ANNUAL PROGRESS REPORT

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OREGON

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

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INTRODUCTION

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

The Oregon Fish and Wildlife Commission adopted a wild fish management policy to reduce adverse impacts of hatchery programs on wild native stocks (ODFW 1992a). The main goal of the policy is to protect the genetic diversity of these stocks recognizing that genetic resources are a major component, not only in sustaining wild stocks, but also in perpetuating hatchery programs and the fisheries they support.

In the past, spring chinook salmon management in the Willamette and Sandy basins focused on hatchery and fish passage issues. Limited information was collected on the genetic structure among basin populations, abundance and distribution of natural spawning, or on strategies for reducing risks that large hatchery programs pose for wild salmon populations. This study is being implemented to gather this information. A schematic of the study plan is presented in **APPENDIX A**.

Work in 1999 was conducted in the mainstem Willamette River at Willamette Falls, and in the McKenzie, North Santiam, Clackamas, and Sandy rivers. Basin descriptions and background information on management and fish runs can be found in subbasin plans developed by the Oregon Department of Fish and Wildlife (ODFW 1988, ODFW 1992b, ODFW 1992c, and ODFW 1996). Task headings below cross reference the study plan outlined in **APPENDIX A.** This report covers work completed in 1999.

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

Methods

Thermal marks were placed on otoliths of all hatchery spring chinook salmon released into the Willamette basin. Quality of the marks was assessed in reference samples collected at the hatcheries and sent to Washington Department of Fish and Wildlife (WDFW) for analysis (Table 1).

Otoliths were taken from yearling juvenile chinook salmon collected in the McKenzie River and at McKenzie Hatchery in November 1998 to test the accuracy of detecting thermal marks. Otoliths were removed from all fish and placed in individual vials. Forty-eight hatchery fish (thermally-marked) were sent as a reference sample to assess the quality of the thermal marks and were identified as hatchery fish. A second collection consisted of otoliths from 30 wild juveniles (collected at the Leaburg Dam bypass trap) and 40 juveniles from McKenzie Hatchery. These otoliths were randomly mixed and put into individually numbered vials, but were not identified as wild or hatchery fish. The WDFW lab was asked to assess the quality of thermal marks in the reference collection, then to identify the second collection ("blind" sample) as being thermally marked or not thermally marked.

Table 1. Data on thermal marking of spring chinook salmon in Willamette River hatcheries and collection of reference samples, 1998 brood. Reference samples were salmon fry (35-50 mm).

Stock	Sample size	Egg takes sampled	Treatment (hrs on/off)	Temperature differential[a] (°F)	Cycles[b]	Comments
McKenzie	194	5	Chilled (24/96)	2-11	4/8[b]	Marked at McKenzie H.
McKenzie	43	1	Heated (48/48)	9-13	7	Marked at Willamette H.
N. Santiam	90	2	Heated (48/48)	7-11	7-8	
Willamette	30	1	Heated (48/48)	8-21	7-8	
Clackamas	51	2	Heated (48/48)	10-20	7	Marked at Willamette H.
S. Santiam	74	4	Heated (48/48)	8-21	7-8	Marked at Willamette H.

[a] *Difference in temperature between heated or chilled treatment and ambient incubation temperature.*

[b] *Number of treatment cycles for hatched fry, except for McKenzie fish marked at McKenzie Hatchery, where thermal marking was administered to eggs prior to hatching (4) and to fry (8).*

Results

High quality thermal marks were seen in all 1998 brood reference samples sent from the upper Willamette basin hatcheries (Table 1). One exception was McKenzie Hatchery where a water chiller failed during post-hatch marking of the last group. However, thermal marks in this group were recognizable because all fish at McKenzie Hatchery were also marked prior to hatching.

The WDFW lab correctly identified 100% of the hatchery fish in the "blind" sample as having thermal marks and 93% of the wild fish as having no thermal marks (Table 2). Based on these results, we would tend to underestimate rather than overestimate the number of wild fish in a hypothetical sample of adults without fin clips or coded wire tags. Further tests of the WDFW lab will be conducted with otoliths collected from wild adult spring chinook from the John Day River and otoliths collected from known McKenzie and North Santiam hatchery adults (based on coded wire tags).

Data on otoliths collected from adult spring chinook salmon are in **APPENDIX B**.

Table 2. Accuracy of the WDFW otolith lab in identifying thermally marked and unmarked juvenile spring chinook from the McKenzie River.

Sample	Number	Correct	Wrong
Hatchery - thermal marked	40	40	0
Wild - not thermal marked	30	28	2

TASK 1.3-- DISTRIBUTION AND ABUNDANCE OF NATURAL SPAWNERS

Abbreviated spawning surveys were conducted in 1999 to document the magnitude of natural spawning of spring chinook salmon in the North Santiam, Clackamas, and Sandy basins. Information from past surveys (Grimes et al. 1996; Lindsay et al. 1997; Lindsay et al. 1998) was used to survey primary spawning areas during peak spawning time in 1999. We surveyed the Clackamas and Sandy rivers above mainstem dams in late September and in mid October, and used the survey with the highest redd counts. In the lower Clackamas, North Santiam, and Little North Santiam rivers, one survey was conducted near the end of the spawning season. Previous investigations in these riverss indicated that redds remained visible throughout the spawning season (Lindsay et al. 1997).

Spawning Ground Surveys in the North Santiam River Basin

The mainstem North Santiam River was surveyed on October 5-8 and the Little North Santiam was surveyed on October 12 (Table 3). One aerial survey was also conducted in the lower reaches of the North and South Santiam rivers, mainly for fall chinook (Table 4). Previous comparisons of aerial and boat surveys showed aerial surveys considerably underestimated the number of redds present in spring chinook spawning areas (Grimes et al. 1996; Lindsay et al. 1997). Abundance and migration timing of adult spring chinook were also monitored at upper and lower Bennett dams in 1999 (Table 5 and Figure 1).

Table 3. Summary of chinook salmon spawning surveys in the North Santiam River, 1999, and comparison to redd densities in 1996-98.

Race and survey section	Length (mi)	1999 Counts		Redds/mi			
		Carcasses	Redds	1999	1998	1997	1996
Spring chinook:							
Minto - Fishermen's Bend	10.0	114	156	15.6	11.8	8.5	7.8
Fishermen's Bend - Mehama	6.5	32	20	3.1	4.3	2.5	3.5
Mehama - Stayton[a]	10.3	--	--	--	3.6	1.7	2.0
Stayton - Greens Bridge[a,b]	13.7	--	--	--	0.4	1.1	0.1
Little North Santiam	10.7	8	11	1.0	2.3	0.5	0.0
Fall chinook:							
Stayton - Greens Bridge[b]	13.7	0	2	0.1	4.3	9.6	0.9
Greens Bridge - mouth[b]	3.0	1	2	0.7	4.7	--	--

[a] *Section not surveyed in 1999*
[b] *Only one chinook carcass was recovered in the North Santiam below Stayton so apportionment for spring or fall race based on analysis of scales from carcasses was not possible. All redds assumed to be from fall chinook.*

Table 4. Chinook salmon redds counted in the Santiam and North Santiam rivers from a helicopter on September 24, 1999.

River basin and section	Length(mi)	Redds	Redds/mi
Mainstem Santiam River:			
Mouth to Interstate 5 bridge	6.0	17	2.8
Interstate 5 bridge to Jefferson	3.5	9	2.6
Jefferson to confluence of north and south forks	2.4	4	1.7
North Santiam River:			
Mouth to Greens Bridge	3.0	5	1.7
Greens Bridge to bottom of Wiseman Island	3.0	2	0.7
Wiseman Island area	10.0[a]	3	0.3
Wiseman Island to Shellburn	2.5	0	--
Shellburn to Stayton	5.5	1	0.2
Stayton to top of Gerren Island (north channel)	3.0	7	2.3
South channel to top of Gerren Island	2.0	1	0.5
South Santiam River:			
Mouth to Highway 226 bridge	7.6	5	0.7
Highway 226 bridge to Lebanon dam	13.0	10	0.8

[a] *Length uncertain in this braided channel section.*

Table 5. Estimated number of spring chinook salmon passing Upper Bennett and Lower Bennett Dams on the North Santiam River, April-September, 1999. Passage counts have been adjusted for a 4% fallback rate.

	April	May	June	July	August	September	Total
Unmarked:							
Adult	2	7	705	1,113	72	235	2,134
Jack	0	0	10	41	2	6	59
Mini jack	0	0	0	15	0	0	15
Adipose clip:							
Adult	0	2	44	63	3	15	127
Jack	0	0	7	17	2	3	29
Mini jack	0	0	0	74	7	0	81
Total	2	9	766	1,323	86	259	2,445

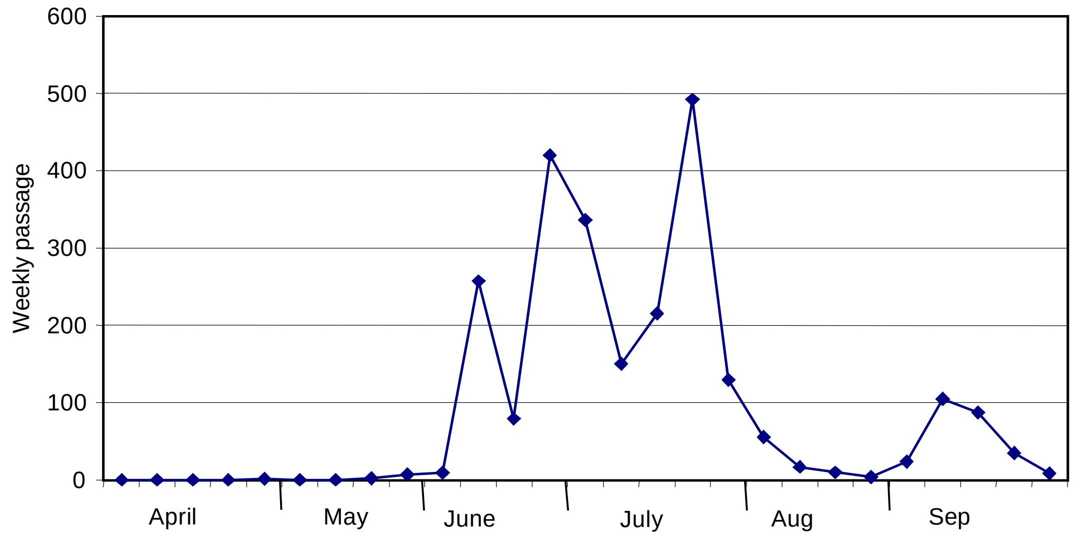

Figure 1. Weekly passage of spring chinook salmon at Upper and Lower Bennett dams on the North Santiam River, 1999.

Spawning Ground Surveys in the Clackamas River Basin

Upper Clackamas River Basin

We surveyed 49 mi in Clackamas basin streams above North Fork Dam in 1999 (Table 6). These data were used to estimate the number of spawners above the dam and to examine the relationship to the adult count at the dam (Table 7). Data on the monthly passage of adult spring chinook at North Fork Dam are in Appendix Table C-1.

Table 6. Summary of spawning surveys for spring chinook salmon in the Clackamas River above North Fork Dam, 1999, and comparison to redd densities in 1996-98.

		Counts			Redds/mi			
Survey section	Length (mi.)	Live Fish[a]	Carcasses[b]	Redds[b]	1999	1998	1997	1996
Clackamas River:								
Sisi Creek - Forest Rd 4650	9.1	10	14	29	3.2	9.6	7.5	3.2
Forest Rd 4650 - Collawash R	8.0	7	14	33	4.1	7.0	5.9	4.1
Collawash River - Cripple Cr.	8.5	8	20	36	4.2	11.4	7.3	6.1
Cripple Creek - South Fork	14.5	14	31	62	4.3	5.2	7.4	3.2[b]
South Fork - Reservoir	1.0	0	2	1	1.0	7.0	17.0	--
Collawash River:								
Forest Rd 63 - Mouth	6.5	0	2	5	0.8	5.7	6.4	1.6
Pinhead Creek:								
Last Creek - mouth	1.0	1	0	1	1.0	0.0	0.0	0.0
South Fork Clackamas River:								
Falls - mouth	0.6	5	1	10	16.7	5.0	11.7	--

[a] *Number observed in mid October survey.*

[b] *Highest number counted in two surveys. Includes carcasses that were seen but not sampled.*

[c] *This section was 0.5 miles shorter in 1996.*

Table 7. Counts of adult spring chinook salmon at North Fork Dam and the relationship to successful spawners in the Clackamas River Basin above the dam, 1996-99.

	Counts			
Year	North Fork Dam[a]	Total redds	Spawners[b]	Fish/redd[c]
1996	824	182	364	4.53
1997	1261	376	752	3.35
1998	1382	380	760	3.64
1999	818	212[d]	424	3.86

[a] *Total up to one week prior to the last spawning survey.*

[b] *Estimated from redds using 1:1 sex ratio and two fish per redd.*

[c] *From dam counts.*

[d] *Expanded by 5%. In 1996-98, an average 95% of all redds were counted in the area surveyed in 1999. 22 redds were added to account for spawning by live fish counted on the last survey.*

Lower Clackamas River

We counted 66 redds and 39 carcasses in 1999 below River Mill Dam, compared to 178 redds and 78 carcasses in 1998. Analysis of scales collected from carcasses indicated that 62% were spring chinook (75% of females and 55% of males), and the remainder were fall chinook (Table 8). The estimated number of spring chinook redds in 1999 was 20% lower than the estimated number in 1998 (Table 9). The estimated number of fall chinook redds was 79% lower in 1999 (25) than in 1998 (129).

Table 8. Overlap of spring and fall chinook salmon in the Clackamas River below River Mill Dam based on scale patterns from recovered carcasses, 1999.

Section	Number of carcasses[a]		Percent spring chinook
	Fall chinook	Spring chinook	
McIver Park – Barton Park	8	18	69
Barton Park – Carver	2	1	33
Carver – mouth	2	1	33

[a] *Only for fish from which scales were collected and could be read.*

Table 9. Summary of spawning surveys for spring chinook salmon in the Clackamas River below River Mill Dam, 1998 and 1999. The proportion of spring chinook was based on analysis of scales collected from carcasses.

	McIver Park – Barton Park (9.5 mi)[a]		Barton Park – Carver (5.5 mi)		Carver – mouth (8.0 mi)		Total	
	1998	1999	1998	1999	1998	1999	1998	1999
Carcasses[b]	31	20	4	1	2	2	37	23
Redds	33	37	5	1	11	3	49	41
Redds/mi	3.4	3.9	0.9	0.2	1.4	0.3	2.1	1.8

[a] *An additional 0.3 mi was surveyed in 1998.*
[b] *Includes carcasses that were seen but not sampled.*

Spawning Ground Surveys in the Upper Sandy River Basin

We surveyed 16 mi in Sandy basin streams above Marmot Dam in 1999 (Table 10). These data were used to estimate the number of spawners above the dam and to examine the relationship to the adult count at the dam (Table 11). Data on the monthly passage of adult spring chinook at North Fork Dam are in Appendix Table C-2.

Table 10. Summary of spawning surveys for spring chinook salmon in the Sandy River above Marmot Dam, 1999, and comparison to redd densities in 1996-98.

Survey section	Length (mi.)	Counts: Live fish[a]	Carcasses[b]	Redds[b]	Redds/mi: 1999	1998	1997	1996
Salmon River:								
Final Falls - Forest Rd 2618	3.2	20	39	61	19.1	66.6	57.8	39.7
Forest Rd 2618 – Bridge St.	3.6	0	20	34	9.4	15.3	12.2	19.7
Bridge Street – Highway 26	6.2	42	85	124	20.0	52.3	45.2	41.5
Still Creek:								
Forest Rd 2612 - mouth	3.3	3	10	33	10.0	17.4	21.5	12.3
Total	16.3	65	154	252	15.5	17.0	17.0	18.8

[a] *Number observed in mid October survey.*
[b] *Highest number counted in two surveys. Includes carcasses that were seen but not sampled.*

Table 11. Counts of adult spring chinook salmon at Marmot Dam and the relationship to successful spawners in the Sandy River Basin above the dam, 1996-99.

Year	Counts: Marmot Dam[a]	Harvest[b]	Total redds	Spawners[c]	Fish:redd[d]
1996	2461	78	569	1138	4.19
1997	3277	233	731	1462	4.16
1998	2606	185	744	1488	3.25
1999	1828	--	310[e]	620	5.90

[a] *Total from video counts (except 1999 from counts at a new fishway trap) up to one week prior to the last spawning survey.*
[b] *For Sandy River above dam. Estimated from punch card data. No fishery in 1999.*
[c] *Estimated from redds using 1:1 sex ratio and two fish per redd.*
[d] *From dam counts minus harvest.*
[e] *Expanded by 9%. In 1996-98, an average 91% of all redds were counted in the area surveyed in 1999. 32 redds were added to account for spawning by live fish counted on the last survey.*

We accounted for just 34% of the adult spring chinook passed upstream at Marmot Dam in 1999 compared to an average of 54% (range 44%-61%) in 1996-98 (Table 11). We hypothesized in previous years that the difference between the Marmot Dam counts and our survey counts could be because of pre-spawning mortality and spawning occurring in areas not surveyed (Lindsay et al. 1998). The large discrepancy between the two counts in 1999 could be because of several factors: 1) a larger percentage of fish spawned in areas outside the 1999 survey sections than had been observed in 1996-98; 2) an increase in pre-spawning mortality; 3) an undercounting of redds in areas where multiple pairs of fish might spawn.

One difference between 1999 and previous years is that all adult spring chinook were trapped and handled in the Marmot Dam ladder to sort marked and unmarked fish. Trapping and handling adult salmon could increase pre-spawning mortality, could alter the upstream distribution of spawners, or could cause fall-back at Marmot Dam resulting in mortality, fish remaining below the dam, or fish ascending the ladder a second time.

TASK 2.1-- MORTALITY IN A CATCH AND RELEASE FISHERY

Hooking Mortality Study

Methods

Study methods were similar to those in 1998 (Lindsay et al. 1998). Changes in gear types in 1999 included use of eggs, sand shrimp, and eggs-sand shrimp combination for bait, and some single hook spinners (Appendix Table D-2). In 1999 adult chinook salmon were tagged with a single tag because tag loss was low in 1998.

Hooking mortality was estimated from combined 1998 and 1999 data. We pooled the two control groups (fishway and river) in each year and compared recoveries of these fish to those caught with sport fishing gear at Willamette Falls. We estimated mortality of the two treatment groups that were caught and released directly into the river, but not of the treatment group that was hoisted into the fishway. Migration of fish hoisted into the fishway could have been affected by trapping of control groups, which occurred upstream of the hoist site. Effects would have been aggravated in 1999 when the fishway trap was operated by the Columbia River Management Section (ODFW) for another study that overlapped and extended beyond our study. The hoisted group was recovered at a lower frequency than the river release groups, especially in 1999, suggesting trapping in the fishway or extra handling affected behavior or migration of these fish. In addition, fish released directly into the river would be most analogous to how fish would be handled in a general catch and release fishery in the lower Willamette River.

Results

Hooking mortality was higher for fish caught on lures than those caught on bait (Table 12). Hooking mortality for both groups combined was 8.6% (Table 12), which is similar to the overall rate (7.6%) reported for chinook salmon fisheries in the Kenai River, Alaska (Bendock and Alexandersdottir 1993). Estimated mortality of wild spring chinook salmon in a catch and release fishery in the Willamette River would be about 3% of the run into the river (Table 13), combining data from lures and bait.

Table 12. Hooking mortality of adult spring chinook salmon caught on lures and on bait and released into the Willamette River, 1998 and 1999. Recovery estimate for the control group is from pooled releases (fishway and river).

Group	Number tagged[a]	Number recovered	Percent recovered	Percent mortality
Lure (river release)	269	105	39.0	15.7
Bait (river release)	239	110	46.0	0.6
Control	475	220	46.3	

Table 13. Estimate of mortality in a catch and release fishery on a hypothetical wild run of 5,000 spring chinook salmon (in a 50,000 fish run) in the Willamette River, based on results of hooking mortality studies and gear surveys of sport fisheries in 1998 and 1999.

	Rate (%)	Estimated number[a]
Catch of wild fish in sport fishery	28[b]	1400
Hooked in jaw and other locations[c]	82	1148
Hooked in tongue	5	70
Hooked in stomach[d]	8	112
Hooked in gill arches	5	70
Mortality in catch and release fishery		
Fish hooked in jaw and other locations[c]	4	46
Fish hooked in tongue	14	10
Fish hooked in stomach[d]	24	27
Fish hooked in gill arches	77	54
Mortality in wild run	2.7	137

[a] *Combined data for fish caught on lures and bait.*
[b] *Mean catch rate in normal fishing seasons, 1970-95 (Foster 1997).*
[c] *Includes fish hooked in roof of mouth and eye.*
[d] *Includes fish hooked in esophagus.*

Chinook salmon hooked in gill arches were recovered at a significantly lower rate than those hooked in the jaw (P<0.001), tongue (P<0.01), or stomach (P<0.10) (Tables 14 and 15). Adult chinook caught in the stomach with bait were recovered at an intermediate rate to those hooked in the jaw or the gill arches (Tables 14 and 15). The percentage of fish hooked with bait that were severely bleeding was higher for those hooked in gill arches (63%) than for those hooked in the stomach (6%) (Table 16). We cut hooks off in 60% of those hooked with bait in the gill arches compared to 94% of those hooked in the stomach.

Table 14. Tests of significance for recovery rates of adult spring chinook salmon hooked in different anatomical locations, 1998-99.

Comparison (recovery rate)[a]	Test value	*P* value	Test
Jaw (47%) v Tongue (40%)	0.14	0.709	Chi square
Jaw (47%) v Gill arches (11%)	25.55	<0.001	Chi square
Tongue (40%) v Gill arches (11%)		0.006	Fisher exact
Jaw (52%) v Stomach (35%)[b]	1.12	0.289	Chi square
Stomach (35%) Gill arches (13%)[b]		0.083	Fisher exact

[a] *River releases only.*
[b] *Test for bait-caught group only, no lure-caught fish were hooked in the stomach.*

Table 15. Recovery by hook location of spring chinook salmon that were caught, tagged, and released at Willamette Falls, 1998-99. Results of statistical tests between recoveries of fish caught with lures or bait are noted where data were sufficient. Excludes fish with no information on hook location.

	Lures[a]			Bait		
Hook location	Number tagged	Number recovered	Percentage recovered	Number tagged	Number recovered	Percentage recovered
Jaw	224	96	43[b]	177	92	52[b]
Tongue	13	6	46[c]	7	2	29[c]
Stomach	0			17	6	35
Gill arches	27	2	7[c]	30	4	13[c]
Eye	2	0	0	3	2	67
Roof of mouth	0			4	2	50

[a] *River releases only.*
[b] *Significant difference (P= 0.09; χ^2 test) in recovery rates.*
[c] *No significant difference (P > 0.25; Fisher exact test) in recovery rates.*

The higher mortality of chinook salmon caught on lures (primarily treble hooks) than those caught on bait (single hooks) may be due to differences in severity of bleeding and the time it took to unhook the fish. The frequency of severe bleeding of fish hooked with lures was similar to that of fish hooked with bait. However, the recovery frequency of fish that were severely bleeding was lower for those caught with lures (8%) than for those caught with bait (15%; Table 16), although sample sizes are low. The lure-caught fish might have sustained more injury than the bait-caught fish because lures were always removed whereas hooks were left in place for deeply hooked fish caught with bait. The difference in recovery of lure-caught fish that were severely bleeding and bait-caught fish that were severely bleeding accounts for just 1% of the overall difference in recovery of the two groups.

Table 16. Severity of bleeding by hook location at the time adult spring chinook salmon were caught and tagged, 1998-1999. Number of recoveries is in parentheses. Excludes fish which had no information on hook location.

Degree of bleeding	Jaw	Tongue	Gill arches	Roof of mouth	Eye	Stomach
			Lures[a]			
None-slight	216 (92)	10 (6)	0	0	1 (0)	0
Moderate	8 (4)	1 (0)	5 (0)	0	1 (0)	0
Severe	0	2 (0)	22 (2)	0	0	0
			Bait			
None-slight	170 (90)	5 (2)	6 (1)	3 (2)	2 (1)	14 (6)
Moderate	7 (2)	2 (0)	5 (0)	1 (0)	1 (1)	2 (0)
Severe	0	0	19 (3)	0	0	1 (0)

[a] *River releases only.*

Recovery frequencies of chinook salmon hooked in the jaw was significantly higher for those caught with bait than for those caught with lures (Table 15), which accounts for most of the overall difference in recovery of the two groups. The increased time to remove treble hooks from fish caught with lures (Table 17) indicates additional handling time for fish caught with lures than for those caught with bait, and may explain some of the difference in the recoveries of the two groups.

Table 17. Tests of significance for processing time of adult spring chinook salmon caught with single or treble hooks and released into the Willamette River, 1999.

Time to–	Processing time (sample size): Single[a]	Processing time (sample size): Treble[b]	t-value	P
Unhook	0:30 (87)	0:41 (70)	2.60	0.01
Tag[c]	1:07 (89)	1:14 (92)	1.36	0.18

[a] *Most caught with bait and released into the river (6 fish caught with single hook lures).*
[b] *Caught with lures and released into the river.*
[c] *Includes time to measure and release fish.*

An average of about 48% of the run past Willamette Falls in 1998 and 1999 was accounted for in hatcheries and at traps above the falls. In these same locations, the 1998-99 average of the pooled recoveries of our two control groups was 46% indicating little mortality from handling and tagging these fish. Tag recoveries from all tag groups were uniformly distributed among the sampled subbasins above Willamette Falls and were similar to the distribution of the general spring chinook run (Figure 2).

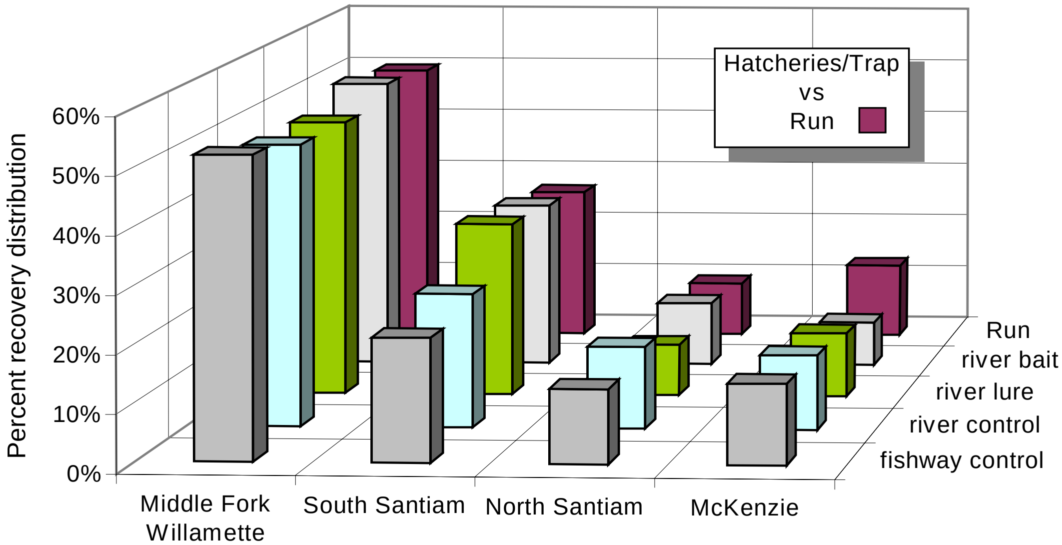

Figure 2. Distribution of spring chinook salmon tag recoveries in hatcheries and fishway traps above Willamette Falls for four hooking mortality study groups, 1998 and 1999. The recovery distribution of the general spring chinook salmon run in the upper Willamette River, excluding tagged fish, is plotted in the back row of the graph.

Additional data on numbers of fish tagged, numbers hooked on various types of gear, anatomical hook locations, days to recovery, and recovery locations are in **APPENDIX D**.

Comparison of the Hooking Mortality Study to the Lower River Fishery

In addition to the hooking mortality study, we conducted a survey of spring chinook salmon anglers in the Willamette River below Willamette Falls in 1999. The purpose of the survey was to identify the types of terminal gear used and the anatomical hook location of fish caught in the general sport fishery for comparison with our hooking mortality study at Willamette Falls. These data along with the hooking mortality data at Willamette Falls were used to predict a mortality rate on the wild run in a selective fishery on hatchery fish (Table 13). Survey methods in 1999 were similar to those used in 1998 (Lindsay et al. 1998). Table 18 shows the anatomical hook locations by specific gear type for all areas combined in the lower river fishery. Table 19 shows the distribution of general gear types used in each of three sections of the lower river and Figure 3 shows distribution of catch in these same three sections.

Table 18. Anatomical hook locations by gear type for spring chinook salmon caught by anglers in the Willamette River below Willamette Falls, March 24-June 21, 1999. Only hook locations verified by an ODFW creel clerk are included.

Gear type	Jaw	Tongue	Gill arch	Stomach	Total
Bait:					
Eggs	13			4	17
Herring	257	11	20	20	308
Herring/spinner	1				1
Prawn	135	6	6	20	167
Prawn/spinner	24				24
Shrimp	19		1	1	21
Shrimp/eggs				1	1
Shrimp/spinner	1				1
Bait total	450	17	27	46	540
Lure:					
Alvin	3				3
Crankbait	1				1
Flatfish	1		1		2
Kwikfish	3				3
Lure	1				1
Plastic prawn	1				1
Plug	4				4
Spinglo	10				10
Spinner	33	1	1	2	37
Spoon	3				3
Wart	4		1		5
Wobbler	1				1
Lure total	65	1	3	2	71

Table 19. The percentage of time spring chinook anglers used different gear types in each of three sections of the lower Willamette River, March 24-June 21, 1999. Baits used with a lure attractor are included under the bait category. Percentages may not add to 100% due to rounding errors.

Gear types	Mouth to St. John's Bridge[a]	St. John's Bridge to Lake Oswego	Lake Oswego to Willamette Falls
Bait:			
Fish	95	70	12
Eggs	0	0	11
Prawns	4	30	76
Unspecified bait	<1	0	<1
Lure:			
Plugs [b]	16	36	8
Spinners	65	50	35
Wobblers, spoons	11	7	3
Spinglo	1	1	54
Other lures [c]	8	5	<1

[a] *Includes Multnomah Channel.*
[b] *Flatfish, Wiggle Warts, etc.*
[c] *Includes corkys, plastic prawn and unspecified lures..*

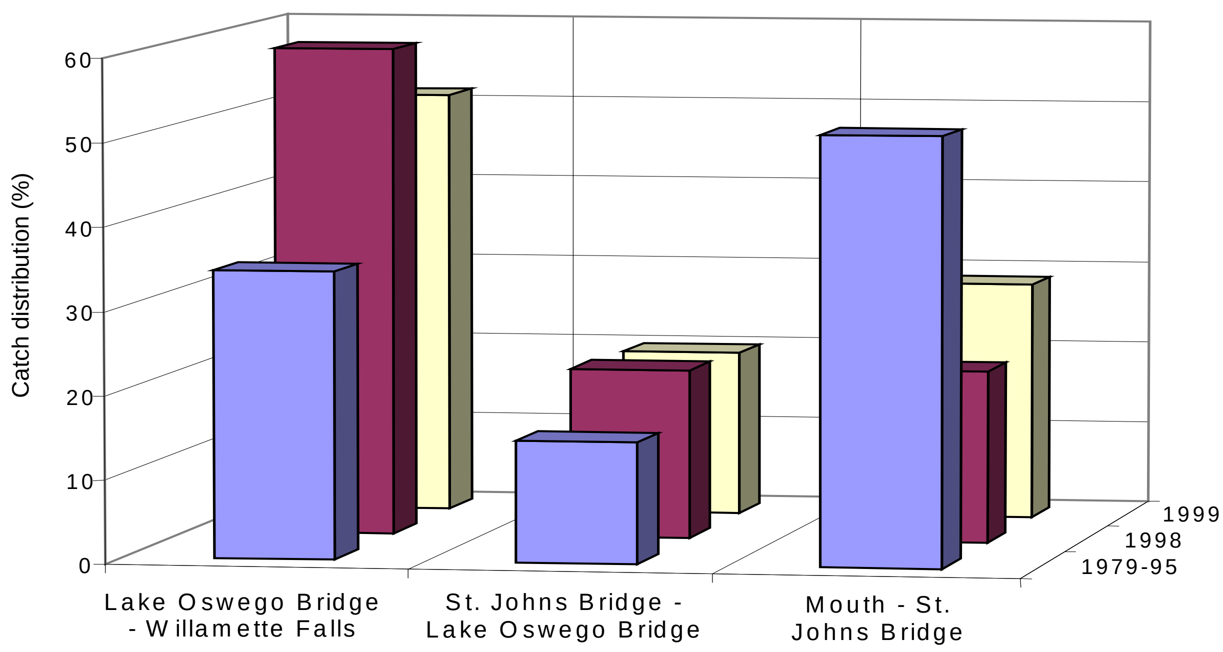

Figure 3. Distribution of the catch of adult spring chinook salmon in three sections of the Willamette River below Willamette Falls, 1979-95 (Foster 1997) and 1998 and 1999 (Craig Foster, ODFW, unpublished data).

TASK 2.2-- MORTALITY FROM CLIPPING HATCHERY FISH

Mortality from clipping fins or maxillary bones of hatchery spring chinook salmon was originally identified as an important factor in evaluating the feasibility of a selective fishery in the lower Willamette River. Hatchery fish needed to be externally marked for anglers to distinguish them from unmarked wild fish. At the time our study was designed, the adipose fin clip was sequestered for use only with coded wire tags. Because coded wire tags are expensive, the adipose clip was not a long-term option for identifying hatchery chinook in the Willamette basin. Beginning with the 1998 brood, however, most of the Willamette spring chinook hatchery production has been marked with adipose fin clips without coded wire tags. Because it is generally accepted that clipping the adipose fin results in lower mortality than any other common clip, the need for evaluating mortality from other clips for Willamette River spring chinook is currently unnecessary. However, because we had already clipped fish in three brood years (Tables 20 and 21) by the time the adipose clip became available for an external mark, we have chosen to complete the study by monitoring adult returns (Table 22) from these three marked brood years. The results may have application at some other locations or time.

Table 20. Quality of ventral and maxillary clips on 1997 brood spring chinook salmon at Marion Forks (North Santiam River) and McKenzie hatcheries at time of release in 1999.

Hatchery, clip quality	Ventral clip	Maxillary clip
Marion Forks	**(RV)**	**(RM)**
Completely clipped	92%	97.2%
75%-50% clipped	4%	1.6%
Less than 50% clipped	1%	0.6%
Wrong side clipped	1%	0.6%
Both ventrals clipped	2%	--
Sample size	335	318
McKenzie	**(LV)**	**(LM)**
Completely clipped	73%	92%
75%-50% clipped	19%	5%
Less than 50% clipped	8%	3%
Sample size	268	289
McKenzie	**(LVAD+CWT)**	**(LMAD+CWT)**
Completely clipped	68%	87%
75%-50% clipped	26%	7%
Less than 50% clipped	6%	6%
Sample size	328	403

Table 21. Groups of spring chinook salmon (1995-97 broods) released as smolts into the McKenzie, North Santiam and Clackamas rivers in 1997-99 to evaluate effects of removing a ventral fin or a maxillary bone on survival to adult.

Hatchery	Mark	Number	Size at release (fish/lb)	Release date
		1995 Brood		
McKenzie	LV	29,632	8.7	Mar 6, 1997
	LM	29,624	8.7	Mar 6, 1997
	AD+CWT	97,148	8.7	Mar 6, 1997
Marion Forks	RV	30,204	15.3	Mar 3-4, 1997
(North Santiam R.)	RM	30,125	13.0	Mar 3-4, 1997
	AD+CWT	33,195	12.9	Mar 4, 1997
Clackamas	LV	26,692	13.6	Mar 31, 1997
	LM	26,526	13.6	Mar 31, 1997
	AD+CWT	29,211	13.6	Mar 31, 1997
		1996 Brood		
McKenzie	RV	32,537	9.3	Mar 5, 1998
	RM	37,723	9.2	Mar 5, 1998
	RVAD+CWT	28,383	8.5	Mar 5, 1998
	RMAD+CWT	29,620	8.5	Mar 5, 1998
	AD+CWT	224,474	9.0	Mar 5, 1998
Marion Forks	LV	30,111	15.7	Mar 2-3, 1998
(North Santiam R.)	LM	30,175	16.0	Mar 2-3, 1998
	AD+CWT	652,585	14.3	Mar 2-3, 1998
Clackamas	RV	29,279	13.9	Mar 18, 1998
	RM	30,438	13.9	Mar 18, 1998
	AD+CWT	31,007	13.9	Mar 18, 1998
		1997 Brood		
McKenzie	LV	27,881	8.3	March 10, 1999
	LM	28,294	8.3	March 10, 1999
	LVAD+CWT	27,034	8.3	March 10, 1999
	LMAD+CWT	25,768	8.3	March 10, 1999
	AD+CWT	89,288	8.3	March 10, 1999
Marion Forks	RV	29,875	13.9	March 12, 1999
(North Santiam R)	RM	29,888	13.9	March 12, 1999
	AD+CWT	343,618[a]	11.5	March 11-12, 1999
Clackamas	LV	29,458	9.5	March 17, 1999
	LM	29,383	9.5	March 17, 1999
	AD+CWT	216,470[a]	9.5	March 17, 1999

[a] *These release numbers have not been finalized in the PSMFC database and are subject to change.*

Table 22. Quality of ventral fin and maxillary bone clips in the return of adult spring chinook salmon to three Willamette basin hatcheries in 1999.

Clip	Clip quality[a]		
	Full	Partial	None
		Minto Hatchery	
Maxillary bone	38	5	3
Ventral fin	12	7	2
		Clackamas Hatchery	
Maxillary bone	48	4	0
Ventral fin	41	20	2
		McKenzie Hatchery	
Maxillary bone	24	1	1
Ventral fin	20	9	1

[a] *Full = 0-50% present for maxillary and 0-25% present for ventral;*
Partial = 50-<100% present for maxillary and 25-75% present or a spike of a few rays remaining for ventral;
None = folded into mouth for maxillary and >75% present but deformed for ventral.

TASK 2.3-- EVALUATION OF NET PENS IN THE LOWER WILLAMETTE RIVER

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

1997 Brood Releases

A study was begun in 1992 to determine if acclimation prior to release could be used to increase harvest of hatchery spring chinook salmon in the lower Willamette River. McKenzie River stock was used because of concerns about straying of other stocks into the McKenzie, a stronghold for wild spring chinook salmon. The evaluation of straying was an important part of the study. Fish were acclimated in net pens and compared to fish trucked directly from the hatchery. Control groups were released into the McKenzie River from McKenzie Hatchery. The study was originally planned for 4 brood years. However, numerous problems led to modifications in study design beginning with the 1995 brood and an extension of the study for four additional years through 1999 brood releases. Lindsay et al. (1997) described releases of experimental groups for 1992-95 broods. Lindsay et al. (1998) shows study releases of 1996 brood spring chinook (along with corrected release numbers for the 1995 brood). Table 23 shows releases of 1997 brood spring chinook.

Table 23. Releases of spring chinook salmon into the lower Clackamas and Willamette rivers to evaluate acclimation in net pens, 1997 brood.

					Size			
Stock	Tag code	Treatment	Location of release	Number AD+CWT	Fish/lb	Length (mm)	Days Accli-mated	Release date
McKenzie	092545	Acclimate	Mult. Channel	55,748	8.3	166.6	21	11/5/98
McKenzie	092544	Direct	Mult. Channel	55,189	7.8	166.9	--	11/5/98
Willamette[a]	092508	Acclimate	River Place	30,625	8.8		21	11/3/98
Willamette[a]	092507	Direct	Will. Park	29,562	9.2		--	11/3/98
McKenzie	092548	Acclimate	Clack. Cove	77,537	10.0	160.4	23	3/09/99
McKenzie	092547	Direct	Clack. Cove	75,336	9.5	161.4	--	3/09/99
McKenzie	092549	Direct	Clack. River	101,051[b]	9.3	166.1	--	3/09/99
McKenzie	092546	Direct	Mult. Channel	57,995[b]	9.6	161.2	--	3/08/99
McKenzie	092446	Control	McK. Hatch.	21,978	9.6	157.9	--	3/10/99
McKenzie	092550	Control	McK. Hatch.	129,554	9.6	156.2		3/10/99
McKenzie	092646	Control	McK. Hatch.	54,350	9.6	154.7	--	3/10/99

[a] *These fish are not part of the net pen evaluation.*
[b] *One truckload (22,278) was accidentally released at Clackamette Park instead of Multnomah Channel. Estimated release based on the percentage of AD+CWT in the 092546 tagged group.*

Adult Recovery of 1992 and 1993 Brood Releases

The main objective of acclimating juveniles in net pens in the lower Willamette River was to increase the sport harvest of these fish when they returned. The PSMFC database on tag recoveries of adults from the first acclimated (1992 brood) releases is largely complete through age 5. The database for the 1993 brood is complete mainly through age 4. Release data for these two brood years is presented in Lindsay et al. (1997).

Acclimated and control groups from the 1993 brood released in fall and spring returned at much higher rates than direct groups (Table 24). The same was true for the spring release of the 1992 brood. Acclimated fish from the 1993 brood also entered the sport fishery at a higher rate than control fish; however, just the reverse was true for 1992 brood sport harvest. Recovery of experimental groups in sport fisheries was low for both brood years because harvest was restricted when they returned as adults. Fish from the 1993 brood released in the fall returned at a higher rate than those released in spring. This may have been due to nitrogen super saturation that occurred in the mainstem Willamette River in the spring when 1993 brood juveniles were released (Lindsay et al. 1997). In general, fish released into the lower river strayed at a higher rate than those released at the hatchery. Of the lower river release groups that were recovered in hatcheries, 52% of the 1993 brood and 46% of the 1992 brood strayed to hatcheries other than the McKenzie where they were reared (Table 24). For comparison, only 1% of control groups released from McKenzie Hatchery were recovered at other hatcheries (Table 24). Recoveries of 1992 brood releases are discussed in more detail in Lindsay et al. (1998).

Table 24. Coded wire tag recoveries (expanded) of experimental fish used to evaluate acclimation in net pens in the Willamette River, 1992 and 1993 broods. Recoveries were adjusted to a 100,000 smolt release. Tag recoveries were obtained from databases of the Pacific States Marine Fisheries Commission, January 2000.

		Fall release		Spring release	
Recovery location	Control	Acclimated	Direct	Acclimated	Direct
1992 Brood					
Ocean					
Troll and net fisheries	12	--	--	20	0
Freshwater					
Columbia River gill net	1	--	--	0	0
Sport fisheries	25	--	--	3	0
Hatcheries:					
Originating	183	--	--	10	5
Other	2	--	--	13	0
Leaburg Dam trap (McKenzie River)	6	--	--	0	0
Spawning grounds (McKenzie River)	3	--	--	0	0
Other[a]	2	--	--	0	0
1993 Brood					
Ocean					
Troll and net fisheries	13	45	3	5	1
Freshwater					
Columbia River gill net	0	0	2	3	0
Sport fisheries	5	9	3	13	0
Hatcheries:					
Originating	73	21	5	2	2
Other	1	23	5	5	0
Leaburg Dam trap (McKenzie River)	4	2	1	0	1
Spawning grounds (McKenzie River)	1	0	0	0	0
Other[a]	1	0	0	0	0

[a] *Includes dead fish found immediately below Willamette Falls, fish sampled in Willamette Falls fishway, and fish caught in treaty and test fisheries.*

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APPENDIX B

Otoliths Collected from Adult Spring Chinook Salmon in Several Willamette River Tributaries, 1997-99.

Stream	Location	Number	Comments
	1999		
North Santiam	Minto pond	45	AD+CWT
McKenzie	Hatchery	84	AD+CWT
	1998		
North Santiam	Spawning ground	5	AD+CWT
	Minto pond	49	AD+CWT
McKenzie	Hatchery	183	AD+CWT
	Spawning ground[a]	94	AD+CWT (19) and unmarked (75)
Middle Fork Willamette	Hatchery	124	AD+CWT, random sample
	1997		
North Santiam	Creel survey	34	Every fish possible
	Spawning ground	134	Every fish possible
	Minto pond	148	Unmarked, every third fish
	Minto pond	45	AD+CWT
McKenzie	Hatchery	209	AD+CWT, over 86 cm
	Leaburg Dam[b]	26	AD+CWT
	Spawning ground	50	AD+CWT and unmarked
Middle Fork Willamette	Hatchery	117	AD+CWT, random sample

[a] *Below Leaburg Dam.*
[b] *These fish were taken to McKenzie Hatchery and spawned, otoliths were collected at the time of spawning.*

APPENDIX C

Monthly Passage of Adult Spring Chinook Salmon at Dams on the Clackamas and Sandy Rivers, 1996-99.

Appendix Table C-1. Monthly percentage of adult spring chinook salmon counted at North Fork Dam on the Clackamas River, 1996-99.

	1996	1997	1998	1999
May	0	1	1	0
June	20	6	14	1
July	24	23	28	19
August	9	21	12	25
September	39	44	36	44
October	8	5	11	11

Appendix Table C-2. Monthly percentage of adult spring chinook salmon counted at Marmot Dam on the Sandy River, 1996-99.

	1996	1997	1998	1999
May	0	2	2	0
June	13	20	14	6
July	37	30	38	40
August	15	20	9	27
September	23	25	34	22
October	12	3	3	5

APPENDIX D

Hooking Mortality Data Collected in the Willamette River, 1998 and 1999.

Appendix Table D-1. Streamflow, temperature, and number of spring chinook salmon tagged on each sample day at Willamette Falls, 1999.

	Streamflow (cfs)[a]	Temperature (^oF)[b]	River releases			Fishway
			Lures	Bait	Control	Control
Apr 27	20,100	--	16			
28	20,600	51	29			
29	19,800	--	23		5	
30	18,000	50	14	6	3	
May 1	16,300	--	14	4		
2	16,600	--	29	7		
3	18,600	51	5	18	1	
4	24,400	51	1	2	2	
10	29,500	50			2	
12	29,600	50		14	11	
13	29,900	48		5	25	
14	30,200	--		7	19	
15	27,100	--		11	26	
17	24,600	49		2	16	
18	21,800	--				22
19	21,000	49				19
20	22,000	50				22
21	21,000	51				20
23	22,400	--	1	11		
24	23,100	--				50
25	23,000	51		2	6	
Total			132	89	116	133

[a] *Measured at the Salem gauge.*
[b] *Water temperature measured in the forebay.*

Appendix Table D-2. Number of spring chinook salmon hooked on various types of terminal tackle, 1999.

Terminal gear	Hook			Number of fish
	Type	Number	Size	
Lures[a]:				
Spinner	Single	1	6/0	8
	Treble	1	1/0	1
	Treble	1	2/0	48
Diving Plug	Treble	1	1/0	4
	Treble	2	1/0,1/0	11
	Treble	2	3,3	35
	Treble	2	3,4	14
	Treble	2	4,4	1
Wobbler	Treble	1	1	1
	Treble	1	2	9
Bait:				
Prawn-spinner	Single	1	4/0	34
Prawn	Single	1	4/0	2
Eggs	Single	1	4/0	39
Eggs/sand shrimp	Single	1	4/0	10
Sand shrimp	Single	1	4/0	4

[a] *River releases only.*

Appendix Table D-3. Four groups of spring chinook salmon tagged at Willamette Falls to evaluate hooking mortality, April-May 1998 and 1999.

Release location, group	Number tagged	
	1998	1999
River releases:		
Lures	137	132
Bait	150	89
Control	105	116
Fishway releases:		
Control	121	133

Appendix Table D-4. Recovery by location and method for experimental groups of adult spring chinook salmon tagged and released at Willamette Falls, 1999.

Location	Method	Fishway control	River Control	River lure	River bait	Total
Middle Fork	Fishery	2	2	6	2	12
Willamette	Hatchery	23	18	18	13	72
Fall Creek	Trap	0	1	1	1	3
McKenzie	Fishery[a]	1	0	0	0	1
	Hatchery	6	3	6	3	18
	Trap	2	0	1	0	3
	Spawning ground	0	1	1	0	2
South Santiam	Fishery	6	4	1	3	14
	Hatchery	13	8	16	9	46
North Santiam	Fishery	1	1	2	1	5
	Hatchery	6	2	2	2	12
	Trap	1	4	1	2	8
Willamette						
above falls	Fishery	1	1	0	3	5
below falls	Fishery	0	2	0	0	2
Clackamas	Fishery	3	0	0	0	3
	Hatchery	2	1	0	0	3
Total		67	48	55	39	209

[a] *Caught and released.*

Appendix Table D-5. Percentage of adult spring chinook hooked in six anatomical locations at Willamette Falls to evaluate hooking mortality, April-May 1998 and 1999. Number of fish caught is in parentheses. Excludes fish which had no information on hook location.

	Lures[a]		Bait	
Hook location	1998	1999	1998	1999
Jaw	82 (110)	86 (114)	86 (128)	55 (49)
Tongue	6 (8)	4 (5)	4 (6)	1 (1)
Gill arches	10 (14)	10 (23)	5 (8)	25 (22)
Eye	1 (2)	0	1 (2)	1 (1)
Stomach	0	0	3 (5)	13 (12)
Roof of mouth	0	0	0	5 (4)

[a] *River releases only.*

Appendix Table D-6. Recovery by hook location of adult spring chinook salmon that were caught, tagged, and released at Willamette Falls, April 27-May 27, 1999. Results of statistical tests between recoveries of fish caught with lures or bait are noted where data were sufficient. Excludes fish which had no information on hook location.

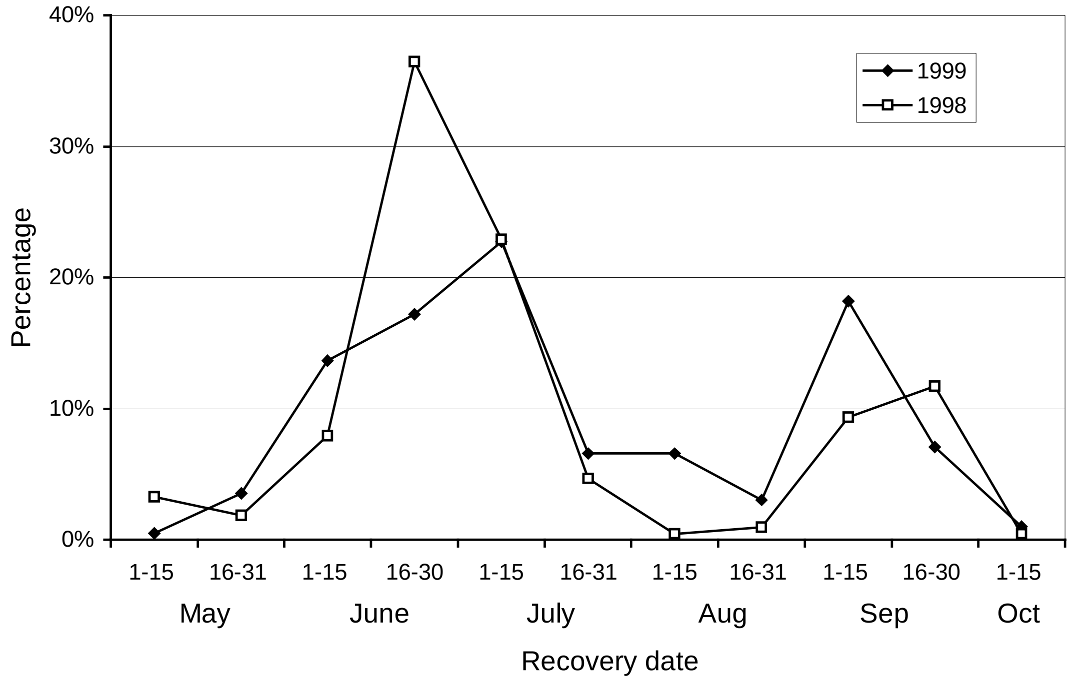
	Lures[a]			Bait		
Hook location	Number tagged	Number recovered	Percentage recovered	Number tagged	Number recovered	Percentage recovered
Jaw	114	50	44[b]	49	28	57[b]
Tongue	5	3	60	1	1	100
Stomach	0			12	4	33
Gill arches	13	2	15[c]	22	3	14[c]
Roof of mouth	0			4	2	50
Eye	0			1	1	100

[a] *River releases only.*
[b] *No significant difference (*P= *0.17;* χ^2 *test) in recovery rates.*
[c] *No significant difference (*P *>0.50; Fisher exact test) in recovery rates.*

Appendix Table D-7. Summary of recoveries of adult spring chinook salmon tagged and released at Willamette Falls, 1998 and 1999.

Recoveries[a]	1998	1999
Above falls	96%	96%
Hatcheries	76%	74%
Traps	10%	7%
Below falls	10 fish	8 fish
Clackamas River	6 fish	6 fish
Angler returns	14%	20%
Days to recovery		
Average	69	69
Range	6 -158	4 -152

[a] *Does not include fishway lure release group.*



Appendix Figure D-1. Temporal distribution of recoveries for adult spring chinook salmon tagged and released at Willamette Falls, 1998 and 1999. Does not include recoveries of the fishway lure group.

APPENDIX E

Return of Adult Spring Chinook Salmon with Clips to Three Willamette Basin Hatcheries, 1999.

Fin clip[a]	Maxillary clip quality[b]				Ventral clip quality[c]				
	Full	Partial	Folded	Total	Full	Partial	Regrown	Spike	Total
				Minto Hatchery					
RM	34	4	2	40					
LM	4	1	1	6					
RV					10	4	1	2	17
RV jack					1	0	0	0	1
LV					1	1	1	0	3
				Clackamas Hatchery					
RM	4	3	0	7					
LM	43	1	0	44					
LM jack	1	0	0	1					
RV					0	3	4	0	7
RV jack					2	0	0	0	2
LV					39	14	4	2	59
ADRV					0	0	1	0	1
ADRV jack					0	1	0	0	1
				McKenzie Hatchery					
RM	1	0	1	2					
LM	22	1	0	23					
RV					0	1	1	0	2
LV					20	8	0	0	28
ADRM jack	1	0	0	1					

[a] *RM = right maxillary, LM = left maxillary, RV = right ventral, LV = left ventral, AD = adipose. All adults unless specified as jacks.*

[b] *Full = 0-50% present, Partial = 50-<100% present, Folded = present but folded into mouth.*

[c] *Full = 0-25% present, Partial = 25-75% present, Regrown = >75% present but deformed, Spike = few rays only remaining.*