ category 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 26.

Table 25. Spring Chinook spawned at hatcheries in the Upper Willamette ESU in 2003.

Hatchery	Males	Females	Jacks	Mk Adult	Unmk Adlt	Mk Jack	Unmk Jack	% UnMk
Marion Forks	309	309	0	599	19	0	0	3.1
S. Santiam	528	548	20	1,044	32	20	0	2.9
McKenzie	499	510	0	958	51	0	0	5.1
Willamette	784	745	0	1,525	4	0	0	0.3
Grand Total	*2,120*	*2,112*	*20*	*4,126*	*106*	*20*	*0*	*2.5*

Table 26. Spring Chinook captured in hatcheries and broodstock collection facilities that died or were killed. (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*	170	0	0	0	170	0.0
	MORTS	91	12	0	0	103	11.7
	BKD CULL	63	0	0	0	63	0.0
	TOTAL	*324*	*12*	*0*	*0*	*336*	*3.6*
S. Santiam	GIVE AWAY	471	0	0	0	471	0.0
	MORTS	333	12	13	0	358	3.4
	OTHER	40	0	36	0	76	0.0
	TOTAL	*844*	*12*	*49*	*0*	*905*	*1.3*
Dexter	*CWT REC-GIVE AWAY*	*467*	*0*	*49*	*0*	516	0.0
McKenzie	GIVE AWAY	1,558	0	27	0	1585	0.0
	MORTS	533	88	1	0	622	14.1
	EXCESS	0	0	6	0	6	0.0
	TOTAL	*2,086*	*88*	*34*	*0*	*2208*	*4.0*
Leaburg	MORTS	70	1	1	0	72	1.4
Willamette	EXCESS	97	0	0	0	97	0.0
	MORTS	589	2	11	0	602	0.3
	TOTAL	*686*	*2*	*11*	*0*	*699*	*0.3*
Grand Total		***4,407***	***114***	***143***	***0***	***4,664***	***2.4***

Task 2.2 Determine the number and percentage of natural-origin (unmarked) spring chinook run that are taken annually for broodstock. If natural component is > 10%, then notify NMFS. [RPM 3,b]

The size of the natural-origin (unmarked) spring chinook run can be estimated using a combination of passage data from ladders at Stayton Island in the North Fork Santiam and at Leaburg Dam on the McKenzie River, data from Chinook spawning ground surveys below the dams, and hatchery collection data (Table 27). 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 combining these two statistics gives a very conservative minimum estimate of the number of unmarked spring chinook run. In all cases, the number of unmarked Chinook spawned falls well within 10% of even this conservative minimum estimate.

Table 27. Estimates of the total natural-origin spring chinook run, 2003.

Basin	Passage at Dams	Natural [a] Spawners	Out-plants [b]	Hatchery Morts	Hatchery Brood	Total	10% of Total
North Fork Santiam	1,262	192	--	12	19	1,454 [c]	145
South Fork Santiam	401	190	--	12	32	635	64
McKenzie River	5,784	234	--	88	33	6,139	614
Middle Fork Willamette	--	35	106	2	4	147	15
Total	7,447	496	216	114	88	8,361	836

[a] *carcasses or redd expansions from areas below fish passage monitoring facilities only (see Task 2.1).*
[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.*

<u>Task 3.1</u> Monitor the effects of hatchery rainbow stocking in the McKenzie Subbasin on listed spring chinook. Sample stomach contents of hatchery-produced steelhead smolts and Rainbow Trout observed during creel surveys for adult chinook and steelhead.

Hatchery releases of trout and steelhead can directly impact native populations of spring chinook by preying upon juvenile fish. To assess this impact, we sampled stomach contents of hatchery-produced rainbow trout and steelhead smolts released in the McKenzie River in 2003. Samples were obtained by examining fish retained in the fishery, sampling fish caught in the bypass trap at Leaburg Dam, seining, and angling. A total of 878 trout were sampled between April 26, 2003 and August 24, 2003. Most samples were collected using the bypass trap and the McKenzie angler survey (Figure 9). The most common prey items found in the gut samples were aquatic invertebrates (71%; Figure 10). No prey items were found in another 20% of fish sampled. Fish were found in the stomach contents of only 1.6% of the trout sampled. All of the identifiable salmonids found were juvenile chinook. Details of trout that had consumed fish are shown in Table 28. Chinook in stomach contents were found from late May until late June. Juvenile chinook may be large enough in the later part of the summer to avoid predation by hatchery-reared trout.

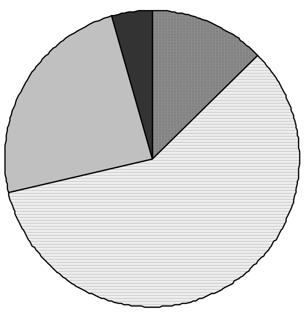


Figure 9. Hatchery trout collection methods

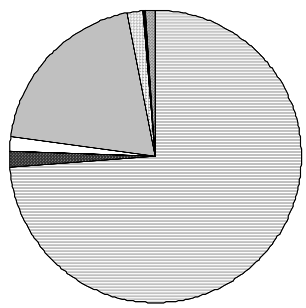


Figure 10. Stomach contents of hatchery trout.

Table 28. Fish found in stomach contents of hatchery-reared trout released in the McKenzie River.

Date	Location caught	Length (mm)	Number of fish	Unidentifiable fish	Unidentifiable salmonids	Chinook	Other
5/29/2003	Bypass	260	5			5	
5/29/2003	Bypass	220	1		1		
5/30/2003	Bypass	200	2			2	
5/31/2003	Bypass	230	1	1			
6/2/2003	Bypass	230	1			1	
6/5/2003	Bypass	230	2		2		
6/24/2003	Bypass	240	1			1	
6/24/2003	Bypass	240	1	1			
6/24/2003	Bypass	240	1	1			
6/24/2003	Bypass	250	1	1			
6/26/2003	Bypass	240	2		2		
7/1/2003	Hendricks to Bellinger	250	1	1			
7/23/2003	EWEB Channel	260	1				1 juvenile lamprey
7/23/2003	EWEB Channel	250	1				1 sculpin
Total			21	5	5	9	2

Controlled studies on gut residence time of juvenile chinook eaten by hatchery trout indicate that gut residence time varies from 3 to 10 hours and depends on factors such as the size of the juvenile chinook eaten, and whether the trout has been starved or fed. Controlled studies also showed that when chinook fry got large enough, trout were unsuccessful in feeding on them. In field samples, the last chinook seen in the stomach contents was found on June 24^{th}, even though 317 trout were sampled after the 24^{th}. It is plausible that after this date juvenile chinook had reached a size where they were better able to evade predation by trout. Approximately 55,000 hatchery trout were planted in the McKenzie River from April 24, 2003 until June 25, 2003.

Expanding stomach contents to make estimates of predation requires that we embrace several assumptions. The assumptions that we have made in our calculations are as follows:

1. Hatchery trout only fed on juvenile chinook for the 62 days between 4-24-2003 and 6-24-2003;
2. Predation rates were consistent throughout the period during which we are making expansions;
3. The average gut residence time was 3-10 hours;
4. Anglers removed 37% of the trout that were stocked (Hutchinson & Hooton 1990);
5. Harvest rates were consistent throughout the period during which we are making expansions;
6. There was no mortality of stocked trout; and
7. There were no hatchery trout 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 48,580 and 161,933 juvenile chinook were consumed by hatchery trout in 2003. There were 845 spring chinook redds counted in the McKenzie River in 2002. Assuming a fecundity of 4,350 eggs per female (10-year average at McKenzie Hatchery, Kurt Kremers, pers. comm.), and egg-fry mortality of 15% gives an estimate of approximately 3 million chinook fry in the McKenzie River in 2003. Thus, we estimate a predation rate of 2-5% on naturally-produced juvenile chinook.

Task 3.2 Monitor the effects of the non-native summer steelhead program in the North and South Santiam and McKenzie rivers. Estimate the percentage of the summer steelhead run that is harvested and/or the number of steelhead potentially spawning naturally in the streams. [RPM 4, e]

Willamette Mainstem Passage
In 2002, 34,291 summer steelhead and 16,658 winter steelhead passed Willamette Falls (Interjurisdictional Fisheries Management Program). Summer steelhead were observed from March through October, with peak passage in May and June (Table 29). Discussion of passage of summer steelhead at other locations can be found in Firman *et al.*, 2002. Details of redd surveys are found in this document under Activity 3.2.3.

Table29. Summer Steelhead in the Upper Willamette, 2002

		Summer Steelhead	Marked kept	Marked released	Unmk released	Reference
Passage	Willamette Falls	34,291				I.J. website*
	North Santiam	6,184				Bennett count
	South Santiam	7,500				Bill Nyara‡
	McKenzie	929				Leaburg count
Harvest	South Santiam**		1,447	329	106	Angler survey
	McKenzie***		1,221	494	189	Angler survey
Broodstock	South Santiam	1,528				Bill Nyara‡
Redds	Mid-Willamette	1,480 ± 836				Spawn Surv.
	Upper Willamette	2,048 ± 1,464				Spawn Surv.
	Total	3,529 ± 1,686				Spawn Surv.

*Interjurisdictional Fisheries Management Program:
http://www.dfw.state.or.us/ODFWhtml/InfoCntrFish/Interfish/2002wfcounts.htm
**Partial angler survey – includes harvest from July through October.
***Partial angler survey – includes harvest from July through August.
‡South Santiam Hatchery Manager

In 2003, 15,834 summer steelhead and 9,092 winter steelhead (2002-2003 run) passed Willamette Falls (Interjurisdictional Fisheries Management Program). Summer steelhead were observed from March through October, with peak passage in May (Table 30). Details of passage at other locations are found under Activity 3.2.2

Table 30. Summer Steelhead in the Upper Willamette, 2003

		Summer Steelhead	Marked kept	Marked released	Unmk released	Reference
Passage	Willamette Falls	15,834				I.J. website*
	North Santiam	4,073				Bennett count
	South Santiam	4,529				Bill Nyara‡
	McKenzie	777				Leaburg count

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

Activity 3.2.1 Conduct creel surveys to determine harvest of summer steelhead

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

Activity 3.2.2 Monitor passage of adipose fin-clipped and unmarked adult summer steelhead passing fishways at Stayton Island (North Santiam) and Leaburg.

Steelhead passage can be monitored at Leaburg Dam on the McKenzie River and at the Upper and Lower Bennett Dams at Stayton Island on the North Santiam River. Summer steelhead first began appearing at Stayton Island in late March of 2003, with peak migration occurring in May and June (Table 31, Figure 9). Almost all of these fish were marked with a fin clip, although there was a small component of unclipped steelhead that passed during this period. Unmarked steelhead outnumbered marked steelhead in late October and early November, but the fish passing during this time period made up a very small proportion of the total run. Scales were collected from late-run unmarked steelhead to verify their origin. Scales from unmarked "summer" steelhead collected in the late summer and fall of 2001 indicated that 18% of these fish were unmarked fish of hatchery-origin, while the remaining 82% were naturally produced. An additional 7 late-run unmarked steelhead were recovered at the Foster trap in 2001. Scale analysis indicated that 5 of these were hatchery steelhead (71%), and 2 were naturally-produced (29%).

At Leaburg Dam on the McKenzie River, summer steelhead began appearing in late April, with peak migration occurring in June (Figure 10). Marked fish outnumbered unmarked fish, but the proportion of unmarked fish in the McKenzie was greater than in the North Fork Santiam. However, since the total number of summer steelhead that passed Leaburg Dam was much lower than at Stayton Island (779 vs. 4,073; Table 31), the total number of unmarked summer steelhead passing Leaburg was slightly lower than at Stayton Island (127 vs. 163).

Table 31. Summer Steelhead passage at Stayton Island, North Santiam River, and Leaburg Dam, McKenzie River, 2003.

Month	North Santiam R.		McKenzie River			
	Marked	Unmarked	Marked	Unmarked	Passed	Recycled
Jan			2	6	0	8
Feb			0	0	0	0
Mar	47	0	1	1	0	2
Apr	429	18	7	0	0	7
May	1,117	11	174	54	188	40
Jun	1,383	27	240	23	263	0
Jul	572	18	120	8	93	35
Aug	49	4	28	1	10	19
Sep	245	20	31	12	7	36
Oct	68	66	34	9	0	43
Nov	0	2	8	8	0	16
Dec			7	5	1	11
Total	**3,910**	**163**	**652**	**127**	**562**	**217**

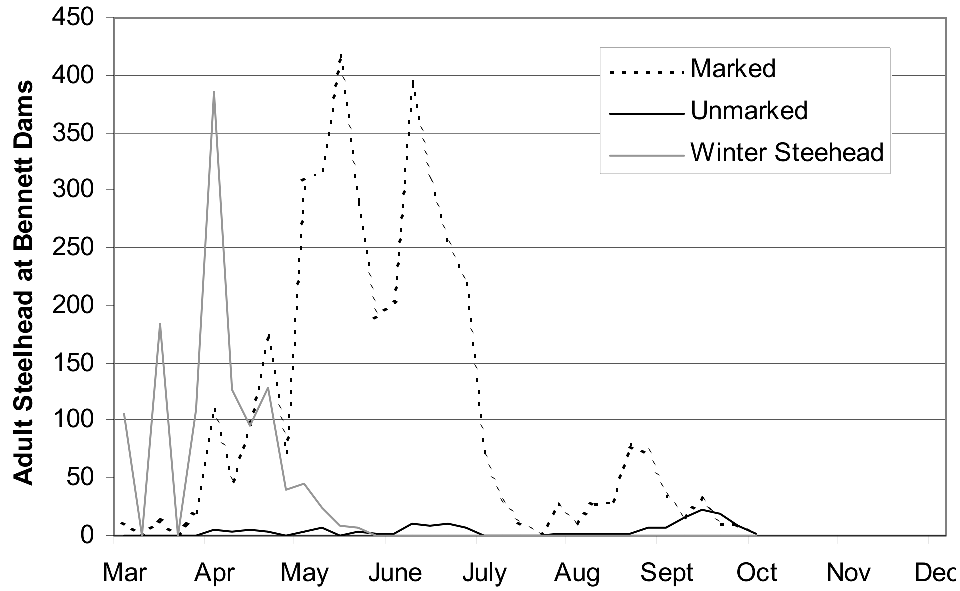


Figure 9. Steelhead run-timing at Stayton Island, N. Fk. Santiam River, 2003.

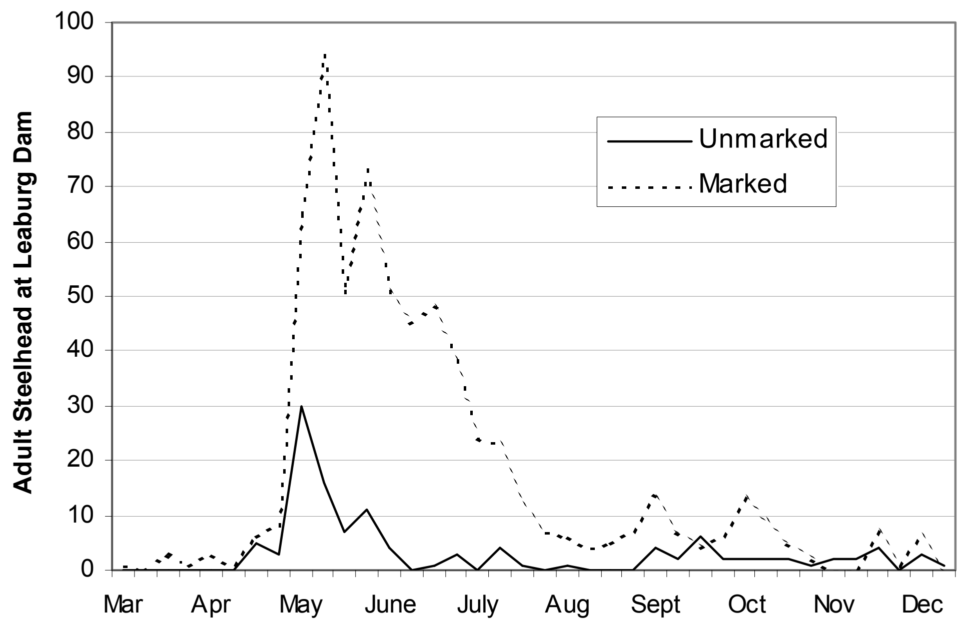


Figure 10. Steelhead run-timing at Leaburg Dam, McKenzie River, 2003.

Activity 3.2.3 Survey spawning areas to determine the number of summer steelhead spawning naturally.

A statistical survey to estimate spawning by summer steelhead strays in the Upper Willamette ESU was conducted for the first time in the winter and early spring of 2003. Surveys were conducted on foot and by boat throughout the supposed spawning distribution of summer steelhead. In addition, 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 weekly to monthly 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 were a particular problem for the mainstem float surveys. Figure 6 illustrates the flow conditions for the 2003 spawning season along with the 95th and 5th percentile of mean daily flows. The flow regime in 2003 was typical. Four significant freshets occurred during the season. The first small freshet occurred during the first week of January. This freshet allowed access to some, but not all spawning areas. The second freshet in late January was much larger and provided access to all spawning grounds. The final two freshets came back to back and resulted in higher flows for the greater part of the month of March.

Spawn timing

Estimates of spawn timing were made based on the observation of fresh redds and spawning adults in survey areas. Figure 12 shows estimates of spawning timing for summer steelhead in the Middle Willamette Monitoring Area (Molalla, North Santiam, South Santiam, and Calapooia 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.

Spawning peaked in late January, and slowly declined until early March. A second, larger peak of steelhead spawners arrived in mid- to late March, but we believe that these were winter steelhead. Several hundred winter steelhead had passed Willamette Falls in early March, and this second peak coincides with the appearance of winter steelhead at our traps at Stayton Island in the North Santiam River (Figure 7). There is no native run of winter steelhead in McKenzie, Middle Fork Willamette or the Coast Fork Willamette, and the later peak was not observed in these areas. Consequently, we excluded all counts after March 10, 2003 when making estimates of spawning by summer steelhead.

Estimates of Abundance

Estimates of the abundance of summer steelhead redds and the associated 95% confidence intervals are provided in Table 32. The confidence interval comes to approximately 50% of the total estimate for the Mid Willamette Monitoring Area and the Upper Willamette ESU. It was over 70% of the estimate for the Upper Willamette Monitoring Area. There were a greater proportion of surveys with no steelhead redds in the Upper Willamette Monitoring Area. This increased the variance, and thus the confidence interval is wider for this segment of the population.

Table 32. Population estimates for summer steelhead redds in the Upper Willamette ESU.

Monitoring Area	Estimate	C.I.	C.I. %
Mid Willamette Monitoring Area	1,480	836	56.5
Upper Willamette Monitoring Area	2,048	1,464	71.5
Upper Willamette ESU	3,529	1,686	47.8

Comparison to traditional surveys

Surveys for summer steelhead redds were conducted at 10 sites in the Calapooia, North Santiam, and South Santiam Rivers that are traditionally surveyed to count winter steelhead redds. Summer steelhead spawning was observed in all but three of these surveys (Table 33). The density of summer steelhead redds was generally lower than that of winter steelhead redds, but the number of summer steelhead redds rivaled the number of winter steelhead redds observed in Mad Creek and Sinker Creek.

Table 33. Comparison of summer steelhead (StS) and winter steelhead (StW) redd counts in 2003 on traditional surveys.
Average and maximum values for winter steelhead are based on 17 to 30 years of data.

Subbasin	Stream	StS Redds	StW Redds	Avg StW Redds	Max StW Redds	n
N Santiam River	Rock Cr.	19	49	6	16	26
N Santiam River	Mad Cr.	26	27	40	77	18
N Santiam River	Elkhorn Cr.	6	18	9	31	16
N Santiam River	Sinker Cr.	14	13	24	63	30
S Santiam River	Wiley Cr, upper	2	19	4	11	24
S Santiam River	Wiley Cr, lower	1	16	10	26	24
S Santiam River	Crabtree Cr.	0	6	27	93	17
S Santiam River	Thomas Cr.	2	13	17	35	18
Calapooia River	N Fk Calapooia	0	11	15	76	20
Calapooia River	Potts Cr	0	2	8	15	21

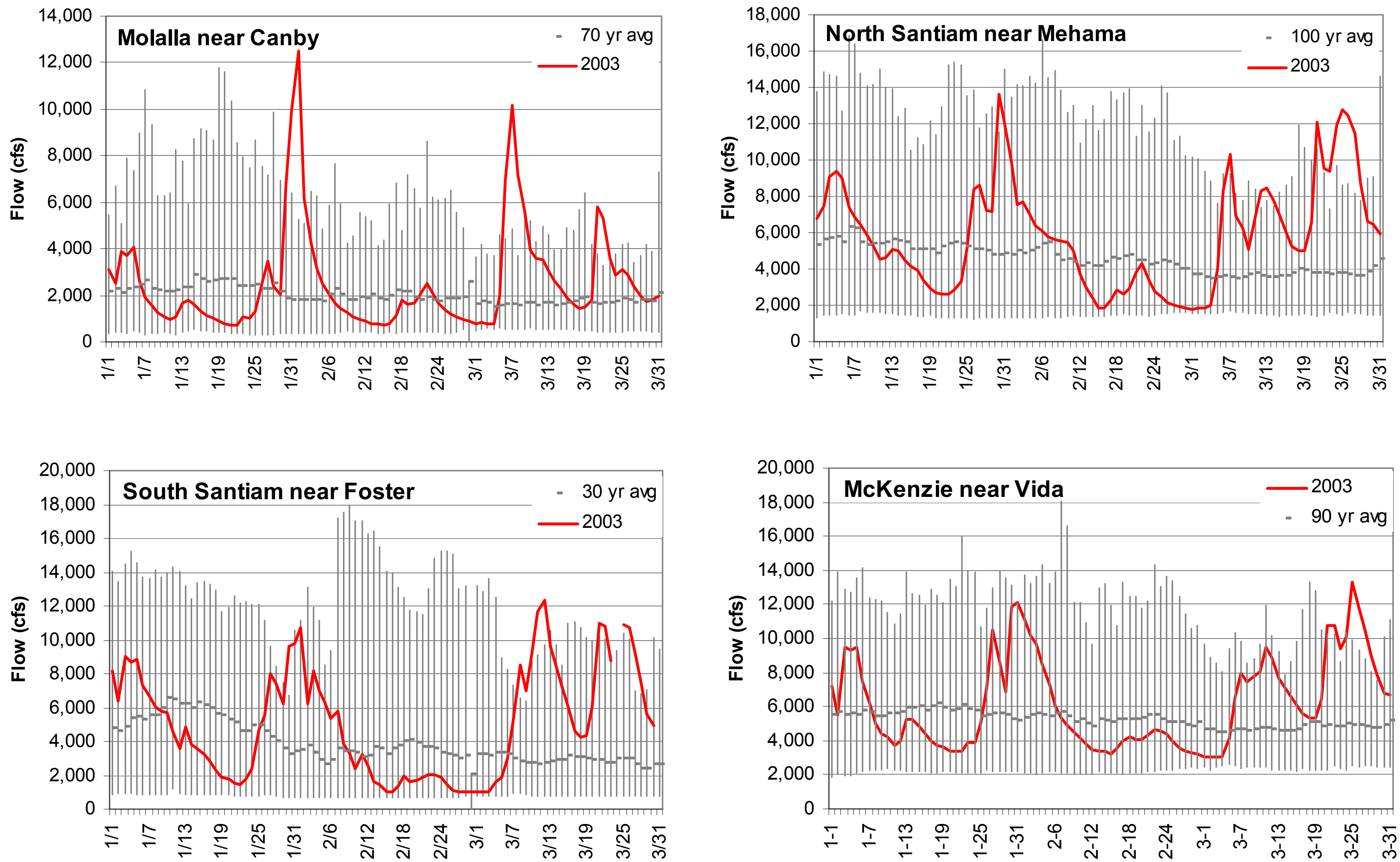


Figure 11. Daily mean river discharge in cubic feet per second for four surface water stations.
Vertical bars represent the 95th and 5th percentiles of mean daily flows for the period of record. Data obtained at http://water.usgs.gov/.

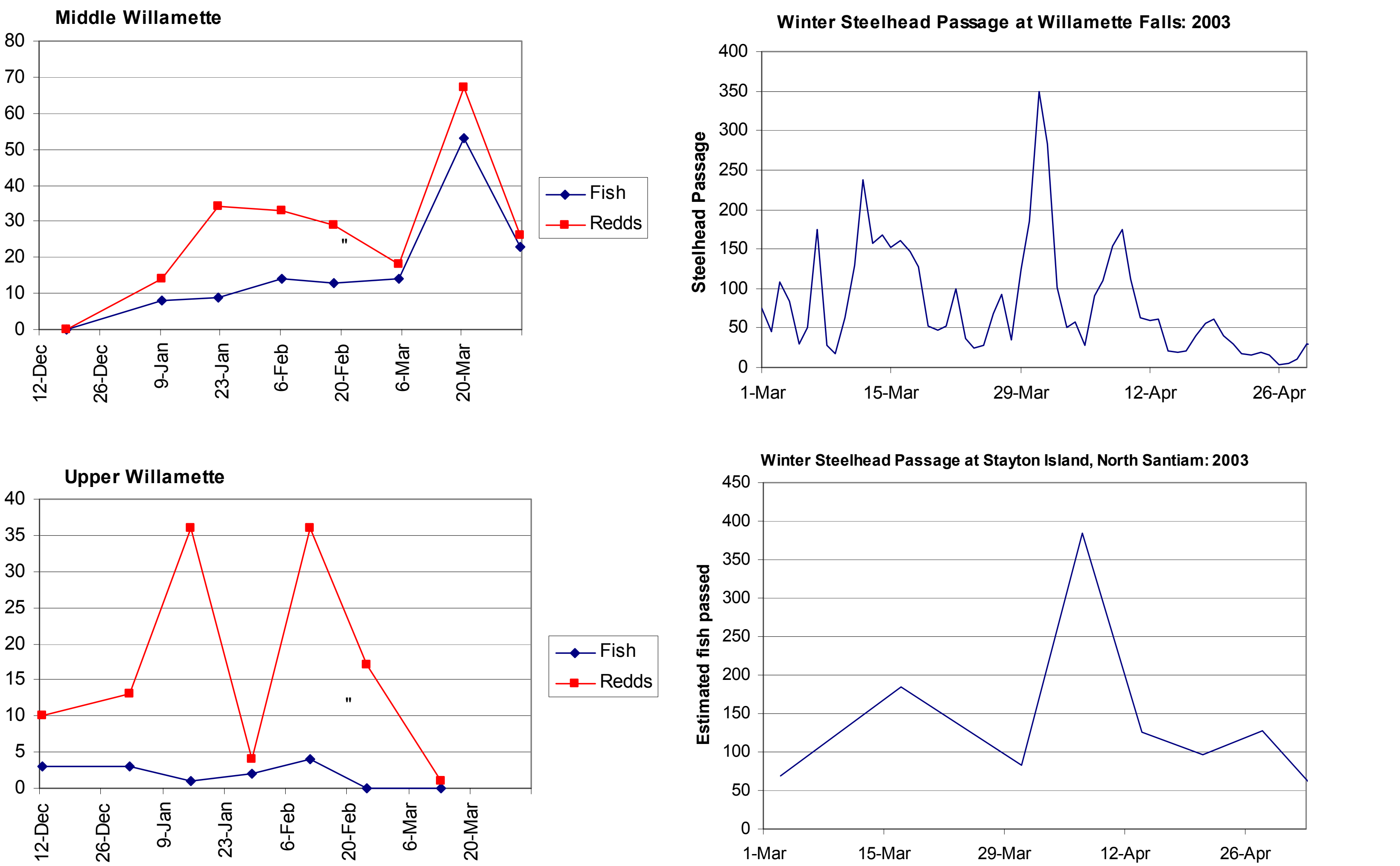


Figure 12. Summer steelhead spawn timing, and winter steelhead run timing in the Upper Willamette ESU. The Middle Willamette Monitoring Area includes the Molalla, North Santiam, South Santiam and Calapooia. The Upper Willamette Monitoring Area includes the McKenzie, Middle Fork Willamette and Coast Fork Willamette. Low counts in the Upper Willamette during the last week of January are the result of poor surveys conditions due to high water.

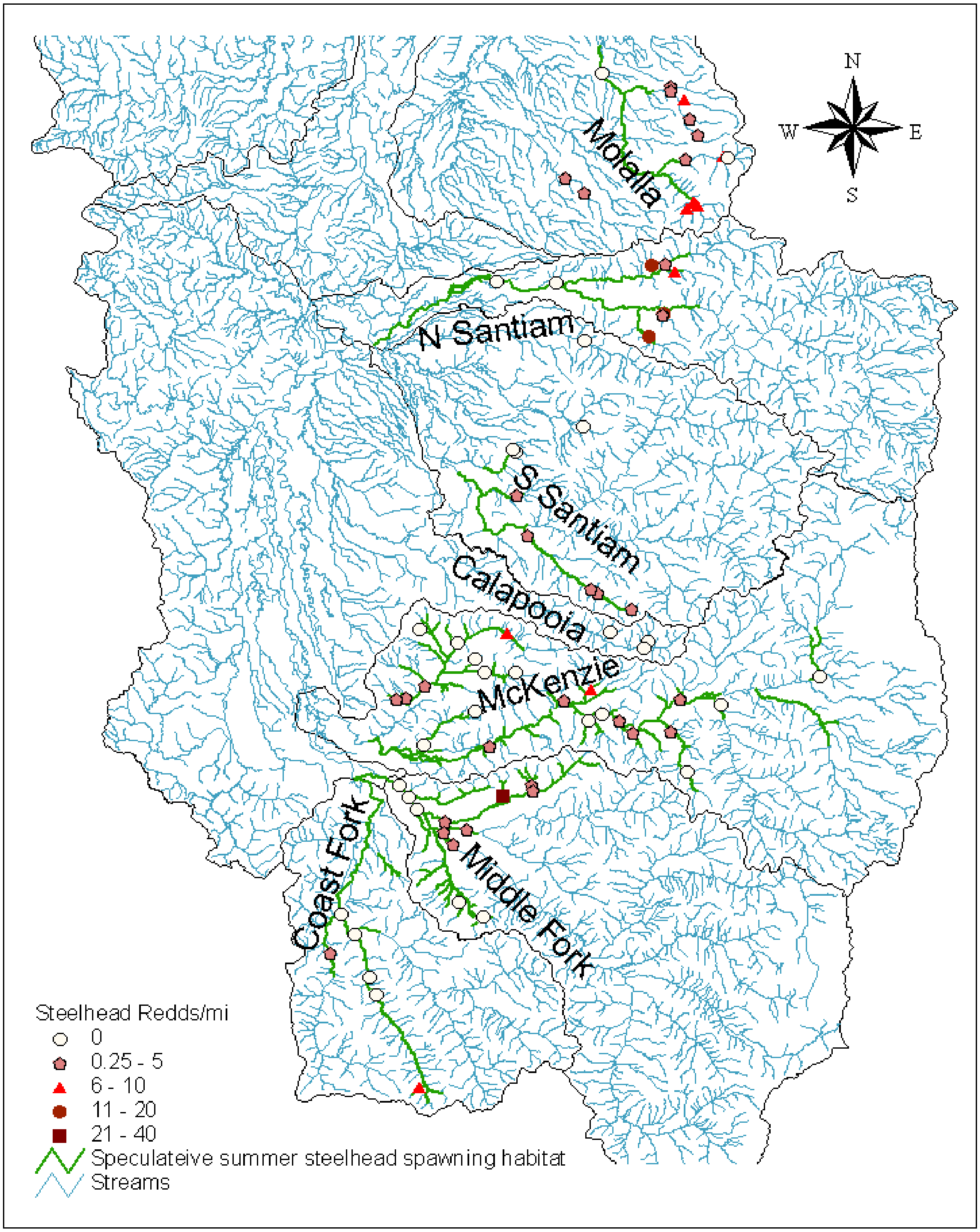


Figure 13. Summer steelhead redd densities in randomly selected surveys and traditional winter steelhead surveys in the Upper Willamette ESU, 2003.

Spawner Distribution

Spawning summer steelhead were widely distributed in the areas surveyed. Densities ranged from 0 to close to 40 redds per mile, with an average density of 1.8 redds per mile (Figure 13; Table 34). The map in Figure 13 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 (4.8 redds/mi) than the average seen in random surveys.

Table 6. Redd densities on randomly selected summer steelhead spawning surveys, 2003.

Subbasin	Reach ID	Seg	Survey	Redds/mi
Molalla River	31398.00	2	Abiqua Creek	0.77
Molalla River	31474.00	1.1	Molalla River	0.00
Molalla River	31488.00	2	Cougar Creek	1.22
Molalla River	31489.00	3	North Fork Molalla River	2.00
Molalla River	31522.00	1	Lost Creek	0.00
Molalla River	31542.00	1	Molalla River	6.50
S Santiam River	31966.00	2	Thomas Creek	0.00
S Santiam River	31991.00	3	South Fork Crabtree Creek	0.00
S Santiam River	32024.00	2	Wiley Creek	1.79
S Santiam River	32028.00	5	Wiley Creek	1.82
N Santiam River	32163.00	1.1	Mehama to Stayton float	0.00
N Santiam River	32212.00	1	Little North Santiam River	5.00
Calapooia River	32414.00	2	Calapooia River	0.00
Mohawk River	32652.00	1	McGowan Creek	1.72
Mohawk River	32654.00	1	McGowan Creek	1.79
Mohawk River	32658.00	1	Parsons Creek	1.87
Mohawk River	32673.00	2	Wolf Creek	0.00
Mohawk River	32674.00	3	Mill Creek	0.00
Mohawk River	32680.00	2	Mill Creek	0.00
Mohawk River	32688.30	2	Crooked Creek	0.00
Mohawk River	32690.00	1	Drury Creek	0.00
Mohawk River	32695.00	6	Mohawk River	6.39
McKenzie River	32699.00	2	Camp Creek	0.00
McKenzie River	32703.00	2	Camp Creek	0.00
McKenzie River	32710.00	1.1	McKenzie River	0.39
McKenzie River	32726.00	1.1	McKenzie River	0.57
McKenzie River	32733.00	1	North Fork Gate Creek	6.56
McKenzie River	32740.00	1	Gale Creek	0.00
McKenzie River	32742.00	1.1	McKenzie River	0.00
McKenzie River	32744.00	1.1	McKenzie River	0.33
McKenzie River	32745.00	2	Deer Cr.	1.94
McKenzie River	32751.00	3	Quartz Creek	1.21
McKenzie River	32761.00	2	Quartz Creek	0.00

Table 34. (cont.)				
Subbasin	Reach ID	Seg	Survey	Redds/mi
McKenzie River	32771.00	1	Blue River	2.32
S Fk McKenzie	32801.00	1	South Fork Mckenzie	0.00
McKenzie River	32889.00	1.1	Mckenzie River	0.00
Mosby Creek	32942.00	1	Row River	0.00
Mosby Creek	32947.00	1.1	Mosby Cr.	0.00
Mosby Creek	32970.00	1	West Fork Mosby Cr.	7.35
Mosby Creek	32976.00	1	Row R: Dorena to Mosby	0.00
Mosby Creek	33024.00	1.1	Coast Fork Willamette River	0.27
M Fk Willamette	33049.00	1.1	Middle Fork Willamette River	0.00
M Fk Willamette	33059.00	1.1	Middle Fork Willamette River	0.00
M Fk Willamette	33062.00	1.1	Fall Creek	0.91
M Fk Willamette	33064.00	2	Norton Creek	38.30
M Fk Willamette	33068.00	1	Sturdy Creek	1.32
M Fk Willamette	33069.00	1	Little Fall Creek	3.38
M Fk Willamette	33070.00	1.1	Fall Creek	3.86
M Fk Willamette	33172.00	2	Guiley Creek	0.00
M Fk Willamette	33173.00	6	Lost Creek	0.00
M Fk Willamette	33174.00	1.1	Middle Fork Willamette River	0.63

Most surveys had low densities of summer steelhead redds. In randomly selected surveys, 51% of sites had no summer steelhead redds, and almost 90% of the sites surveyed had fewer than 5 redds per mile surveyed (Figure 9). In traditional surveys, 62% of surveys had fewer than 5 redds, and at the 90th percentile there were 15 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.

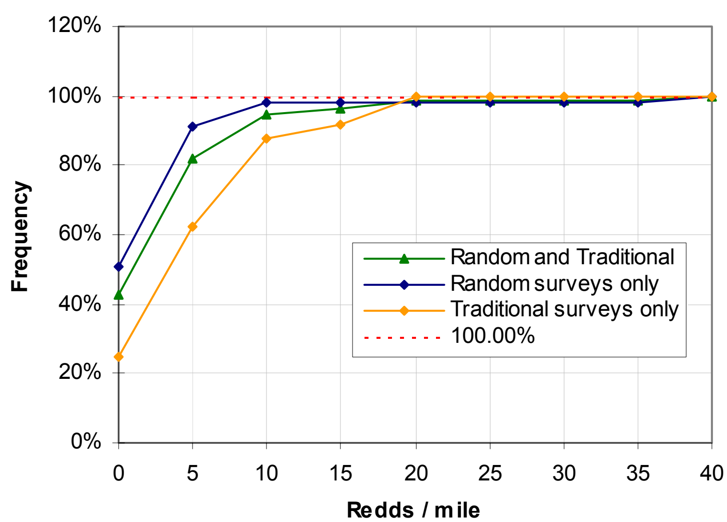


Figure 14. Cumulative frequency distribution of summer steelhead redds within the Upper Willamette ESU.

Activity 3.2.4 Estimate the number of natural-origin steelhead smolts migrating past Leaburg Dam.

Leaburg Dam diverts approximately 2000 cubic feet per second (cfs) of water into the power canal. Just below the power canal intake, fish screens divert downstream migrating juvenile salmonids into a 60 cfs bypass channel. A four-foot rotary screw trap in the bypass channel diverts captured fish to a concrete holding tank. Once the peak migration of downstream chinook fry is over and fry reach an average length of 50mm, EWEB turns on screen pumps that drop the bypass channel to 15 cfs allowing capture of virtually all fish using the bypass channel. The downstream trap was checked daily from January 23rd to June 28th 2003.

To calibrate trap efficiencies, up to 25 steelhead smolts were marked daily with caudal clips and transported two miles upstream for release. Efficiencies were calculated using the following equations:

$$N=ni/Ei$$

and

$$Ei=ri/mi$$

Where

N = total estimated out migrants, ni = number of fish captured,
Ei = estimated trap efficiency, and
ri = number of recaptured marked fish, and mi = number of marked fish released.

Efficiencies were calculated weekly unless there were less than five recaptures in a week. The data from weeks with fewer than five recaptures were combined. Bootstrap statistical methods using 1,000 iterations were used to determine 95% confidence intervals, variances and estimates of the population bias (Efron and Tibshiani, 1986). A negative population bias indicates the population estimate could be an underestimate. A positive population bias indicates the population estimate could be an overestimate.

Population Estimates

Summer steelhead smolt estimates were broken into two parts due to highly different trap efficiencies at the bypass channel. The first population estimate was made using data from April 3rd to May 31st. We captured and marked 302 smolts and recaptured 20 (6.6%) giving an estimate of 5,447 $\pm$ 2,575 smolts and a bias average of –4.35%. The second estimate was made using data from June 1st to June 28th when it was possible to sample all fish using the bypass channel. We captured and marked 91 smolts; of these 45 smolts were recaptured (49.4%) giving an estimate of 298 $\pm$ 77 smolts and a bias average of –1.63%.

Length Frequency of Steelhead Smolts

Steelhead smolts captured at Leaburg Dam ranged in size from 120-280 mm, with a mean length of 180 mm (n=543; Table 35).

Table 35. Length frequency of steelhead smolts captured at Leaburg Dam Bypass.

Length	*Frequency*	*Cumulative %*	*100*	*Frequency*	*Cumulative %*
120	2	.37%	180	196	36.10%
140	10	2.21%	200	146	62.98%
160	110	22.47%	160	110	83.24%
180	196	58.56%	220	71	96.32%
200	146	85.45%	140	10	98.16%
220	71	98.53%	240	5	99.08%
240	5	99.45%	120	2	99.45%
260	1	99.63%	280	2	99.82%
280	2	100.00%	260	1	100.00%
300	0	100.00%	300	0	100.00%

Timing of Steelhead Smolt Downstream Migration

Trapping for juvenile chinook and steelhead outmigrants started on January 23, 2003 and continued through June 28th, 2003. Steelhead smolts first appeared in the trap on April 3rd, with peak passage occurring in late May (Figure 15).

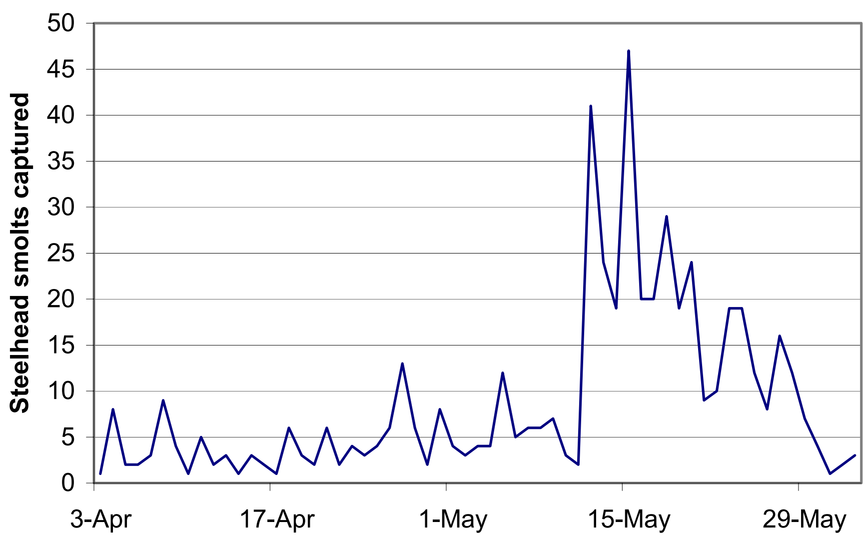


Figure 15. Downstream timing of migrating steelhead smolts at the Leaburg Dam bypass trap.

Task 3.3 Conduct angler surveys to determine the location and total catch of adipose fin-clipped and unmarked spring chinook in the North Santiam River, Middle Fork Willamette River, and McKenzie River.

Activity 3.3.1 Conduct a statistical creel survey on the North and South Santiam rivers to determine the location and total catch of marked and unmarked spring chinook.

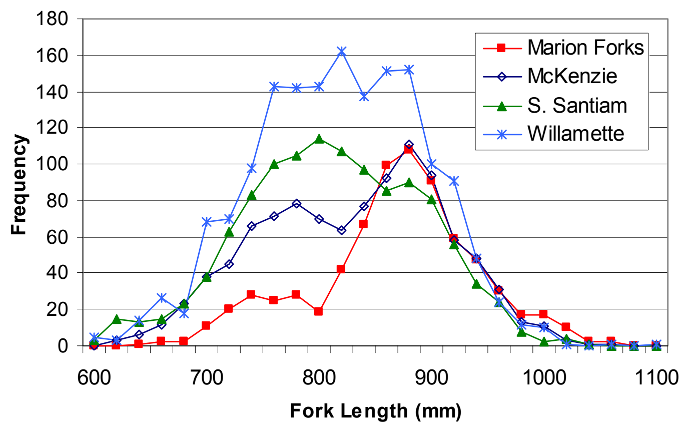
Activity 3.3.2 Conduct a statistical creel survey on the McKenzie River to determine the location and total catch of marked and unmarked spring chinook.

Activity 3.36.3 Conduct a statistical creel survey on the Middle Fork Willamette River to determine the location and total catch of marked and unmarked spring chinook.

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

Task 4.1 Record the date, number, length, sex and origin (hatchery vs. wild) of spring chinook spawned (by hatchery: McKenzie, Dexter, Minto, and S. Santiam). [RPM 5, c]

The number of spring chinook spawned, the sex ratio, and the mark rate are shown in Table 25 under Task 2.1. Length statistics for spring chinook spawned in hatcheries in the Upper Willamette ESU are presented in Table 36. Length data were collected for 4,526 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 (49 of 4,575), and were excluded from this analysis. Lengths ranged between 600 and 1,100 mm, with an overall average length of 821.8 ± 2.3 mm.



Bimodal length frequency distributions were seen at three of the four Upper Willamette Hatcheries, with peak frequencies at 780-800 mm and 880 mm (Figure 16). At Marion Forks and McKenzie hatcheries the peak at 880 mm predominated, while at Santiam Hatchery the peak at 800mm was larger. The pattern at Marion Forks was less defined.

Figure 16. Length frequency distributions of hatchery broodstock, 2003.

Table 36. Fork Length statistics from Upper Willamette hatchery broodstock, 2003.

Hatchery	Mark	Count	Min. (mm)	Max. (mm)	Mean (mm)	95% C.I.
Marion Forks	Unmk	15	850	1,000	894.3	20.9
Marion Forks	Marked	711	610	1,050	860.3	5.4
S. Santiam	Unmk	57	610	1,000	814.9	21.4
S. Santiam	Marked	960	600	1,060	825.8	5.2
McKenzie	Unmk	42	635	950	811.1	22.7
McKenzie	Marked	1,120	600	1,035	805.3	4.6
Willamette	Unmk	64	640	1,100	789.5	17.5
Willamette	Marked	1,557	600	1,050	814.8	3.8
Marion Forks	All	726	610	1,050	861.0	5.3
S. Santiam	All	1,017	600	1,060	825.2	5.0
McKenzie	All	1,162	600	1,035	805.5	4.5
Willamette	All	1,621	600	1,100	813.8	3.7
All	Unmk	178	610	1,100	811.6	11.5
All	Marked	4,348	600	1,060	822.2	2.4

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 ($p<0.05$ 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 Marion Forks hatchery (861.0 ± 5.3 mm) and least at McKenzie Hatchery (805.5 ± 4.5 mm; Figure 17 and Figure 19). Mean fork length was greater for marked fish (822.2 ± 2.4 mm) than for unmarked fish (811.6 ± 11.5 mm; Figure 18 and Figure 20).

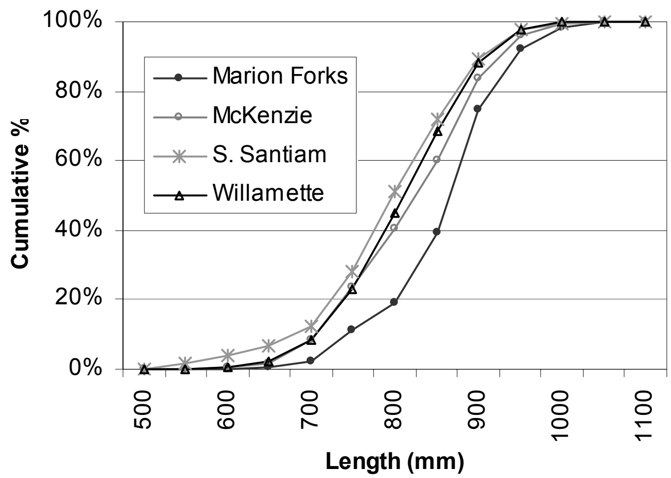


Figure 17. Cumulative frequency distributions of fork length for chinook broodstock: comparison among hatcheries.

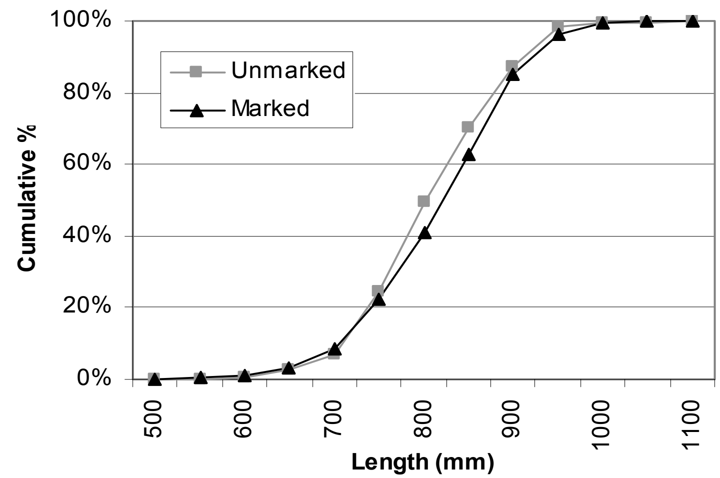


Figure 19. Cumulative frequency distributions of fork length for chinook broodstock: marked vs. unmarked fish.

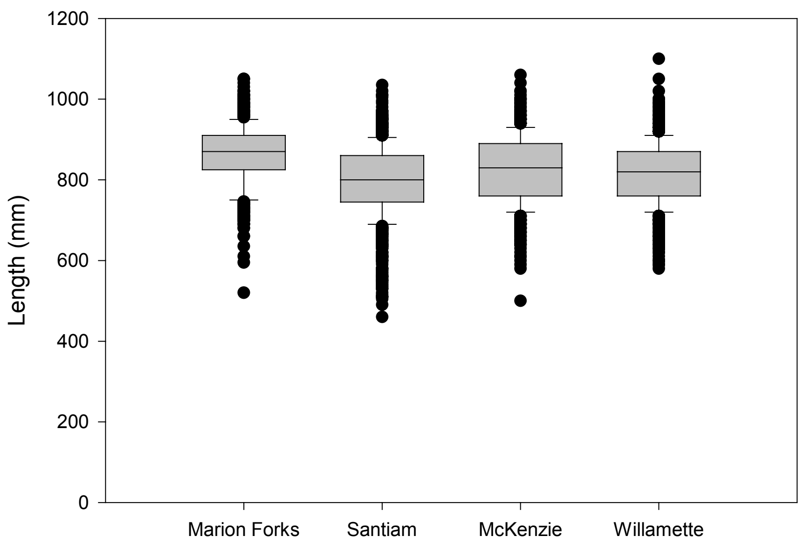


Figure 18. Box-whisker plots of fork length for chinook broodstock: comparison among hatcheries.

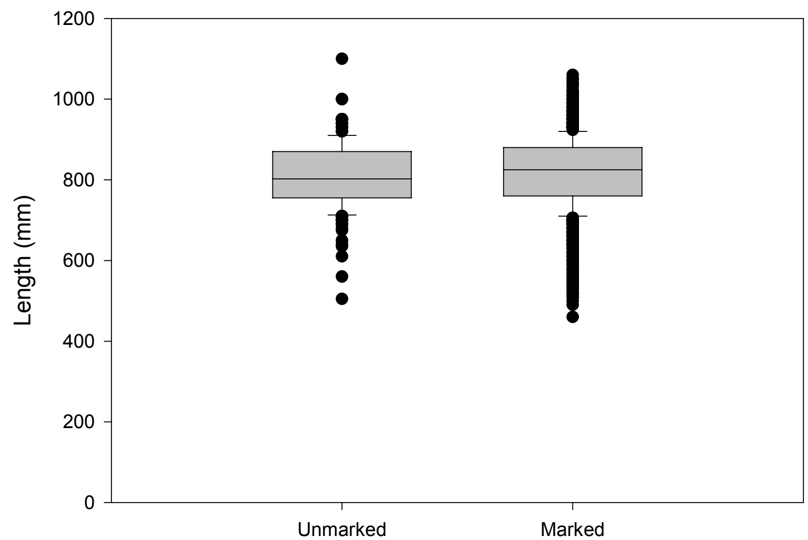


Figure 20. Box-whisker plots of fork length for chinook broodstock: comparison between marked and unmarked.

Box borders = 25^{th} and 75^{th} percentiles, whiskers = 5^{th} and 95^{th} percentiles. Outliers are plotted as individual points.

Task 4.3 Assess impacts of the Foster Reservoir recreational trout fishery, created and sustained by the stocking of hatchery rainbow trout, on listed steelhead and spring chinook. [Terms and Conditions s,e]

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

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