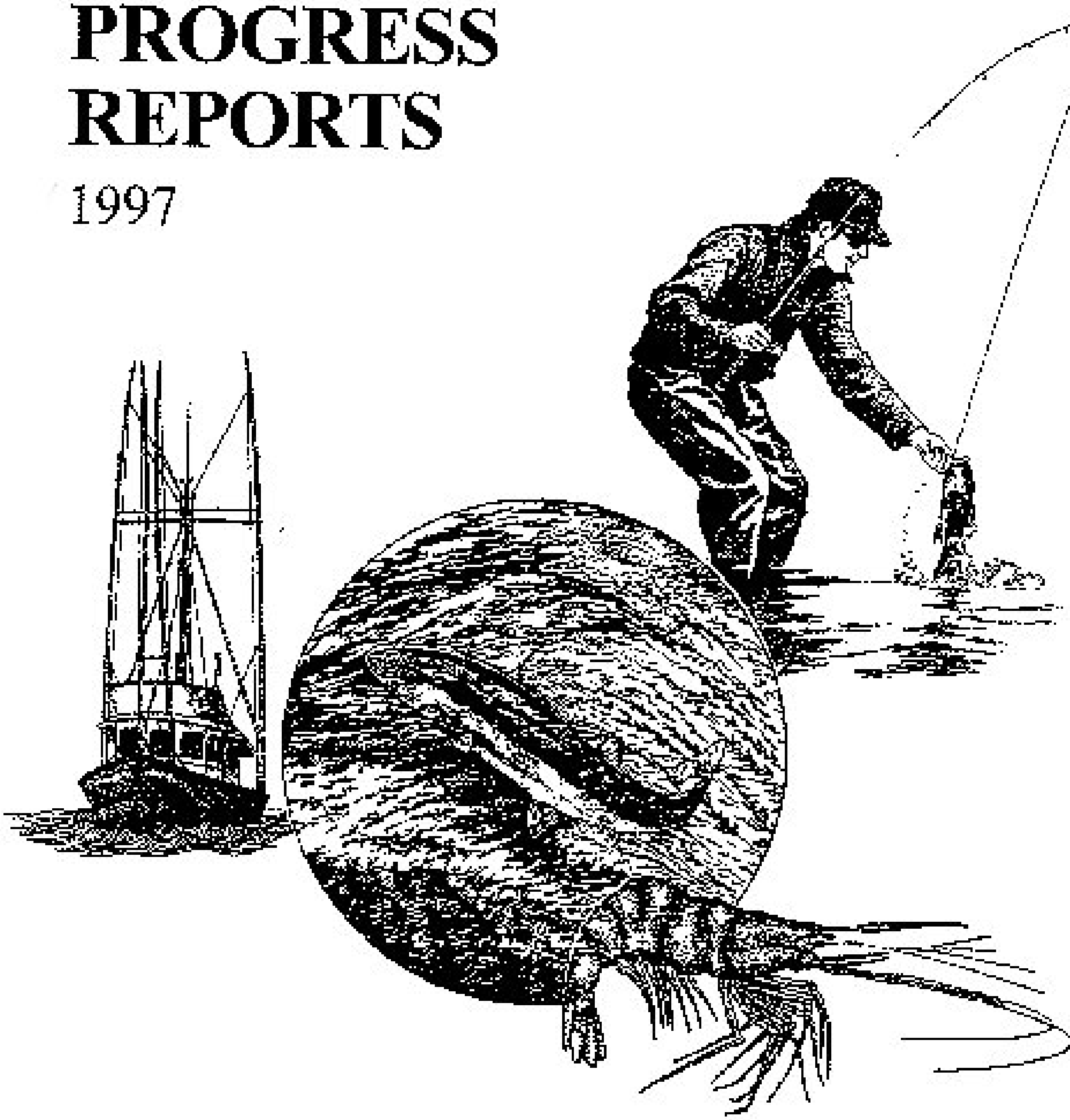
PROGRESS REPORTS

1997



FISH DIVISION

Oregon Department of Fish and Wildlife

Spring Chinook Salmon in the Willamette and Sandy Rivers

ANNUAL PROGRESS REPORT

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OREGON

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INTRODUCTION

The Willamette and Sandy rivers support intense spring chinook salmon (*Oncorhynchus tshawytscha*) recreational fisheries in the heart of Oregon's most populous region. These fisheries rely primarily on annual hatchery production of 5-8 million juveniles. Hatchery programs exist in the McKenzie, Middle Fork Willamette, North Santiam, Clackamas and Sandy basins mainly as mitigation for dams that blocked natural production areas. Natural spawning populations occur in the McKenzie, North Santiam, Clackamas, and Sandy basins and a few smaller tributaries upstream of Willamette Falls.

The Oregon Fish and Wildlife Commission has adopted a wild fish management policy to reduce adverse impacts of hatchery programs on wild native stocks (ODFW 1992). 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 production, or on strategies for reducing risks that large hatchery programs pose for wild salmon populations. This study is being implemented to fill these information needs. A schematic of the study plan is presented in **Appendix A**.

Work in 1997 was conducted in the mainstem Willamette River at Willamette Falls, and in the McKenzie, North Santiam, Clackamas, and Sandy river basins. Basin descriptions and background information on management and fish runs can be found in subbasin plans developed by the Oregon Department of Fish and Wildlife (ODFW 1988, ODFW 1992a, ODFW 1992b, and ODFW 1996). Task headings below cross reference the study plan outlined in **Appendix A**. This report covers work completed in 1997 including some analyses of data collected in 1996.

TASK 1.1-- GENETIC SAMPLING

Samples of naturally produced spring chinook salmon in the Clackamas, Sandy, and McKenzie rivers were collected in 1996 and 1997 for genetic analysis (Table 1). Fork lengths were measured (except for McKenzie fish) and scales taken from each fish collected. The fish were then individually wrapped in plastic and bagged, noting the sample site and date. Bagged fish were put on dry ice for transport to a freezer (-80° F) where they were stored until we obtained about 80 fish. Samples were then delivered to the National Marine Fisheries Service (NMFS) in Port Orchard, Washington for analysis by methods described by Aebersold et al. (1987) and for inclusion in NMFS's regional database on chinook salmon. Our primary interest is to determine if genetic differences exist among natural and hatchery spring chinook salmon populations in the Willamette and Sandy basins. Hatchery spring chinook salmon collected at Dexter, McKenzie, Marion Forks, and Clackamas hatcheries from 1982 to 1990 have been previously analyzed by NMFS.

Only the Clackamas sample of wild fish was analyzed by NMFS during the report period. They found that these fish were genetically similar to populations of hatchery spring chinook in the Willamette basin (personal communication, David J. Teel, NMFS, Port Orchard, Washington). However, Willamette basin hatchery spring chinook salmon, as a group, are genetically unique relative to other chinook populations in the Columbia basin (personal communication, David J. Teel, NMFS, Port Orchard, Washington).

Table 1. Genetic samples of spring chinook salmon collected from the Sandy, Clackamas, and McKenzie rivers, 1996-97.

	Sandy	Clackamas	McKenzie
Date sampled:	Aug 1997	Nov, Dec 1996; Apr, May 1997	Oct 1997
Location:	Salmon River	North Fork Dam	Leaburg Dam
Method:	Seine	Trap	Trap
Number:	93	81	102
Mean fork length (mm):	81	131	Fingerling

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

Scales

We analyzed scales of spring chinook salmon collected in 1996 in the McKenzie River to determine if wild fish could be separated from hatchery fish based on scale patterns. We also determined the age composition of the fish (**APPENDIX B**). Borgerson and Bowden (1993) have successively used scale analysis to identify the rearing origin of spring chinook salmon from the Snake River.

The first step in our analysis was to obtain reference collections of hatchery and of wild fish. Because of the widespread use of coded wire tags in hatcheries, we could easily obtain reference collections of hatchery fish. Reference collections of known wild fish were more difficult because many unmarked hatchery fish are released in the Willamette basin and they cannot be separated from wild fish. However, all fish released from McKenzie Hatchery in 1994 (yearling smolts, 1992 brood year) were fin clipped. Assuming straying is minimal, unmarked age-4 adults that returned to the McKenzie in 1996 should have been wild fish. Our original plan was to use these reference collections to develop a statistical function to separate unmarked hatchery fish from wild fish.

Methods

Scales were collected at McKenzie Hatchery, Leaburg Dam and on spawning grounds in the McKenzie River in 1996. We mounted scales on gummed cards and then made acetate impressions of the card. We made visual interpretations of scale patterns with a microfiche projector. Ages were assigned according to a visual count of annuli.

We initially aged all fish from scales without field data to avoid biasing our interpretations. Prior to aging the fish, we looked at a small number of reference scales from known age fish that were coded wire tagged at McKenzie Hatchery. While aging the fish we saw several distinct scale patterns on unmarked age-4 fish. Because all unmarked age-4 fish were assumed to be wild, we did not expect to see this much variation in scale patterns. Consequently, we re-read all the McKenzie scales and categorized each into one of four different pattern types. In addition, we read scales from a sample of tagged and unmarked fish from Dexter Pond on the Middle Fork Willamette River and also assigned them to pattern types. Because of its proximity to the McKenzie, spring chinook salmon from the Middle Fork stray into the McKenzie more than do other Willamette basin populations.

Results and Discussion

We identified four main patterns within the group of unmarked, age-4, returns to the McKenzie River (Table 2). The most common pattern (Pattern A) indicated a large size at ocean entrance with the freshwater annulus and ocean entrance superimposed as if the fish had migrated in the winter. Pattern B was much like we expected to see on wild fish that migrated to sea in spring as yearlings. Pattern C looked like the McKenzie Hatchery pattern with three distinct "checks" interspersed with strong, even growth. Pattern D indicated a yearling life history, small to medium size at ocean entrance, and slow, even growth throughout freshwater residence. This pattern appeared to be a hatchery pattern because of the evenness of growth throughout freshwater residence. However, the pattern lacked the three distinct checks observed on most McKenzie Hatchery scales so we also called this an unknown pattern.

Based on past scale reading experience, Pattern A was not a result of wild rearing. The pattern (large size at ocean entrance in winter) did not match that normally found in wild spring chinook salmon from basins outside the Willamette. To determine where these fish may have originated, we looked at scales from fish in the Middle Fork Willamette (Table 2).

Table 2. Scale patterns of age-4 spring chinook salmon in the McKenzie and Middle Fork Willamette rivers, 1996 run year.

	Percentage in each scale pattern category:				
Location/mark	A (Unknown)	B (Wild)	C (Hatchery)	D (Unknown)	Sample size
McKenzie River					
McK. Hatchery:					
Unmarked	60	16	21	3	68
Ad+CWT	0	0	89	11	45
Spawn grounds, unmarked	74	19[a]	7	0	27
Leaburg Dam, unmarked	72	13	10	5	86
Middle Fork Willamette River					
Dexter[b]:					
Unmarked	60	9	31	0	35
Ad+CWT[c]	92	0	8	0	13

[a] *Includes two fish that migrated to sea as sub-yearlings.*
[b] *Fish were hatched at Willamette Hatchery and transferred to Dexter Pond for release.*
[c] *Tag code 070253, a November 1993 release.*

We found a high incidence of Pattern A on tagged fish that returned to the Middle Fork Willamette River in 1996 from releases in November, 1993. Tagged fish represented 10.5% (26,000) of the total November 1993 releases. However, none of the tagged fish were recovered in the McKenzie River suggesting that few unmarked fish from the fall release strayed into the McKenzie. Because a November release explained the superimposed annulus and ocean entrance checks, we searched the Willamette basin records for other November releases. We found that 34,400 juveniles reared at McKenzie Hatchery, but transported to net pens in the lower Willamette River near Oregon City, were released unmarked in November of 1993. We suspect that some of these net-penned fish may have returned to the McKenzie River and contributed to the group of Pattern A fish. However, because of the small number released, it is unlikely that these fish accounted for the large percentage of Pattern A seen in the McKenzie. Other possibilities include returns or strays from unmarked fingerling releases (1992 brood) into Blue River Reservoir in the upper McKenzie, and Fall Creek and Lookout Point reservoirs in the Middle Fork Willamette. These fish tend to leave the reservoirs in the fall, although the number that do so is thought to be small. Finally, wild juvenile salmon migrate through the McKenzie River at all life stages. Consequently, scale patterns on returning wild adults may be more variable than we expected, particularly for those juveniles that rear in the lower McKenzie and upper Willamette rivers.

Our ability to obtain a reference collection of wild fish in the McKenzie River in 1996 was based on the assumption that unmarked age-4 adults in the river could be considered wild because all 1992 brood hatchery fish released at McKenzie Hatchery were marked. However, not all 1992 brood hatchery fish from McKenzie hatchery were marked. In addition, the variability of scale patterns on unmarked fish was high with the main pattern appearing to be a fall hatchery pattern. Because of these uncertainties, we concluded our reference collection for wild was inadequate and no statistical function could be developed to separate unmarked hatchery fish from wild fish based on scales.

Otoliths

Methods

Work in 1997 included analysis of otoliths from juvenile spring chinook salmon from the 1992-94 broods and collection of otoliths from adults. Water temperatures were manipulated at Marion Forks and McKenzie hatcheries to place a thermal mark on the otoliths of hatchery fish (Brothers 1990; Volk et al. 1990). Following experimental marking in the 1991 brood year, hatchery releases have been thermally marked since the 1992 brood year at Marion Forks Hatchery and since the 1993 brood year at McKenzie Hatchery (Table 3). Beginning with the 1997 brood, releases from Willamette and South Santiam hatcheries will also be thermally marked.

Table 3. Data on thermal marking of spring chinook salmon in Willamette River hatcheries and collection of reference samples.

Brood year	Stock	Size (mm)	Sample size	Treatment (hrs on/off)	Cycles	Temperature (°F)
1996	McKenzie	35-40	21	Chilled (24/72)	6	5-6
	N. Santiam	35-40	34	Heated (24/24)	4	10-12
1995	McKenzie	45-50	26	Chilled (24/72)	4	5-6
	N. Santiam	35-40	48	Heated (24/24)	4	11-14
1994	McKenzie	35-55	17	Chilled (24/72)	5	5-6
	N. Santiam	35-40	21	Heated[a]	a	2-9
	N. Santiam	120-145	19	Heated[a]	a	2-9
1993	McKenzie[b]	35-40	29	Heated (12/48)	8	4-6
	McKenzie[c]	35-40	31	Heated (12/48)	5	4
	McKenzie	35-40	30	Chilled (24/96)	4	3-6
	N. Santiam	No sample	--	Heated[d]	d	2-14
1992	N. Santiam	130-160	10	Heated[e]	e	5-9

[a] *Same treatment sampled twice; 9 days on/2 days off, 10 days on/3 days off, 20 days on.*
[b] *Marked at Marion Forks Hatchery.*
[c] *Held at Willamette Hatchery.*
[d] *2-20 days on heated water, with 1-2 days on unheated water for three groups; 12-13 days on heated water for two groups.*
[e] *Exposed to warm water for a 14-day period.*

Juvenile fish, collected from 1992-94 broods, were sent to the Washington Department of Fish and Wildlife for analysis in 1997 (Table 3). Wild juvenile fish from the McKenzie River collected from the 1990, 1991, 1995, and 1996 brood years were also sent to the lab as reference collections. Preparation and analysis of the otoliths were by methods described in Volk et al. 1990. Otoliths were examined with a compound microscope under 100x or

200x magnification to ascertain the presence or absence of thermal marks. Thermal marks were compared to temperature records and were evaluated for clarity.

Otoliths were collected from adult chinook salmon caught in the North Santiam, McKenzie, and Middle Fork Willamette rivers in 1997. In the North Santiam River, we collected otoliths and scales from adults in a sport fishery and from carcasses recovered on spawning grounds. In addition, we also collected otoliths from every third fish returning to the Minto collection facility that did not have an adipose fin clip and from every fish with an adipose fin clip.

In the McKenzie River we collected otoliths and scales from adult spring chinook salmon under 86 cm that had an adipose clip. Because thermal marking began with the 1993 brood year, we used length frequency data from previous McKenzie Hatchery returns to determine that most fish over 86 cm were older than 4 years old. In addition, otoliths were collected from AD+CWT fish that were trapped at Leaburg Dam and spawned at McKenzie Hatchery, and from carcasses in spawning surveys in the McKenzie River.

We also collected a random sample of adult spring chinook salmon with adipose clips at Willamette Hatchery to serve as a reference collection of hatchery fish that were not thermally marked. We will use these fish and the samples from the fish that should have been thermally marked to test the accuracy of the WDFW laboratory in identifying thermally marked otoliths.

Results and Discussion

Juveniles:

Analysis of the thermal marking conducted at Marion Forks and McKenzie hatcheries indicated limited success in placing an identifiable thermal mark on otoliths for the 1992-94 broods (Table 4). The analysis suggests several problems exist with the marking procedures that were used in the 1992-94 brood years. At Marion Forks Hatchery, temperature differentials of 8-12° F were occasionally achieved, but the fish were generally exposed to long periods of warm water rather than to short, alternating cycles of warm and cold water that is necessary to achieve good thermal marks. At McKenzie Hatchery, the temperature differential was only 4-6° F, which achieved a moderate banding pattern. However, natural banding from daily fluctuations in stream temperatures masks the clarity of this pattern. Detecting this pattern in the otoliths of returning adults may be difficult. We will send reference collections from the 1995-97 broods to the WDFW lab in early 1998 to assess the quality of thermal marks on these broods and to recommend changes in marking procedures, if necessary.

Table 4. Results of otolith analysis by Washington Department of Fish and Wildlife to detect thermal marks in juvenile spring chinook salmon from the 1992-94 brood years.

Brood year	Stock	Marking hatchery	Thermal marks?	Clarity
1992	N. Santiam	Marion Forks	No	--
1993	McKenzie	McKenzie	Yes	Fair
	McKenzie	Marion Forks	Yes	Good
	McKenzie	Willamette	No	--
	N. Santiam	Marion Forks	No sample	--
1994	McKenzie	McKenzie	Yes	Fair
	N. Santiam	Marion Forks	No	--

Although thermal marks can be created with temperature differentials of less than 8° F, extra time is required to prepare and analyze the otoliths, and recognizable patterns can still be difficult to identify (Grimm and Volk, 1997). In addition, natural daily fluctuations in water temperature during incubation produce a visual pattern in otoliths that can mimic or obscure the induced marking pattern. Use of many regularly spaced, twenty-four hour manipulations of temperature (e.g. eight 24 hour cold water events, each separated by two days of warm water) can be used to create a pattern that is discernable from the background pattern.

Grimm and Volk (1997) recommend three procedures to enhance the otolith marking at ODFW hatcheries: 1) provide two water sources with a temperature differential of 8-12° F, 2) schedule aggressive marking programs to compensate for effects of naturally fluctuating water temperature during incubation, and 3) create multiple thermal mark patterns as reported in Volk et al. 1994, each unique to the hatchery of rearing.

Adults:

Otoliths and scales were collected in 1997 from returning adults in the North Santiam, McKenzie, and Middle Fork Willamette rivers (Table 5). Because fall chinook salmon are present in the North Santiam River, we will use scales and coded wire tags to eliminate fall chinook from the otolith samples we collected. We recovered stray adults from the Middle Fork Willamette, from South Santiam, and from net-pen releases into the lower Willamette in the North Santiam River in 1997. Most of these hatchery strays were not thermally marked. In addition, returning North Santiam stock from the 1992 brood did not receive a good thermal mark on their otoliths, and questions remain about the mark on the 1993 brood. Because of these complications, we will not be able to use otoliths to separate hatchery from naturally produced fish that returned in 1997 in the North Santiam.

Table 5. Otoliths collected from adult spring chinook in several Willamette River streams, 1997.

Stream	Location	Number	Comments
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, every fish
McKenzie	Hatchery	209	AD+CWT, over 86 cm
	Leaburg Dam[a]	26	AD+CWT
	Spawning ground	50	AD+CWT and unmarked
Middle Fork Willamette	Hatchery	117	AD+CWT, random sample

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

Coded wire tags from adults collected in the McKenzie River will be used to determine which of our samples are from the 1993 brood year and from McKenzie Hatchery releases. Although thermal marking of the 1993 brood at McKenzie Hatchery was successful, McKenzie eggs that were transferred to Willamette Hatchery, then returned to McKenzie Hatchery for later release were not successfully marked (Table 4). These fish accounted for about 20% of the 1993 brood chinook released into the McKenzie River. In addition, return data showed some adults from Willamette Hatchery releases strayed into the McKenzie River in 1997 (*see* Table 9). Because spring chinook salmon reared at Willamette Hatchery did not have thermal marks, their otolith patterns will not be distinguishable from those of naturally produced fish. Because of these factors, we will be unable to use otoliths from the 1997 return year to separate hatchery fish from wild fish in the McKenzie River. However, we may be able to use some samples collected in 1997 to test the accuracy of the WDFW laboratory to identify marked otoliths.

TASK 1.3-- DISTRIBUTION AND ABUNDANCE OF NATURAL SPAWNERS

Methods

We documented the geographic distribution, timing, and magnitude of natural spawning of spring chinook salmon in the McKenzie, North Santiam, Clackamas, and Sandy basins in 1997. General methods used to survey these basins were reported in Grimes et al. 1996. Additional survey areas were added to all basins in 1997, except the McKenzie, after reviewing 1996 data and discussions with biologists from the U.S. Forest Service, Portland General Electric Company, and Oregon Department and Fish and Wildlife (ODFW). Further, "core" survey sections (those most heavily used in 1996) were identified for each basin. Redd counts from the core sections were used to determine peak spawning time. We surveyed most core sections each week through the spawning period. A survey cycle was the period of time required to survey all core sections in a basin. Sections other than core sections were surveyed from one to five times during the season. We attempted to begin surveys before spawning started and to continue surveys through the end of spawning except in the McKenzie River where more historical data on timing are available.

Data collected from salmon carcasses in 1997 were similar to that collected in 1996 (Grimes et al. 1996). However, because of the large number of carcasses collected in the Sandy in 1996, we reduced sampling in that basin in 1997 to every third carcass handled in September and every fifth carcass handled in October.

Survey protocol differed in the McKenzie River but was consistent with surveys conducted in 1990 and 1992. Every redd was counted during each survey, therefore, the total redd counts each week included redds counted during previous surveys. About 10 miles of the mainstem McKenzie River between Ollalie boat ramp (RM 80) and McKenzie River Trail boat ramp (RM 70) were surveyed 4 times. About 5 miles of the mainstem McKenzie River between

Leaburg Dam and Leaburg boat ramp were surveyed 5 times. We also surveyed about 4 miles of Gate Creek and the South Fork of Gate Creek, the standard sections on Lost Creek, and the Carmen spawning channel. Surveys began in early September and ended in early October. In addition, we conducted one aerial survey on the mainstem McKenzie River from Trail Bridge Dam to the mouth and on the South Fork McKenzie River below Cougar Dam on September 29. Specific redd sites were mapped on all drift surveys and the aerial survey. Because we recovered so few carcasses above Leaburg Dam in 1996, we trapped and removed AD-CWT fish from the ladder as they passed the dam in 1997 to increase the recovery rate of marked fish.

Results and Discussion

Comparison of Spawn Timing among Basins

Spawning began about the first week of September and ended by mid to late October in 1997 (Figure 1). Some spawning was observed as early as the last week in August and some new redds were observed as late as the last surveys on October 23. The progression of spawning was the same for the Clackamas and Sandy basins but was about 10 days earlier in the North Santiam basin (Figure 1). This is in contrast to the spawning time distribution observed in 1996 where the Clackamas and North Santiam were similar and the Sandy was a week later (Figure 1). Progression of spawning was similar between years in the Sandy and North Santiam but later in the Clackamas in 1997 (Table 6).

Table 6. Date when 50% of the redds were observed in the Clackamas, Sandy, and North Santiam basins, 1996 and 1997.

Basin	Date of 50% spawning 1996	1997
Clackamas	19-Sep	26-Sep
Sandy	25-Sep	23-Sep
N.Santiam	19-Sep	15-Sep

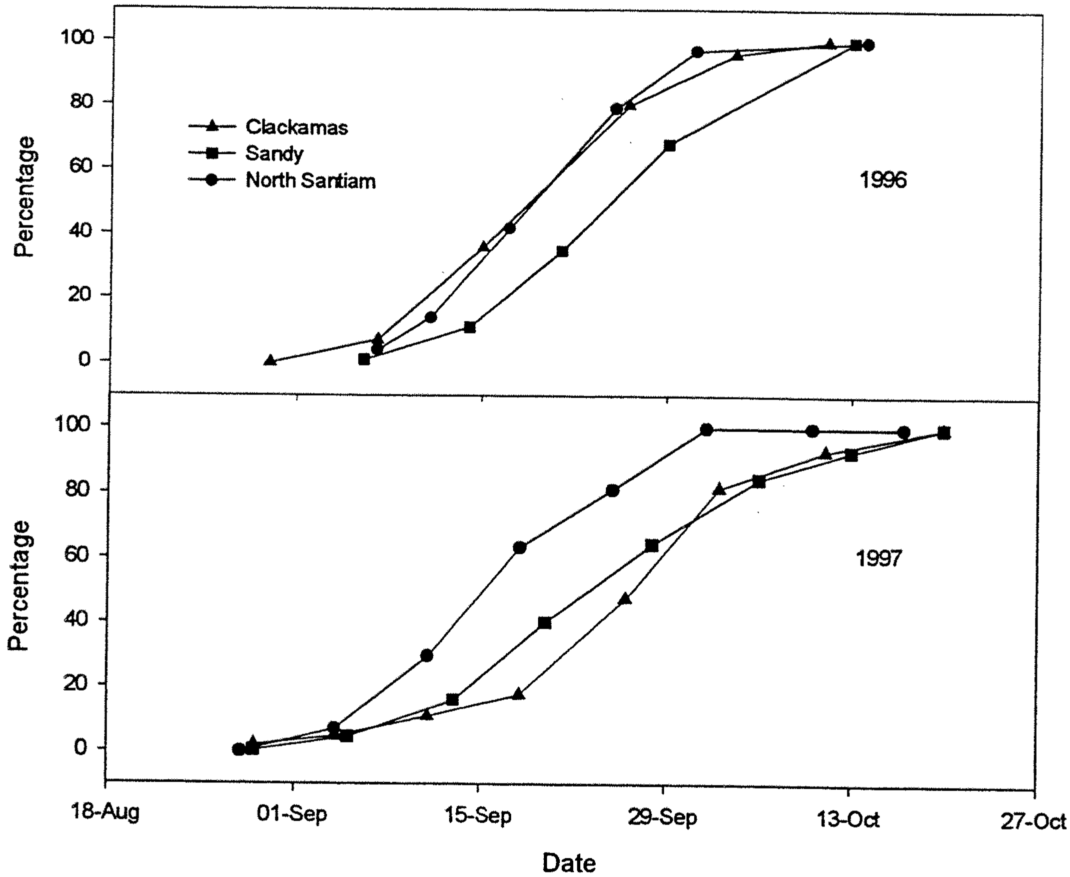

Figure 1. Progression of spawning of spring chinook salmon in the Clackamas, Sandy, and North Santiam rivers, 1996 and 1997. Data points represent the cumulative distribution of new redds observed and are plotted by the midpoint of the survey week.

Redd Visibility

The period of time a redd remained visible was investigated in the Clackamas, Sandy, and North Santiam basins in 1997. Beginning in late August, we marked two fresh redds during each survey until we had marked six to eight redds in each basin. We selected redds that were representative of the locations normally used by spring chinook salmon and that varied in sun exposure. Redds were identified with a unique number on flagging attached to adjacent streambank vegetation. We examined these marked redds on each subsequent survey and noted their condition and visibility. We noted the date when a redd might no longer be recognizable to a hypothetical observer on his first survey.

Clackamas River:

We marked seven redds in mainstem and side channel areas (Table 7). All the study redds remained distinguishable throughout the fall survey period as long as water conditions remained favorable. Even after several periods of rain, the redds remained visible after the water level and turbidity decreased. The superimposition of another redd prevented assessment at one marked site and this site was excluded from Table 7.

Sandy River:

We marked six redds in Salmon River, one in Still Creek, and one in Lost Creek (Table 7). All the redds remained distinguishable throughout the fall survey period under favorable water conditions. We noted the presence of filamentous green algae attached to the substrate in the Salmon River downstream of Bridge Street bridge and in Still Creek downstream of Cool Creek during October. Although there was increased algae growth in these areas, redds were still distinguishable. The concentrated development (summer homes, residences, golf course) along the streambanks and adjacent upslope areas of those two sections appeared to be related to the presence of algae.

North Santiam River:

We marked seven redds in mainstem areas (Table 7). Five of seven redds were visible until higher water levels from releases from Detroit Dam upstream obscured them. Unlike the Clackamas and Sandy rivers with no storage reservoirs above survey areas, water levels in the North Santiam never dropped again after increasing during the later part of September. Significant algal growth made recognition difficult on five of the seven redds after 29 September. Redd superimposition occurred on three of the redds and impacted the assessment.

Spawning Ground Surveys in the McKenzie River Basin

Peak counts of redds below Leaburg Dam in drift boat surveys occurred the last week of September (Table 8). This coincides with the historical timing of aerial surveys. Counts by helicopter were much lower in the areas immediately downstream of the dam where superimposition of redds is high. Counts from the Greenwood boat ramp to the Leaburg ramp were similar between aerial and ground surveys, but redd locations differed. Either different redds were counted in the helicopter survey than in the boat survey or there were mapping discrepancies. Counts declined in late September and early

Table 7. Redd visibility in the Clackamas, Sandy, and North Santiam basins, 1997.

Basin and river section	Sun/shade	Date redd marked	Date redd obscured[a]
Clackamas:			
Big Bottom	Shade	26 Aug	--
Big Bottom	Shade	2 Sep	--
Below Roaring R	Sun	2 Sep	--
Big Bottom	Sun	8 Sep	--
Below 4650 bridge	Shade	8 Sep	--
Below Collawash	Sun	23 Sep[b]	--
Sandy:			
Still Creek (Rd 20 bridge)	Sun	28 Aug	--
Flyfishing bridge	Sun	4 Sep	--
Lost Creek	Sun	10 Sep	--
Below 2618 bridge	Shade	10 Sep	--
Middle Salmon (forest boundary)	Sun	18 Sep	--
Middle Salmon (forest boundary)	Shade	18 Sep	--
Lower Salmon (Arrahwanna Bridge)	Sun	22 Sep	--
Lower Salmon (Arrahwanna Bridge)	Shade	22 Sep	--
North Santiam:			
Packsaddle	Shade	1 Sep[c]	29 Sep
Minto Park	Sun	1 Sep[c]	7 Oct
Packsaddle	Shade	9 Sep	7 Oct
Minto Park	Sun	9 Sep[c]	--
Packsaddle	Shade	15 Sep	29 Sep
Below Dewitt	Shade	16 Sep	--
Fish Bend	Shade	25 Sep	7 Oct

[a] *No date indicates redd was still visible by the end of the survey season.*

[b] *Redd was not visible on 13 Oct due to high water. Redd was visible the following week when water levels were lower.*

[c] *Visibility affected by superimposition of another redd.*

Table 8. Redd counts of spring chinook salmon by survey cycle in core sections of the McKenzie River, 1997. All redds counted were included in each survey period.

Survey section, method	Survey cycle			
	Sep 8-Sep 14	Sep 15-Sep 22	Sep 23-Sep 29	Sep 30-Oct 7
Leaburg Dam to Greenwood boat ramp				
Boat	26	65	85	67
Helicopter	--	--	28	--
Greenwood boat ramp to Leaburg boat ramp				
Boat	12	22	34	30
Helicopter	--	--	29	--
Leaburg boat ramp to mouth of the McKenzie				
Helicopter	--	--	10	--
Ollalie boat ramp to McKenzie River Trail boat ramp				
Boat	45	78	117	--[a]
Helicopter	--	--	34	--
Lost Creek	12	13	16	28
Carmen Spawning Channel	2	5	--	--[a]
Gate Creek	--	--	15	--

[a] *Results from this survey were disregarded because of unreliable data.*

October. Although we did not try to estimate redd visibility through time on the McKenzie, we felt that many of the redds had disappeared by late September, especially below Leaburg Dam where there was a large number of spawning fish.

Based on expansion of coded wire tags recovered from carcasses below Leaburg Dam (Table 9), we estimated that 20% of the spawners in that area were wild. However, some of the carcasses could have been from fish that spawned above the dam then drifted below. An estimated 83% of the fish passing Leaburg Dam were wild. We plan to increase the frequency of gathering carcasses below Leaburg Dam in 1998 to increase the sample size and the accuracy of the estimates.

Spawning Ground Surveys in the North Santiam River Basin

About 40 miles of the mainstem North Santiam River between Minto Dam (RM 43.5) and Greens Bridge (RM 3.0) were surveyed between three and eight times in 1997. Migration is blocked at Minto Dam. Some spawning activity was found in all sections surveyed. Surveys began August 27 and ended on October 16.

We observed substantially more fall chinook spawning in the North Santiam in 1997 than in 1996. We intensively surveyed the braided channels around Wiseman Island (RM 6-8) between Stayton and Green's Bridge following an aerial survey on September 23 when we observed 169 redds, many with fish on them. We suspected that many of these spawning fish were fall chinook. We collected scales from carcasses in this area to separate the chinook into spring and fall races based on life history patterns. Only five (10%) of the 49 carcass scales we collected from this area showed a spring chinook life history pattern (Table 10). We used this subset of carcass samples to apportion the 147 redds we ground surveyed in this area into 15 spring chinook redds and 132 fall chinook redds.

Spawning activity for spring chinook was highest in the 10 mile reach from Minto to Fisherman's Bend (RM 33.5). Redd density for spring chinook in this uppermost section (8.5 redds/mile) was higher than any other surveyed for spring chinook (Table 11). Spawning activity for fall chinook was highest in the eight mile braided channel reach between Shellburn and Greens Bridge. The relative distribution of spring chinook redds within the North Santiam basin was similar in 1997 to that observed in 1996 with the greatest number of spawners in the upper main stem areas (Figure 2).

Table 9. Coded wire tag information from fish marked with adipose fin clips and recovered in spawning ground surveys in the McKenzie, North Santiam, Clackamas and Sandy rivers, 1997. PSC = Pacific Salmon Commission.

Recovery location, tag code	Number	Brood year	Release site	Hatchery of origin	Stock	Experimental group
McKenzie R. at Leaburg Dam[a]:						
07-63-28	1	1992	M Fk. Will	Willamette	Willamette	Oxygen study
07-63-25	1	1992	M Fk. Will	Willamette	Willamette	Oxygen study
07-63-24	1	1992	M Fk. Will	Willamette	Willamette	Oxygen study
07-04-28	10	1992	McKenzie	McKenzie	McKenzie	Feb release
07-02-36	2	1992	McKenzie	McKenzie	McKenzie	Slowed growth
07-02-40	6	1992	McKenzie	McKenzie	McKenzie	Normal growth
07-61-21	10	1992	McKenzie	McKenzie	McKenzie	Normal growth
07-02-54	6	1992	McKenzie	McKenzie	McKenzie	Normal growth
07-04-29	1	1992	McKenzie	McKenzie	McKenzie	Graded smalls
07-05-63	1	1993	M Fk. Will.	Dexter	Willamette	PSC Indicator
07-08-51	1	1993	McKenzie	McKenzie	McKenzie	Netpen control
07-08-47	1	1993	Lower Will.	McKenzie	McKenzie	Direct release
07-04-44	1	1993	McKenzie	McKenzie	McKenzie	Netpen control
07-08-50	1	1993	McKenzie	McKenzie	McKenzie	Netpen control
07-08-31	1	1993	Lower Will.	McKenzie	McKenzie	Direct release
07-08-34	1	1993	Lower Will.	McKenzie	McKenzie	Netpens
07-08-35	1	1993	Lower Will.	McKenzie	McKenzie	Netpens
07-04-43	1	1993	S. Santiam	Dexter	S. Santiam	Production
07-02-33	3	1993	S. Santiam	Willamette	S. Santiam	Production
McKenzie below Leaburg Dam[b]:						
07-63-23	1	1992	M. Fk. Will.	Willamette	Willamette	Oxygen study
07-63-27	1	1992	M. Fk. Will.	Willamette	Willamette	Oxygen study
07-02-40	4	1992	McKenzie	McKenzie	McKenzie	Normal growth
07-02-54	2	1992	McKenzie	McKenzie	McKenzie	Normal growth
07-04-28	3	1992	McKenzie	McKenzie	McKenzie	Feb release
07-61-21	2	1992	McKenzie	McKenzie	McKenzie	Normal growth
07-08-51	1	1993	McKenzie	McKenzie	McKenzie	Netpen control
07-03-43	1	1993	Young's Bay	Klaskanine	Willamette	Netpen study
North Santiam R.						
07-04-30	1	1992	Minto	Marion Forks	North Santiam	Acclimated
07-04-32	3	1994	Stayton	Stayton Pond	ChF-Tanner Cr.	Production
07-08-52	1	1994	Stayton	Stayton Pond	ChF-Tanner Cr.	Production
07-63-28	1	1992	MF Willamette	Willamette	MF Willamette	Oxygen
Salmon River[c]						
07-03-54	1	1992	Sandy River	Clackamas	Clackamas, (early)	Production
Clackamas River						
07-03-61	1	1993	Clackamas	Clackamas	Clackamas, (early)	Production
07-08-30	1	1993	Lone Star, net pen	McKenzie	McKenzie	Netpen

[a] *Six additional adipose marked carcass had no coded wire tag.*
[b] *Four additional adipose marked carcass had no coded wire tag.*
[c] *One additional adipose marked carcass had no coded wire tag.*

Table 10. Overlap of spring and fall chinook salmon in the North Santiam River based on fish scale patterns from recovered carcasses, 1997.

Section	Number of carcasses		Percent spring chinook
	Fall chinook	Spring chinook	
Mouth to Greens Bridge	12	3	20
Greens Bridge to Stayton	32	2	6
Stayton to top of Gerren Island	1	0	0
Gerren Island to Mehama	0	2	100
Mehama to Fish Bend	1	23	96
Fish Bend to Minto	1	57	98

Peak spawning of spring chinook salmon in the North Santiam in 1997 occurred during September 15-19 (Table 12) based on weekly surveys in the main stem North Santiam upstream of Mehama (RM 27.0). This was about one week earlier than peak spawning in the same section in 1996 (September 23-27). The earlier spawning time for 1997 is apparent also if the data are grouped into two-week periods (Figure 3). The peak spawning time for sections downstream of Mehama and in the Little North Santiam could not be determined because they were not surveyed regularly.

We sampled 157 carcasses during spawning surveys in the North Santiam in 1997 (Table 11). This was more than three times as many carcasses as we collected in 1996. The increase in the number of carcasses recovered is likely due to the increased frequency of surveys over 1996 (eight versus six in 1996), improvements in survey methodology (use of a 10 foot viewing tower on a survey boat), and an increase in abundance of both spring and fall chinook.

Table 11. Summary of chinook salmon spawning surveys for the North Santiam River, 1997.

Race and Survey section	Length (mi)	1997 Counts		1997 redds/ mile	1996 redds/ mile
		Carcasses[b]	Redds		
Spring chinook:					
Minto - Fishermen's Bend	10.0	59	85	8.5	7.8
Fishermen's Bend - Mehama	6.5	26	16	2.5	3.5
Mehama - Stayton	10.3	6	18	1.7	2.0
Stayton - Greens Bridge[a]	13.7	4	15	1.1	0.1
Little North Santiam	20.5	10	10	0.5	0.0
Fall chinook:					
Stayton - Greens Bridge[a]	13.7	37	132	9.6	0.9

[a] *Total chinook redds and carcasses were apportioned into 10% spring and 90% fall race based on scale analysis from carcasses in 1997.*
[b] *An additional 15 carcasses were recovered from the 3 mile section of the North Santiam from Green's Bridge to the mouth.*

Table 12. Redd counts of spring chinook salmon by survey date in sections of the North Santiam River, 1997. Only redds not previously counted were included in each survey period.

Survey Section	Survey dates							
	Aug 25-29	Sep 1-5	Sep 8-12	Sep 15-19	Sep 22-26	Sep 29-Oct 3	Oct 6-10	Oct 13-17
Minto - Fishermen's Bend	0	6	18	29	13	19	0	0
Fishermen's Bend - Mehama	0	1	5	5	5	0	0	0
Total	0	7	23	34	18	19	0	0

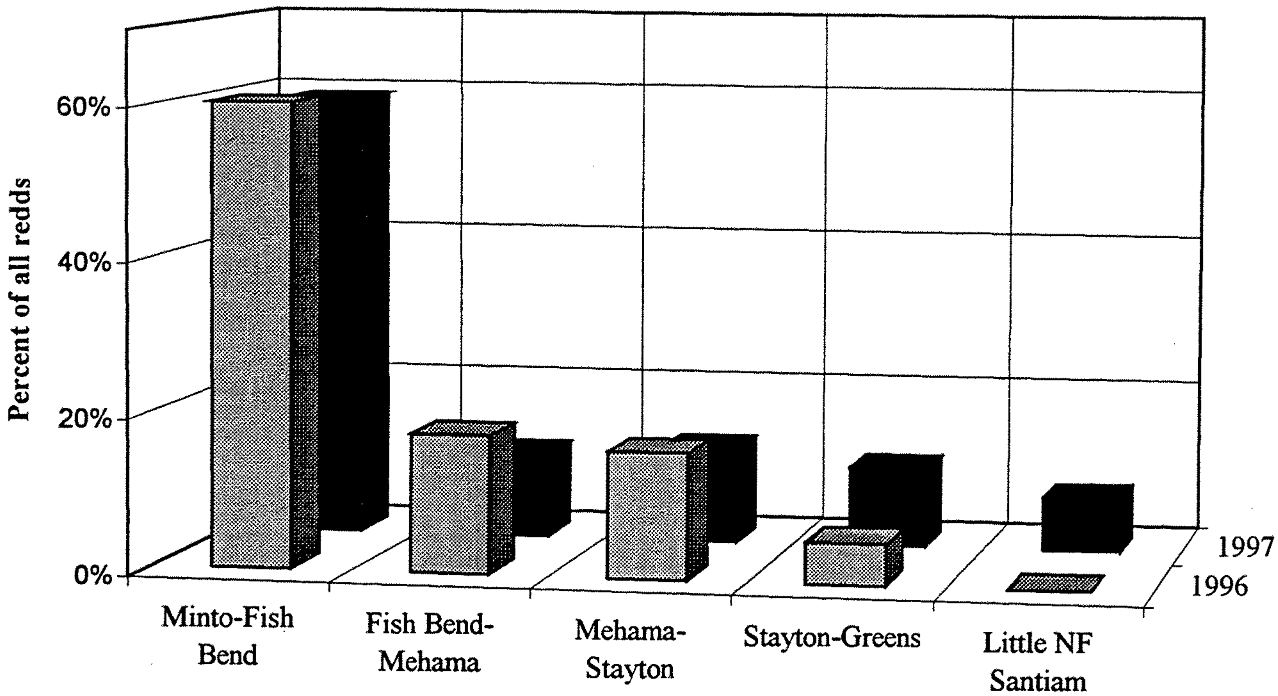

Figure 2. Distribution of spring chinook redds in the North Santiam by area for 1996 and 1997.

Six coded wire tagged fish were recovered (Table 9) during carcass surveys in 1997. Four of the tagged fish were fall chinook returning from releases at Stayton Pond. All four were recovered in the lower North Santiam near Wiseman Island. One tagged fish was from a group of spring chinook acclimated prior to release at Minto Pond. One tagged fish was a stray from a group of spring chinook released at Dexter on the Middle Fork Willamette River above Eugene.

We attempted to estimate the passage of chinook salmon at Gerren Island in 1997. We subsampled the numbers of chinook passing diversion dams at Gerren Island similar to methodology used in 1996 (Grimes et al. 1996). We counted 1,778 spring chinook from late April through mid-September in 4-5 days per week of sampling at the fishways. An expansion of those counts by using methodology similar to 1996 (based on the proportion of days the fishways were trapped) yielded a large number of chinook (3,352). We do not believe the run of spring chinook was as large as the expansion at Gerren Island would suggest, a 227% increase over 1996. Counts of spring chinook over Willamette falls in 1997 (26,885) were 24% greater than in 1996 (21,605). Redd counts

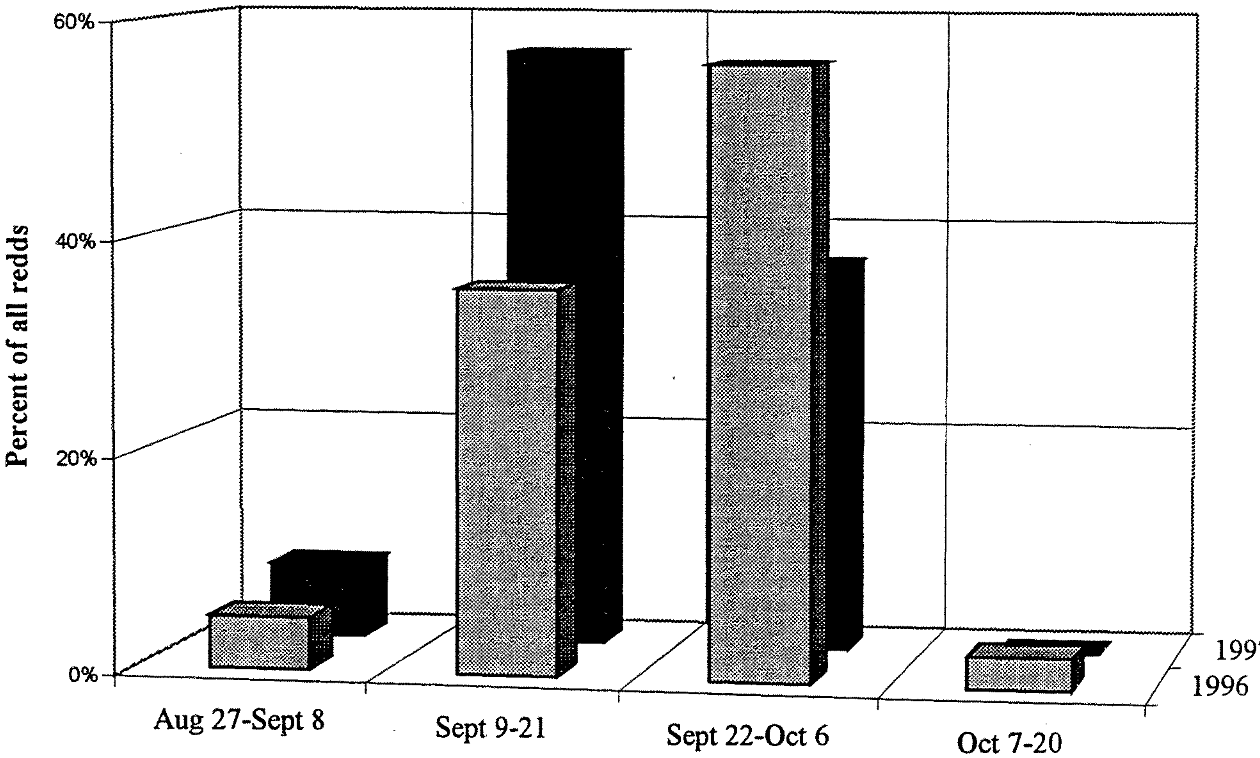

Figure 3. Distribution of spring chinook redds in the North Santiam River through time for 1996 and 1997.

above Gerren Island were 2% lower in 1997 than in 1996. Returns to Minto Dam were 898 chinook, 42% higher than in 1996 (634). The buildup of gravel point bars near the top of Upper Bennett Dam may have increased the probability that spring chinook counted and passed through the fishway fell back over the dam and were counted a second time at the fishway. Previous work at the fishway in 1994 estimated a fallback rate of about 3%. To minimize handling of spring chinook, we did not tag any chinook to assess this rate in 1997. Sampling at the fishway in 1998 will include some marking of spring chinook to assess fallback. Most chinook that migrate past Gerren Island use Upper Bennett Dam fishway.

We surveyed sections of the Little North Fork Santiam River on three dates between 23 September and 16 October. We observed ten redds in the Little North Santiam and recovered ten carcasses (Table 11). District personnel (ODFW) observed five adult chinook in 4.8 miles of the Little North Santiam snorkeled in July.

ODFW has conducted aerial surveys of the North Santiam since 1970 to count chinook salmon redds as an index of spawning abundance. Although the surveys were designed and timed to index fall chinook spawners below the mouth of the Little North Fork Santiam River, surveys were done annually since 1991 (except 1995) up to Big Cliff Dam (RM 46.4) to include spring chinook spawning areas. On average, 45% of redds observed were in the area above the Little North Fork Santiam River in primarily spring chinook spawning areas.

In 1997 we flew in a small helicopter from the mouth of the North Santiam River upstream to Big Cliff Dam. A total of 260 redds were observed in the mainstem North Santiam River from the air, more than twice the 116 observed from the ground through the season to that date (Table 13). This is in sharp contrast to the comparison from last year when only 11% of redds surveyed from the ground were observed from the air. The difference is largely due to the abundant fall chinook redds in the braided channel system in the lower North Santiam. This large braided channel network was not fully surveyed by the time of the helicopter flight. When this braided channel system is excluded, the 49 redds observed from the air is about half of the 99 redds observed from the ground in the major spring chinook spawning section from Stayton to Minto.

Spawning Ground Surveys in the Clackamas River Basin

We surveyed nearly 67 miles of Clackamas basin streams above North Fork Dam in 1997, and counted 376 redds (Table 14). As in 1996, the main stem Clackamas River sections were the most heavily used, accounting for 80% of the redds and 90% of the carcasses (Table 14 and Figure 4).

Of the 24 redds (6 % of the total) that were counted in 3.6 miles of new survey areas, all were found in a one mile section at the head of North Fork Reservoir or in the South Fork Clackamas River.

The number of redds we counted in the basin in 1997 was two times higher than the 1996 counts. The counts in all sections surveyed in both years increased from 1996 to 1997 (range of 19%-300%; Figure 4). We recovered 73

Table 13. Comparison of redd counts from a helicopter with those from ground surveys for several time periods prior to the helicopter count in the North Santiam River, 1997.

Survey section	Helicopter (23 Sept)	Ground surveys Up to flight (27 Aug-24 Sept)	Ground surveys Season total (27 Aug-16 Oct)
Minto - Gates	28	49	61
Gates - Mill City	2	13	16
Mill City - Fish. Bend	0	4	8
Fish. Bend - Mehama	2	16	16
Mehama - Gerren Is.	4	5	5
Gerren Is. - Stayton	13	12	13
Stayton - Greens Br.	169	17[a]	147
Greens Br. - Mouth	42	--	29
Total	260	116	295

[a] *Not all areas were surveyed from the ground at the time of the aerial flight. The aerial flight identified heavily used areas by spawning chinook prompting subsequent ground surveys after September 23.*

carcasses in 1997 (Table 15), compared to 17 recovered in 1996. The increase in the number of carcasses recovered in 1997 reflects an increase in spawners throughout the basin in 1997 and the addition of new survey areas. The spring chinook count over North Fork Dam in 1997 was 54% higher than that in 1996.

The general distribution of redds in the basin was similar to 1996, although shifts of relative contribution between sections occurred (Figure 4). Compared to 1996, spawning occurred farther upstream in the Clackamas River (0.5 miles), Collawash River (0.75 miles), and Fish Creek (1.0 miles) in 1997. Several factors that could affect the relative distribution of redds in the basin include ongoing changes in gravel distribution following floods in 1996 and 1997, increased base stream flow in 1997, and high rainfall in September 1997.

Table 14. Summary of spring chinook salmon spawning surveys for the Clackamas River, 1997. Survey data for shorter sections of the river are shown in **APPENDIX C.**

Survey section	Length (mi.)	Counts: Live fish	Counts: Carcasses[a]	Counts: Redds	1997 redds/ mile	1996 redds/ mile
Clackamas River:						
Sisi Creek - Forest Rd 4650	9.1	83	6	68	7.5	3.2
Forest Rd 4650 - Collawash River	8.0	46	10	47	5.9	4.1
Collawash River - Cripple Creek	8.5	78	35	62	7.3	6.1
Cripple Creek - South Fork	14.5	75	28	108	7.4	3.2[d]
South Fork - reservoir	1.0	5	10	17	17.0	--
Collawash River:						
Collawash Falls - mouth[b]	7.5	48	4	48	6.4	1.6
Hot Springs Fork:						
Pegleg Falls - mouth[c]	5.0	2	0	1	0.2	0.0
Pinhead Creek:						
Last Creek - mouth	1.0	0	0	0	0.0	0.0
Roaring River:						
Falls - mouth	2.0	8	0	6	3.0	3.0
Fish Creek:						
Silk Creek - mouth	4.7	18	5	12	2.6	1.1[e]
South Fork Clackamas River:						
Falls - mouth	0.6	15	1	7	11.7	--
North Fork Clackamas River:						
Fall Creek - mouth	1.5	0	0	0	0.0	0.0
Total	63.4	378	99	376	6.0	2.9

[a] *Includes carcasses that were seen but not sampled.*
[b] *2.0 mi upstream of Collawash Falls were surveyed; no fish or redds counted.*
[c] *1.3 miles upstream of Pegleg Falls were surveyed; no fish or redds counted.*
[d] *This section was 0.5 miles shorter in 1996.*
[e] *This section was 0.2 miles shorter in 1996.*

Table 15. Spring chinook salmon carcasses sampled during spawning ground surveys in the Clackamas and Sandy basins, 1997.

River, sex	Number[a]	Mean length (mm)	Number unspawned	Adipose fin clips
Clackamas:				
Males	26	894	0	1
Females	47	852	1	1
Unknown	0	--	--	--
Sandy:				
Males	43	888	0	0
Females	77	876	0	2
Unknown	0	--	--	--

[a] *Includes only those fish from which scales could be collected.*

We counted six redds in the Sisi Creek - Forest Road 4650 section (commonly known as Big Bottom) during our first survey in late August. The redds were unattended and no carcasses were found in that section or in the adjacent downstream section until September 18. Spawning of spring chinook salmon in late summer has been observed historically in the Big Bottom area (personal communication, D. Cramer, Portland General Electric Co., Portland, OR). The documentation of August spawning in 1997 suggests a small segment of these early spawners may still persist. We recommend that the Big Bottom area be more intensely surveyed in August to determine when spawning begins. We noted spawning coho salmon in late September in the Sisi Creek-Pinhead Creek section. Spawning coho were noted in other Clackamas River sections on subsequent surveys as far downstream as the Collawash River. In many instances, the coho were digging redds in the general vicinity of spring chinook redds and some superimposition of spring chinook redds was noted.

Based on surveys in core sections, peak spawning in the upper Clackamas Basin occurred in late September to early October, during the fifth and sixth survey cycles (Table 16). Sixty-four percent of the total redds were counted during those two weeks. However, the percentage of redds counted during this time period varied among the individual sections from 19% in the Clackamas

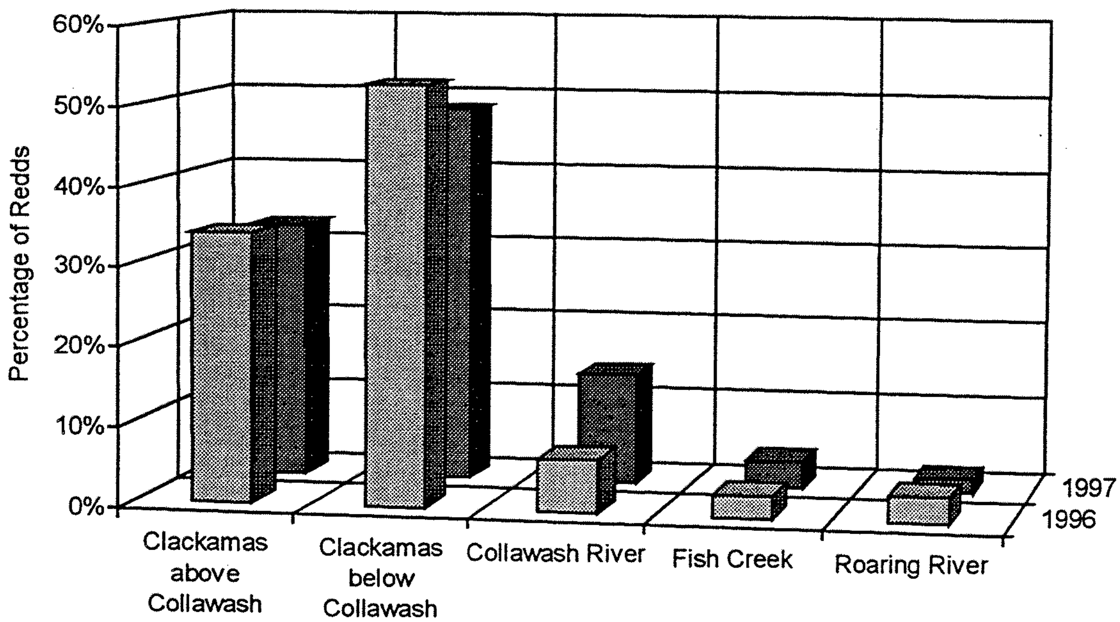

Figure 4. Geographical distribution of spawning for spring chinook salmon in the Clackamas River Basin upstream of North Fork Dam, 1996 and 1997. Only for those areas surveyed in both 1996 and 1997.

River just above the confluence with the Collawash to 86% in Clackamas just below the Collawash (Table 16). The general timing of the 1997 peak was identical to the timing in 1996 (Figure 5). As in 1996, spawning in the tributary streams began after significant rainfall.

The ratio of the North Fork Dam adult count (1,264) to the redd count (376) was 3.4:1 in 1997 compared to a ratio of 4.6:1 in 1996. Using a 1:1 sex ratio from Clackamas Hatchery and assuming that each redd we counted was made by two spawners, we were able to account for about 60% of the fish passing over North Fork Dam. Because 94% of the redds we counted in 1997 occurred in the same areas as were counted in 1996, we believe there are not large spawning areas that remain to be identified in the basin. Although some redds in the survey areas could be missed entirely or may not be counted if multiple redds are present, we believe these are relatively minor sources of error. At this time, we believe most of the unaccounted spawners were pre-spawning mortalities.

Table 16. Redd counts of spring chinook salmon by survey cycle in core sections of the Clackamas River, 1997. Only redds not previously counted were included in each survey period.

Survey section	Survey cycles							
	Aug 25-Sep 1	Sep 2-7	Sep 8-14	Sep 15-22	Sep 23-29	Sep 30-Oct 7	Oct 8-16	Oct 17-24
Pinhead Creek - Road 4650	6	6	7	4	25	6	2	4
Road 4650-Collawash River	0	1	7	14	6	3	12	4
Collawash- Cripple Creek	--	0	5	0[b]	37	16	4	0
Cripple Cr.- South Fork Clackamas	--	1	0	--	17	69	13	8
Collawash River[a]	0	0	0	2	5	7	3	5
Total	6	8	19	20	90	101	34	21

[a] *Hot Springs Fork to mouth.*
[b] *Poor visibility.*

Spawning Ground Surveys in the Sandy River Basin

We surveyed 43 miles of streams in the Sandy River Basin above Marmot Dam in 1997, and counted 731 redds (Table 17). As in 1996, the Salmon River and Still Creek were primary spawning streams (Figure 6). Additionally, the Zigzag River (a new survey section) was also a major spawning stream. Collectively, these sections accounted for 95% of the total redds and 99% of the total carcasses.

We increased our survey area in the upper Sandy Basin by about 12 miles over that surveyed in 1996. New sections included Zigzag River (5.5 mi), Muddy Fork (2.0 mi), and Cheeney Creek (2.0 mi). We expanded the survey areas in Camp and Lost creeks (2.0 mi in each), and in Clear Creek (0.9 mi). The lowest section of the Salmon River was shortened by 0.5 miles, but we surveyed two new tributary streams in this area (1.0 mi in each). Additionally, we did not survey a short section of the Sandy River that was surveyed in 1996. We counted 83 redds in the new survey areas (90% in the Zigzag River), representing 11% of the total.

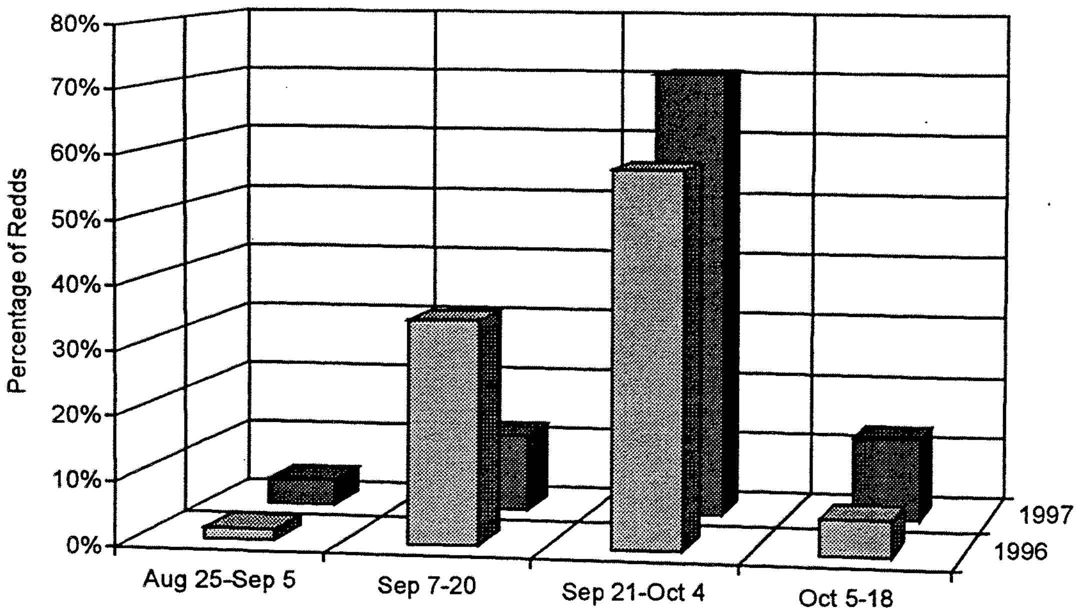

Figure 5. Timing of spring chinook salmon spawning in the Clackamas River Basin upstream of North Fork Dam, 1996-97.

The 1997 redd count was 28% higher than in 1996, at least half of which was attributed to redds counted in the new survey areas. However, the counts in individual sections varied from decreases of about 70% to increases of 100% over counts made in the same sections in 1996. We recovered 120 carcasses in 1997 (Table 15), compared to 491 in 1996. In 1997, we did not sample all of the carcasses encountered in order to cover more spawning area.

The general distribution of redds in the upper basin was similar to 1996, although shifts of relative contribution between sections occurred (Figure 6). Compared to 1996, spawning occurred farther upstream in Still Creek (0.8 mi), farther downstream in Camp Creek (0.5 mi), and was about the same in Lost and Clear Fork creeks. An impassable falls limits upstream movement in the Salmon River.

Based on surveys in core sections, peak spawning in the upper Sandy Basin occurred from mid-September to early October, during the fourth through sixth survey cycles (Table 18). Sixty-eight percent of the spawning took place during this time. The timing of spawning by two-week periods was more

Table 17. Summary of spring chinook salmon spawning surveys for the Sandy River, 1997. Survey data for shorter sections of the river are shown in **APPENDIX C.**

Survey section	Length (mi.)	Counts: Live fish	Counts: Carcasses[a]	Counts: Redds	1997 redds/ mile	1996 redds/ mile
Salmon River:						
Final Falls - Forest Rd 2618	3.2	173	74	185	57.8	39.7
Forest Rd 2618 - Bridge Street	3.6	74	58	44	12.2	19.7
Bridge Street - Highway 26	6.2	647	247	280	45.2	41.5
Tributaries	4.0	2	0	10	2.5	--
Still Creek:						
Forest Rd 2612 - mouth	5.3	129	72	114	21.5	12.3
Zigzag River:						
Devil Canyon Creek - mouth	5.5	85	8	5	13.6	--
Camp Creek:						
Laurel Hill - mouth	4.0	10	1	12	3.0	3.0[b]
Clear Creek:						
Powerline - mouth	1.4	0	0	0	0.0	2.0[c]
Clear Fork:						
Barrier - mouth	0.6	3	2	2	5.0	6.0[c]
Lady Creek:						
1 mile upstream - mouth	1.0	0	0	0	0.0	0.0[d]
Henry Creek:						
1.0 mile upstream - mouth	1.0	0	0	0	0.0	0.0
Devil Canyon Creek:						
Falls - mouth	0.8	0	0	0	0.0	0.0
Lost Creek:						
Lost Creek Campground - mouth	4.5	6	2	8	0.8	4.8[b]
Total	43.1	1,130	484	731	17.0	18.8

[a] *Includes carcasses that were not sampled.*
[b] *This section was 2.0 miles shorter in 1996.*
[c] *This section was 0.9 miles shorter in 1996.*
[d] *This section was 0.5 miles shorter in 1996.*

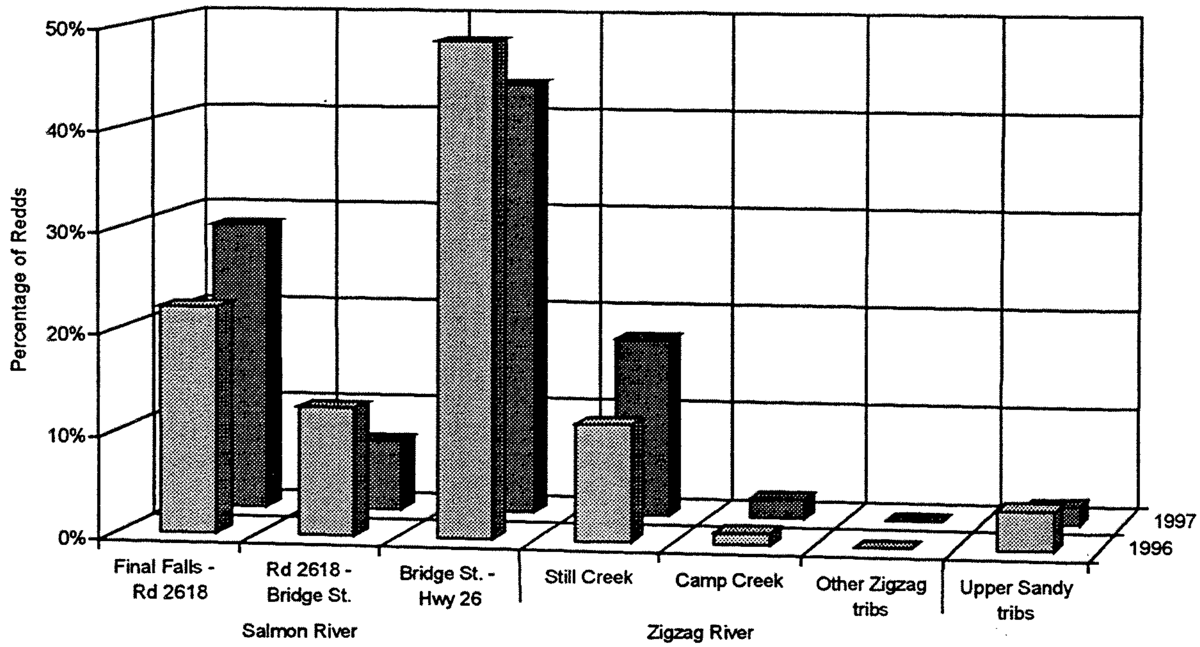

Figure 6. Geographical distribution of spawning for spring chinook salmon in the Sandy River Basin upstream of Marmot Dam. Only for those areas surveyed in both 1996 and 1997.

protracted in 1997 than in 1996 (Figure 7). In 1997, we observed fresh chinook redds and spawning fish during the last surveys (October 22-23) in the lower Salmon and lower Zizag rivers when spawning was essentially completed in the rest of the basin.

The ratio of the adult count over Marmot Dam (3,301) to the redd count (731) was 4.5:1 in 1997. Using a sex ratio of 1:1 and assuming that each redd we counted was made by two spawners, we were able to account for just 44% of the fish passing Marmot Dam. These results are the same as in 1996, although the expanded surveys in 1997 accounted for 11% of the total redd count. The most likely explanations for the unaccounted fish are pre-spawning mortality and spawning occurring in areas not surveyed, particularly the main stem Sandy River above Marmot Dam. Although the Sandy River is difficult to survey because of poor visibility during spring chinook spawning season, we believe that some surveys should be conducted during periods of good visibility to document whether or not spring chinook are using this stream in large numbers.

Table 18. Redd counts of spring chinook salmon by survey cycle in core sections of the Sandy River, 1997. Only redds not previously counted were included in each survey period.

Survey section	Survey cycles							
	Aug 26-Sep 1	Sep 2-9	Sep 10-17	Sep 18-24	Sep 25-Oct 2	Oct 3-9	Oct 10-16	Oct 17-23
Salmon River:								
Final Falls - Road 2618	--	22	19	9	78	12	45	0
Road 2618 - Bridge Street	--	1	7	20	4	9	1	2
Bridge St. - Hwy 26	--	6	27	87	35	78	12	35
Zigzag River[a]	1	--	14	31	17	3	1	5
Still Creek	2	0	12	18	34	35	1	7
Total	3	29	79	165	168	137	60	49

[a] *Still Creek to mouth.*

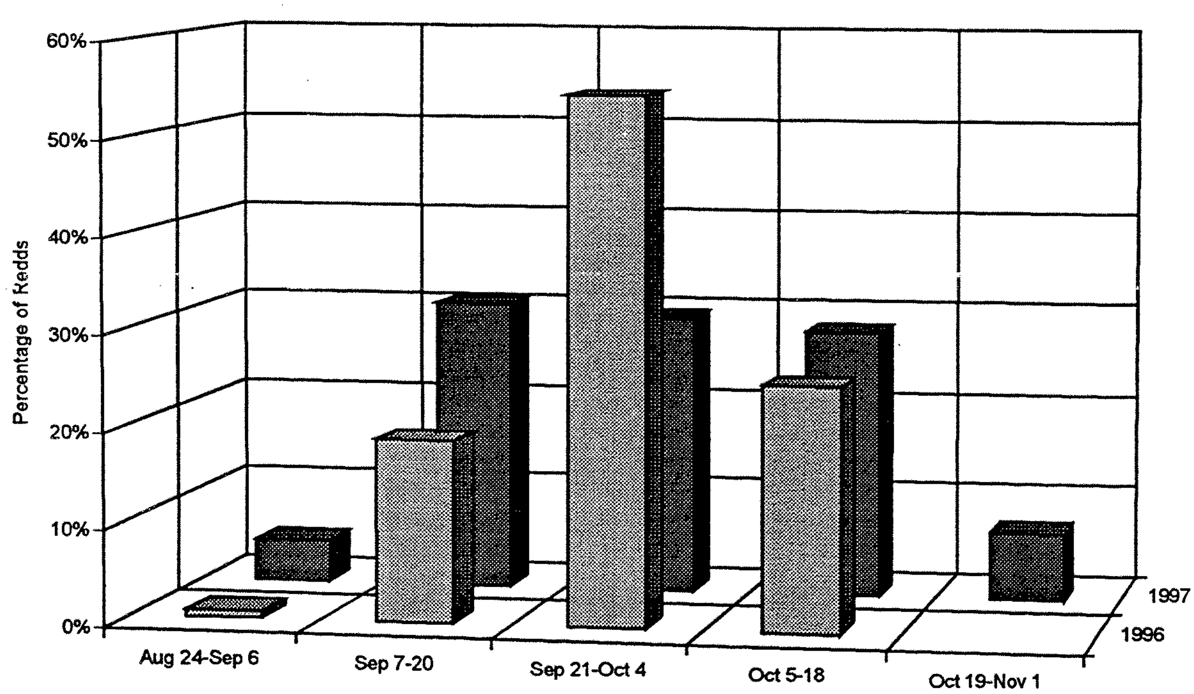

Figure 7. Timing of spring chinook salmon spawning in the Sandy River upstream of Marmot Dam, 1996-97.

TASK 2.1-- MORTALITY IN A CATCH AND RELEASE FISHERY

Freshwater harvest of Willamette spring chinook salmon accounted for about 70% of the total harvest in ocean and freshwater fisheries over a 5-year period from 1989 through 1993 (Bennett 1994). Freshwater sport fisherman took 55% of the total catch and the Columbia River gill-net fishery accounted for another 15% of the catch (Bennett 1994). Harvest rates on 4 and 5 year old fish in Willamette River sport fisheries averaged about 30% each year. Recreational catch is underestimated because it does not include fisheries in the upper mainstem Willamette or in tributaries above the falls (Bennett 1994).

From these data, it is clear that freshwater fisheries account for the bulk of the harvest mortality on Willamette spring chinook with most of that occurring in sport fisheries. These fisheries, driven by hatchery programs, may be contributing to overharvest of wild spring chinook salmon. To decrease harvest, we are evaluating the feasibility of a catch and release fishery on wild fish that will maintain traditional recreational fisheries on hatchery fish. This evaluation includes estimating the hooking mortality managers can expect on spring chinook salmon that are caught and released in Willamette sport fisheries and estimating mortality from fin-marking hatchery fish (*see* **TASK 2.2**). Hatchery fish would need to be externally marked so anglers could distinguish them from wild fish.

Jaw Tagging Spring Chinook at Willamette Falls

In anticipation of a hook and release mortality experiment to be conducted in the spring of 1998, we investigated methods of handling treatment and control groups of adult spring chinook at Willamette Falls in 1997. On April 30, May 8, and May 14 we operated a trap in the cul-de-sac arm of the fishway at Willamette Falls (RM 26). Twenty-four spring chinook were sampled. Length, sex, and fin marks were recorded and a scale sample was collected. Each fish was tagged with a numbered aluminum band (Aluminum butt-end leg bands, National Band and Tag Company, Lexington KY) by crimping the band onto the lower left jaw of the fish. Fish were not anesthetized. Each fish was held immobile for tagging by placing them upside down in a modified cradle with hinged sides that squeezed together to hold the fish steady. The cradle we used was similar to that described by Larson (1995). The tagging and data collection operation took approximately 3 minutes for each fish. After tagging, the fish was placed back into the fishway.

On May 3, May 10, and May 23 we angled from a motorboat in the Willamette River immediately below Willamette Falls for the purpose of catching, tagging, and releasing adult spring chinook. Typical sport fishing gear was used. Water temperatures ranged from 52-62° F and flows ranged from 14,300-33,100 cfs (at Salem). After a fish was landed, the hook was removed and the fish was placed in the tagging cradle suspended in the water from the side of the boat. Fish remained in the net even while in the cradle. Fork length and fin marks were recorded for each fish caught. Sex was recorded inconsistently because often males and females could not be differentiated. No scale sample was collected to minimize handling time and stress on the fish. Each fish was tagged with the same style aluminum bands described above. Tagged chinook were released into the water at the fishing site an average of 2 minutes 47 seconds after capture (n= 39).

Ninety-two spring chinook were caught, of which 78 were tagged. Ten of the 92 (11%) were bleeding from hook wounds and six of these were released without tags. We sometimes had two fish hooked at the same time, so one fish was released to avoid holding it for longer than normal. One released fish had extensive marine mammal injuries. Two jack chinook were released because they were too small to tag. Four of the 92 (4%) fish were snagged. The rest were either hooked in the jaw (83%), nose (5%), tongue (3%), or gill arch (2%). Chinook were caught primarily on wobblers and plugs.

Tag Recovery

We tagged spring chinook on the left side of the jaw to allow us the opportunity to see those tags swim past the observation window in the fishway at Willamette Falls. Passage is monitored 24 hours a day with the use of a color video camera trained on the observation window. ODFW personnel observed only six tags while making passage counts from the videotapes. Poor illumination of the view window is likely responsible for missed tags. We had hopes of being able to use different colored tags for treatment and control groups and to use observations at the view window to assess short-term mortality.

Twenty-five tags were recovered after tagging. Three of these tags were observed but no number was recorded. Hatchery personnel at an upriver facility observed one chinook in September that had an obvious mark on the lower jaw suggesting a lost jaw tag. The overall condition of tagged fish and of the jaw where the tag was crimped was generally good. Seventeen (81%) of the 21 comments from people that observed tags reflected generally good fish condition. One tag had worn through to the jawbone, and three other tags had abraded the jaw area. This low tag loss and low injury rate was expected based on National Marine Fisheries Service tagging experience in the Snake

River (personal communication, Jerry Harmon, NMFS, Lewiston, ID). However, tag application was slow and difficult on unanesthetized fish. We will likely use Floy tags for the experiment in 1998.

Fallback (movement downstream after release) occurred in the sport-caught group and in the control group tagged in the ladder. Six tagged chinook were observed in the Clackamas River (Table 19), a Willamette River tributary downstream (RM 24) of the tagging site at Willamette Falls. Five of the six were from the sport-caught group and one was from the ladder group. One tagged chinook was reportedly caught in the Sandy River, a Columbia River tributary upstream from the Willamette River, but could not be confirmed by observation or tag number.

Most tag recoveries came from hatchery facilities (63%) and anglers (21%). A couple of tags were observed at fishways and a couple of tags were recovered from carcasses found on the streambank. Tagged fish were recovered throughout the upper Willamette River with most coming from the Middle Fork Willamette (Table 19).

We observed a similar recovery rate between ladder and sport-caught groups. Seventeen percent of the ladder-trapped group and 23% of the sport-caught group were recovered. This is lower than the expected 40% average recovery rate in the upper basin for spring chinook that pass Willamette Falls. It is unknown if the low recovery rate was due to a high level of handling mortality or whether jaw tags were difficult to see. We received comments from several hatcheries that jaw-tagged adults were easily overlooked. In some cases jaw tags were missed by two fish handlers prior to being noticed by the third person in the processing line.

TASK 2.2-- MORTALITY FROM FIN MARKING HATCHERY FISH

The first brood (1995) of spring chinook salmon marked by removing either a ventral fin or a maxillary bone was released in 1997 to determine survival to adult return. These groups were released in early spring from McKenzie, Marion Forks (North Santiam River), and Clackamas hatcheries (Table 20). Coded wire tagged fish released at the same time at each hatchery served as controls. These fish will begin to return as age 4 adults in 1999. The experimental design for the remaining 3 years of the mark evaluation is shown in **APPENDIX D**.

Table 19. Recovery of jaw-tagged spring chinook salmon in 1997.

River	Number recovered by: Hatchery	Angling	Fishway observation	Carcass recovery	Percent of total
Clackamas	2	3	0	1[c]	25
North Santiam	2[a]	0	2[b]	0	17
South Santiam	0	1	0	0	4
McKenzie	4	0	0	1[d]	21
Middle Fork Willamette	7	1	0	0	33
Percent of total	63	21	8	8	--

[a] *Includes one fish obviously missing a jaw tag.*
[b] *Includes two fish observed at Gerren Island fishways with only part of the numbers visible.*
[c] *Found dead on Clackamas River 1 month after tagging.*
[d] *Found dead on Gate Creek during spawning surveys 4 months after tagging.*

The ability of markers to remove either the ventral fin or a maxillary bone was examined at the time smolts were released from Marion Forks and McKenzie hatcheries (Table 21). Fish at Clackamas hatchery were not checked because of the difficulty sampling their large rearing pond. However, Clackamas fish are marked at Marion Forks Hatchery prior to being transfered to Clackamas Hatchery. Quality checks of Marion Forks fish were assumed to be representative of Clackamas fish because both are marked by the same personnel during the same time period.

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

Table 20. Groups of spring chinook salmon (1995 brood) released as smolts into the McKenzie, North Santiam and Clackamas rivers in 1997 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
McKenzie	LV	29,632	8.7	Mar 6, 1997
	LM	29,624	8.7	Mar 6, 1997
	Ad+CWT[a]	100,328	8.7	Mar 6, 1997
Marion Forks (North Santiam R.)	RV	30,384	15.3	Mar 3-4, 1997
	RM	30,224	13.0	Mar 3-4, 1997
	Ad+CWT[b]	34,254	12.9	Mar 4, 1997
Clackamas	LV	26,529	13.6	Mar 31, 1997
	LM	25,798	13.6	Mar 31, 1997
	Ad+CWT[c]	30,342	13.6	Mar 31, 1997

[a] *Coded wire tag codes 071258, 091803, 091804.*
[b] *Coded wire tag codes 071259, 071260.*
[c] *Coded wire tag code 071357.*

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 beyond what occurs with fish released directly.

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 stock was to be used because of concerns for straying of other stocks into the McKenzie River, a stronghold for wild spring chinook salmon. The evaluation of straying was an important part of the study. Fish were acclimated in net pens in fall and in spring and compared to fish trucked directly from the hatchery. Control groups were released only in spring directly 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 three additional years through 1998 brood releases. The following describes methods and problems of brood years released to date.

Table 21. Quality of ventral and maxillary marks on 1995 brood spring chinook salmon at Marion Forks (North Santiam River) and McKenzie hatcheries at time of release in 1997.

Hatchery/clip quality	Ventral clip	Maxillary clip
Marion Forks	(RV)	(RM)
Completely clipped	82%	96%
75%-50% clipped	12%	1%
Less than 50% clipped	4%	2%
Not clipped	2%	2%
Sample size	197	198
McKenzie	(LV)	(LM)
Completely clipped	79%	97%
75%-50% clipped	21%	3%
Less than 50% clipped	0%	0%
Not clipped	0%	0%
Sample size	30	29

1992 Brood

Acclimated fish were released in spring into the main stem Willamette River at a site controlled by Lone Star Northwest, Inc. a cement and gravel company (RM14) (Table 22). Direct-trucked fish were released at the same time at Willamette Park (RM 15) (Table 22). No fall release was made. The number of Ad+CWT fish in control groups was large for this brood because of other studies requiring 100% marking of yearling smolts released into the McKenzie River. The rearing, acclimation, and release of this brood went according to the study plan.

1993 Brood

Acclimated fish were released at the Lone Star site and direct-trucked fish were released at Willamette Park in November 1994 and March 1995 as scheduled (Table 23). Releases in fall were made with no problems. Spring releases were complicated by supersaturated water below Willamette Falls because of freshet conditions after the fish were transported to net pens for

Table 22. Releases of spring chinook salmon into the lower Willamette River to evaluate acclimation in net pens, 1992 brood.

Stock	Tag code	Treatment	Location of release	Number Ad+CWT	Number released	Size		Days accli-mated	Release date
						Fish /lb	Length (mm)		
McKenzie	070452	Acclimate	Lone Star	30,862	43,127	8.5	168.4	23	3/8/94
McKenzie	070453	Acclimate	Lone Star	30,382	38,747	8.3	170.2	23	3/8/94
McKenzie	070454	Acclimate	Lone Star	28,878	43,869	8.5	169.2	23	3/8/94
McKenzie	070455	Direct	Will. Park	29,548	44,352	9.0	160.3	--	3/8/94
McKenzie	070456	Direct	Will. Park	29,606	43,373	8.8	161.6	--	3/8/94
McKenzie	070457	Direct	Will. Park	28,789	43,079	8.8	162.2	--	3/8/94
McKenzie	070240	Control	McK. Hatch.	144,006	158,024	9.0	162.7	--	3/2/94
McKenzie	070254	Control	McK. Hatch.	37,895	41,583	9.0	162.7	--	3/2/94
McKenzie	076121	Control	McK. Hatch.	169,400	185,890	9.0	162.7	--	3/2/94

acclimation (**APPENDIX E**). Two of the three the net-penned groups were released after only 7 days because of high mortality. The premature release and high mortality will complicate comparisons between acclimated and direct-trucked groups when adults return.

1994 Brood

Clackamas River stock was substituted for McKenzie River stock in 1994 because insufficient broodstock returned to McKenzie Hatchery. The number of fish released was reduced from three to two groups for each of the acclimated and direct-trucked groups in November and in March (Table 24). The fish from Clackamas River stock were reared at McKenzie Hatchery.

We continued to use the Lone Star site for acclimation of the fall 1995 release. No unanticipated problems were associated with fall releases of either acclimated or direct-truck groups.

The acclimation site for spring releases in 1996 was changed to a protected, off-channel bay ("Clackamette Cove") located at about river mile 0.5 on the Clackamas River to avoid mortality from future freshets in the Willamette River as occurred in spring 1995. Clackamette Cove was formed by gravel mining in the 1950's and receives flow primarily from the Clackamas River (EnviroScience, Inc. 1997). The cove is about 50 acres in size. Direct-truck groups were released into Clackamette Cove at the same location as net-penned groups. The Pathology section of ODFW diagnosed Bacterial Kidney Disease (BKD) in direct-trucked groups and detected traces of BKD in the acclimated groups.

Initial plans called for using two groups of McKenzie stock as controls in spring. However, high incidence of mortality from BKD in various groups at McKenzie Hatchery resulted in only one group being suitable as a control.

1995 Brood

November and March release groups of McKenzie stock were reared at McKenzie Hatchery. Because the Lone Star acclimation site in the main stem Willamette River was damaged by a flood in February 1996 and an alternative site could not be found by that fall, existing net pens in Clackamette Cove were used.

Table 23. Releases of spring chinook salmon into the lower Willamette River to evaluate acclimation in net pens, 1993 brood.

Stock	Tag code	Treatment	Location of release	Number Ad+CWT	Number released	Size Fish /lb	Size Length (mm)	Days accli-mated	Release date
McKenzie	070830	Acclimate	Lone Star	27,441	30,793	8.2	161.9	22	11/9/94
McKenzie	070834	Acclimate	Lone Star	33,338	33,925	8.9	161.3	22	11/9/94
McKenzie	070835	Acclimate	Lone Star	20,540	21,149	7.2	163.8	22	11/9/94
McKenzie	070831	Direct	Will. Park	29,712	31,578	7.7	170.2	--	11/8/94
McKenzie	070832	Direct	Will. Park	29,487	31,363	7.8	168.3	--	11/8/94
McKenzie	070833	Direct	Will. Park	29,379	30,932	7.9	173.4	--	11/8/94
McKenzie[a]	--	Direct	Will. Park	0	73,028	7.4	167.7	--	11/8/94
McKenzie	070846	Acclimate	Lone Star	20,880	29,610	9.0[b]	--	7	2/24/95
McKenzie	070845	Acclimate	Lone Star	21,226	29,610	9.0[b]	--	7	2/24/95
McKenzie	070836	Acclimate	Lone Star	19,899	30,662	8.6	154.1	20	3/8/95
McKenzie	070847	Direct	Will. Park	31,139	43,208	8.7	162.8	--	3/8/95
McKenzie	070848	Direct	Will. Park	25,497	38,889	8.8	160.9	--	3/8/95
McKenzie	070849	Direct	Will. Park	26,957	42,075	8.8	161.3	--	3/8/95
Marion Fks[a]	--	Direct	Will. Park	0	112,216	12.7	--	--	3/8/95
McKenzie	070850	Control	McK. Hatch.	27,738	27,738	8.5	170.5	--	3/1/95
McKenzie	070851	Control	McK. Hatch.	27,022	27,022	8.5	170.5	--	3/1/95
McKenzie	070444	Control	McK. Hatch.	27,924	27,924	8.5	170.5	--	3/1/95

[a] *These fish are not part of the net pen evaluation.*

[b] *Fish/lb was calculated from samples on day of transport because of an emergency release 7 days later.*

Table 24. Releases of spring chinook salmon into the lower Clackamas and Willamette rivers to evaluate acclimation in net pens, 1994 brood.

Stock	Tag code	Treatment	Location of release	Number Ad+CWT	Number Released	Size		Days accli-mated	Release date
						Fish /lb	Length (mm)		
Clackamas	071045	Acclimate	Lone Star	33,666	33,666	8.9	160.4	21	11/8/95
Clackamas	071046	Acclimate	Lone Star	25,317	25,624	8.7	158.1	21	11/8/95
Clackamas	071047	Direct	Will. Park	30,543	32,842	8.5	158.2	--	11/8/95
Clackamas	071048	Direct	Will. Park	28,853	31,917	8.4	159.8	--	11/8-9/95[b]
Willamette[a]	070955	Direct	Will. Park	28,349	172,858	6.6	170.2[c]	--	11/28/95
Clackamas	071049	Acclimate	Clack. Cove	41,471	42,078	7.5	169.8	21	3/15/96
Clackamas	071243	Acclimate	Clack. Cove	38,087	38,240	7.5	169.2	21	3/15/96
Clackamas	071050	Direct	Clack. Cove	39,454	40,014	8.1	164.8	--	3/15/96
Clackamas	071051	Direct	Clack. Cove	39,457	39,655	7.7	165.9	--	3/15/96
McKenzie	070860	Control	McK. Hatch.	25,058	25,058	7.7	163.5	--	3/08/96

[a] *These fish are not part of the net pen evaluation.*

[b] *This group was released over two days due to mechanical problems on a liberation truck.*

[c] *Length frequency was conducted on 31 October 1995; fish were not released until 28 November 1995.*

Fall releases consisted of two groups acclimated in net pens in Clackamette Cove, two groups direct-released into Clackamette Cove, and two groups direct-released into the Clackamas River at Clackamette Park (RM 0.5) (Table 25). Direct releases into the Clackamas River will allow us to determine the effects of Clackamette Cove on smolt survival.

No major problems were associated with fall releases. Initially we were concerned about high water temperatures in the Cove during October. Water temperature was 59° F several days prior to transferring fish to the net pens. However, water temperatures dropped to 53° on the day fish were transferred to the net pens and continued to drop to 46° near the end of the acclimation period.

Spring releases in 1997 consisted of two groups acclimated in Clackamette Cove, two groups released directly into Clackamette Cove, and two groups released directly into Multnomah Channel (RM 20.5) on the mainstem Willamette River (Table 25). In addition, three coded wire tagged control groups were released from McKenzie Hatchery in March 1997.

Table 25. Releases of spring chinook salmon into the lower Clackamas and Willamette rivers to evaluate acclimation in net pens, 1995 brood.

Stock	Tag code	Treatment	Location of release	Number Ad+CWT	Number Released	Size		Days accli-mated	Release date
						Fish /lb	Length (mm)		
McKenzie	091758	Acclimate	Clack. Cove	29,049	29,491	8.0	167.8	22	11/8/96
McKenzie	091759	Acclimate	Clack. Cove	29,407	29,525	7.9	168.2	22	11/8/96
McKenzie	091756	Direct	Clack. Cove	29,610	29,942	7.1	174.0	--	11/8/96
McKenzie	091757	Direct	Clack. Cove	28,955	29,792	7.1	174.0	--	11/8/96
McKenzie	091754	Direct	Clack. River	33,415	34,916	7.0	172.0	--	11/8/96
McKenzie	091755	Direct	Clack. River	27,699	29,937	6.9	173.6	--	11/8/96
Willamette[a]	091715	Acclimate	River Place	14,301	39,948	7.7	167.5	24	11/9/96
Willamette[a]	091715	Direct	Will. Park	16,587	46,268	9.3	--	--	11/5/96
McKenzie	091801	Acclimate	Clack. Cove	30,529	42,561	9.5	158.1	21	3/13/97
McKenzie	091802	Acclimate	Clack. Cove	24,996	31,016	8.2	164.9	21	3/13/97
McKenzie	091760[b]	Direct	Clack. Cove	30,677	39,085	9.1	165.5	--	3/13/97
McKenzie	091762[b]	Direct	Clack. Cove	30,538	32,287	8.9	161.9	--	3/13/97
McKenzie	091761	Direct	Mult. Channel	29,020	42,067	10.1	156.0	--	3/13/97
McKenzie	091763	Direct	Mult. Channel	29,888	42,720	8.9	160.8	--	3/13/97
McKenzie	071258	Control	McK. Hatch.	29,143	29,143	8.7	167.7	--	3/6/97
McKenzie	091803	Control	McK. Hatch.	34,167	34,167	8.7	167.7	--	3/6/97
McKenzie	091804	Control	McK. Hatch.	33,838	33,838	8.7	167.7	--	3/6/97

[a] *These fish are not part of the net pen evaluation.*

[b] *Tag codes not in PSMFC database as of 12/31/97.*

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McKenzie	070832	Direct	Will. Park	29,487	31,363	7.8	168.3	--	11/8/94
McKenzie	070833	Direct	Will. Park	29,379	30,932	7.9	173.4	--	11/8/94
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[a] *These fish are not part of the net pen evaluation.*

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Clackamas	071046	Acclimate	Lone Star	25,317	25,624	8.7	158.1	21	11/8/95
Clackamas	071047	Direct	Will. Park	30,543	32,842	8.5	158.2	--	11/8/95
Clackamas	071048	Direct	Will. Park	28,853	31,917	8.4	159.8	--	11/8-9/95[b]
Willamette[a]	070955	Direct	Will. Park	28,349	172,858	6.6	170.2[c]	--	11/28/95
Clackamas	071049	Acclimate	Clack. Cove	41,471	42,078	7.5	169.8	21	3/15/96
Clackamas	071243	Acclimate	Clack. Cove	38,087	38,240	7.5	169.2	21	3/15/96
Clackamas	071050	Direct	Clack. Cove	39,454	40,014	8.1	164.8	--	3/15/96
Clackamas	071051	Direct	Clack. Cove	39,457	39,655	7.7	165.9	--	3/15/96
McKenzie	070860	Control	McK. Hatch.	25,058	25,058	7.7	163.5	--	3/08/96

[a] *These fish are not part of the net pen evaluation.*

[b] *This group was released over two days due to mechanical problems on a liberation truck.*

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McKenzie	091759	Acclimate	Clack. Cove	29,407	29,525	7.9	168.2	22	11/8/96
McKenzie	091756	Direct	Clack. Cove	29,610	29,942	7.1	174.0	--	11/8/96
McKenzie	091757	Direct	Clack. Cove	28,955	29,792	7.1	174.0	--	11/8/96
McKenzie	091754	Direct	Clack. River	33,415	34,916	7.0	172.0	--	11/8/96
McKenzie	091755	Direct	Clack. River	27,699	29,937	6.9	173.6	--	11/8/96
Willamette[a]	091715	Acclimate	River Place	14,301	39,948	7.7	167.5	24	11/9/96
Willamette[a]	091715	Direct	Will. Park	16,587	46,268	9.3	--	--	11/5/96
McKenzie	091801	Acclimate	Clack. Cove	30,529	42,561	9.5	158.1	21	3/13/97
McKenzie	091802	Acclimate	Clack. Cove	24,996	31,016	8.2	164.9	21	3/13/97
McKenzie	091760[b]	Direct	Clack. Cove	30,677	39,085	9.1	165.5	--	3/13/97
McKenzie	091762[b]	Direct	Clack. Cove	30,538	32,287	8.9	161.9	--	3/13/97
McKenzie	091761	Direct	Mult. Channel	29,020	42,067	10.1	156.0	--	3/13/97
McKenzie	091763	Direct	Mult. Channel	29,888	42,720	8.9	160.8	--	3/13/97
McKenzie	071258	Control	McK. Hatch.	29,143	29,143	8.7	167.7	--	3/6/97
McKenzie	091803	Control	McK. Hatch.	34,167	34,167	8.7	167.7	--	3/6/97
McKenzie	091804	Control	McK. Hatch.	33,838	33,838	8.7	167.7	--	3/6/97

[a] *These fish are not part of the net pen evaluation.*

[b] *Tag codes not in PSMFC database as of 12/31/97.*

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APPENDIX A

Schematic of Willamette Spring Chinook Salmon Study Plan

STUDY PLAN OVERVIEW

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

To Achieve this Goal, 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

Age Composition of Spring Chinook Salmon Sampled in 1996 and 1997

Appendix Table B-1. Age composition of chinook salmon sampled in the McKenzie River, 1996.

			Fork length (mm)			
Mark/age	Sample size	Percent	Mean	Std. Dev.	Minimum	Maximum
			McKenzie Hatchery			
Unmarked:						
3	2	0.4	575	20.0	555	595
4	91	18.5	774	51.0	570	855
5	393	79.7	810	37.9	665	900
6	7	1.4	805	36.2	755	850
Ad+CWT:						
3	2	0.8	555	30.0	525	585
4	197	75.5	744	46.1	590	860
5	62	23.8	812	39.7	690	905
			Leaburg Dam			
Unmarked:						
3	1	0.5	560	0.0	--	--
4	149	73.8	760	42.1	595	845
5	52	25.7	817	40.5	670	890
Ad+CWT:						
4	4	80.0	668	13.0	690	760
5	1	20.0	840	0.0	--	--
			Spawning Grounds			
Unmarked:						
4	28	44.4	792	43.5	700	876
5	35	55.6	840	52.3	720	940
Ad+CWT:						
4	4	50.0	789	56.6	725	850
5	4	50.0	860	48.5	790	910

Appendix Table B-2. Age composition of chinook salmon collected as carcasses in spawning surveys on the North Santiam River in 1996.

Race, age, and sex	Number	Mean fork length (mm)	Number unspawned	Number adipose clips
Fall chinook:				
3.1:				
Male	2	688	0	0
Female	1	840	0	0
Spring chinook:				
4.2:				
Male	4	843	0	0
Female	2	730	0	0
5.2:				
Male	6	901	0	0
Female	23	866	8	2
Unknown	2	-	-	-
6.2:				
Female	1	860	1	0

Appendix Table B-3. Age composition of chinook collected as carcasses on spawning surveys on the North Santiam River in 1997.

Race[a], age, and sex	Number	Mean fork length (mm)	Number unspawned	Number adipose clips
Fall chinook:				
3.1:				
male	18	789	0	1
female	27	753	2	3
4.1:				
male	1	870	0	0
female	1	770	0	0
Spring chinook:				
4.2:				
male	30	773	2	0
female	29	792	8	1
5.2:				
male	10	872	2	0
female	17	869	2	1
6.2:				
male	1	1060	0	0

[a] *An additional 10 fish could not be separated by race.*

APPENDIX C

Spawning Surveys for Spring Chinook Salmon in the Willamette and Sandy Basins, 1996, 1997

Appendix Table C-1. Number of chinook redds and carcasses observed in the North Santiam River in 1997.

Survey section	Length (mi)	Number of surveys	Counts	
			Redds	Carcasses[a]
North Santiam:				
Minto - Packsaddle	1.7	8	10	3
Packsaddle - Gates	2.6	8	51	23
Gates - Mill City	3.7	8	16	28
Mill City - Fishermen's Bend	2.0	8	8	5
Fishermen's Bend - Mehama	6.5	8	16	26
Mehama - Power line	3.5	2	4	5
Powerline - Gerren Island	3.5	2	1	0
N. + South Channels - Stayton[b]	3.3	2	13	1
Stayton - Shellburn	5.5	2	2	2
Shellburne - Greens bridge	8.2	3	145	39
Greens bridge - mouth	3.0	1	29	15
Little North Santiam River:				
Elkhorn Bridge - Salmon Falls	1.0	2	3	0
Salmon Falls - Golf bridge	3.5	2	1	2
Golf bridge - Middle bridge	5.3	2	6	8
Middle bridge - Mouth	7.2	2	0	0

[a] *Includes carcasses that could not be reached to sample.*

[b] *The north channel was surveyed twice and one carcass and two redds were counted. The south channel was surveyed twice and no carcasses and 6 redds were counted.*

Appendix Table C-2. Spring chinook salmon spawning surveys in the Clackamas River, 1997.

Survey section	Length (mi.)	Number of surveys	Counts		
			Live fish	Carcasses[a]	Redds
Clackamas River:					
Sisi Creek - Pinhead Creek	5.8	2	10	2	8
Pinhead Creek - Forest Rd 4650	3.3	8	73	4	60
Forest Rd 4650 - Collawash River	8.0	8	46	10	47
Collawash River - Oak Grove Fork	3.8	7	50	22	38
Oak Grove Fork - Cripple Creek	4.7	6	28	13	24
Cripple Creek - Fish Creek	6.8	6	47	13	59
Fish Creek - South Fork Clackamas	7.7	4	28	15	49
South Fork Clackamas - North Fork Reservoir	1.0	4	5	10	17
Collawash River:					
2.0 miles upstream - Collawash Falls	2.0	1	0	0	0
Collawash Falls - Upper Forest Rd 63	1.0	4	2	0	4
Upper Forest Rd 63 - Hot Springs Fork	2.0	5	22	0	22
Hot Springs Fork - mouth	4.5	8	24	4	22
Hot Springs Fork:					
Bagby Trail Bridge - Pegleg Falls	1.3	1	0	0	0
Pegleg Falls - mouth	5.0	3	2	0	1
Pinhead Creek:					
Last Creek - mouth	1.0	1	0	0	0
Roaring River:					
Falls - mouth	2.0	4	8	0	6
Fish Creek:					
Silk Creek - mouth	4.7	4	18	5	12
North Fork Clackamas River:					
Fall Creek - mouth	1.5	1	0	0	0
South Fork Clackamas River:					
Falls - mouth	0.6	6	15	1	7

[a] *Includes carcasses that could not be reached to sample.*

Appendix Table C-3. Spring chinook salmon spawning surveys in the Sandy River, 1997.

Survey section	Length (mi.)	Number of surveys	Counts: Live fish	Carcasses[a]	Redds
Salmon River:					
Final Falls - Rolling Riffle	1.5	7	75	47	83
Rolling Riffle - Forest Rd 2618	1.7	7	98	27	102
Forest Rd 2618 - Bridge Street	3.6	7	74	58	44
Bridge Street - start of USFS survey section	1.1	7	184	91	82
USFS survey section	0.2	7	88	15	33
End of USFS section - Arrah Wanna campground	0.5	7	33	12	16
Arrah Wanna - Hwy 26	4.4	7	343	129	149
Tributaries:					
Cheeney Creek	2.0	3	2	0	8
Boulder Creek	1.0	1	0	0	1
Unnamed (near Wildwood)	1.0	1	0	0	1
Still Creek:					
Forest Rd 2612 - Cool Creek	2.0	3	0	4	4
Cool Creek - Road 20	1.7	8	94	21	72
Road 20 - smolt trap	1.3	7	35	47	37
Smolt trap - mouth	0.3	1	0	0	1
Zigzag River:					
Devil Canyon Cr. - Camp Cr.	1.5	1	0	0	0
Camp Cr. - Still Cr.	2.0	2	2	1	3
Still Cr. - mouth	2.0	7	83	27	72
Camp Creek:					
Laurel Hill - campground	2.0	2	0	0	0
Campground - mouth	2.0	4	10	1	12

Appendix Table C-3. (Continued).

Survey section	Length (mi.)	Number of surveys	Counts: Live fish	Carcasses[a]	Redds
Clear Creek:					
Powerline - mouth	1.4	3	0	0	0
Clear Fork:					
Barrier - mouth	0.6	4	3	2	3
Lady Creek:					
1.0 miles upstream - mouth	1.0	1	0	0	0
Henry Creek:					
E. Henry road - mouth	1.0	2	0	0	0
Devil Canyon Creek:					
Falls - mouth	0.8	2	0	0	0
Muddy Fork Creek:					
2.0 miles upstream - mouth	2.0	1	0	0	0
Lost Creek:					
Lost Cr. campground - Riley Cr. campground	2.5	2	0	0	0
Riley Cr. campgrd - mouth	2.0	3	6	2	8

[a] *Includes carcasses that could not be reached sample.*

APPENDIX D

Experimental Design of the Fin-clip Mortality Study
in the Willamette Basin.

Brood year	Hatchery	Mark[a]	Number	Release date
1996	McKenzie	Ad+CWT	88,000	March 1998
		RV	30,000	March 1998
		RM	30,000	March 1998
		RVAd+CWT	30,000	March 1998
		RMAd+CWT	30,000	March 1998
	Marion Fks[b]	Ad+CWT	357,000	March 1998
		LV	30,000	March 1998
		LM	30,000	March 1998
	Clackamas	Ad+CWT	30,000	March 1998
		RV	30,000	March 1998
		RM	30,000	March 1998
1997	McKenzie	Ad+CWT	30,000	March 1999
		LV	30,000	March 1999
		LM	30,000	March 1999
		LVAd+CWT	30,000	March 1999
		LMAd+CWT	30,000	March 1999
	Marion Fks[b]	Ad+CWT	30,000	March 1999
		RV	30,000	March 1999
		RM	30,000	March 1999
	Clackamas	Ad+CWT	30,000	March 1999
		LV	30,000	March 1999
		LM	30,000	March 1999

APPENDIX D

(Continued)

Brood year	Hatchery	Mark	Number	Release date
1998	McKenzie	Ad+CWT	30,000	March 2000
		RV	30,000	March 2000
		RM	30,000	March 2000
		RVAd+CWT	30,000	March 2000
		RMAd+CWT	30,000	March 2000
	Marion Fks[b]	Ad+CWT	30,000	March 2000
		LV	30,000	March 2000
		LM	30,000	March 2000
	Clackamas	Ad+CWT	30,000	March 2000
		RV	30,000	March 2000
		RM	30,000	March 2000

[a] *RV = right ventral, RM = right maxillary, LV = left ventral, LM = left maxillary, Ad = adipose, CWT = coded wire tag.*

[b] *Marion Forks Hatchery is located on the North Santiam River.*

APPENDIX E

Gas Supersaturation in Net Pens in the Lower Willamette River, 1995

On Friday February 17, 1995, 120,000 McKenzie stock spring chinook smolts (1993 brood) were trucked to six net pens in the lower Willamette River to begin three weeks of acclimation. Willamette River flow at Salem was 34,000 cfs on the 17th. Heavy rain and snow melt created freshet conditions and flow increased to 72,000 cfs on the 18th, and peaked at 94,000 cfs on Sunday the 19th. Flow dropped slightly to 90,000 cfs on Monday the 20th, and dropped quickly over the following days to 40,000 cfs by Thursday the 23rd. Water temperature increased from 42°F on Friday the 17th to 49°F on Tuesday the 21st. No temperature data were recorded on Sunday and Monday during the peak flows.

Mortality in net pens was first observed on Tuesday the 21st, and was estimated at 50-200 per net pen. River turbidity made recovering and estimating mortality difficult. The Pathology Section (ODFW) observed gas bubbles in gills and fins of dead fish, with no other signs of disease except low levels of bacterial kidney disease. Gas saturation at the net pen site was measured at 114% on Tuesday when river flow had dropped to 69,000 cfs. Initial estimates of mortality were as high as 60%, which included counts of direct mortality plus estimating the potential delayed mortality. Examination of live fish on Friday the 24th indicated that 71% had gas bubbles present in fins and eyes. The estimated high mortality and continued presence of gas bubbles in the fish resulted in the decision to release four of the six net pens on Friday the 24th. Fish in two net pens were retained. Gas saturation was measured at 110% on Friday.

Fish from the two retained net pens were examined periodically for signs of gas bubbles until their scheduled release on March 8th. Detection of gas bubbles in these fish dropped over the holding period to 10% and finally to zero by the day of release. Examination of both live and dead fish showed scale loss and erosion of the pectoral fins, indicating that fish were possibly impinged on the netting by high river velocities. Velocity at the net pen site during the peak flows tested the integrity of the net pens with stay cables pulled extraordinarily tight and anti-billowing devices severely bent. The bent anti-billowing devices reduced the pen depth from the standard 8 feet to 6 feet or less.

Although no gas saturation measurements were taken during peak flows, we suspect that saturation levels were much higher at 94,000 cfs than the 114% measured at 69,000 cfs. At this time it appears unlikely that we can back-calculate gas saturation levels at the peak flows since most of our measurements were taken at substantially lower flows. Initially there was some question whether the supersaturation was occurring at Willamette Falls. Saturometer readings taken in the McKenzie River, the Middle Fork Willamette, Willamette River at Corvallis, and immediately above Willamette Falls all ranged between 100% and 101.6%.

Fish typically disperse deeper in the water column under supersaturated conditions. Net pen fish, which were forced near the surface by high velocities and distorted nets, would have been unable to move deeper to compensate for potentially lethal levels of gas saturation. Stress probably became a contributing factor in the observed mortality when fish were forced into the downstream end of the nets by river velocity. When river flows decreased and gas levels dropped fish were able to recover, with fewer fish showing signs of gas bubbles over time.

We took length and weight samples on the remaining two pens prior to their release on March 8. The surviving fish appeared active and healthy at time of release. The final estimate of mortality for all the net pen fish was 30%. Delayed mortality, which we initially expected, did not occur.

Since gas saturation levels have not been historically monitored in the lower Willamette, we have no baseline data for reference. Apparently flows of ~90,000 cfs cause high levels of supersaturation below Willamette Falls, but we have no record at that flow. Willamette River flow records examined for the last 24 years showed that flows greater than 50,000 cfs occurred 14 times and flows over 70,000 cfs occurred 6 times (Personal communication, Kevin Goodson, ODFW, Corvallis, OR). Undoubtedly these flows along with gas superstaturation will be encountered in the future in the lower Willamette River.

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