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INTRODUCTION

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

The Oregon Fish and Wildlife Commission adopted the 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, hatchery programs and fish passage issues were the focus of spring chinook salmon management in the Willamette and Sandy basins. Limited information was collected on the genetic structure among basin populations, on abundance and distribution of natural spawning, on rearing and migrating of juvenile salmon, or on strategies for reducing risks that large hatchery programs pose for wild salmon populations. This study is being implemented to gather this information. A schematic of the study plan is shown in **APPENDIX A**.

We conducted work in the main-stem Willamette River at Willamette Falls, and in the McKenzie, and North Santiam rivers in 2001. 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 tasks that were worked on in late 2000 through early fall 2001.

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

Implementation of the Wild Fish Management Policy requires information on hatchery and wild fish in spawning populations. Partly in response to this need, but primarily to implement a selective fishery, all hatchery spring chinook salmon in the Willamette basin were marked with adipose fin clips beginning with the 1997 brood. Although intentions were to mark all hatchery chinook, less than 100% of the returning adults will have an external mark for several reasons. First, a percentage of hatchery releases do not receive a clip because fin-clipping personnel do not clip the adipose fin or clip only a portion of the fin, which then regenerates. For example, about 3% of hatchery fish were released without a clip in a sample of 76 release groups from the

1996–1999 broods. Second, fry and pre-smolts without fin clips have been released in the basin. Given the large numbers of hatchery fish released, even a small percentage of unmarked hatchery fish can bias estimates of wild spawners, especially because the number of wild fish in the basin is low. To help separate hatchery fish without fin clips from wild fish, otoliths were thermally marked on all hatchery spring chinook released into the McKenzie and North Santiam rivers in the 1995 and 1996 brood years, and on all Willamette basin releases beginning with the 1997 brood year.

Methods

Juveniles

Thermal marks were placed on otoliths of all 2000 brood, hatchery spring chinook salmon released into the Willamette basin. Reference samples were collected at the hatcheries and will be analyzed for mark quality at the otolith laboratory operated by Washington Department of Fish and Wildlife (WDFW) (Table 1).

Table 1. Data on thermal marking of spring chinook salmon in Willamette River hatcheries and collection of reference samples, 2000 brood. Reference samples consisted of 40–50 fry (35–50 mm) from each egg take.

Stock	Egg takes sampled	Treatment (hrs on/off)	Temperature differential (°F) [a]	Cycles[b]	Comments
McKenzie	4	Chilled (24/72)	2.0–7.8	12[c]	--
N. Santiam	3	Heated (48/48)	7.0–10.0	6–7	--
Willamette	3	Heated (48/48)	12.0–18.0	8	--
Clackamas	3	Heated (48/48)	12.0–18.5	8[d]	Marked at Willamette H.
S. Santiam	6	Heated (48/48)	10.0–18.5	7–9	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 where noted.*
[c] *4–6 cycles were administered to eggs and the 6–8 cycles to hatched fry.*
[d] *Half of one egg take (2 stacks of incubation trays) received only 4 treatments.*

Adults

Adult returns of spring chinook in 2000 and 2001 provided us the first opportunity to estimate the proportion of naturally produced ("wild") fish on spawning grounds in the North Santiam and McKenzie rivers by using thermal marks in otoliths to identify unclipped hatchery fish. Most of the hatchery fish released in the McKenzie and North Santiam rivers from the 1996 and 1997 broods were externally marked with fin clips (mostly adipose fin clips), but only a portion of the 1995 brood was clipped. We conducted weekly carcass surveys on spawning grounds in the North Santiam and McKenzie rivers to collect otoliths from unclipped spring chinook (Table 2 and **APPENDIX B**). We collected scales from carcasses to determine age. We removed otoliths from carcasses and put otoliths into individually numbered vials. In addition, we collected otoliths from adult fish at Minto (North Santiam River) and McKenzie hatcheries to serve as reference samples (Table 2 and **APPENDIX B**).

We initially hoped to estimate the number of wild fish in the McKenzie and North Santiam rivers in the 2000 and 2001 adult returns. However, analysis of otoliths collected in 1999 indicated that identification of thermal marks in returning adults was poor in 1995 brood fish released from McKenzie Hatchery (Lindsay et al. 2000). Therefore, we confined the analysis of natural production in the 2000 adult return to the North Santiam River. Because North Santiam hatchery fish in the 1996 brood were given fin clips, all otoliths collected from unclipped 1996 brood adults were examined for thermal marks (Table 2). In contrast, because only a portion of the North Santiam hatchery fish in the 1995 brood were clipped, we sent in about 50% of the otoliths collected from unclipped adults of this brood. Otoliths collected in 2001 in the McKenzie and North Santiam rivers will be analyzed in 2002. Otoliths are analyzed at the WDFW otolith lab to identify presence or absence of thermal marks.

Table 2. Number of otoliths collected from adult spring chinook in the North Santiam River basin, 2000. Numbers in parentheses are samples that were sent to the WDFW otolith lab for analysis.

Group, location	Brood Year 1995	Brood Year 1996
Adipose fin not clipped		
North Santiam	199 (100)	52 (52)
Little North Santiam	2 (2)	2 (2)
Minto Hatchery	44 (12)	13 (13)
Adipose fin clipped		
Minto Hatchery	6 (6)	44 (16)

Results

Nine percent of adult spring chinook salmon without fin clips were naturally produced based on otoliths collected on spawning grounds in the North Santiam River basin (Table 3). A similar percentage of unclipped adults sampled at Minto Hatchery also lacked an otolith mark (Table 3). In contrast, a thermal pattern unique to fish marked at Marion Forks Hatchery was identified in otoliths of all clipped fish sampled at Minto Hatchery (Table 3).

The estimated number of adult spring chinook salmon without fin clips in the North Santiam River in 2000 was 1,047 (**APPENDIX C**). From the otolith analysis, we estimated that 94 of these fish were naturally produced (9% of 1,047). The escapement of adult spring chinook in the North Santiam was likely underestimated in 2000 (*see* **APPENDIX C**). However, because the percentage of naturally produced fish was only 9%, even if we doubled the escapement at Bennett, naturally produced spring chinook salmon would number less than 200 fish in the North Santiam River in 2000.

Table 3. Presence or absence of hatchery-induced thermal marks in otoliths collected in the North Santiam River basin from adult spring chinook salmon in 2000.

	Induced thermal mark (%)—			
Group, location	Absent	Present (Marion Forks pattern)	Present (other hatchery pattern)[a]	Sample size
No fins clipped				
North Santiam	9	78	13	151
Little North Santiam	25	0	75	4
Minto Hatchery	8	68	24	25
Adipose fin clipped				
Minto Hatchery	0	100	0	22

[a] *Thermal patterns did not match those identified in juvenile reference collections from Marion Forks Hatchery, but were likely hatchery-induced.*

TASK 1.3–DISTRIBUTION AND ABUNDANCE OF NATURAL SPAWNERS

We surveyed the North Santiam and McKenzie rivers in 2001 by boat and on foot to count spring chinook salmon carcasses and redds. We counted redds during surveys designed to collect otoliths from carcasses. Surveys began on August 14 in the North Santiam River and on August 21 in the McKenzie River.

Sections of the North Santiam River were surveyed regularly through October 11 (Table 4). Active redd building by chinook salmon was first observed in the North Santiam River on August 14, earlier than in previous years. However, our weekly surveys began earlier in 2001 than in previous years. We infrequently surveyed the North Santiam River in August 1997, 1998, and 2000, but did not observe any redds in those years until early September. We regularly surveyed sections of the McKenzie River through October 17 (Table 5). Active redd building was first observed in the McKenzie River on September 4, consistent with previous sampling. We used the peak number of redds counted in any one survey as the total number of redds for an individual section. In 2001, peak counts generally occurred the first week of October.

Abundance and migration timing of adult spring chinook were also monitored at upper and lower Bennett dams in 2001 (Table 6 and Figure 1) with methods similar to previous years. Corrected passage numbers for the 2000 run year are in **APPENDIX C**. Most spring chinook salmon spawn above Bennett dams.

We calculated approximate fish/redd ratios for spring chinook salmon in the North Santiam basin above Bennett dams. The fish/redd ratio was almost twice as high in 2001 (8.6) as in 1998–1999 (4.5), consistent with our observations in 2001 of high numbers of spring chinook salmon that died before spawning. For comparison, fish/redd ratios for spring chinook salmon in the Clackamas and Sandy rivers averaged 4.1 from 1996 through 1999 (Schroeder et al. 1999). We estimated the number of potential spawners in the North Santiam from escapement estimates at Bennett 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). We did not use 2000 data because of sampling problems at upper Bennett Dam (*see* **APPENDIX C**). The fish/redd estimates are maximal because we included fish released from the collection pond into the river above Minto Dam, an area not surveyed for redds. We suspect a substantial number of these fish fall back over Minto Dam and may be counted again at the Minto collection pond. Because more fish were passed above Minto Dam in 1998 (1297) and 1999 (1078) than in 2001 (294), the potential for error is higher in 1998–1999 than in 2001. Consequently, fish/redd estimates may be more inflated in 1998–1999 than in 2001 and the actual difference between fish/redd ratios in the two periods would be larger than we estimated.

Table 4. Summary of spawning surveys for spring chinook salmon in the North Santiam River, 2001, and comparison to redd densities in 1996–2000.

Survey section	Length (mi)	Number		Redds/mi					
		Carcasses	Redds	2001	2000	1999	1998	1997	1996
Minto – Fishermen's Bend	10.0	347	179	17.9	27.9	15.6	11.8	8.5	7.8
Fishermen's Bend – Mehama	6.5	68	37	5.7	5.8	3.1	4.3	2.5	3.5
Mehama – Stayton	10.3	19	92	8.9	0.6	--	3.6	1.7	2.0
Stayton – Greens Bridge	13.7	--	--	--	--	0.0	0.4	1.1	0.1
Little North Santiam	10.7	7	18	1.7	2.1	1.0	2.3	0.5	0.0

Table 5. Summary of chinook salmon spawning surveys in the McKenzie River, 2001, and comparison to redd densities in 1996, 1997, and 2000.

Survey section	Length (mi)	Number		Redds/mi			
		Carcasses	Redds	2001	2000	1997	1996
Ollalie to McKenzie Trail	10.3	114	182	17.7	5.6	11.4	7.0
McKenzie Trail to Hamlin	9.9	31	49	4.9	1.6	--	2.1
South Fork McKenzie below bridge	2.1	31	17	8.1	7.6	--	2.9
South Fork McKenzie to Forest Glen	2.4	1	2	0.8	2.1	--	0.8
Forest Glen to Rosboro Bridge	5.7	55	75	13.2	5.8	--	6.1
Rosboro Bridge to Ben and Kay	6.5	26	41	6.3	3.2	--	4.9

Table 6. Estimated number of spring chinook salmon passing upper and lower Bennett dams on the North Santiam River, May–September, 2001. Passage counts have been adjusted for a 2.5% fallback rate.

	May	June	July	August	September	Total
Unmarked:						
Adult	72	198	70	19	29	388
Jack	6	12	2	2	0	22
Fin-clipped:						
Adult	1331	3804	1027	152	84	6398
Jack	13	114	53	12	3	195
Total	1422	4128	1152	185	116	7003

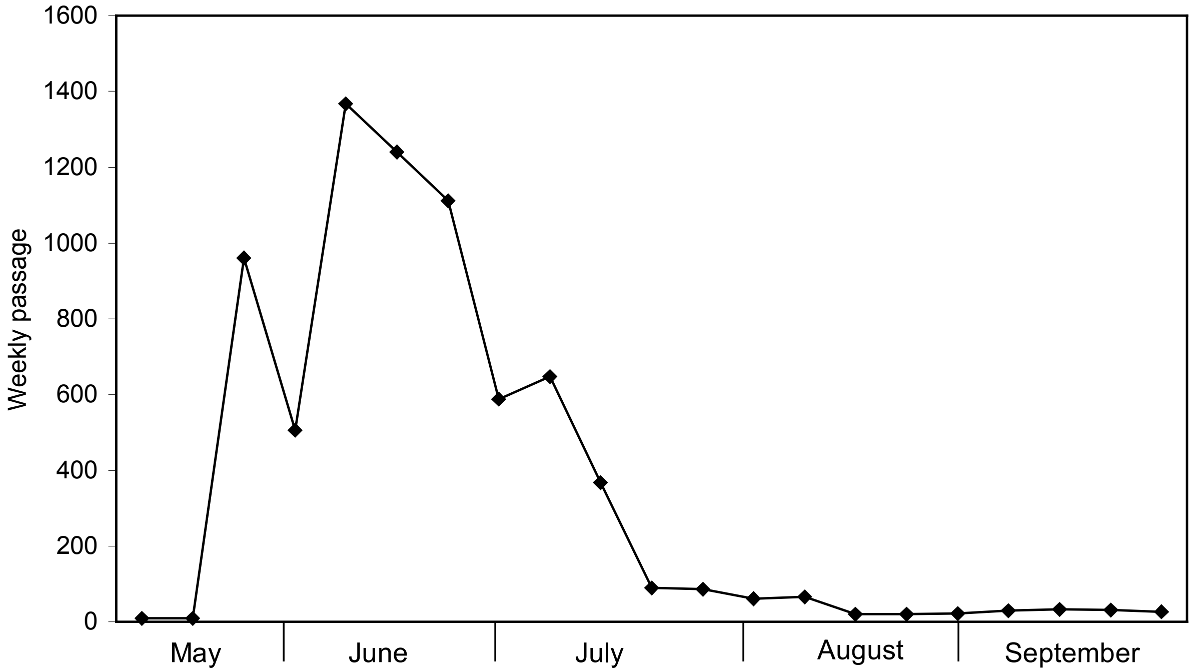

Figure 1. Weekly passage of spring chinook salmon at Upper and Lower Bennett dams on the North Santiam River, 2001.

TASK 2.1– MORTALITY IN A CATCH AND RELEASE FISHERY

Estimating Hooking Mortality

We conducted a study of hooking mortality of spring chinook salmon in the lower Willamette River sport fishery in 1998–2000. Preliminary results for all 3 years were presented in Lindsay et al. 2000. During the 2001 report period, hooking mortality data were re-analyzed, another gear survey of the spring chinook fishery was conducted, and a manuscript was prepared for publication in a fishery journal.

Anatomical Hook Location of Fish Caught in the Lower River Fishery

Spring chinook salmon anglers were surveyed in 2001 in the Willamette River below the falls (RM 26). One of the purposes 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. These data will be used with the hooking mortality data at Willamette Falls (Lindsay et al. 2000) to estimate a mortality rate for wild fish in a selective fishery on hatchery fish in the lower Willamette River. Survey methods in 2001 were similar to those used in 1998 (Lindsay et al. 1998).

Anglers below Willamette Falls primarily used bait to fish for spring chinook salmon, although the type of bait varied by river sections (Table 7). In 2001, bait accounted for 66% of the fish caught by anglers and lures accounted for 34% (Table 8). Most fish were hooked in the jaw (Table 8), but the percentage of fish hooked in the jaw was higher for those caught with lures (91%) than for those caught with bait (76%).

Table 7. The percentage of time spring chinook anglers used different gear types in each of three sections of the lower Willamette River, March 2–June 3, 2001. Baits used with a lure attractor are included under the bait category. Percentages may not add to 100% due to rounding.

Gear types	Mouth to St. John's Bridge[a]	St. John's Bridge to Lake Oswego	Lake Oswego to Willamette Falls
Bait:			
Herring	63	45	4
Eggs	<1	<1	2
Prawns/shrimp	9	41	51
Unspecified bait	0	0	<1
Lure:			
Plugs[b]	9	6	11
Spinners	16	6	14
Wobblers, spoons	2	2	10
Spinglo	<1	<1	9
Other lures[c]	<1	<1	<1

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

The harvest of spring chinook salmon below Willamette Falls in 2001 was greatest from the mouth to the St. John's bridge, similar to the 1981–1995 average, but higher than in 1998–2000 (Figure 2). Because of low runs of spring chinook salmon in 1998–2000, angling was closed some days of the week and the season length was shortened. These restrictions shifted harvest from the lowermost to the uppermost section of the river compared to 1981–1995 (Figure 2). Although harvest of spring chinook salmon in 2001 was restricted to fish with an adipose fin clip, angling was opened 7 days a week for the entire season. The similarity in harvest distributions between 2001 under selective fishery regulations and 1981-1995 under typical regulations suggest selective fisheries in the future will not change the harvest distribution in the lower Willamette River.

Table 8. Anatomical hook locations by gear type for spring chinook salmon caught by anglers in the Willamette River below Willamette Falls, March 2–June 3, 2001. Only hook locations that were verified by ODFW creel clerks are included.

Gear	Jaw	Tongue	Gill arches	Eye	Stomach	Total
Bait:						
eggs	1				1	2
eggs/prawn	1					1
eggs/shrimp	2					2
herring	71	5	4	1	5	86
prawn	66	10	10		5	91
prawn/diver	1	2				3
prawn/spinglo	2	1				3
prawn/spinner	7		2	1	1	11
shrimp	6		1			7
shrimp/spinner	1					1
Bait total	158	18	17	2	12	207
Lure:						
alvin	8					8
buzz bomb	1					1
Canadian wonder	1					1
clancy	2					2
dicknite	3					3
flatfish	2					2
fst	1					1
kwikfish	6					6
kwikfish wrap	4					4
k-wobbler	2					2
lure	1					1
prawn/kwikfish	1					1
spinglo	3					3
spinner	50	2	5		2	59
wart	2					2
wobbler	9					9
Lure total	96	2	5		2	105
Unspecified	1					1

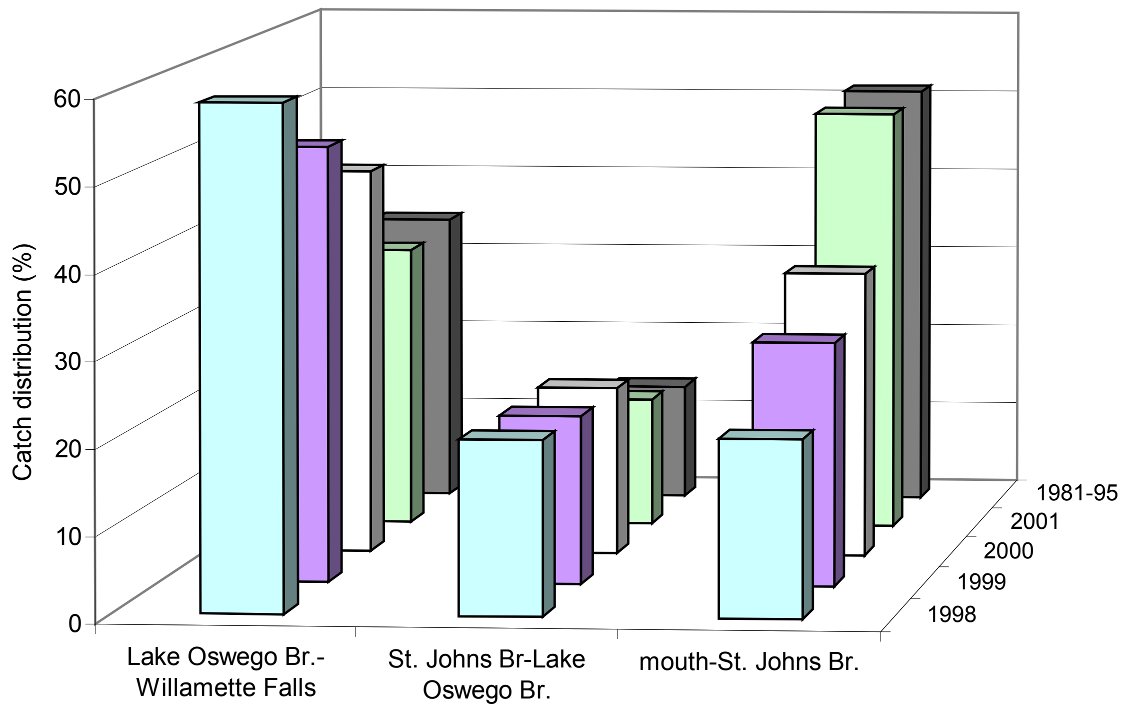

Figure 2. Distribution of the catch of adult spring chinook salmon in three sections of the Willamette River below Willamette Falls, 1981–1995 (Foster 1997) and 1998–2001 (Craig Foster, ODFW, unpublished data).

The shift in harvest distribution among river sections in 1998–2000 could affect estimates of anatomical hook location in the sport fishery because terminal gear varies among sections of the river (Table 7) and because anatomical hook locations are affected by gear type (Table 8). Because harvest distributions among river sections were atypical in 3 of the 4 years that we monitored anatomical hook locations of sport-caught salmon (Figure 2), we used the mean harvest distribution among river sections in 1981–1995 (Foster 1997) to best represent a typical harvest distribution in the lower Willamette River. Mean distributions of anatomical hook locations were calculated by river section based on 1998–2001 fishery surveys and then weighted by the typical harvest distribution to obtain a distribution of anatomical hook locations that represented a typical fishing season in the lower Willamette River (Table 9). This adjusted distribution of anatomical hook locations will be applied to estimates of hooking mortality rates made at Willamette Falls for each anatomical hook location to obtain an estimate of hooking mortality for the lower Willamette River sport fishery (Lindsay et al., in preparation).

Table 9. Comparison of distributions (%) of anatomical hook locations of spring chinook salmon caught in the lower Willamette River fishery in 1998–2001 and an adjusted estimate based on the mean harvest distribution in 1981-1995. For 1998–2001, observed anatomical hook locations in each river section were expanded by the estimated total harvest of spring chinook by section to calculate overall distributions of hook locations.

Year	Jaw	Tongue	Gill arch	Eye	Stomach
1998	69.2	6.8	8.6	0.0	15.4
1999	86.5	2.0	4.1	0.0	7.4
2000	79.2	5.0	4.3	1.5	10.1
2001	83.0	5.5	6.1	0.5	5.0
Adjusted	81.5	5.1	5.1	0.4	7.8

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

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

1999 Brood Releases

A study was begun in 1994 to determine if acclimation prior to release could be used to increase harvest of hatchery spring chinook salmon in the lower Willamette River. We used McKenzie River stock in the study because of concerns about straying of other stocks into the McKenzie, a stronghold for wild spring chinook salmon. The evaluation of straying was an important part of the study. Fish were acclimated in net pens and compared to fish trucked directly from the hatchery. Control groups were released into the McKenzie River from McKenzie Hatchery. The study was originally planned for 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. Releases from 1992–1998 broods are described in Lindsay et al. (1997), Lindsay et al. (1998), Schroeder et al. (1999), and Lindsay et al. (2000). Table 10 shows releases of the 1999 brood spring chinook. The types of experimental groups released in all brood years are summarized in **APPENDIX D**.

Adult Recovery of 1992–1995 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 below Willamette Falls when they returned. Most of the sport fishery for spring chinook salmon in the Willamette River occurs below Willamette Falls. Creel surveys in the lower Willamette and Clackamas rivers are used to expand the number of coded wire tags recovered in the fishery. Although some catch of spring chinook salmon occurs above Willamette Falls, the fisheries generally are not surveyed. Based on salmon catch card records, the fishery above Willamette Falls accounted for 25% of the mean annual catch in the Willamette River basin, 1990-1996 (Foster 1997). Most coded wire recoveries above the falls come from hatcheries, traps at dams, and spawning ground surveys. Adult recoveries from 1992 through 1995 broods are reported in Tables 11–14. Data for 1992–1994 broods are largely complete; data for 1995 brood are incomplete.

Table 10. Releases of spring chinook salmon into the lower Clackamas and Willamette rivers to evaluate acclimation in net pens, 1999 brood.

Stock	Tag code	Treatment	Location of release	Number AD+CWT	Fish/lb	Length (mm)	Days Accli-mated	Release date
McKenzie	093135	Acclimate	Mult. Channel	24,691	8.6	164.3	21	11/7/00
McKenzie	093136	Acclimate	Mult. Channel	26,402	8.4	165.6	21	11/7/00
McKenzie	093137	Direct	Mult. Channel	31,734	8.2	146.6	--	11/7/00
McKenzie	093138	Direct	Mult. Channel	30,573	7.9	158.4	--	11/7/00
McKenzie	093141	Acclimate	Clack. Cove	39,320	11.2	153.9	21	3/07/01
McKenzie	093142	Acclimate	Clack. Cove	36,740	10.4	156.5	21	3/07/01
McKenzie	093143	Direct	Clack. Cove	38,336	9.5	152.7	--	3/07/01
McKenzie	093144	Direct	Clack. Cove	38,895	9.6	152.8	--	3/07/01
McKenzie	093145	Direct	Clack. River	35,849	9.3	158.9	--	3/06/01
McKenzie	093146	Direct	Clack. River	38,740	9.7	158.3	--	3/06/01
McKenzie	093139	Direct	Mult. Channel	37,891	9.1	153.8	--	3/08/01
McKenzie	093140	Direct	Mult. Channel	38,233	9.4	152.2	--	3/08/01
McKenzie	093147	Control	McK. Hatch.	32,893	9.5	155.1	--	3/07/01
McKenzie	093148	Control	McK. Hatch.	32,778	9.0	151.8	--	3/07/01

Several tentative conclusions can be reach based on tag recoveries reported to date. First, smolt releases into the lower Willamette River did not increase sport catch. Sport catch below the falls of controls released from McKenzie Hatchery was equal to or higher than catch of fish from acclimated or direct groups released into the lower main-stem Willamette. Secondly, fish released into the lower Willamette River tended to stray. The highest straying was between the Clackamas and McKenzie rivers, but some fish were found in most other tributaries as well. Third, based on hatchery recoveries, fish released into Clackamette Cove returned mainly to the Clackamas River. Finally, in the main-stem Willamette, acclimated groups survived better than direct groups. There were no clear differences in survival between acclimated and direct groups released into Clackamette Cove, although data to date are limited.

Table 11. Recovery of 1992 brood spring chinook salmon from the net pen evaluation in the lower Willamette basin. Numbers were adjusted to a standard release of 100,000 smolts. Tag recoveries were obtained from databases of the Pacific States Marine Fisheries Commission, October 2001.

		Willamette River			
		Fall release		Spring release	
Recovery location	McKenzie control	Accli-mated	Direct	Accli-mated	Direct
Fisheries:					
Ocean	13	--	--	20	0
Columbia River	2	--	--	0	0
Willamette below the falls	25	--	--	3	0
(% in Clackamas River)	(8)	--	--	(0)	--
Hatcheries:					
McKenzie	185	--	--	10	5
Clackamas	1	--	--	12	0
Other	1	--	--	2	0
Spawning areas:					
McKenzie River	3	--	--	0	0
Clackamas River	0	--	--	0	0
Other	0	--	--	0	0
Leaburg Dam	7	--	--	0	0
Misc. Willamette[a]	2	--	--	0	0

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

Table 12. Recovery of 1993 brood spring chinook salmon from the net pen evaluation in the lower Willamette basin. Numbers were adjusted to a standard release of 100,000 smolts. Tag recoveries were obtained from databases of the Pacific States Marine Fisheries Commission, October 2001.

		Willamette River			
		Fall release		Spring release	
Recovery location	McKenzie control	Accli-mated	Direct	Accli-mated	Direct
Fisheries:					
Ocean	16	41	3	5	1
Columbia River	1	1	2	3	0
Willamette below the falls	15	16	14	16	0
(% in Clackamas River)	(33)	(62)	(36)	(75)	--
Hatcheries:					
McKenzie	149	57	8	13	8
Clackamas	1	32	5	8	2
Other	0	5	1	2	1
Spawning areas:					
McKenzie River	4	2	1	0	0
Clackamas River	0	2	0	0	0
Other	0	0	0	0	0
Leaburg Dam	7	5	2	2	1

Table 13. Recovery of 1994 brood spring chinook salmon from the net pen evaluation in the lower Willamette basin. Clackamas stock was used for all groups except the control, which was McKenzie stock. Numbers were adjusted to a standard release of 100,000 smolts. Tag recoveries were obtained from databases of the Pacific States Marine Fisheries Commission, October 2001.

		Willamette River fall release		Clackamas River spring release	
Recovery location	McKenzie control	Accli-mated	Direct	Cove acclimated	Cove direct
Fisheries:					
Ocean	0	47	0	0	5
Columbia River	0	5	0	1	0
Willamette below the falls	20	7	0	4	5
(% in Clackamas River)	(0)	(0)	--	(100)	(0)
Hatcheries:					
McKenzie	144	24	8	0	0
Clackamas	0	37	3	14	15
Other	0	10	2	0	1
Spawning areas:					
McKenzie River	4	3	2	0	1
Clackamas River	0	3	0	0	3
Other	0	2	0	0	0
Leaburg Dam	8	2	0	0	0
Misc. Willamette[a]	0	4	0	0	0

[a] *Includes dead fish found immediately below Willamette Falls and fish sampled in Willamette Falls fishway.*

Table 14. Recovery of 1995 brood spring chinook salmon from the net pen evaluation in the lower Willamette basin. Numbers were adjusted to a standard release of 100,000 smolts. Tag recoveries are from ODFW database (August 2000), except for ocean recoveries which are from the Pacific States Marine Fisheries Commission database (October 2001). Data are preliminary.

		Multnomah Channel		Clackamas River				
		Spring release		Fall release			Spring release	
Recovery location	McKenzie control	Accli-mated	Direct	Cove-acclimated	Cove-direct	River-direct	Cove-acclimated	Cove-direct
Fisheries:								
Ocean	20	--	7	10	10	15	4	0
Columbia River	1	--	0	3	2	0	0	0
Willamette below the falls	19	--	3	19	24	22	13	0
(% in Clackamas River)	(0)	--	(0)	(26)	(38)	(32)	(15)	--
Hatcheries:								
McKenzie	124	--	9	2	3	29	0	0
Clackamas	0	--	0	14	34	25	14	5
Other	0	--	0	0	10	5	0	0
Spawning areas:								
McKenzie	2	--	0	0	0	0	0	0
Clackamas	0	--	0	0	0	0	0	0
Other	0	--	0		0	0	0	0
Leaburg Dam	22	--	2	0	0	0	0	0

TASK 4.1– MIGRATION TIMING OF WILD JUVENILE SPRING CHINOOK SALMON

We started field work in 1999–2000 under Objective 4 of our project study plan (**APPENDIX A**). Information collected under Objective 4 will allow managers to better understand spatial and temporal use of habitat by juvenile wild spring chinook in the Willamette basin and to better protect existing natural production areas. Initial work was begun on wild chinook in the McKenzie River. Three life history types of wild chinook were defined at Leaburg Dam on the McKenzie: age 0 fry that migrate in late winter through early spring, age 0 fingerlings that migrate in fall, and yearling smolts that migrate in early spring. Initial work has concentrated on determining juvenile migration timing of these three life history stages below Leaburg Dam in the McKenzie and Willamette rivers.

Methods

We used PIT tags (Prentice et al. 1990a, 1990b) to monitor migration of juvenile spring chinook salmon in the McKenzie and Willamette rivers. Age 0 juvenile chinook salmon migrating in fall 2000 were collected in a bypass trap at Leaburg Dam. Yearling smolts migrating in spring 2001 were collected with a rotary screw trap installed in the Leaburg Dam bypass flume. The bypass trap could not be used to collect yearlings because fry, which migrate past Leaburg Dam at the same time as yearlings, are impinged on diversion screens in Leaburg Canal when the bypass trap is operated. Fry were collected with beach seines in July and August because they were too small to tag when they migrated past Leaburg Dam in February–April. We confined our sampling to the lower McKenzie and upper Willamette rivers downstream of spawning reaches to insure our sample consisted of fish that had migrated. We also tagged a sample of age 0 hatchery fish that were released in the fall from McKenzie Hatchery. We injected fish with 134.2 kHz tags, and used a tag detector (Destron-Fearing® FS2001F), a laptop computer, and a computer program developed by Pacific States Marine Fisheries Commission (PSMFC) to enter data. All tagging data were loaded into the PSMFC PIT tag database (PTAGIS).

We used screw traps at the mouth of the McKenzie River (RM 175) and below Harrisburg (RM 156) to capture juvenile chinook salmon and scan them for PIT tags. Migrating juvenile chinook salmon were also scanned with a tag detector (Destron-Fearing® FS1001) in the bypass system at Portland General Electric Company's (PGE) Sullivan Plant at Willamette Falls. Only a portion of the juvenile chinook migrating past Willamette Falls uses the bypass system (Royer et al. 2001). Additional tags were detected and reported by the National Marine Fisheries Service during their juvenile salmonid studies in the Columbia River estuary (Ledgerwood et al. 2000).

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

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

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

Results

During 2000–2001 migrations we tagged almost 5,600 juvenile wild spring chinook salmon in the McKenzie and Willamette rivers and 1,000 hatchery fish from McKenzie Hatchery (Table 15). In addition, we tagged over 2,800 age 0 wild chinook salmon in the lower McKenzie and upper Willamette rivers in summer 2001 (Table 16). These fish will be recaptured as migrants in the next report period (2001–2002).

Only fish that were PIT-tagged in 2000 and spring 2001 migrated during the report period. Most of these fish were detected at the Sullivan Plant at Willamette Falls (Table 15). The detection of juvenile chinook salmon tagged at Leaburg Dam in the fall increased from 1% in 1999–2000 to 7% in 2000–2001. The detection of fish tagged at McKenzie Hatchery increased from 4% in 1999–2000 to 12% in 2000–2001. Low river flow in 2000–2001 likely increased the percentage of juveniles that migrated through the interrogator at the Sullivan Plant. In addition, the passive interrogator at Willamette Falls was operational almost 100% of the time in 2000–2001 compared to 67% of the time in 1999–2000 (Lindsay et al. 2000).

Wild spring chinook salmon tagged as age 0 fish in summer and fall generally migrated past Willamette Falls the following spring, with peak migration in March (Figure 3). In contrast, the migration of hatchery fish released in fall peaked at Willamette Falls shortly after release (Figure 3). However, over 20% of hatchery fish released in fall 2000 were detected at Willamette Falls after January, whereas no hatchery fish released in fall 1999 were detected after January. The protracted migration of hatchery fish in 2000–2001 may have been because of low flow in the Willamette River. The mean monthly flow (at Salem) of the Willamette River from October through May was 50% lower in 2000–2001 than in 1999–2000. Flow in 1999–2000 was typical of the 35-year average (1965–2000). Of the wild chinook salmon that were tagged in fall 2000 at Leaburg Dam, 85% were detected at Willamette Falls after January, which is similar to the detection of wild fish tagged in fall 1999 (90%). However, the detector at Willamette Falls was inoperable much of December 1999 and January 2000. The peak migration at Willamette Falls of chinook salmon smolts tagged in the spring was in May (Figure 3). Although the migration of wild smolts was relatively rapid, their median travel time was almost twice that of the hatchery fish released in the fall (Table 15).

Table 15. Detection of juvenile wild and hatchery spring chinook salmon given PIT tags and released, 2000–2001. Tags were detected at the PGE Sullivan Plant at Willamette Falls unless noted.

	Number detected by tagging location and release dates (number tagged)				
	Leaburg Dam	Leaburg Dam	McKenzie River	Willamette River	McKenzie Hatchery
	Oct 24 –Nov 17, 2000 (3000)	Mar 9 –Apr 13, 2001 (934)	Jul 31–Sep 11, 2000 (650)	Jul 25 –Sep 7, 2000 (796)	Nov 10, 2000 (1000)
Month tag detected					
October[a]	0	--	0	1	--
November	14[b]	--	1	0	54[b]
December	16	--	3	0	38
January	2	--	0	0	1
February	38	--	5	1	4
March	80	2	12	3	16
April	40[c]	28[d]	3	1	6
May	19[d]	105[e]	0	0	0
June	0	3	0	0	0
Detection rate at Willamette Falls (%)	6.9	14.1	3.7	0.8	11.7
95% CI	6.0–7.8	11.9–16.4	2.3–5.1	0.2–1.3	9.7–13.7
Median days to Willamette Falls	129	46	191	215	25
Mean length (mm) at time of tagging for—					
Fish released	111.1	103.6	109.1	113.7	161.7
Fish detected	115.4	106.1	109.9	115.0	165.7

[a] *Sullivan Plant tag detector operated for 9 days October 2–20, and continuously starting October 26.*
[b] *Includes three fish caught in McKenzie screw trap (RM 175): one tagged at Leaburg Dam and two tagged at McKenzie Hatchery.*
[c] *Does not include one fish that was previously captured in November in the McKenzie screw trap and one fish detected in the Columbia River estuary (RM 47) that was previously detected at Willamette Falls.*
[d] *Includes one fish detected in Columbia River estuary.*
[e] *Includes five fish detected in Columbia River estuary; excludes one fish detected in Columbia River estuary that was previously detected at Willamette Falls.*

Table 16. Number of wild spring chinook salmon (age 0) that were seined, PIT-tagged, and released in the McKenzie River below Hendricks Bridge (RM 21) and in the Willamette River, July–September 2000 and July–August 2001.

River	Number tagged		Mean length (mm)	
	2000[a]	2001	2000	2001
McKenzie	650	1897	109.1	94.8
Willamette	796	937[b]	113.7	94.4

[a] *An additional 67 and 136 hatchery fish were seined and tagged in the McKenzie and Willamette rivers, respectively.*
[b] *Does not include four hatchery fish.*

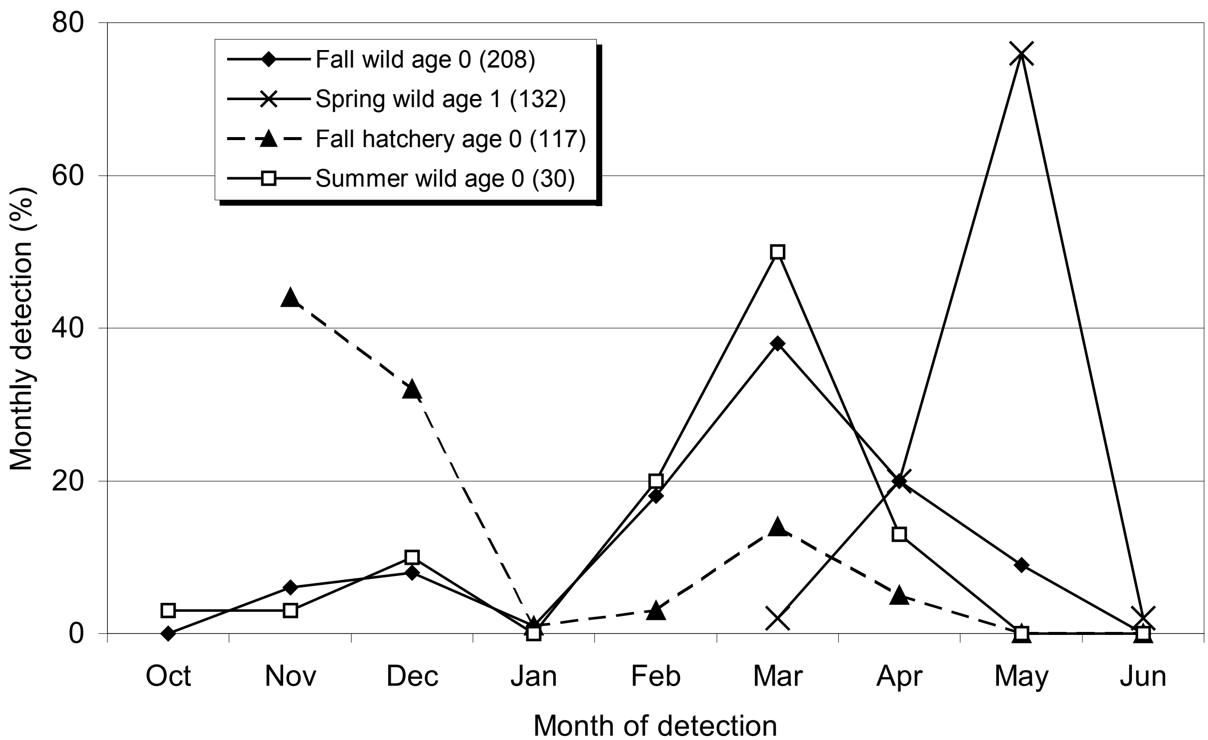

Figure 3. Migration timing of juvenile spring chinook salmon past Willamette Falls, 2000–2001. Based on detection of fish given PIT tags in the McKenzie and upper Willamette rivers. The number of detected tags is given in parentheses in the legend.

The mean fork length of tagged juvenile chinook salmon that were later detected was generally larger than the mean fork length of all fish tagged (Table 15). Differences between the mean length of detected fish and the mean length of all tagged fish were significant (*P* <0.05) for fish tagged at Leaburg Dam and at McKenzie Hatchery. Within tag groups, larger fish generally migrated faster than smaller fish (Figure 4).

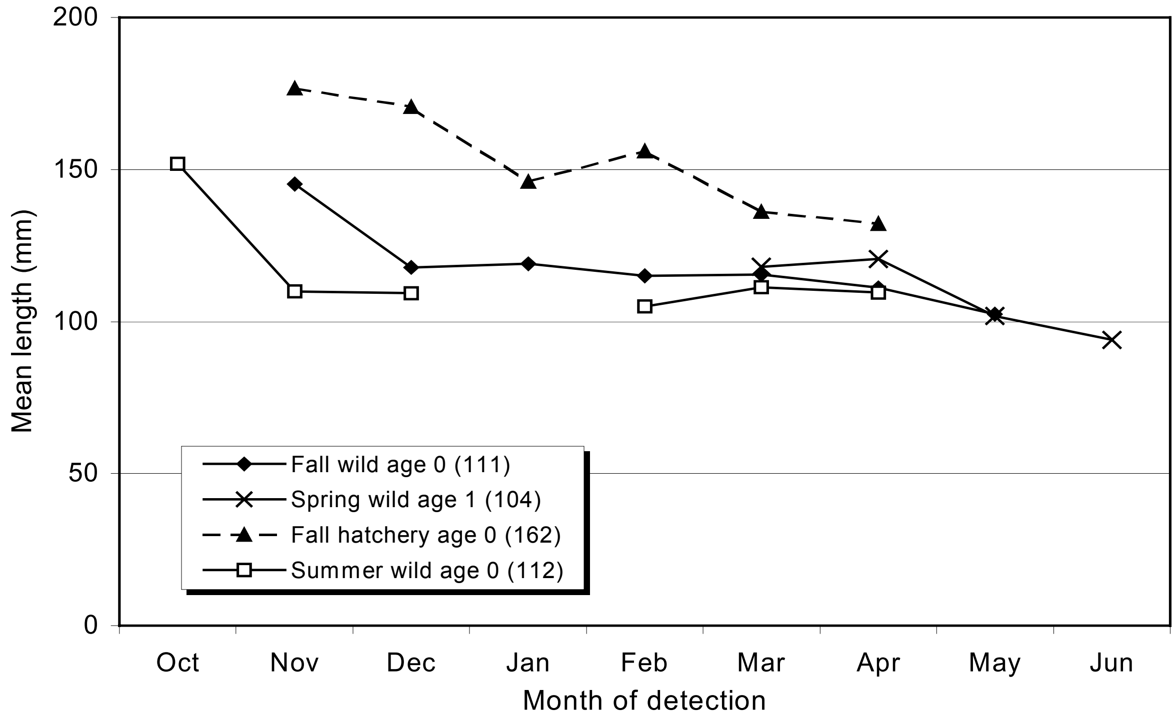

Figure 4. Mean lengths (measured at time of tagging) by month of PIT-tagged juvenile chinook salmon that were detected, 2000–2001. The mean length of all fish tagged by group is shown in parentheses in the legend.

Screw traps were operated almost continuously from October through May in the McKenzie and Willamette rivers, but few tagged chinook salmon were recovered (**Appendix E**), similar to results in 2000. Because of the low catch, we will not operate these traps in the 2001–2002 migration period.

Age 0 spring chinook salmon were found throughout the lower McKenzie and upper Willamette rivers. In the Willamette River, 95% of the chinook salmon were caught in the area from Harrisburg to the McKenzie River mouth where our effort was concentrated. We averaged 6.1 fish/seine set above Harrisburg and 1.4 fish/set below Harrisburg. By comparison, the catch of spring chinook salmon in the McKenzie River averaged 10.9 fish/set. During our seining season, we recaptured about 3% of the tagged fish; 91% of these were recaptured in the same sample site as they were tagged 6–15 days earlier. These results are similar to what we observed in 2000.

The mean length of juvenile spring chinook salmon in the Willamette River increased 5.5 mm from the first half of the sampling season to the second half of the season (*P*<0.01), but remained the same in the McKenzie River (Figure 5). The overall mean length of tagged fish was similar in both rivers (94–95 mm). Wild spring chinook salmon captured in late July and early August were smaller in 2001 than in 2000 by 12 mm in the McKenzie River (*P* < 0.01, 95 and 107 mm) and by 3 mm in the Willamette River (*P* = 0.36, 98 and 101 mm).

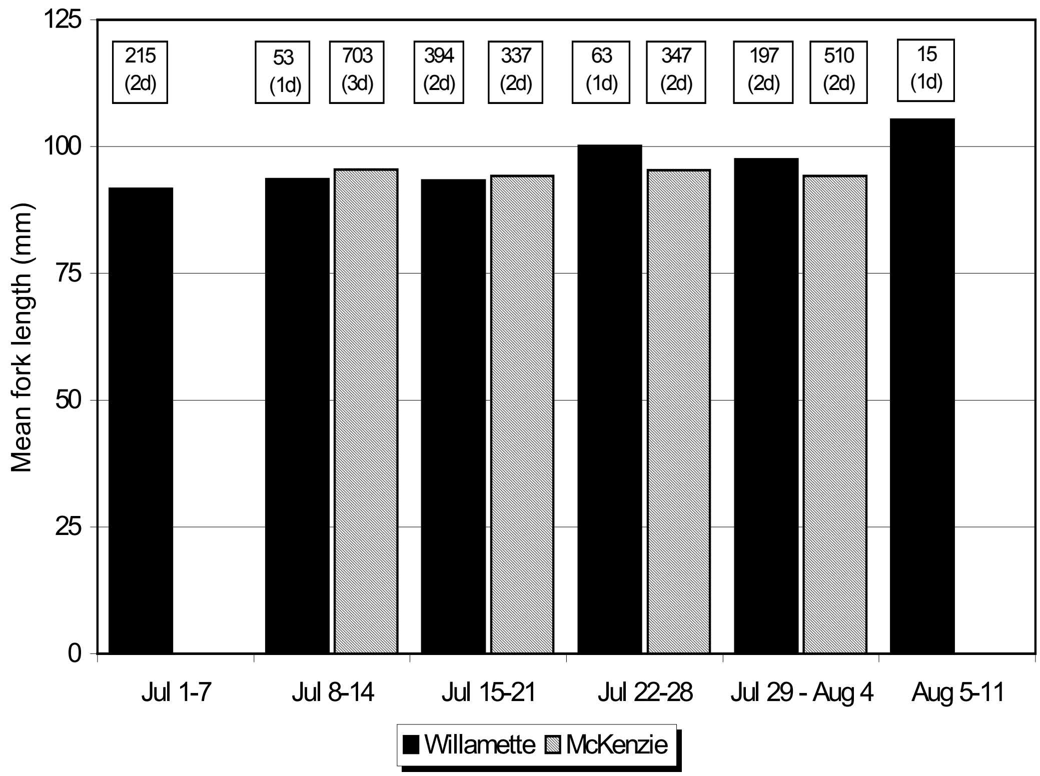

Figure 5. Mean weekly fork length of juvenile spring chinook salmon that were seined in the Willamette and McKenzie rivers over a six-week period in July and August, 2001. Data are for wild fish only (no adipose clips). Numbers in boxes denote sample size and number of sample days in each week.

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APPENDIX A

Schematic of Willamette Spring Chinook Salmon Study Plan

MANAGEMENT GOAL: A management strategy for spring chinook salmon in the Willamette and Sandy basins that (1) protects the genetic integrity of natural populations, and (2) maintains sport and commercial fisheries and the programs that support them.

STUDY PLAN OVERVIEW
(see proposal for details)

To Achieve this Goal, R&D will Help Managers:

OBJ. 1

Determine the numerical status of existing natural populations and develop methods for monitoring that status. Determine if these populations belong to one or more gene conservation groups.

- **1.1.** Determine if Sandy and Clackamas ChS belong to the same gene conservation group as ChS above the falls
- **1.2.** Estimate the proportion of wild fish in spawning populations
- **1.3.** Develop annual indexes for monitoring natural spawner abundance of ChS
- **1.4.** Establish escapement goals for natural production in Willamette subbasins and in the Sandy

OBJ. 2

Decrease mortality of wild fish in fisheries by determining feasibility of catch and release sport fisheries and by exploring options for reducing mortality in commericial fisheries.

- **2.1.** Estimate sport angling mortality of caught and released fish
- **2.2.** Estimate mortality that would occur from finclipping hatchery fish so that anglers could tell hatchery from wild
- **2.3.** Evaluate other mass marking techniques so anglers can identify hatchery adults in sport fisheries
- **2.4.** Explore options with Salmon Program Mgr. and Columbia River Mgt for reducing mortality of wild fish in commericial fisheries

OBJ. 3

Reduce the risk that large hatchery programs pose for natural populations by developing ways of decreasing interactions between wild and hatchery in streams and by determining need for more wild fish in hatchery broodstocks

- **3.1.** Evaluate fishery contribution and straying from netpen releases below the falls
- **3.2.** Determine if hatchery fish released in the fall overwinter, potentially competing with wild ChS
- **3.3.** Explore options for trapping hatchery ChS above or near traditional fisheries but below wild spawning areas
- **3.4.** Determine need and look at ways of incorporating wild fish into hatchery broodstock
- **3.5.** Look at overlap of spawning between fall and ChS

OBJ. 4

Protect existing natural production areas by defining temporal and spatial use patterns by life stages of ChS and identify the habitat/environmental attributes conducive to that use.

- **4.1.** Document distribution of spawning and rearing, timing of emergence and migration in basins used by ChS
- **4.2.** Identify ChS habitat & environmental attributes
- **4.3.** Identify life histories and the habitat/environment critical to maintaining them

OBJ. 5

Increase natural production by improving habitat in existing production areas and by re-establishing populations where they were found historically.

- **5.1.** Identify opportunities to re-establish populations and to improve habitat
- **5.2.** Estimate the potential of Willamette/Sandy (post-dam) to produce wild ChS
- **5.3.** Evaluate current efforts to re-establish ChS (S. Santiam above dams, Thomas, Crabtree, and Calapooia)

APPENDIX B

Otoliths Collected from Adult Spring Chinook Salmon in the McKenzie and North Santiam Rivers, 2001

River and Location	Group	Number
McKenzie:		
Carmen–Smith spawning channel	Not clipped	43
Ollalie Boat Ramp–McKenzie Bridge	Not clipped	116
McKenzie Bridge–Forest Glen	Not clipped	29
Forest Glen–Ben and Kay Doris Park	Not clipped	49
Helfrich–Leaburg Lake	Not clipped	2
Horse Creek	Not clipped	38
South Fork McKenzie below Cougar Reservoir	Not clipped	25
McKenzie Hatchery	AD clipped	50
McKenzie Hatchery	Not clipped	4
North Santiam:		
Minto–Fishermen's Bend	Not clipped	48
Fishermen's Bend–Mehama	Not clipped	10
Mehama–Stayton	Not clipped	7
Little North Santiam	Not clipped	3
Minto collection pond	AD clipped	50

APPENDIX C

Corrected Number of Spring Chinook Salmon Passing Upper and Lower Bennett Dams and the Stayton Power Canal Dam on the North Santiam River, 2000.[a]

	May	June	July	August	September	Total
Unmarked:						
Adult	171	567	180	23	106	1047
Jack	0	5	0	0	3	8
Fin-clipped:						
Adult	260	747	263	18	51	1339
Jack	2	45	28	7	11	93
Total	433	1364	471	48	171	2487

[a] *Corrected Table 6 from Lindsay et al. 2000 to account for all fin-clipped salmon. Passage counts were expanded for days the trap was not operated and were adjusted for a 4.8% fallback rate*. *Because numerous spring chinook salmon were observed holding below upper Bennett Dam during the days when the trap was operated, extra water was run through the ladder on weekend days when the trap was not operated to encourage fish passage and few fish were seen holding below Bennett Dam after the weekends (Bart DeBow, ODFW, personal communication). Our escapement estimate assumes equal passage on days when the trap is operated and on days when the trap is not operated. An increase in the numbers of fish passing the dam on days when the trap was not operated would underestimate escapement.*

APPENDIX D

Experimental Groups of Hatchery Spring Chinook Released to Evaluate Acclimation in Net Pens, 1992–1999 Brood Years.

Release locations are described in Lindsay et al. (1997). McKenzie River stock was used except where noted.

	Willamette River				Clackamas River		
	Lone Star (RM 14),	Willamette Park (RM 15),	Multnomah Channel (RM 20.5)		Clackamette Cove (RM 0.5)		Clackamette Park (RM 0.1),
Time of release	Acclimate	Direct	Acclimate	Direct	Acclimate	Direct	Direct
				1992			
Fall							
Spring	X	X					
				1993			
Fall	X	X					
Spring	X[a]	X					
				1994[b]			
Fall	X	X					
Spring					X	X[c]	
				1995			
Fall					X	X	X
Spring				X	X	X	
				1996			
Fall			X	X			
Spring				X	X	X	X
				1997[d]			
Fall			X	X			
Spring				X[e]	X	X	X[e]
				1998			
Fall			X	X			
Spring				X	X	X	X
				1999			
Fall			X	X			
Spring				X	X	X	X

[a] *Two of three groups acclimated for just 7 days because of nitrogen supersaturation.*
[b] *Clackamas stock used because of insufficient brood stock at McKenzie Hatchery.*
[c] *Bacterial kidney disease infection in this group.*
[d] *No replicated tag groups this year.*
[e] *One truckload (22,278) accidentally released at Clackamette Park instead of Multnomah Channel.*

APPENDIX E

Fish Species and Numbers Caught in Traps and Seines in the McKenzie and Willamette Rivers, 2001

Appendix Table E-1. Catch of various fish species by month in the screw trap at the mouth of the McKenzie River, October 1, 2000–May 17, 2001[a]. Catch was not expanded for capture efficiency or for unsampled days.

	2000			2001				
Species	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Chinook (unmarked)	2	50	29	9	10	23	2	1
Chinook (adipose)	1	348	6	0	203	74	3	0
Chinook fry	0	0	0	163	133	145	44	30
Steelhead (adipose)	0	0	0	0	0	0	26	31
Rainbow trout	2	3	13	1	1	2	3	0
Cutthroat trout	1	1	23	17	16	89	89	26
Trout (fry)	8	3	14	5	10	15	30	9
Mountain whitefish	2	1	4	0	0	0	0	1
Redside shiner	58	102	172	132	31	62	11	15
Northern pikeminnow	8	15	43	11	16	13	6	7
Peamouth	1	1	0	2	0	2	0	0
Chiselmouth	0	0	0	0	0	0	0	0
Largescale sucker	4	9	55	49	29	63	47	34
Dace	13	15	4	4	21	388	590	444
Lamprey (adult)	0	0	0	0	0	0	0	1
Lamprey (ammocete)	55	13	186	41	28	119	45	81
Sculpin	4	8	6	8	15	8	11	13
Sand roller	1	2	1	1	1	0	1	1
Stickleback	1	2	9	3	3	1	3	0
Bluegill	4	6	3	0	0	1	0	0
Largemouth bass	0	0	0	0	0	0	0	0

[a] *The trap was inoperable October 9, October 28–29, November 3, December 23–26, and March 16–18 because of debris.*

Appendix Table E-2. Catch of various fish species by month in the screw trap in the main-stem Willamette River, near Harrisburg, October 1, 2000–March 8, 2001[a]. Catch was not expanded for capture efficiency or for unsampled days.

	2000			2001	
Species	Oct	Nov	Dec	Jan	Feb
Chinook (unmarked)	1	25	48	1	5
Chinook (adipose)	2	179	13	1	200
Chinook fry	0	0	0	69	93
Rainbow trout	0	0	1	1	0
Cutthroat trout	0	0	1	0	0
Trout (fry)	0	0	3	0	0
Mountain whitefish	0	4	17	0	0
Redside shiner	270	460	727	174	135
Northern pikeminnow	35	26	73	29	35
Peamouth	1	6	41	18	21
Chiselmouth	1	16	48	7	3
Largescale sucker	17	76	164	82	47
Dace	60	25	4	7	24
Lamprey (ammocete)	92	95	230	75	63
Sculpin	8	9	3	8	8
Sand roller	0	0	1	0	0
Stickleback	0	0	0	0	0
Bluegill	0	0	1	0	0
Largemouth bass	1	0	1	0	0

[a] *Trap was inoperable November 17, December 15, December 23–26 because of debris, January 13 because of vandalism, and February 23, March 1–8 because of algae build-up.*

Appendix Table E-3. Catch with seines of various fish species in the McKenzie River below Hendricks Bridge and in the upper Willamette River, July 1–August 11, 2001.

	McKenzie		Willamette	
Species	Jul 1– 21	Jul 22–Aug 11	Jul 1– 21	Jul 22–Aug 11
Chinook (unmarked)	1081	876	693	304
Chinook (adipose)	0	0	3	1
Rainbow trout	653	561	775	438
Cutthroat trout	680	67	719	284
Trout (fry)	146	118	228	128
Mountain whitefish	114	8	288	60
Redside shiner	305	328	1814	2014
Northern pikeminnow	78	167	1555	5007
Peamouth	3	0	150	269
Chiselmouth	0	0	1	62
Largescale sucker	7	5	271	859
Dace	6	7	129	33
Lamprey	0	0	0	0
Sculpin	65	30	37	33
Sand roller	2	0	2	1
Stickleback	5	1	43	28
Bluegill	0	0	1	0
Smallmouth bass	0	0	0	0
Largemouth bass	0	0	0	11