HATCHERY IMPACTS ON THE UPPER WILLAMETTE RIVER CHINOOK SALMON AND STEELHEAD ESUS

Introduction

Objectives of anadromous salmonid hatchery programs include genetic safeguarding, supplementation and recovery of depressed natural stocks, or simply providing for increased harvest opportunities. Typically, hatchery-reared juveniles are released into streams and some proportion of returning adults mix with naturally produced adults in fisheries, and also “stray” to natural spawning grounds, often interbreeding with naturally-produced adults. There has been much contention in recent decades over the affects that hatchery fish can have upon wild populations. Many authors have concluded that hatchery programs pose risks to wild populations genetically (e.g., Reisenbichler and McIntyre 1977, Weitkamp et al. 1995, Currens et al. 1997, Reisenbichler and Rubin 1999) and ecologically (e.g., Nickelson et al. 1986, Chilcote 2003, Kostow et al. 2003). Genetic risks can occur from interbreeding between hatchery and wild fish, which may erode wild population fitness, lead to loss of genetic diversity, and alter life-history attributes such as timing of spawning and fry emergence. Ecological risks include increased competition for food resources as well as spawning and rearing sites, increased predation on both naturally and hatchery produced fish, as well as direct predation of hatchery fish on wild fish. Increased harvest or incidental fishery mortality of wild fish and disease transfer between hatchery and wild fish may occur. However, it is not necessarily the case that adverse impacts are inherent to artificial propagation, but these can be largely confused with effects of ill-considered management goals and decisions and other, unrelated, factors (Campton 1995, Brannon et al. 2004). Hatcheries can supplement natural populations and production, protect genetic resources and provide for stream nutrient enrichment (Steward and Bjornn 1990; Cuenco *et al*. 1993). In summary, whereas some biologists feel that properly managed hatchery programs can provide for fisheries as well as supplement numbers of fish that spawn naturally, thus increasing natural production, while acceptably reducing biological risks, others doubt that this is the case (Waples 1999; ISAB 2003).

Releases of hatchery reared Chinook salmon in the Willamette basin began as early as 1902 in the McKenzie River, 1916 in the main stem Willamette River, 1918 in the Santiam River, 1920 in the Middle Fork Willamette River, 1939 in the Clackamas River, 1957 in the Mollalla/Pudding Rivers, 1968 in the Luckiamute River, 1970 in the Mary’s River, and 1981 in the Calapooia River. Over the 20th century programs throughout the basin have released over 500,000,000 Upper Willamette Chinook salmon ESU fish and over 200,000,000 fish from other Chinook salmon ESUs. All releases of fish of other ESUs ended by the early 1990’s. However, there are still small remnant populations of fall Chinook salmon in west-side tributaries and the lower main stem, as well as in the lower Santiam River, and the Clackamas River (Myers et al. 2006). There are currently hatchery programs for Upper Willamette spring Chinook salmon in all four of the sub-basins of the Willamette River basin with Core populations as defined by the

Willamette/Lower Columbia Technical Recovery Team (WLC-TRT), as well as in the one sub-basin with a genetic legacy population (McIlheny et al. 2006):

- Clackamas River (Core population)
- North Santiam River (Core population)
- South Santiam River (Core population)
- McKenzie River (Genetic legacy population)
- Middle Fork Willamette River (Core population)

There were releases of hatchery-reared native winter steelhead from 1930-1998, discontinued out of concerns for the health of the wild populations. Non-native summer steelhead programs began as early as 1926. Summer steelhead of Skamania stock are currently raised at most of the rearing facilities in the Upper Willamette basin, and released in the North and South Santiam, McKenzie and Middle Fork Willamette Rivers. The spring Chinook hatchery programs have the goals of providing returning adults to mitigate for lost harvest opportunities associated with natural population reductions due to the construction of dams and reservoirs, as well as to provide broodstock for hatchery and ongoing and future recovery projects (ODFW 2004a). The summer steelhead program is also a mitigation program aimed at providing for sports fisheries and replacement of fisheries lost due to habitat and production loss in the Willamette as well as other lower Columbia basins (ODFW 2004b). For both spring Chinook salmon and summer steelhead hatchery programs, there are efforts made to reduce adverse impacts on native wild stocks.

Impacts of spring Chinook salmon hatchery programs

Broodstock Management

The spring Chinook salmon hatchery programs all involve a natural spawning supplementation aspect, that is, hatchery fish spawn naturally, supplementing wild spawners. There are also ongoing attempts to restore production by outplanting of adults to underutilized streams or to streams to which passage is blocked by dams. Accordingly, efforts are made to maintain genetic integrity and diversity in the hatchery stocks, including employing broodstock from throughout the run temporally and employing spawners of all ages roughly proportionate to their relative abundance in the run (ODFW 2004a,b). Except for in the Clackamas sub-basin, hatchery stocks were all founded from native stocks of the sub-basins, although there have been occasional inputs from out-of-sub-basin or out-of-basin stocks. The Clackamas hatchery stock originated from the McKenzie stock, but it has now been kept isolated from out-of-sub-basin inputs for many generations. Except for fingerling releases in Quartzville Creek, upstream of Green Peter dam in the South Santiam, all hatchery fish in the basin are released as smolts that are expected to immediately migrate, thus limiting ecological interaction and competition with naturally produced fish. Additionally, a large majority of smolts are released directly from rearing facilities to reduce straying rates (ODFW 2004a). However, stray rates among carcasses found on spawner surveys indicate that incorporation of strays from other sub-basins probably occurs at significant rates at the various hatchery facilities (Firman et al. 2005) (Tables 1 and 2).

In keeping with current recommendations on broodstock management for supplementation programs (e.g., Ford 2002; Mobrand et al. 2005), the programs are now integrated, that is, wild fish are being incorporated into all hatchery broodstocks. The goal is to have 5% to 10% (preferably) of each year's broodstock be of wild origin without employing more than 10% of the total wild returners for such purpose. However, there are difficulties encountered. Unmarked (non fin-clipped) fish made up at least 10% of the fish spawned at two of the four hatchery programs in 2004 (Table 3), but some hatchery fish are purposefully or inadvertently not given fin-clips, thus significant proportions of unmarked fish are sometimes of hatchery origin (Figure 1). There are plans and efforts underway to increase the quality and effectiveness of fin-marking. Hatchery fish are also all now given otolith thermal marks, but these can only be detected under magnification by trained employees, after fish are killed and spawned. Thus, these will likely not be useful as an in-season tool for controlling the proportions of wild and hatchery spawners that contribute to production. Also, for the South Santiam and Middle Fork Willamette sub-basins there are currently no estimates of wild adult escapement to spawning areas and collection facilities. This is because the trapping facilities are at dams (Foster and Dexter, respectively) that block passage at the upstream end of the natural spawning areas that fish can reach on their own (i.e., mark/recapture population estimates based on trapping and subsequent upstream recoveries on spawning grounds are not possible). This hampers the broodstock integration program because it is not possible to estimate the percentage of wild fish that can be used as hatchery broodstock (i.e., this use of wild spawners should not exceed 10%). In the McKenzie, the percentage of escapement that is of wild origin is large, thus many wild adults can be used as hatchery broodstock. In the North Santiam, wild adults make up only a very small percentage of returning adults, thus fewer of these can be used as hatchery broodstock (Table 4).

Intermixing of hatchery- and naturally- produced adults

Proportions of hatchery fish among all natural spawners vary widely among sub-basins of the Upper Willamette Chinook salmon ESU (Table 5). Only in the McKenzie and Clackamas (above North Fork dam) sub-basins do naturally produced spawners predominate. However, in neither of these sub-basins do hatchery spawners make up ten percent or less of natural spawners as called for in ODFW's Native Fish Conservation Policy (NFCP). Low returns of naturally produced adults and poor natural production success may be related to the relatively high fractions of hatchery fish among natural spawners. The most effective measure to reduce hatchery risk is to isolate hatchery fish from wild populations.

In 2004, 71% of the 30,989 fish collections were released alive, the great majority of released fish being of hatchery origin (Table 6). A total of 4,321 fish were employed as hatchery broodstock. High proportions of captured hatchery adults are released upstream of dams, or in various tributaries, to remove them from the areas downstream of dams where most naturally produced fish spawn, and to perhaps restore productivity in these underutilized habitats (Table 7). However, large numbers of marked fish are released with unmarked fish above Foster reservoir (South Santiam). In the North and South Santiam and the Clackamas, in order to increase fishery opportunities, fair to very large proportions of trapped, marked adults are "recycled" downstream in spring and early summer into main stem areas where wild fish will spawn. In the Clackamas, for example, many fish are recycled 2-3 times, and some as many as 7-8 times, but catches of recycled fish are relatively few (ODFW 2003). ODFW currently transports many hatchery fish away from stream reaches where wild fish spawn. Hatchery fractions among natural spawners could be further substantially reduced by removing (killing) hatchery fish captured at downstream facilities, transporting surplus hatchery fish above passage block dams in complete isolation from releases of wild fish, and discontinuing the practice of recycling. At Bennet dams, for example, hatchery spawners could be almost eliminated if mark rates approached 100%. However, killing of hatchery fish at downstream dams and cessation of recycling could substantially impact the sport fisheries that are a major reason the hatchery programs exist, and would likely result in public disapproval (ODFW 2004a).

Although the carcasses of killed hatchery fish could still be used for stream nutrient enrichment, killing of fish would substantially lower the numbers of adults that currently supplement natural spawning. Reductions in hatchery fraction are generally advisable as a safeguard of wild population genetic integrity to avoid outbreeding depression (loss of fitness) (e.g., Ford 2002), and they are called for in the NFCP. However, the hatchery programs are meant to supplement natural production, particularly in those sub-basins with low numbers of naturally produced spawners. Furthermore, it is not clear that increases in productivity of the wild population would result from reductions or absence of hatchery fish. There are various other mechanisms that severely impact and limit productivity. Trapping, handling and passage problems at dams may be largely to blame for the high prespawn mortality rates often observed among females (Table 8), particularly in the North Santiam (Ken Kenaston, ODFW, personal communication), and in adults released above Foster dam in the South Santiam (Steve Mamoyac, ODFW, personal communications). Warm water temperatures may also be responsible, particularly in the Middle Fork Willamette (Kirk Schroeder and Jeff Ziller, ODFW, personal communication). Warm water temperatures, due to fall reservoir drawdowns, during the spawning period or afterwards during egg incubation also have profound adverse impacts on egg and fry survival (ODFW 2004a). Also, attempts to reestablish production above dams or in underutilized streams using marked adults, unmarked adults, or both, have had mixed success.

In summary, the presence of large numbers of hatchery spawners may or may not be significant compared to the other factors that clearly currently constrain recovery of natural populations. As broodstock management and hatchery practices improve, potential impacts of hatchery programs should abate to at least some extent. NFCP recovery goals also include restoring natural populations to $\geq$50% of historic habitat. This requires transporting spawners above dams, and hatchery fish are currently used for this purpose, as well as to remove them from the wild spawners. Were limiting factors to be successfully managed such that natural production of returning adults was greatly increased, then killing of hatchery spawners or even discontinuation of hatchery programs might be appropriate, assuming that wild spawners could be safely transported above dams in large numbers.

Because return and spawning timing of natural and hatchery fish is very similar, it seems unlikely that the two populations could be separated temporally. Attempts to shift the timing of the hatchery fish would be likely to shift the timing of naturally produced fish through interbreeding (e.g., Flagg et al. 1995, Quinn et al. 2000; Tipping and Bussack 2004), except perhaps in those cases (e.g., Bennett dams, North Fork dam on the Clackamas) where hatchery fish could be culled downstream of spawning areas.

Finally, as long as hatchery and wild adults are intermixed spatially and temporally, it seems unlikely that incidental mortality of naturally produced fish in fisheries directed at hatchery fish can be much reduced. Proportions of spring Chinook salmon caught in the sport fishery that are unmarked are fairly high (Table 9), but almost all are released and post release mortalities are likely relatively low in numbers (Firman et al. 2005). However, if and when natural production achieves recovery, fisheries for naturally produced fish might be sustainable.

Impacts of summer steelhead and resident trout hatchery programs

Efforts to minimize impacts on native populations

The upper Willamette summer steelhead hatchery program also recognizes potential harm to the ESA-listed populations of the Upper Willamette basin, and they are managed to maximize harvest and minimize impacts. The ODFW Hatchery and Genetics Management Plan (HGMP) (ODFW 2004c) cites potential adverse effects on wild winter steelhead population productivity, as has been demonstrated by Chilcote (1998; 2003).

For the North and South Santiam Rivers (the two sub-basins with WLC-TLT defined Core populations), the HGMP and the *Santiam and Calapooia Subbasin Fish Management Plan* (Oregon Administrative Rules 1998) discuss policies for limiting these adverse impacts. Hatchery summer steelhead are managed for harvest but monitored for possible natural production. Only smolt-sized fish are released to minimize competition with native salmonids and encourage rapid outmigration. Smolts, all fin-clipped, are only released at the South Santiam hatchery and the Minto adult collection/rearing facilities (North Santiam) to minimize straying and maximize return to fishery targeted areas and trapping facilities. Catchable trout released into Foster Reservoir are also fin-clipped, and unmarked trout must be released. No smolts are released into the Little North Santiam River, which is being managed for wild fish production for both winter steelhead and spring Chinook salmon. Broodstock is collected May through October to maintain broad run-timing and genetic diversity and to reduce run timing overlap with native winter steelhead, thus reducing the possibility of interbreeding. Returning hatchery adults are not recycled in the fall but are instead removed to avoid having them spawn naturally, and the daily bag limit was recently increased to maximize harvest.

In the McKenzie and Middle Fork Willamette summer steelhead programs, returning adults are recycled through the fishery until approximately mid-October to maximize harvest, which continues until December. To minimize straying of returning adults and competition with wild smolts, hatchery steelhead are stocked as full term smolts, ensuring rapid migration, and most are released at the hatchery sites. One exception is the release of Roaring River Hatchery smolts into the main stem Willamette at Eugene, and for this program out-of-system-reared smolts yield the highest catch rate. Other exceptions include off-station releases approximately 14 miles downstream from Leaburg Hatchery (McKenzie) and approximately 8 miles downstream from Dexter Rearing Facility (Middle Fork Willamette) that effectively disperse angling pressure. All hatchery steelhead are fin-marked.

Potential genetic impacts

Firman et al. (2005) reported large numbers of summer steelhead redds in the "Middle Willamette Monitoring Area" in 2003 and 2004, which contains the four sub-basins with demographically independent populations of native winter steelhead (Mollalla, North Santiam, South Santiam and Calapooia). These authors also estimated many summer steelhead redds in the McKenzie and Middle Fork Willamette sub-basin (Table 10). Thus, substantial potential for genetic affects to the wild winter steelhead population through interbreeding might exist. Furthermore, ecological affects in terms of competition for spawning habitat among adults and competition for rearing habitat and food resources among juveniles might also occur.

Were interbreeding between winter and summer run steelhead occurring to a great extent one might expect to see a shift to earlier spawning timing for the winter fish. However, an analysis by ODFW in 1990 reported that historic run timing of native winter steelhead did not appear to have shifted (ODFW 1990a). Passage monitoring at Willamette Falls and Bennett dams and spawner surveys in the Middle Willamette Monitoring Area indicated mostly distinct migration and spawning timing for summer steelhead (spawning: January-early March) and winter steelhead (spawning: early March and later) (Firman et al. 2005). Also, surveys conducted on traditional surveys with historically high winter steelhead redd densities found only low densities of summer steelhead redds. Overall, temporal and spatial overlap between summer and winter steelhead spawners, and thus potential genetic impacts, occur but appear to be limited. Kostow et al. (2003) reported similar findings in the Clackamas.

Potential ecological impacts

Owing to the substantial amount of natural spawning by summer steelhead, there is substantial potential for competition for rearing habitat and food resources among juvenile summer and winter steelhead. Studies performed in the Columbia basin have clearly demonstrated that such competition can have substantial impacts on native steelhead populations (Chilcote 2003; Kostow et al. 2003). Successful natural production of non-native summer steelhead occurs in the upper Willamette basin (Chilcote 1997). Firman et al. (2005) found that only very small numbers of returning summer steelhead adults in the North and, particularly, the South Santiam were of natural origin. This suggests very limited reproductive success of hatchery summer steelhead natural spawners compared to winter steelhead spawners. However, it may be that low survival of naturally produced summer steelhead occurs not only during the freshwater rearing stage, but particularly after smolt emigration (Kostow et al. 2003). Ecological interactions between progeny of native winter and non-native summer steelhead certainly exist and could be fairly substantial.

There is also potential for predation of summer steelhead parr and smolts on wild winter steelhead and spring Chinook salmon sub-yearlings. This potential also exists between these sub-yearlings and steelhead smolts and resident trout released from hatcheries throughout the Upper Willamette basin. Evaluation by Firman et al. (2005) of predation on spring Chinook salmon sub-yearlings by hatchery steelhead and rainbow trout was somewhat inconclusive, but it appeared that hatchery-released fish might result in the consumption of significant numbers of sub-yearling spring Chinook salmon. Finally, in the Firman et al. (2005) study there also appeared to be certain areas in which summer steelhead were perhaps particularly congregated, including in the Little North Santiam River which is being managed for production from only wild spring Chinook salmon and winter steelhead adults.

The purpose of the summer steelhead hatchery programs is to provide for harvest opportunities to mitigate for habitat lost to production upstream of dams and inundated by reservoirs. The objective is to provide maximum harvest opportunity while not jeopardizing recovery of native winter steelhead in the Upper Willamette River ESU (ODFW 2001c). Firman et al. (2005) provided the most recent data on incidental mortality impacts on adult winter steelhead, and these impacts appeared to be quite small.

Tables and Figures

Table 1. Origin of hatchery spring chinook salmon from recoveries of coded wire tags in spawning ground surveys, 2003. (Reprinted from Firman et al. 2005.)

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

[a] *McKenzie stock acclimated or directly released in the lower Clackamas River.*

[b] *McKenzie stock acclimated or directly released in the lower Willamette River.*

[c] *South Santiam and McKenzie stocks.*

[d] *Includes releases in Fall Creek.*

[e] *Middle Fork Willamette stock released into netpens near mouth of Columbia River.*

Table 2. Origin of hatchery spring chinook salmon from recoveries of coded wire tags in spawning ground surveys, 2004. Data are preliminary. (Reprinted from Firman et al. 2005.)

		Origin of coded wire tags recovered				
River surveyed	n	Local	Netpen[a]	Lower Willamette[b]	Molalla[c]	South Santiam
Middle Fork Willamette	5	5	0	0	0	0
McKenzie	19	9	2	7	0	1
S. Santiam	121	91	5	23	2	--
N. Santiam	28	10	1	9	5	3
Molalla	2	1	0	1	--	0

[a] *McKenzie stock released in the lower Clackamas or Willamette rivers.*

[b] *McKenzie stock reared at Willamette Hatchery and released into the lower Willamette River.*

[c] *South Santiam and McKenzie stocks.*

Table 3. Spring Chinook spawned at hatcheries in the Upper Willamette ESU in 2004. (Reprinted from Firman et al. 2005.)

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

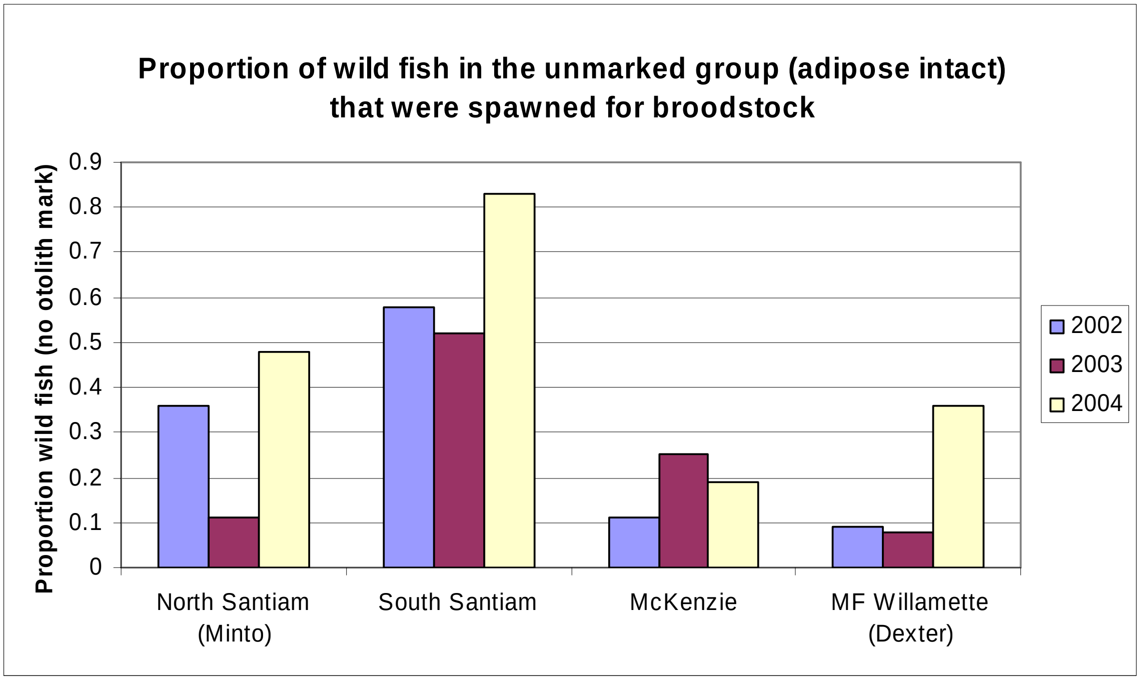

Figure 1. Proportion of wild fish among unmarked adults spawned in hatchery programs.

Table 4. Estimated number of wild and hatchery adult spring chinook salmon in the McKenzie and North Santiam rivers above dams estimated from counts at the dams and from presence of induced thermal marks in otoliths of unclipped carcasses recovered on spawning grounds. Numbers at dams were from video counts (McKenzie) and expanded trap counts (North Santiam, from 4 d/wk counts). (Reprinted from Firman et al. 2005.)

	At dam		No clip carcasses	Estimated number		
Run year	Not fin clipped	Fin clipped	with thermal marks (%)[a]	Wild	Hatchery	Percent wild
			McKenzie			
2001	3,433	869	15.9	2,887	1,415	67
2002	4,223	1,864	14.7	3,602	2,485	59
2003	5,784	3,543	11.1	5,142	4,185	55
			North Santiam			
2000[b]	1,045	1,241	90.7[b]	97	2,189	4
2001	388	6,398	43.4	220	6,566	3
2002	1,231	6,409	51.0[c]	604	7,036	8
2003	1,262	11,570	78.5[c]	271	12,561	2

[a] *Adjusted by distribution of redds among survey areas.*

[b] *Escapement at Bennett Dam was likely underestimated (*see *Schroeder et al. 2001).*

[c] *Weighted average of adjusted spawning ground samples and samples from Minto Pond.*

Table 5. Composition of spring Chinook salmon in the Willamette and Sandy basins based on carcasses recovered, weighted for distribution of redds among survey areas within a watershed (except Middle Fork Willamette). For comparison, the percentages of wild carcasses not weighted for redd distribution are also presented. (Reprinted from Schroeder and Kenaston 2004.)

River (section), run year	Fin clipped	Not fin clipped[a]		Percent wild	
		Hatchery	Wild	Weighted	Not weighted
McKenzie (above Leaburg Dam)					
2001	62	50	265	70	69
2002	140	78	454	68	62
2003	130	44	351	67	62
North Santiam (Minto–Bennett Dam[b])					
2000[c]	128	264	27	6	6
2001	385	43	56	12	6
2002	230	44	45	14	13
2003	855	89	27	3	4
South Santiam (Foster–Waterloo)					
2002	1,604	37	224	12	12
2003	970	31	151	13	13
Middle Fk Willamette (Dexter–Jasper[d])					
2002	167	151	15	--	5
2003	62	48	4	--	4
Molalla (Copper Creek–Trout Creek)					
2002	94	5	3	3	2
2003	17	6	1	4	4
Clackamas (above North Fork Dam)					
2002	e	31	70	69	59
2003	5[e]	40	145	76	79
Sandy (above Marmot Dam)					
2002	3[e]	26	121	81	81
2003	9[e]	14	106	82	80

[a] *The proportion of hatchery and wild fish were determined by presence or absence of thermal marks in otoliths.*

[b] *Including Little North Fork Santiam.*

[c] *About 95% of the 1995 brood (5-year-old) was released without an adipose fin clip.*

[d] *Including Fall Creek.*

[e] *Fish were sorted at the dams and all or most of clipped fish were removed.*

Table 6. Fate of marked and unmarked spring chinook entering hatcheries & collection facilities: 2004. (Reprinted from Firman et al. 2005.)

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

Table 7. Releases of spring chinook captured in hatcheries and collection facilities: 2004. (Reprinted from Firman et al. 2005)

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

Table 8. Number and percentage of carcasses of spring chinook salmon (females) in the Willamette River basin that died before spawning and starting dates of spawning surveys, 2001–2004. (Reprinted from Firman et al. 2005.)

River	Starting date	Carcasses	Pre-spawn mortality Number	Pre-spawn mortality Percent
		2001		
McKenzie	Aug 21	198	14	7
North Santiam	Aug 14	319	238	75
		2002		
Middle Fork Willamette	Aug 7	162	134	83
Fall Creek	Aug 27	36	21	58
McKenzie	Aug 15	509	41	8
South Santiam	Aug 6	794	204	26
North Santiam	Aug 1	229	120	52
		2003		
Middle Fork Willamette	Jul 15	49	49	100
Fall Creek	Aug 27	9	4	44
McKenzie	Aug 7	362	75	21
Calapooia	Jul 31	27	27	100
South Santiam	Jul 14	660	187	28
Thomas Creek	Aug 12	9	8	89
North Santiam	Jun 27	740	530	72
Little North Fork Santiam	Jul 10	27	22	81
Molalla	Aug 27	13	9	69
		2004		
Middle Fork Willamette	Aug 24[a]	76	75	99
McKenzie	Aug 18	343	59	17
South Santiam	Jul 20	557	399	72
North Santiam	Jun 17	287	222	77
Little North Fork Santiam	Jul 14	8	4	50

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

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

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

Table 9. Spring chinook harvested and released in the Middle Fork fishery, 2003. (Reprinted from Firman et al. 2005.)

Kept

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

Released

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

Table 10. Population estimates for summer steelhead redds in the Upper Willamette ESU. (Reprinted from Firman et al. 2005.)

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

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