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Introduction

The National Marine Fisheries Service (NMFS) has listed spring Chinook salmon (*Oncorhynchus tshawytscha*) and winter steelhead (*O. mykiss*) in the upper Willamette River Evolutionarily Significant Unit (ESU) as threatened under the Endangered Species Act (NMFS 1999a; NMFS 1999b). As a result, any actions taken or funded by a federal agency must be evaluated to assess whether they are likely to jeopardize threatened and endangered species, or result in the destruction or impairment of critical habitat. Several hatcheries produce and release hatchery salmonids in the upper Willamette Basin (Figure 1), which may impact wild populations of listed species. All are operated by the Oregon Department of Fish and Wildlife (ODFW) and are funded (50–100%) by the U.S. Army Corps of Engineers (Corps).

Potential risks of artificial propagation programs have been widely debated (e.g. Kostow and Zhou 2006, Levin and Williams 2002). Risks include disease transfer, competition for food and spawning sites, increased predation, increased incidental mortality from harvest, loss of genetic variability, genetic drift, and domestication (Steward and Bjornn 1990; Hard et al. 1992; Cuenco et al. 1993; Busack and Currens 1995, and Waples 1999). Hatcheries can also bolster the abundance of wild salmonid ESUs, (a critical consideration for those on the verge of extirpation) by providing a genetic reserve, as well as provide opportunities for nutrient enrichment of streams (Steward and Bjornn 1990; Cuenco et al. 1993). The objective of this project is to conduct baseline monitoring of returning adult fish and evaluate the potential effects of hatchery programs on naturally spawning populations of spring Chinook salmon and winter steelhead in the upper Willamette River Basin.

This report fulfills a requirement under Task Order NWPPM-09-FH-05, covering activities of July 2009–May 2010 that were implemented by ODFW on behalf of the Corps to assist with meeting the requirements of the reasonable and prudent alternatives (RPAs) and measures prescribed in the Willamette Project Biological Opinion (BiOp) of July 2008 (NOAA 2008). The Corps provided funding to continue ongoing monitoring activities and initiate long-term planning. Primary tasks by species included:

<u>Spring Chinook salmon</u>

Task 1.1: Determine abundance, distribution, and percent hatchery-origin fish on spawning grounds downstream of federal dams.

Task 1.2: Monitor clipped & unclipped fish passing Leaburg and Upper Bennett dams.

Task 2.1: Collection, spawn timing, and hatchery/wild composition for broodstock management.

Task 2.2: Determine survival of outplanted fish (upstream of federal dams) and abundance of spawners.

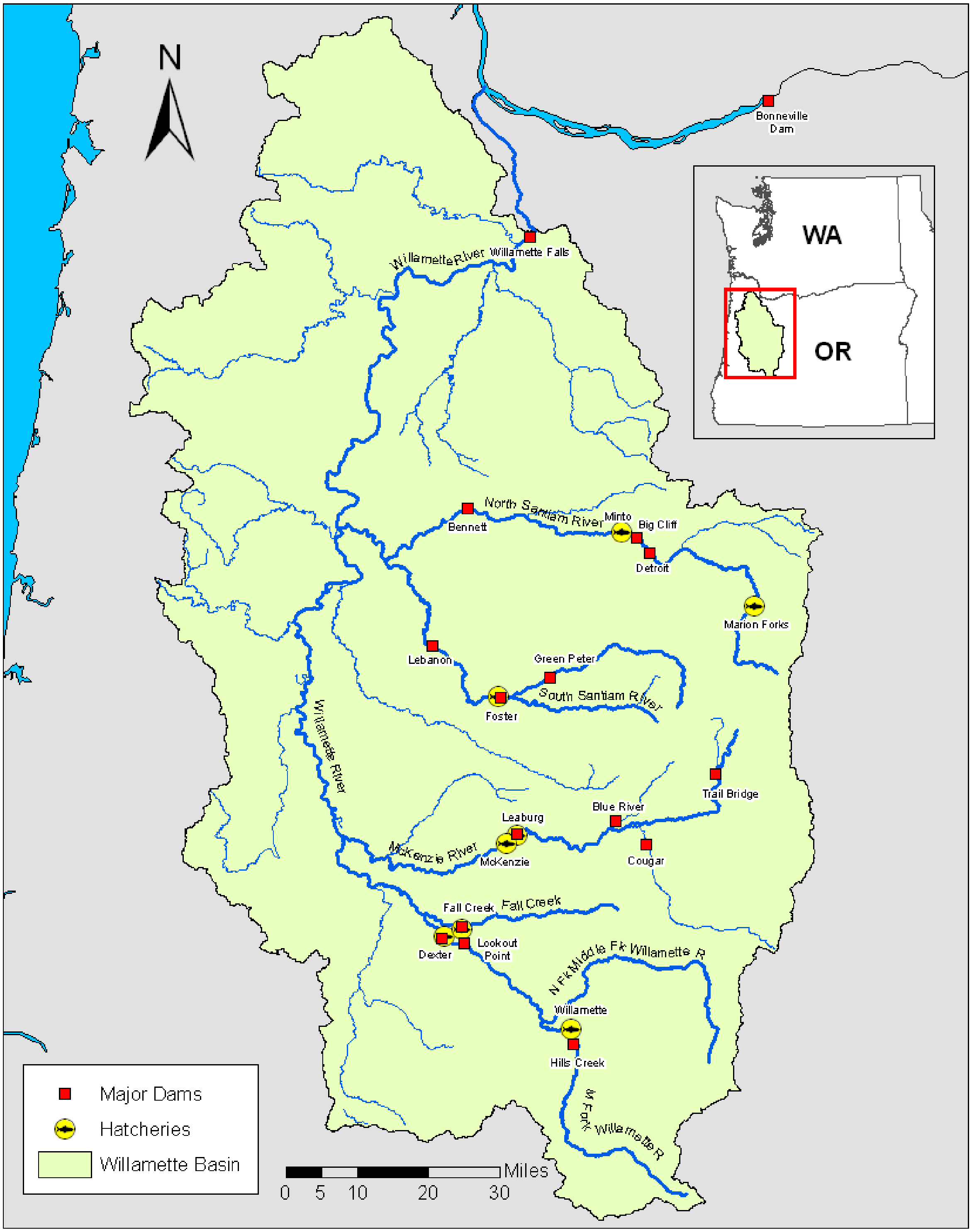

FIGURE 1.—The upper Willamette Basin with major dams, hatcheries, and fish collection facilities.

Steelhead

Task 3.1: Determine the extent of summer (hatchery origin) steelhead reproduction in the wild.

Task 3.2: Evaluate release strategies for summer steelhead to increase migration and reduce impacts on wild fish.

A detailed description of subtasks referred to in this report and the RPAs associated with each primary task are provided in Appendix 1. Several other tasks conducted under this contract were added as an amendment (Tasks 4–6) but will be addressed in separate draft reports provided to the Corps in July 2010. Task 3.2 is addressed in Appendix 4.

Methods

Task 1.1: Distribution, Abundance, and Proportion of Hatchery and Natural-Origin Chinook Salmon

Spawning Ground Surveys Downstream of Corps Dams (Task 1.1.1).—We surveyed four major eastside tributaries in the Willamette Basin upstream of Willamette Falls (Figure 1) in 2009 by boat and on foot to count spring Chinook salmon carcasses and redds. We counted redds from late August through October to encompass the peak times of spawning based on data from surveys conducted in past years. Carcasses were examined for adipose fin clips to determine the proportion of hatchery fish on spawning grounds. In addition, we collected otoliths and scale samples from carcasses without fin clips to separate unclipped hatchery fish from naturally-produced fish (*see Proportion of hatchery spawners*, below). We used hand-held electronic tag detectors manufactured by Northwest Marine Technology, Inc. to determine if carcasses with adipose fin clips had a coded wire tag (CWT), and in the McKenzie River to determine if unclipped carcasses had a CWT (double-index release group). We collected the snouts of tagged fish and put them in plastic bags with individually numbered labels. Tags were removed and identified at the ODFW Clackamas lab. We measured carcasses (cm FL), determined gender, and estimated the proportion of remaining eggs to document pre-spawning mortality.

Variability of redd counts (Task 1.1.2).—In 2009, we assessed variability within and between surveyors during foot surveys. We flagged redds on medium and small-sized streams within the McKenzie, South Santiam and North Santiam rivers. A stream was classified as medium if the surveyor had to cross the stream to observe areas on the other side, or small if the surveyor could observe both sides of the stream without crossing (Schroeder et al. 2005). Each location where one or more redds were identified was flagged with the number of redds, the date, and a unique identification number. Flagging was done to help identify older redds that otherwise may have been omitted during subsequent survey periods. We also conducted a pilot resurvey of one medium-sized stream. A surveyor conducted the survey and flagged all redds. Within 24 hours one supervising surveyor resurveyed the same stream and recorded all redds again.

Our second approach was to assess the variability between our most experienced surveyors on a large river by conducting a one-day training session. Training was conducted on two sections of the South Santiam River from Foster Dam to Pleasant Valley boat ramp. Rafts with elevated viewing towers with one observer and one rower each were sent down the river at 30 minute intervals to improve observer independence. Each observer enumerated all observed redds for each river section. Due to logistical constraints, we could not flag redds during boat surveys so only the total number of redds observed by each surveyor can be compared.

Proportion of hatchery spawners (Task 1.1.3).---Restoration of spring Chinook salmon under the ESA and the implementation of ODFW's Native Fish Conservation Policy requires monitoring the number of hatchery and wild fish comprising the spawning populations in the Willamette basin. The Willamette Projects Biological Opinion identified the need to reduce hatchery fish spawning in the wild to "the lowest extent possible (0–10%)" (NOAA 2008). To differentiate between hatchery and wild Chinook salmon, and to implement a selective fishery, all hatchery spring Chinook salmon in the Willamette basin beginning with the 1997 brood year were marked with adipose fin clips. Thermal marks are also induced in the otoliths of all hatchery Chinook released in the basin to provide a secondary mark for identifying unclipped hatchery fish. A percentage of juvenile Chinook are released without a fin clip, which varies by hatchery and by brood year (Schroeder et al. 2005). However, the percentage of unclipped fish in hatchery releases has decreased in recent years because use of an automated fin-clipping system has resulted in increased precision. Other factors that have resulted in the return of unclipped hatchery fish include release of unclipped hatchery fish with coded wire tags (double-index), and regeneration of partially clipped adipose fins.

We estimated the proportion of naturally-produced (wild) and hatchery-origin fish on spawning grounds in the Willamette basin using otoliths collected on the spawning grounds in 2009. We collected samples from adult spring Chinook without fin clips on spawning grounds in four subbasins (McKenzie, North and South Santiam, and Middle Fork Willamette). Otoliths were removed from carcasses without fin clips and placed into individually numbered vials. The samples were subsequently sent to the otolith laboratory operated by Washington Department of Fish and Wildlife for analysis.

Pre-spawning mortality (Task 1.1.4).—We surveyed the major tributaries of the Willamette basin by boat and foot in 2009 to estimate pre-spawn mortality based on the proportion of unspawned female salmon carcasses.

Straying of hatchery fish (Task 1.1.5).—A portion of the juvenile hatchery Chinook in the Willamette Basin are released with coded-wire tags (CWTs). We used handheld tag detectors to check for tags in carcasses with adipose fin clips (*see Task*

1.1.1). The binary codes of CWTs were read to identify the release site. We estimated the extent and origin of stray hatchery fish by expanding the number of recovered fish with a specific tag code for the percentage of fish in a release group that were tagged.

In addition to the incidence of hatchery fish straying from their basin of release, we also assessed the proportion of hatchery Chinook adults that did not return to the hatchery and "strayed" to the spawning ground. We analyzed returns to the McKenzie basin to assess the extent of straying and to provide the basis for developing and implementing actions to reduce straying. These analyses are presented in Appendix 3.

Task 1.2: Monitor clipped & unclipped fish passing Leaburg and Upper Bennett dams

We used video recording equipment at Leaburg Dam on the McKenzie River and Upper Bennett Dam on the North Santiam River to monitor the number of fish migrating upstream. An adult fish trap is also present at both sites, although only the trap at Leaburg Dam was used in 2009.

Monitor passage of clipped and unclipped spring Chinook at Leaburg Dam (Task 1.2.1 and 1.2.2).—Passage of spring Chinook salmon through the fishways at Leaburg Dam was monitored with video recording equipment. We recorded fish passage at both the left bank and right bank fish ladders at Leaburg Dam. The video equipment uses software designed to automatically scan and record fish movement and to create video files from these images. Fish detected by the video system were identified by species and by the presence or absence of an adipose fin clip. Fish passage was recorded continuously during the year except for brief outages over several days in 2009. We extrapolated the number of fish that may have passed during the outages based on the fish counts recorded for the remainder of the day.

We also used the adult trap at Leaburg Dam to monitor spring Chinook salmon passage on the McKenzie River. The adult fish trap is located in the fish ladder on river left (looking downstream). Adult salmon captured in the trap were examined for presence or absence of adipose fin clips. Unclipped spring Chinook were passed upstream and clipped fish were transported to McKenzie River Hatchery downstream of Leaburg Dam and incorporated into the hatchery broodstock.

Monitor passage of clipped and unclipped spring Chinook at Upper Bennett Dam (Task 1.2.3).—Passage of spring Chinook at Upper Bennett Dam was monitored May 27–Dec 8, 2009 with video recording equipment located in the fishway. The video system uses software that automatically identifies frames containing fish and creates video files. Fish counts were compiled from the video files by species and by presence or absence of adipose fin clips. Fish that were observed drifting downstream were subtracted from the total counts. Video monitoring was operated continuously except when batteries or the hard drive were changed, when the viewing window was cleaned, or during outages caused by power or equipment failures. Outages occurred July 26, September 24–28, October 10–28, and November 5–9. Passage at Lower Bennett Dam was not conducted in 2009 because there is currently no video system in place.

Task 2.1: Collection, spawn timing, and composition (hatchery or wild) for broodstock management

Collection, spawn timing, composition, and disposition of broodstock (Task 2.1.1 and 2.1.3).—Traps are operated at each of the Willamette hatcheries to collect spring Chinook salmon for broodstock. Chinook salmon are also trapped at Leaburg Dam and Leaburg Hatchery and transported to McKenzie River Hatchery. Disposition of collected salmon is recorded at each hatchery by presence or absence of an adipose fin clip.

Collection of biological data from spawned and outplanted broodstock and otoliths collected from broodstock (Task 2.1.1 and 2.1.2).—We collected biological data from all Chinook that were outplanted or spawned at the hatcheries. Data collected from spawned fish included fork length, sex, and presence or absence of an adipose fin clip. Fork length was measured on every third fish except at Willamette Hatchery where every fifth fish was measured. Scales and otoliths were collected from all unclipped fish. For fin-clipped Chinook, scale samples were collected from every tenth fish. We collected tissue samples (small portion of a fin) from outplanted fish, and recorded gender and presence or absence of a fin clip.

Task 2.2: Determine Survival of Outplanted Fish and Abundance of Spawners

Subtasks 1–6 (combined).—To monitor the success of spring Chinook salmon outplanted upstream of Project dams, we conducted regular surveys above Detroit Dam in the North Santiam and Breitenbush rivers, above Foster Dam in the South Santiam River, above Cougar Dam in the South Fork McKenzie River, above Fall Creek Dam in Fall Creek and above Lookout Point Dam in the North Fork Middle Fork Willamette River. The Little North Fork Santiam River was also surveyed to determine spawning success of unclipped salmon outplanted from Minto Pond. We conducted surveys by foot and kayak to count spring Chinook salmon carcasses and redds (for detailed methodology see *Task 1.1.1 and 1.1.4*).

Task 3.1: Determine the extent of summer steelhead reproduction in the wild.

We addressed subtasks 1, 2, 5, and 6 (Appendix 1) in 2009. We collected tissue samples from unclipped juvenile steelhead at the PGE Sullivan hydroelectric facility at Willamette Falls and from unclipped adult steelhead in the South (Foster) and North (Minto) Santiam rivers. Samples were collected in April and May.

We anesthetized juvenile steelhead with MS-222 and excised a small piece of the lower caudal lobe using surgical-grade scissors. Samples were put into vials filled with alcohol. The cut margin of the caudal lobe was dipped in iodine, and the fish were allowed to fully recover from anesthesia.

Results and Discussion

Task 1.1: Distribution, Abundance, and Proportion of Hatchery and Natural-Origin Chinook Salmon

Spawning Ground Surveys Downstream of Corps Dams (Task 1.1.1).—Sub-basins upstream of Willamette Falls were surveyed July-October 2009 to recover carcasses and count redds. Counts of spring Chinook redds were lower in 2009 than the 2002–2008 averages for all basins except the Middle Fork Willamette River (Table 1).

TABLE 1.—Spring Chinook salmon redds counted in the four major watersheds of the upper Willamette River basin, 2002–2009.

Watershed	2009	2008	2007	2006	2005	2004	2003	2002
Middle Fork Willamette[a]	72	134	9	184[b]	9	9	14	64
McKenzie	698	869	1,487	793	1,147	1,129	1,187	922
South Santiam[c]	483	209	483	510	530	373	619	914
North Santiam	281	226	494	254	325	360	673	306

[a] Includes Fall Creek.

[b] Includes 111 redds counted by ODFW and 73 redds counted by Corps biologists in side channels.

[c] Includes Thomas and Crabtree creeks during 2002-2005.

The North Santiam River was regularly surveyed July 13–October 22. Redd construction was first observed on September 8 and peak spawning occurred in late September to early October. As in previous years, the redd density in 2009 was highest in the section immediately downstream of Minto Dam (Table 2). Redd counts and densities were higher or similar in 2009 compared to 2008, except in the Little North Fork Santiam River (Tables 1–2). Of the carcasses we recovered in the North Santiam in 2009, 44% had fin clips (Table 3); lower than the 2002–2008 average (77%).

We surveyed the McKenzie River from July 14 to October 13. The first redd was observed on September 3, similar to previous years. Peak spawning occurred in late September to early October. The total number of redds in 2009 (698) was 20% lower than in 2008 and was the lowest count since the comprehensive surveys began in 2002 (Table 1). Redd densities have been variable in 2000–2009 within survey sections (Table 4). Redd densities downstream of Leaburg Dam were lower in 2009 than in 2008, but were higher than in all past years except 2003 (Table 4). The percentage of redds counted in the mainstem upstream of Forest Glen was lower in 2007–2009 than in 2002–2006, whereas the percentage of redds downstream of Leaburg Dam was higher in 2008–2009 than in previous years (Figure 2).

TABLE 2.—Summary of spawning surveys for spring Chinook salmon in the North Santiam River, 2009, and redd densities (redds/mi) for 2002–2009. Spawning in areas downstream of Stayton may include some fall Chinook salmon.

Survey section	Length (mi)	2009		Redds/mi							
		Carcass	Redds	2009	2008	2007	2006	2005	2004	2003	2002
Minto–Fishermen's Bend	10.0	49	188	18.8	10.7	32.3	14.8	20.6	17.7	55.5	16.2
Fishermen's Bend–Mehama	6.5	23	25	3.8	1.5	11.1	4.9	3.1	2.8	6.5	9.4
Mehama–Stayton Island	7.0	5	4	0.6	0.6	2.1	3.1	2.0	12.6	4.7	6.1
Stayton Island–Stayton	3.3	3	1	0.3	0.3	6.1	3.9	7.3	7.9	3.6	3.0
Stayton–Greens Bridge	13.7	4	24	1.8	0.0	--	0.4	0.3	0.2	0.1	0.4
Greens Br.–mouth	3.0	2	9	3.0	0.3	--	--	0.0	0.0	1.7	4.7
Little North Santiam[a]	17.0[b]	49	26	1.5	6.1	4.4	2.0	3.6	3.0	1.8	1.8

[a] 220 (2009) and 157 (2008) unclipped adult spring Chinook were released; for 2002–2007 release data see McLaughlin et al. 2008.
[b] 14.4 miles surveyed in 2007.

TABLE 3.—Composition of naturally-spawning spring Chinook salmon from carcasses recovered in the North Santiam River, 2009.

Section	Fin-clipped	Unclipped (%)
Minto Dam–Stayton Island		
Minto–Fishermen's Bend	34	15 (31)
Fishermen's Bend–Mehama	13	10 (43)
Mehama–Stayton Island	5	0 (0)
Little North Fork Santiam	2	47 (96)
Total upstream of Stayton Island	54	72 (57)
Stayton Island–mouth	6	3 (33)
Total	60	75 (56)

The percentage of fin-clipped carcasses upstream of Leaburg Dam in 2009 (Table 5) was similar to the 2002–2008 average. Downstream of Leaburg Dam, more than half of carcasses were fin-clipped in 2009, but was lower than in 2008 (82%) or 2007 (76%).

Other rivers surveyed in 2009 included the South Santiam (July 7–October 12) and Middle Fork Willamette rivers (July 9–October 6). Active redd building began in early September, with peak counts observed in late September to early October. Redd density in the upper section of the South Santiam was higher in 2009 than in 2008 (Table 6), which was the lowest since surveys began in 2002. Redd density in the Middle Fork Willamette was lower in 2009 than the highest levels of 2008 and 2006 (Table 6).

TABLE 4.—Summary of Chinook salmon spawning surveys in the McKenzie River, 2009, and redd densities (redds/mi) for 2000–2009.

Survey section	Length (mi)	2009		Redds/mi[a]									
		Carcass	Redds	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000
McKenzie River													
Spawning channel	0.1	11	8	1.5	3.2	6.8	13.8	12.8	18.6	7.2	15.4	--	--
Olallie–McKenzie Trail	10.3	18	108	10.5	11.9	10.4	14.1	31.1	22.1	24.7	16.3	17.7	5.6
McKenzie Trail–Hamlin	9.9	24	43	4.3	2.2	6.0	1.8	4.2	9.4	4.0	5.2	4.9	1.6
Hamlin–S. Fork McKenzie	0.3	0	2	6.7	6.7	93.3	6.6	--	--	10.0	36.7	--	--
South Fork–Forest Glen	2.4	8	18	7.5	3.3	26.7	10.8	12.1	12.1	19.2	16.7	0.8	2.1
Forest Glen–Rosboro Bridge	5.7	47	87	15.3	16.1	30.5	6.7	3.7	36.1	26.8	14.9	13.2	5.8
Rosboro Br.–Ben and Kay Park	6.5	17	45	6.9	10.3	16.6	8.9	12.5	10.3	7.4	16.2	6.3	3.2
Ben and Kay–Leaburg Lake	5.9	5	0	0.0	0.6	--	--	0.3	--	12.0	2.9	3.2	--
South Fork McKenzie													
Cougar Dam–Road 19 Bridge	2.3	52	39	17.0	26.5	16.5	23.9	22.2	49.1	31.7	36.5	--	--
Road 19 Bridge–mouth	2.1	24	29	13.8	11.0	37.6	14.8	16.7	13.8	5.7	11.4	8.1	7.6
Horse Creek													
Pothole Creek–Separation Creek	2.8	0	2	0.7	14.3	22.5	9.3	5.4	5.4	18.6	--	--	--
Separation Creek–mouth	10.7	18	113	10.6	13.0	33.3	16.1	19.2	10.3	13.6	12.1	7.4	--
Lost Creek													
Spring–Limberlost[b]	2.8	1	12	4.3[b]	1.8[b]	35.7	3.2	15.4	6.4	9.3	--	--	--
Limberlost–Hwy 126[c]	2.0	1	24	12.0	10.5	53.6	30.0	78.5	13.5	21.0	--	--	--
Hwy 126–mouth[c]	0.5	0	1	2.0	14.0	--	0.0	14.0	4.0	30.0	32.0	--	--
McKenzie River													
Leaburg Dam–Leaburg Landing[d]	6.0	93	167	27.8	39.2	23.5	12.0	12.5	16.5	28.5	19.2	12.3	--

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

[b] Surveyed from Cascade to Limberlost (0.6 mi) In 2008–2009.

[c] Limberlost–Hwy 126 and Hwy 126–mouth sections were combined in 2007.

[d] Additional carcasses were recovered downstream of Leaburg Landing (4 in 2009; 3 in 2008, 2007, and 2006); 0 redds were counted in 2009, 5 in 2008, none in 2007, and 12 redds were counted in 2006.

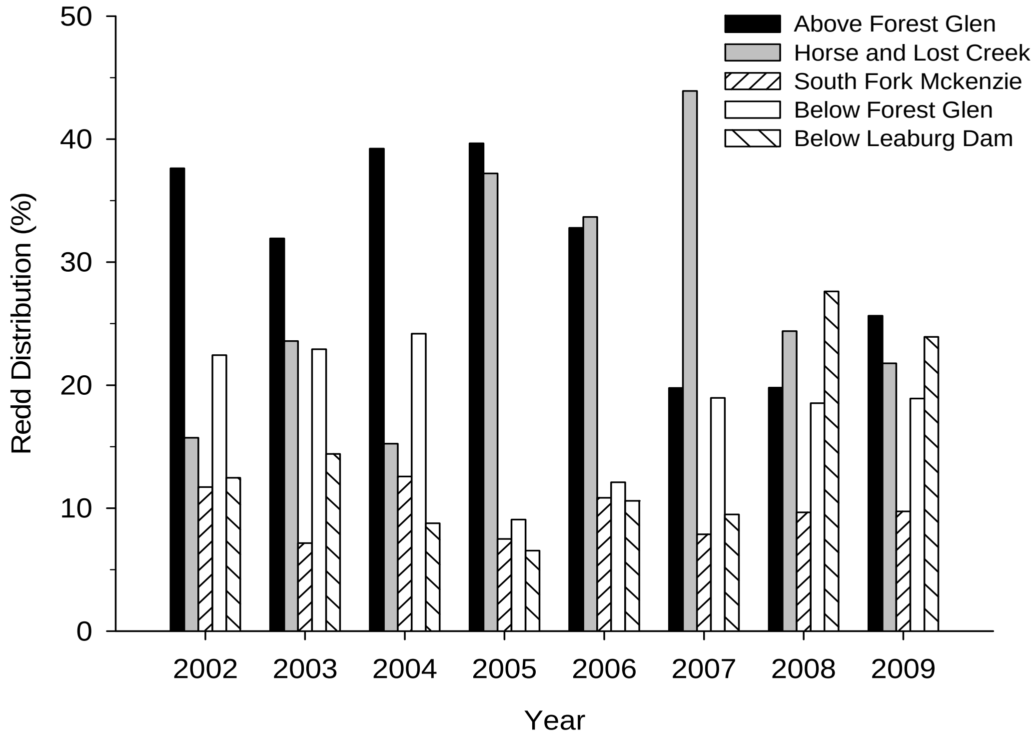

FIGURE 2.—Distribution of spring Chinook salmon redds in the McKenzie River basin, 2002–2009.

TABLE 5.—Composition of naturally spawning spring Chinook salmon from carcasses recovered in the McKenzie River, 2009.

Section	Fin-clipped	Unclipped (%)
Upstream of Leaburg Dam		
McKenzie spawning channel	4	7 (64)
Olallie–Forest Glen	9	41 (82)
Forest Glen–Leaburg Lake	26	43 (62)
South Fork McKenzie	6	70 (92)
Horse Creek	1	17 (94)
Lost Creek	0	2 (100)
Total upstream of Leaburg Dam	46	180 (80)
Downstream of Leaburg Dam	65	33 (34)
Total	111	213 (66)

TABLE 6.—Summary of Chinook salmon spawning surveys in the South Santiam and Middle Fork Willamette rivers, 2009, and redd densities (redds/mi) for 2002–2009.

				Redds / mi							
River, section	Length (mi)	Carcasses	Redds	2009	2008	2007	2006	2005	2004	2003	2002
South Santiam											
Foster–Pleasant Valley	4.5	434	431	95.8	40.2	92.9	102.9	112.7	75.1	132.0	194.4
Pleasant Valley–Waterloo	10.5	42	52	5.0	2.7	6.2	4.4	2.2	3.3	1.5	1.8
Middle Fork Willamette											
Dexter–Jasper	9.0	55	36	4.0	14.9	1.0	20.4[a]	1.0	1.0	1.5	7.1

[a] Based on 184 redds (111 counted by ODFW and 73 counted by Corps of Engineers biologists in side channels).

Variability of redd counts (Task 1.1.2).—We conducted surveys of the South Santiam upstream of Foster Dam on consecutive days (September 29 and 30), and counted 36 redds and 40 redds, respectively. The relatively small stream, which could be thoroughly covered by one surveyor likely contributed to the small discrepancy between the two counts. Additional tests will be conducted in the future.

We conducted multiple surveys on two sections of the South Santiam River downstream of Foster Dam on a single day (September 17) as part of a training session. The difference between the high and low counts was over two fold in both sections (Table 7). Unfortunately, we had limited information to ascertain the “real” count because redds were not mapped and additional follow-up surveys were not conducted by the more experienced surveyors to assess what type of counting error (omissions or false identification) may have contributed to the variable counts. Several factors may have affected counts among surveyors. First, because the substrate of the South Santiam River is very dark, evidence of disturbance caused by redd construction is less apparent in the South Santiam than in other rivers in the Willamette basin. Secondly, redd density was very high in a short section of river just downstream of the dam, and contained multiple and superimposed redds, which can be difficult to accurately count. Finally, redds in the upper section downstream of the dam are constructed on the same gravel patches each year, which retain their physical shape because controlled release of water from the dam limits the year-to-year movement of gravel.

Variability in redd counts exists among individual surveyors and can arise from factors such as environmental conditions (e.g., turbidity), high density of spawners (multiple redds and redd superimposition), survey method (foot versus boat), size of stream, and surveyor experience. These factors can lead to observer errors and cause surveyors to undercount or overcount redds. Observer errors in redd surveys have been classified as either omissions or false identifications (Dunham et al. 2001; Muhlfeld et al. 2006). Omissions occur when redds are not counted because they are not recognized, and false identifications occur when natural disturbances of the substrate, such as water scour, are incorrectly counted as redds. Calibration through training and repeated surveys is designed to minimize these errors. Redd counts are repeated and accumulate throughout the entire spawning season. Omission errors were considered to be more likely than overcounts in most of the survey areas and for this reason weekly counts were not reduced if subsequent observers found fewer redds in any given survey. The practice of marking redds on a map helped to reduce the likelihood of overcounts. In 2010, we plan to conduct repeated surveys in other rivers in the Willamette basin and map redds.

TABLE 7.—Number of redds counted by six surveyors in two sections of the South Santiam River on September 17, 2009, with mean, standard deviation (SD), and coefficient of variation (CV). Section 1 = Boat launch to top of island; Section 2 = top of island to Pleasant Valley.

	Observer								
	1	2	3	4	5	6	Mean	SD	CV (%)
Section 1	213	111	175	171	134	253	176	51	29
Section 2	32	37	79	51	35	60	49	18	37

Proportion of hatchery spawners (Task 1.1.3).—During surveys in 2009, we sampled unclipped Chinook salmon carcasses and collected 213 otoliths in the McKenzie River, 75 in the North Santiam River, 366 in the South Santiam River (308 downstream of Foster Dam and 58 upstream), 11 in the Middle Fork Willamette River, and 56 in Fall Creek. Fish were determined to be naturally produced by absence of an adipose fin clip and induced thermal marks in the otoliths. We previously documented a significant difference between the distribution of redds and the distribution of carcasses recovered among survey areas (Firman et al. 2005), and used the distribution of redds among survey areas to weight the number of unclipped carcasses in each area. We used otolith analysis to estimate an expected number of wild fish that would have spawned within a survey area. We used the weighting function only for the McKenzie and North Santiam rivers in 2009 because redd and carcass distributions were not significantly different in the other rivers.

As in previous years, the percentage of wild spring Chinook determined from recovery of carcasses was highest in the McKenzie River (Table 8). Although the percentage of wild spring Chinook decreased in 2009 from that in 2008 except in the South Santiam, the percentage of wild fish was generally higher in 2005–2009 than in 2002–2004.

The estimated number of wild fish in the McKenzie River upstream of Leaburg Dam was lower in 2009 than in 2001–2008, and the percentage of wild fish decreased in 2009 compared to 2005–2008 (Table 9). We estimated a relatively low number of wild Chinook in the North Santiam in 2009, but this represents a partial estimate because video counts were conducted only at Upper Bennett Dam and no counts were conducted at Lower Bennett Dam.

TABLE 8.—Composition of spring Chinook salmon in the Willamette Basin based on carcasses recovered. Weighted for distribution of redds among survey areas within a watershed (except as indicated in table).

		Unclipped[a]		
River (section), run year	Fin-clipped	Hatchery	Wild	% wild[b]
McKenzie (upstream of Leaburg Dam)				
2002	140	78 (15)	454	68 (62)
2003	131	60 (15)	333	64 (62)
2004	134	26 (8)	316	66 (60)
2005	32	15 (6)	251	84 (84)
2006	32	4 (2)	247	87 (83)
2007	68	3 (1)	352	83 (83)
2008	18	5 (3)	142	86 (84)
2009	37	12 (6)	180	79 (74)
North Santiam (Minto–Bennett dams[c])				
2002	230	44 (49)	45	14 (13)
2003	855	89 (77)	27	3 (4)
2004	321	21 (27)	56	14 (15)
2005	163	25 (24)	80	30 (30)
2006	109	12 (17)	59	33 (32)
2007	136	7 (14)	42	23 (25)
2008	9	3 (9)	32	(73)
2009	53	9 (12)	65	51 (51)
South Santiam (Foster–Waterloo)				
2002	1,386	38 (14)	225	14 (12)
2003	970	31 (17)	151	13 (13)
2004	838	30 (26)	85	9 (9)
2005	467	12 (9)	128	21 (20)
2006	243	9 (15)	50	17 (16)
2007	302	6 (8)	70	19 (19)
2008	51	1 (2)	53	(50)
2009	168	11 (3)	292	(62)
Middle Fk Willamette (Dexter–Jasper[d])				
2002	228	91 (85)	16	(5)
2003	62	48 (92)	4	(4)
2004	120	32 (59)	22	(13)
2005	37	10 (50)	10	(18)
2007	21	2 (18)	9	(28)
2008	20	5 (9)	56	(69)
2009	55	5 (8)	61	(50)

[a] The proportion of hatchery and wild fish was determined by presence or absence of thermal marks in otoliths. Number in parentheses is the percent of unclipped fish that had a thermal mark (unclipped hatchery fish).

[b] Percent not weighted for redd distribution is in parentheses.

[c] Including Little North Fork Santiam.

[d] Including Fall Creek except 2007. Data on clipped fish in spawning population were incomplete for 2006.

TABLE 9.—The number of wild and hatchery adult spring Chinook salmon in the McKenzie and North Santiam rivers upstream of dams as estimated from the count at the dams and from presence of induced thermal marks in otoliths of non fin-clipped carcasses recovered on spawning grounds.

Run year	Dam count		Unclipped with thermal marks (%)[b]	Estimated number		
	Unclipped	Fin-clipped[a]		Wild	Hatchery[a]	Percent wild[a]
			McKenzie			
2001	3,433	780 (869)	16.1	2,880	1,333	68 (67)
2002	4,223	1,352 (1,864)	14.7	3,602	1,973	65 (59)
2003	5,784	2,298 (3,543)	15.3	4,899	3,183	61 (53)
2004	4,788	2,417 (4,246)	7.7	4,419	2,816	61 (49)
2005	2,579	377 (515)	5.6	2,435	521	82 (79)
2006	2,225	410 (945)	1.6	2,189	445	83 (69)
2007	2,757	510 (558)	0.8	2,735	532	84 (83)
2008	1,458	213 (290)	3.4	1,408	263	84 (81)
2009	1,219[c]	332 (487)	6.3	1,143	407	74 (67)
			North Santiam			
2001	388	6,398	43.4	220	6,566	3
2002	1,233	6,407	51.0[d]	604	7,036	8
2003	1,262	11,570	78.5[d]	271	12,561	2
2004	1,510	12,021	67.6[d]	489	13,042	4
2005	924	3,958	27.8[d]	667	4,215	14
2009[e]	252	1,427	15.7[d]	212	1,467	13

[a] The dam counts of fin-clipped fish in the McKenzie River are adjusted by the ratio of fin-clipped to unclipped carcasses recovered upstream of the dam to account for fallback at the dam. The unadjusted dam counts and the estimate of percent wild based on the unadjusted counts are in parentheses.

[b] Adjusted by the distribution of redds among survey areas.

[c] Includes 11 unclipped fish trapped in the fishway and taken to McKenzie Hatchery, then later released (two of the 13 transported unclipped fish died at the hatchery).

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

[e] Counts for Upper Bennett Dam only; lower Bennett Dam trap not operated.

Pre-spawning mortality (Task 1.1.4).—Estimates of pre-spawning mortality of spring Chinook salmon in 2009 were generally the same as in 2008 in the North and South Santiam rivers, but were higher in the McKenzie and Middle Fork Willamette rivers (Table 10). Although all of the female carcasses collected in the Middle Fork Willamette in 2009 were unspawned (100% mortality), 36 redds were counted. We derived an estimated pre-spawning mortality for the Middle Fork Willamette by assuming the seven unprocessed carcasses (too decomposed to determine spawning or too deep to recover) after September 29 were successful spawners.

The estimated pre-spawning mortality was significantly higher (unpaired t-test; $P < 0.05$) downstream than upstream of dams in the McKenzie and North Santiam rivers (Figure 3a), similar to that reported in the Clackamas and Sandy rivers (Schroeder et al. 2007).

Mortality of fin-clipped fish was higher than unclipped fish in 2009 in the North and Santiam rivers, but was lower in the McKenzie River, although sample sizes were generally small (Table 11). Mortality of fin-clipped fish was lower than unclipped fish over several years in the McKenzie and North Santiam rivers, and was higher in the South Santiam (Figure 3b), but the differences were not statistically significant.

Several factors can potentially affect estimates of pre-spawning mortality that are derived from recovery of carcasses. Within and between year variation in the temporal and spatial intensity of surveys affect the recovery of carcasses because scavengers or high river flows can affect the length of time carcasses remain in the river or remain in places where they can be spotted and recovered. Late season carcasses can be difficult to recover after flows begin to increase, and these fish would be primarily successful spawners, thus introducing a potential for systematic bias. Pre-spawning mortality estimates of outplanted fish are affected by the time of the year fish are released upstream of dams, the quality of release sites, and water temperature. Estimates of pre-spawning mortality should be viewed in relative terms (e.g., high, medium, low) rather than as absolute values.

TABLE 10.—Estimated percent pre-spawning mortality for Chinook salmon in the Willamette Basin based on the recovery of female carcasses, 2001–2009. Only areas and years with ≥ 10 recoveries are included. Date of first survey is in parentheses.

Location	2009	2008	2007	2001–2006[a]
Middle Fork Willamette	77[b] (Jul 9)	17 (Jul 14)	95 (Jul 10)	86
McKenzie above Leaburg	6 (Aug 6)	1 (Aug 26)	5 (Aug 15)	10
McKenzie below Leaburg	23 (Jul 14)	9 (Aug 20)	37 (Jul 31)	30
North Santiam above Bennett[c]	30 (Jul 22)	30 (Jul 15)	41 (Jul 3)	61
South Santiam above Lebanon	11 (Jul 20)	8 (Jul 23)	8 (Jul 16)	35

[a] Detailed data for 2001–2006 can be found in Schroeder et al. (2007).

[b] All recovered females were unspawned, but we counted 36 redds; to estimate pre-spawning mortality, we assumed that 7 unprocessed carcasses recovered after Sep 29 were successful spawners.

[c] Does not include Little North Fork Santiam.

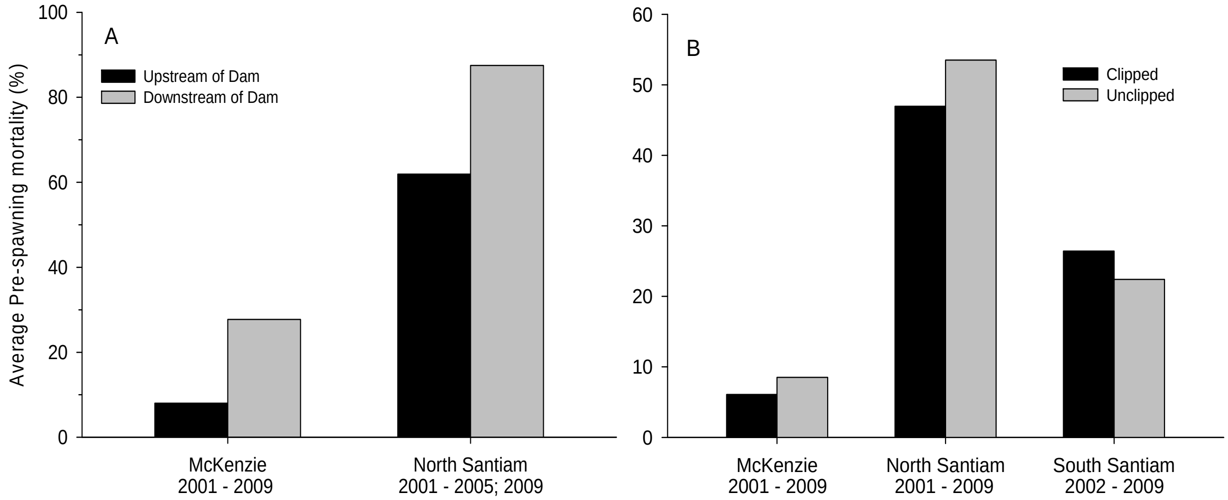

FIGURE 3.—Average pre-spawning mortality of adult spring Chinook salmon in Willamette Basin rivers based on recovery of female carcasses for (A) upstream and downstream of dams, and (B) clipped and unclipped fish. Note different Y-axis scale.

TABLE 11.—Pre-spawning mortality (percentage in parentheses) of fin-clipped and unclipped spring Chinook salmon carcasses based on recovery of female carcasses, 2009.

	Not spawned		Spawned	
Location	clipped	unclipped	clipped	unclipped
McKenzie above Leaburg	1 (3%)	9 (7%)	35	121
McKenzie below Leaburg	9 (18%)	7 (35%)	40	13
North Santiam above Bennett	12 (39%)	2 (13%)	19	14
South Santiam above Lebanon	20 (21%)	10 (5%)	74	179

Straying of hatchery fish (Task 1.1.5).—Few coded-wire tags (CWT) were recovered from spring Chinook salmon on the spawning grounds in 2009 (Table 12), making it difficult to assess the percentage of stray hatchery fish in river basins. Of the tagged fish recovered, most were from releases made within the basin (26 of 28 recovered CWT carcasses). As in previous years, some fish strayed from off-station releases. One South Santiam stock fish released in the Molalla River returned to the South Santiam River. A Middle Fork Willamette stock fish reared at Leaburg Hatchery and released in the Lower Columbia River returned to the McKenzie River.

TABLE 12.—Number of spring Chinook salmon that were composed of hatchery fish released within the basin (local) or released in other basins, 2007–2009, determined from coded-wire tags in carcasses on spawning grounds. The sample size was expanded (in parentheses) by the percentage of each release group that was tagged.

		Origin of release				
River, run year	n	Local	Lower Columbia netpens	Molalla	North Santiam	Fall Creek (M. Fork Willamette)
McKenzie						
2007	4 (26)	3 (23)				1 (3)
2008	10 (63)	10 (63)				
2009	4 (22)	3 (21)	1 (1)[a]			
North Santiam						
2007	3 (50)	2 (48)		1 (2)		
2008	1 (2)	1 (2)				
2009	7 (59)	7 (59)				
South Santiam						
2007	17 (122)	16 (98)			1 (24)	
2008	4 (9)	1 (6)	3 (3)			
2009	10 (83)	9 (79)		1 (4)		
M. Fork Willamette						
2007	2 (23)	2 (23)				
2008	2 (11)	2 (11)				
2009	7 (27)	7 (27)				

[a] Reared at Leaburg Hatchery (McKenzie River).

Task 1.2: Monitor fin-clipped & unclipped fish passing Leaburg and Upper Bennett dams

Monitor passage of fin-clipped and unclipped spring Chinook at Leaburg Dam (Task 1.2.1 and 1.2.2).—Video monitoring at Leaburg Dam ran continuously in 2009, with the first spring Chinook recorded on April 20. Of the spring Chinook passing Leaburg Dam, 71% were unclipped, including jacks (Table 13). In addition, 81 spring Chinook were captured in the adult trap, which was operated for 24 days in June–October (Table 13). Spring Chinook captured in the trap were taken to Mckenzie River Hatchery, and unclipped adults were later released after a decision was made to stop collecting unclipped adults at the trap for broodstock.

TABLE 13.—Spring Chinook salmon counted at Leaburg Dam, McKenzie River, 2009.

	Video monitoring[a]					Adult trap[b]			
Month	Unclipped adults	Fin-clipped adults	Unclipped jacks	Fin-clipped jacks	Total	Unclipped adults	Fin-clipped adults	Jacks	Total
April	2	0	0	0	2	--	--	--	--
May	77	2	0	0	79	--	--	--	--
June	830	222	4	7	1,063	13	2	0	15
Jul	201	74	2	1	278	0	8	0	8
Aug	34	32	2	2	70	0	0	0	0
Sep	62	155	2	0	219	0	52	3	55
Oct	2	2	0	0	4	0	3	0	3
Total	1,208	487	10	10	1,715	13	65	3	81

[a] Video monitoring data for April–October.

[b] Adult trap data from June–October.

The proportion of unclipped spring Chinook passing Leaburg Dam in 2009 was similar to the 2002–2008 average, but was lower than the previous two years (Table 14). The number of unclipped adults in 2009 decreased by about 20% from 2008 and was about half the 2005–2007 average. In contrast, the number of fin-clipped adults at Leaburg Dam increased by almost 70% over that in 2008, but was about 30% lower than the 2005–2007 average.

TABLE 14.—Spring Chinook passage at Leaburg Dam, 2002–2009.

Year	Unclipped adults	Fin-clipped adults	Unclipped jacks	Fin-clipped jacks	Total	Percent unclipped
2002	4,019	1,949	--	--	5,968	67
2003	5,784	3,543	--	--	9,327	62
2004	4,788	4,246	11	7	9,052	53
2005	2,579	515	7	7	3,108	83
2006	2,226	945	0	0	3,171	70
2007	2,759	559	0	0	3,318	83
2008	1,458	290	1	12	1,761	83
Average[a]	3,373	1,721	4	5	5,101	66
2009	1,208	487	10	10	1,715	71

[a] Average includes 2002–2008 for adults and 2004–2008 for jacks. Jacks were not counted in 2002–2003.

Passage of adult spring Chinook salmon at Leaburg Dam in 2009 extended from April to October, with peak numbers occurring in June (Figure 4). A secondary peak passage of fin-clipped Chinook occurred in September (155), which represented over 30% of the total passage of fin-clipped adults. This September peak has been observed in other years and could present an opportunity to selectively operate the fishway trap and remove hatchery Chinook.

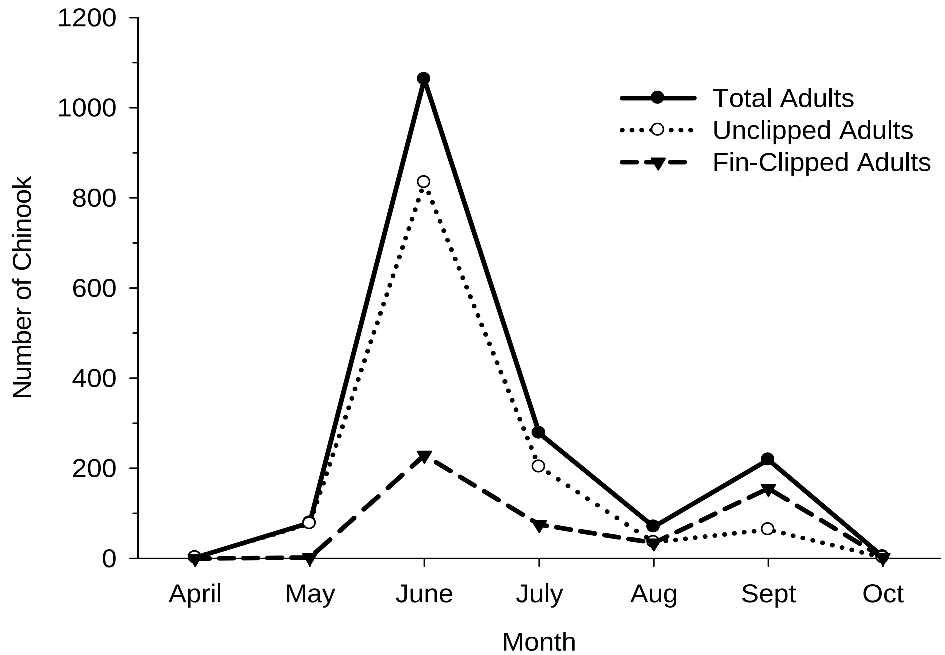

FIGURE 4.—Timing of spring Chinook salmon passage at Leaburg Dam, 2009.

Monitor passage of clipped and unclipped spring Chinook at Upper Bennett Dam (Task 1.2.3).—Passage of spring Chinook was monitored at Upper Bennett Dam by video recording in May–October 2009 (Table 15). Because monitoring did not start until May 27, an unknown portion of the adult run was uncounted. However, the passage of adult Chinook at Bennett dams (upper and lower) through late May averaged 25% of the season total in 2000–2004 (Figure 5). Based on the partial video counts in 2009, most of the Chinook salmon passed Upper Bennett in June (Figure 6). A larger percentage of the passage occurred during July in 2000–2004 (Figure 5) than in 2009, which may be attributed to variability in run timing or may reflect modifications to the Upper Bennett fishway in 2006–2007, which were made to improve fish passage. We could not identify 101 large salmonids by species based on video images; these fish were called “large unknowns” and may have been Chinook, coho salmon, or steelhead. Poor lighting at times compromised the video resolution and made it difficult to distinguish species or identify fin clips. Upgrades are planned for the video system in 2010.

TABLE 15.—Spring Chinook salmon counted at Upper Bennett Dam, North Santiam River, 2009. Fish observed going downstream were subtracted from the upstream counts. No counts were conducted at Lower Bennett Dam.

Month	Unclipped	Fin-clipped	Unknown mark	Jacks	Total
May	7	58	15	0	80
June	230	1,350	120	37	1,737
Jul	9	59	0	2	70
Aug	1	1	0	1	3
Sep	12	8	3	**a**	21
Oct	1	1	1	0	3
2009	260	1,477	139	38	1,914

[a] The only two jacks observed in September were going downstream, and these were subtracted from the yearly total.

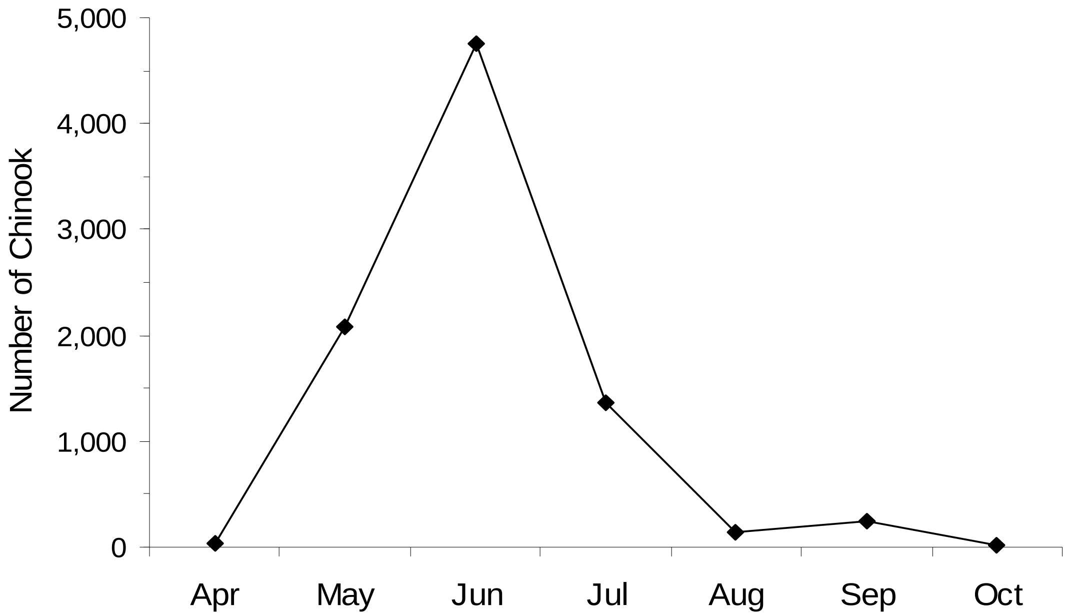

FIGURE 5.—Passage of spring Chinook salmon at Upper and Lower Bennett dams, 2000–2004.

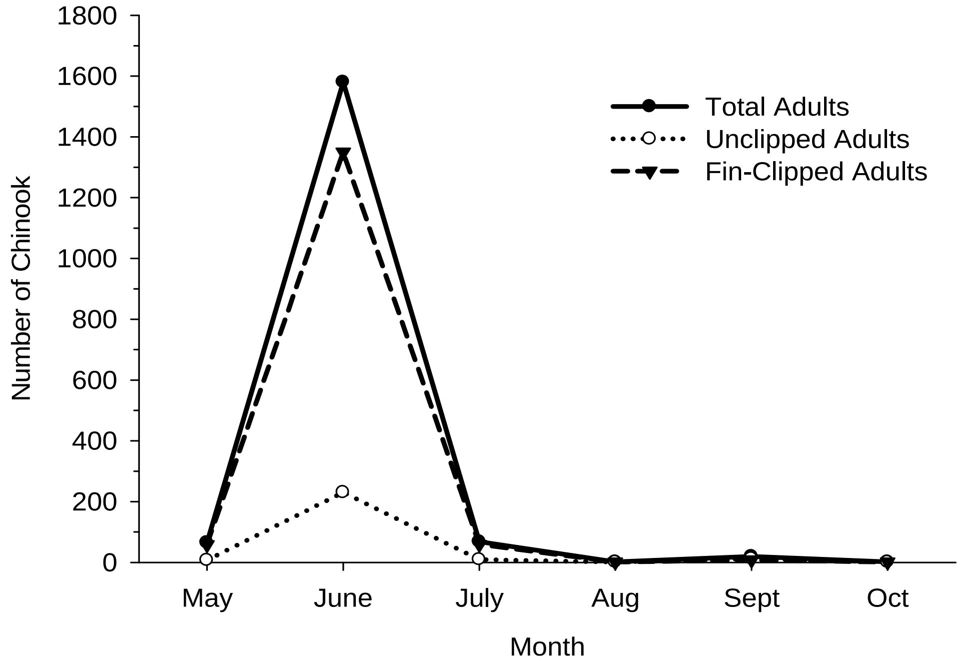

FIGURE 6.—Timing of spring Chinook salmon passing Upper Bennett Dam, North Santiam River, 2009. Total adults include only those of known fin clip status. Video equipment was not operable until late May.

Investigate the feasibility of video monitoring at Lower Bennett Dam and Lebanon Dam (Task 1.2.4).—The feasibility of installing video monitoring equipment at Lower Bennett Dam on the North Santiam River was investigated by staff from ODFW Research, ODFW District, and Corps. Preliminary planning was conducted and was used to develop funding and logistical details for the 2010 Hatchery RM&E proposal to the Corps. Additionally, installation of video monitoring equipment in the north and south bank fishways of Lebanon Dam on the South Santiam River is under consideration by ODFW and the Corps.

Task 2.1: Collection, spawn timing, and H/W composition for broodstock management

Collection, spawn timing, composition, and disposition of broodstock (Task 2.1.1 and 2.1.3).—Adult traps were operated at each of the upper Willamette basin hatcheries from May to October 2009 (*see* Appendix Tables 2.1–2.4 for detailed fish counts and dates of operation). In some cases, the number of fish counted at the traps did not exactly match the final disposition count (broodstock, outplants, etc.) due to counting errors, recycled fish, or misclassification of fin clips. Of the Chinook handled at the hatcheries in 2009, 7% of the adults were unclipped compared to 1.4% of the jacks, excluding those of unknown clip status (Table 16). In 2005–2008, the percentage of unclipped adult Chinook collected at hatcheries was higher (average of 11%) because more unclipped fish were kept for broodstock at McKenzie and Marion Forks.

TABLE 16.—Disposition of fin-clipped and unclipped spring Chinook salmon entering Willamette basin hatcheries and collection facilities, 2009. Unspawned includes mortalities, green fish, excess fish (including those sacrificed to recover coded-wire tags), and females culled for BKD testing.

		Adults			Jacks			
Hatchery	Disposition	fin-clipped	unclipped	Total	fin-clipped	unclipped	Total Chinook	Percent unclipped
Marion Forks	Spawned[a]	571	7	578	0	0	578	1.2
	Outplanted	910	220	1,130	0	12	1,142	20.3
	Recycled	107	48	155	65	0	220	21.8
	Unspawned[b]	235	0	235	74	0	309	0
	Tribes	106	0	106	0	0	106	0
	Total	1,929	275	2,204	139	12	2,355	12.2
S. Santiam	Spawned	721	0	721	13	0	734	0.0
	Outplanted[c]	0	425	425	0	21	446	100.0
	Recycled[d]	257	2	259	0	0	259	0.8
	Unspawned[c]	969	0	969	436	0	1,405	0.0
	Food Share[c]	120	0	120	567	0	687	0.0
	Tribes	100	0	100	13	0	113	0.0
	Total	2,167	427	2,594	1,029	21	3,644	12.3
Willamette	Spawned	1,894	31	1,925	0	0	1,925	1.6
	Outplanted	1,386	19	1,405	775	3	2,183	1.0
	Unspawned	655	13	668	164	0	832	1.6
	Recycled	0	0	0	373	0	373	0.0
	Total	3,935	63	3,998	1,312	3	5,313	1.2
McKenzie	Spawned[e]	1,019	86	1,105	7	0	1,112	7.7
	Outplanted	1,508	11	1,519	132	0	1,651	0.7
	Unspawned[e]	245	7	252	90	4	346	3.2
	Tribes	601	0	601	25	0	626	0.0
	Total	3,373	104	3,477	254	4	3,735	2.9
Grand Total		11,404	869	12,273	2,734	40	15,047	6.0

[a] Includes 218 fin-clipped adults spawned at McKenzie Hatchery.

[b] Includes 68 fin-clipped adults that were spawned for an egg survival study.

[c] Includes one unclipped mini-jack that was outplanted and 466 mini-jacks that were disposed or given to the Food Share program.

[d] Does not include 168 recycled fish that were later recaptured in the trap.

[e] Includes 150 spring Chinook trapped at Leaburg Dam (81) and Leaburg Hatchery (69) and transported to McKenzie Hatchery.

Spring Chinook salmon collected by the hatcheries or fish collection facilities were used primarily for broodstock or reintroduction above the dams (Table 16). The total number of Chinook may include fish handled more than once because some fish were recycled downstream more than once for fisheries. A higher percentage of unclipped fish returned to hatcheries in the North and South Santiam (12%), compared to the two other hatcheries (1–3%), and the Santiam hatcheries outplanted a higher number of unclipped Chinook upstream of dams.

The majority of outplanted Chinook were fin-clipped in the McKenzie and Middle Fork Willamette rivers (Table 16). Only unclipped fish were outplanted in the South Santiam River. Fin-clipped Chinook were outplanted upstream of dams in the North Santiam Basin and unclipped fish were outplanted into Little North Fork Santiam. In addition to outplanted Chinook, surplus fish were donated to the Tribes and various food share programs.

The return timing of spring Chinook to the upper Willamette hatcheries varied among hatcheries (Figure 7). The trap data provide a general time of return (*see* Appendix Tables 2.1–2.4), but the traps are not operated continuously and therefore trap data do not completely reflect return timing. The peak return for Willamette Hatchery (Dexter collection) was at the end of June (26%). Spring Chinook returned to South Santiam Hatchery, Marion Forks Hatchery (Minto collection), and McKenzie River Hatchery with two peaks. South Santiam Hatchery had peak returns in early July (19%) and early September (13%). Spring Chinook returned to Marion Forks Hatchery with peaks in mid-July (22%) and mid-September (31%). Peak returns to McKenzie River Hatchery occurred in mid-June (27%) and a small return in mid-September (11%).

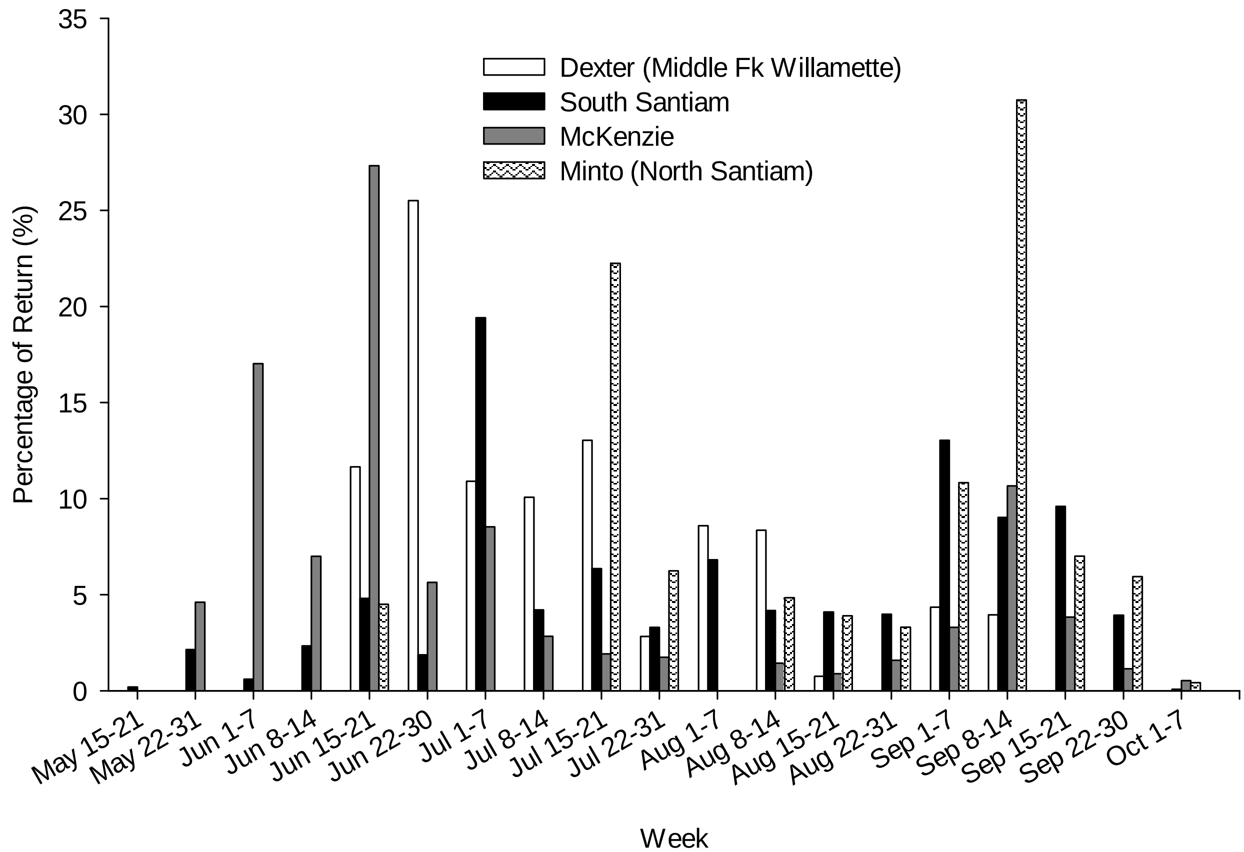

FIGURE 7.—Spring Chinook salmon returns to Upper Willamette hatcheries by week, 2009.

Collection of biological data from spawned and outplanted broodstock and otoliths collection from broodstock (Task 2.1.1 and 2.1.2).—We measured 2,436 fin-clipped and unclipped spring Chinook used for broodstock in 2009. We used otolith verified numbers for the following analysis. Among the fish measured, 83% were 70–90 cm FL (Figure 8). Mean fork lengths of hatchery origin, natural origin, and all fish combined were 77 cm, 80 cm, and 77.5 cm, respectively (Table 17). Differences in size may be due to differing age distributions (Figure 8).

We compared median fork lengths of natural-origin Chinook broodstock among hatcheries. Median fork lengths of natural-origin broodstock at Willamette Hatchery (84 cm) and McKenzie Hatchery (81 cm) were not significantly different (one-way ANOVA; $P = 0.07$), though the power of this test was low (< 0.8). The small sample of natural origin fish (7) in the Santiam rivers did not allow us to include those hatcheries in the analysis.

Median fork length of hatchery-origin broodstock at Marion Forks Hatchery was significantly larger than at all hatcheries and hatchery-origin fish at Willamette Hatchery were significantly larger than at South Santiam Hatchery (Kruskal-Wallis one way ANOVA on ranks; $H=77.60$, $P<0.01$, $df = 3$) (Figure 9).

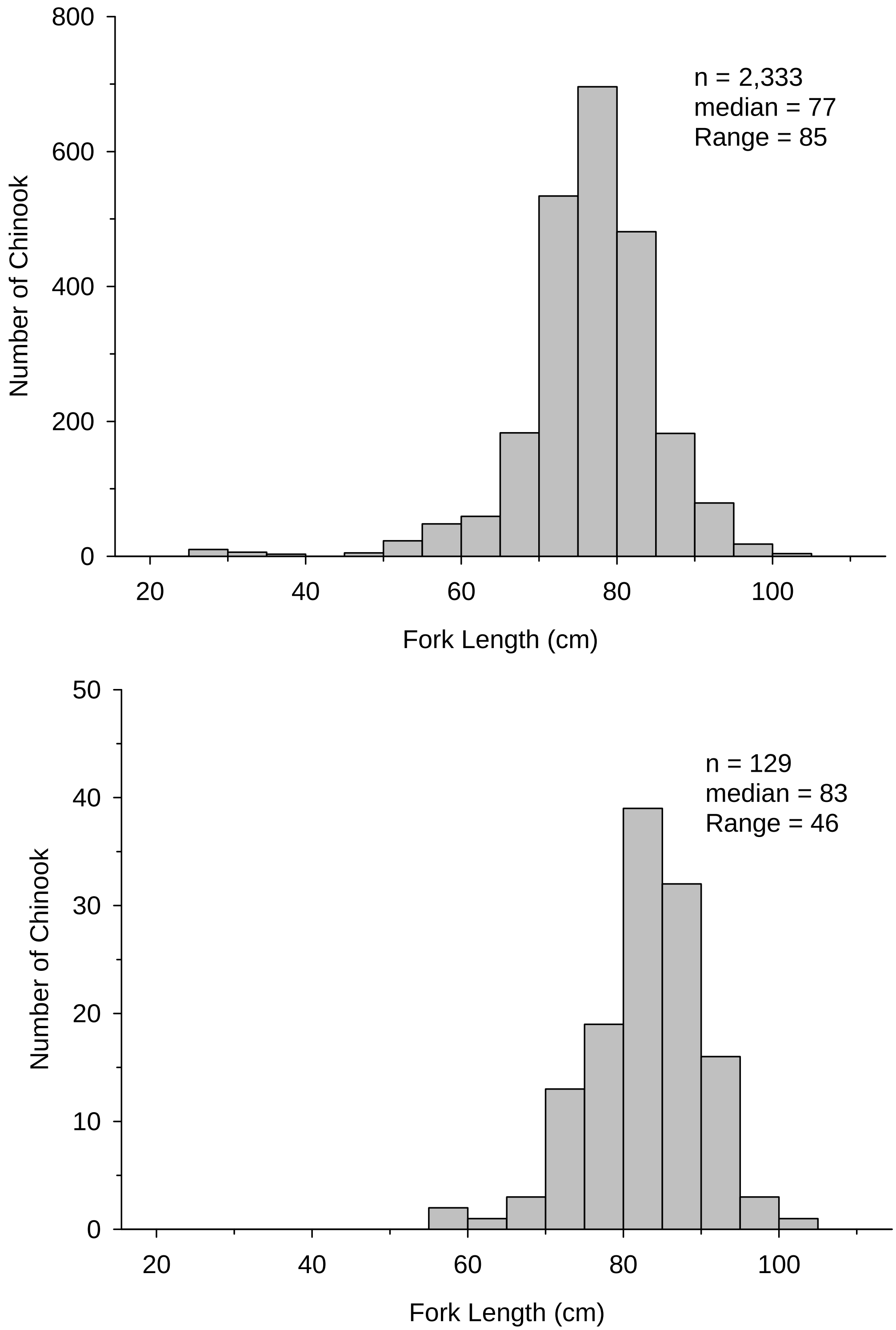

FIGURE 8.—Fork length distribution of fin-clipped (A) and unclipped (B) spring Chinook salmon used for broodstock in upper Willamette Basin hatcheries, 2009.

TABLE 17.—Fork length summary of natural and hatchery-origin spring Chinook salmon used for broodstock at Willamette basin hatcheries, 2009.

Hatchery	Mark	Number	Minimum	Maximum	Mean
Marion Forks	Natural	5	82	93	86
	Hatchery	427	31	102	79
	Total	432	31	102	79
S. Santiam	Natural	2	80	86	83
	Hatchery	639	20	105	75
	Total	641	20	105	75
Willamette	Natural	61	64	103	84
	Hatchery	574	60	100	77
	Total	635	60	103	78
McKenzie	Natural	59	57	92	81
	Hatchery	669	26	95	75
	Total	728	26	95	75

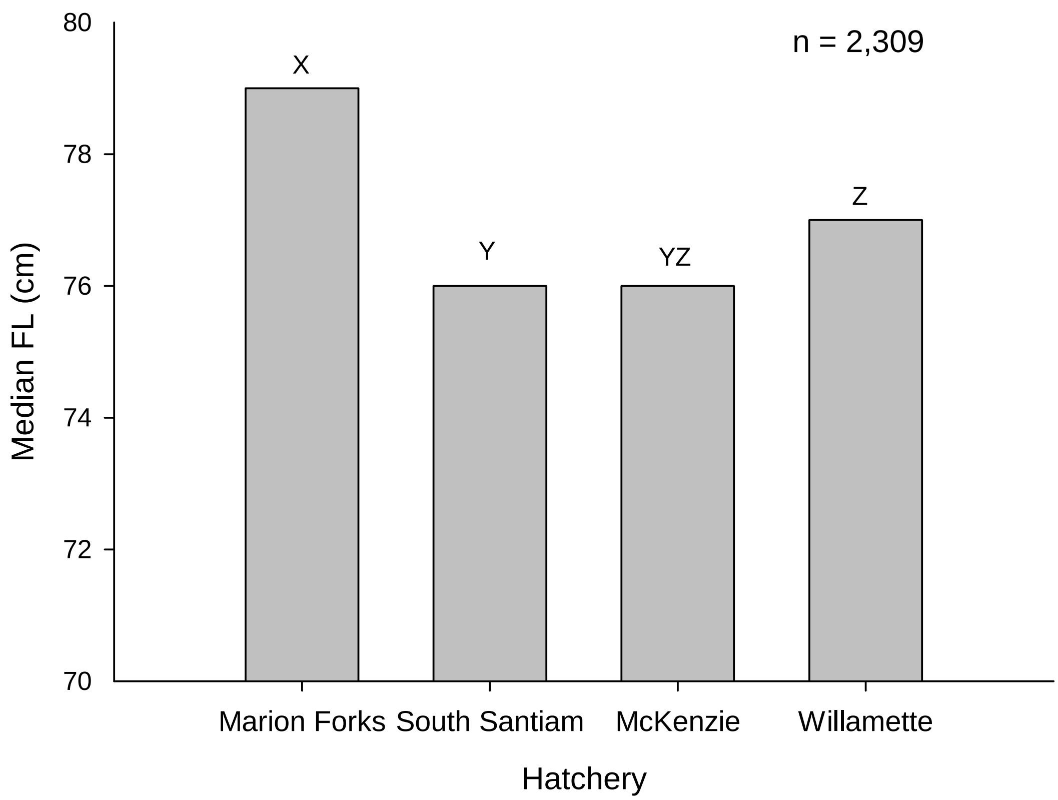

FIGURE 9. —Median fork lengths of hatchery origin broodstock at upper Willamette hatcheries, 2009. Significant differences in median fork length are indicated where bars do not share a letter in common.

Otoliths were collected in 2009 from unclipped spring Chinook spawned at Willamette basin hatcheries to determine the number and percentage of wild fish incorporated into the broodstocks. We collected 95 otolith samples from McKenzie Hatchery, nine from Minto Pond, six from South Santiam Hatchery, and 118 from Willamette Hatchery. The percentage of wild fish in the broodstock in 2009 was lower than in previous years at all four upper Willamette hatcheries (Table 18). Wild fish were incorporated at a very low rate at the Santiam hatcheries in 2009 because a decision was made to release almost all unclipped fish back into the river, compared to a concerted effort to keep and incorporate wild fish in previous years (Table 18). Otoliths were collected from Chinook that appeared to have partially clipped adipose fins to determine their origin. Of the 17 fish at McKenzie Hatchery and 24 fish at Willamette Hatchery with partial adipose clips, 65% and 67% were of hatchery origin, respectively. Marion Forks and South Santiam hatcheries each had four partial adipose clipped fish, and 75% were of hatchery origin at each hatchery.

Tissue samples (fin clips) were collected from 98% of the 4,912 spring Chinook outplanted upstream of the upper Willamette Basin dams (Table 19). Samples were not collected from Chinook outplanted upstream of Fall Creek Dam. All or nearly all fish were sampled at McKenzie (100%) and Willamette (>99%) hatcheries, and the sampling rate was 98% for South Santiam and 90% for North Santiam outplants upstream of dams. The tissue samples are being stored in ethanol at ODFW facilities in anticipation of pedigree studies or other genetic analysis.

TABLE 18.—Composition of unclipped spring Chinook salmon spawned at Willamette basin hatcheries, based on the presence or absence of thermal marks in otoliths, 2002–2009. Unclipped fish includes those with partial or questionable fin clips; therefore the total of unclipped and fin-clipped fish spawned may not agree with numbers reported elsewhere. See Kenaston et al. (2009) for notes on number of otoliths analyzed. See Appendix Tables 2.5–2.8 for data used to estimate run and spawners.

River, year	Unclipped		Fin-clipped hatchery	Percent wild—		
	wild	hatchery		in broodstock	of run	of spawners
McKenzie[a]						
2002	13	101	933	1.2	0.3	0.4–0.9
2003	14	42	953	1.4	0.3	0.3–0.8
2004	24	105	880	2.4	0.5	0.6–1.4
2005	20	40	1,022	1.8	0.8	0.8–0.9
2006	100	46	845	10.1	4.0	4.2–5.8
2007	81	48	891	7.9	2.7	2.7–2.9
2008	90	65	1,111	7.1	5.5	5.6–5.8
2009	59	36	1,026	5.3	4.7	5.2–5.5
North Santiam (Minto)						
2002	4	7	671	0.6	0.6–0.8	2.1–3.4
2003	2	17	599	0.3	0.7–0.8	2.5–3.1
2004	12	13	541	2.1	1.7–2.3	7.4–11.5
2005	18	16	470	3.6	2.4–2.9	7.9–8.0
2006	197	12	335	36.2	25.3–28.2	48.7–60.8
2007	158	17	375	28.7	17.3–18.8	31.4–33.0
2008	154	6	342	30.7	16.9–19.2	27.5–30.8
2009	5	4	571	0.9	0.8–0.9	1.7–1.8
South Santiam						
2002	26	19	1,174	2.1	2.3	7.3
2003	25	23	1,048	2.3	3.6	11.1
2004	78	16	905	7.8	3.9	31.4
2005	71	19	999	6.5	5.3	20.3
2006	137	46	957	12.0	28.9	39.6
2007	89	13	783	10.1	22.6	27.7
2008	268	16	516	33.5	36.7	49.7
2009	2	4	734	0.3	0.2	0.3
Middle Fork Willamette						
2002	5	53	1,602	0.3	3.1	42.0
2003	5	59	1,465	0.3	8.8	76.3
2004	16	28	1,807	0.9	8.2	81.0
2005	19	24	1,497	1.2	16.3	88.4
2006	45	55	1,608	2.6	17.3	27.5
2007	161	67	1,364	10.1	33.4	96.2
2008	105	81	1,314	7.0	25.5	45.4
2009	61	57	1,807	3.2	27.8	76.5

[a] Includes unclipped fish trapped at Leaburg Dam and taken to McKenzie Hatchery in 2006 (92), 2007 (139), 2008 (91).

TABLE 19.—The number of tissue samples collected from spring Chinook salmon that were outplanted upstream of upper Willamette Basin dams, 2009.

Hatchery	Adult female	Adult male	Jack	Total
Marion Forks	142	664	0	806
South Santiam	167	263	4	434
McKenzie River	629	650	107	1,386
Willamette	447	951	775	2,173
Total	1,385	2,528	886	4,799

Develop monitoring of spring Chinook at Bennett dams for index of broodstock management (Task 2.1.4).—As discussed in Task 1.2.4, passage at the Bennett dams can be used to estimate spring Chinook numbers on the North Santiam River. Using video monitoring equipment will give a count of clipped and unclipped Chinook passing Bennett dams, helping to evaluate the composition of potential broodstock in any given year. Video monitoring equipment is in place at Upper Bennett Dam and was used in 2009. At this time, Lower Bennett Dam does not have video monitoring equipment but construction of a station is tentatively planned for 2010. The composition of the spring Chinook run could be estimated from Upper Bennett Dam video monitoring data, but it would be an incomplete estimate without data on the composition of spring Chinook over Lower Bennett Dam.

Task 2.2: Determine Survival of Outplanted Fish and Abundance of Spawners

In an effort to reintroduce populations in historic habitats upstream of Willamette basin dams and to increase natural production, adult spring Chinook salmon have been collected at trapping facilities and transported to release sites upstream of Project dams. In 2009, 5,266 fish (primarily of hatchery origin) were released upstream of Detroit, Foster, Cougar, Lookout Point, and Fall Creek dams; an additional 232 unclipped fish were released in the Little North Fork Santiam River (Table 20).

TABLE 20.—Adult spring Chinook salmon outplanted, redd counts, fish per redd, and percent pre-spawning mortality in upper Willamette basin tributaries, 2009.

Section	Fish outplanted	Females	Redds	Adults/ redd	Females/ redd	Pre-spawn mortality (%)
Breitenbush above Detroit	453	36	19	23.8	1.9	a
North Santiam above Detroit	447	111	88	5.1	1.3	14
South Santiam above Foster	445	172	84	5.3	2.0	7
South Fork McKenzie	1,387	629	274	5.1	2.3	60[b]
Middle Fork Willamette	927	147	11	c	c	c
North Fork M Fk Willamette	1,253	361	193	6.5	1.9	42
Fall Creek	354	166	36	9.8	4.6	84
Little North Fork Santiam	232	87	26	8.9	3.3	81

[a] Pre-spawning mortality not estimated because no female carcasses were recovered.

[b] From radio telemetry data.

[c] Outplants on the Middle Fork Willamette were above Hills Creek Reservoir. Only one survey was done because of fire restrictions.

North Santiam River above Detroit Dam.—Surplus fin-clipped spring Chinook salmon collected at Minto Pond were outplanted into the North Santiam and Breitenbush rivers upstream of Detroit Dam (Table 20). A total of 453 adult fish were released into the Breitenbush River at Cleator Bend (rm 12) near the Hills Creek confluence on five occasions between July 22 and September 26. However, only 36 (8%) of the outplanted fish were females. The Breitenbush River was regularly surveyed on 10 occasions from August 13 to October 8 to recover carcasses and count redds. Redd construction was first observed on September 16 and peak spawning occurred in late September or early October. There were a total of 19 redds observed, none above the South Fork confluence (Table 21). Surveyors reported a rock weir near the hot springs that may have inhibited upstream movement. We could not estimate pre-spawning mortality because no female carcasses were recovered.

In the North Santiam River above Detroit Dam,388 adults (92 females) were released at Cooper’s Ridge Road (rm 62) on four dates between August 18 and September 14. An additional 59 adults (19 females) were released at Parish Lake Road (rm 94) on September 26. The North Santiam River above Detroit was surveyed on 15 occasions July 27–October 14. The first redd was observed on September 16 with the peak counts in late September and early October. Of the 88 redds counted in the North Santiam River, 55% occurred in Horn Creek directly below the Marion Forks Hatchery (Table 21). Pre-spawning mortality was low (14%) based on the recovery of 21 female carcasses.

South Santiam River above Foster Dam.—Unclipped adult Chinook were outplanted in the South Santiam River above Foster Dam (Table 20) using three sites: 194 adults (81 females) released at Calkins boat ramp at the head of the reservoir (rm 40), 29 adults (14 females) released at Riverbend State Park (rm 44), and 222 adults (77 females) released at Gordon Road (rm 54). Adults were outplanted throughout the run on 16 dates (June 24–September 29); however, upstream release at the Gordon Road site did not begin until mid August. Most fish were Floy® tagged to assess distribution and spawning success. Of the fish outplanted at Calkins, we recovered 18 tags and 14 (78%) were downstream of Foster Dam at the hatchery or in the river. Fallback most likely occurred during spill events at Foster Dam from late July through late August.

The South Santiam River was surveyed upstream of Foster Dam on 17 occasions at regular intervals August 3–October 12. The first redd was observed on September 9. The highest concentration of redds were counted from the Gordon Road release site to three miles upstream (Table 21). Pre-spawning mortality was low (7%) based on the recovery of 28 female Chinook carcasses, two of which were unspawned.

South Fork McKenzie River above Cougar Dam.—Fin-clipped fish were outplanted into the South Fork McKenzie River above Cougar Dam on 12 dates between June 8 and August 11 (Table 20). Outplant numbers by location were: 161 fish at the Slide Creek boat ramp into the reservoir (rm 8.5), 209 fish from the FS Road 1980 bridge (rm 11.5), 283 at Hard Rock Campground (rm 11.5), and 734 fish at FS Road 430 bridge near Homestead Campground (rm 18). These included 651 adult males, 629 adult females, and 107 jacks.

Spawning surveys were conducted October 6–14 from the head of the reservoir to Elk Creek. In addition to redd and carcass surveys, project personnel conducted a radio-telemetry study on outplanted females. Estimates of pre-spawning mortality of the outplanted fish were ambiguous. Radio telemetry data suggested that 60% of the tagged females died before spawning. Assuming that each redd represented one surviving female, then mortality would be 56%. Carcass recovery was poor in the South Fork McKenzie upstream of Cougar Dam, and only 31 females were recovered of which 3 had died before spawning (10%). The recovery rate of female carcasses in the South Fork (5%) was similar to that in the North Fork Middle Fork Willamette (7%), but was lower than that in South and North Santiam rivers and Fall Creek upstream of dams (15–22%). The latter streams are smaller and easier to walk. Carcasses can be difficult to retrieve because of scavenging, swift current, deep pools, and other factors.

Middle Fork Willamette River above Lookout Point Dam.—In an effort to re-establish populations above Lookout Point Dam, adult spring Chinook were outplanted into the North Fork Middle Fork River and the Middle Fork above Hills Creek Reservoir on six dates (July 17–August 17). Approximately 41% of the outplanted fish were males, 27% were females, and 32% were jacks. The release site on the North Fork Middle Fork was at milepost 16. Spawning and carcass surveys were conducted by ODFW biologists in support of an adult condition study conducted by the University of

TABLE 21.—Spring Chinook salmon survey sections and redd counts above Willamette Valley project dams, 2009.

Stream	Section	Miles surveyed	Redds
Breitenbush River	NF Breitenbush: Mink Cr. to mouth	1.5	0
	SF Breitenbush: Debris jam to mouth	1.5	0
	SF Breitenbush to Hills Cr.	2.0	7
	Hills Cr. To Scorpion Cr.	1.7	3
	Scorpion Cr. to Fox cr.	1.4	9
	Fox Cr. to Humbug Cr.	1.4	0
	Humbug Cr. to Byars Cr.	1.5	0
	Byars Cr. to Wind Cr.	1.4	0
	Wind Cr. to Reservoir	1.0	0
North Santiam River	Parrish Lake Rd. to Straight Cr.	3.5	5
	Straight Cr. to Bugaboo Cr.	2.6	0
	Bugaboo Cr. To Horn Cr.	1.7	3
	Horn Creek: Mouth to weir	0.5	48
	Marion Creek: Mouth to weir	0.5	15
	Horn Cr. to Minto Cr.	1.2	5
	Minto Cr. to Pamelia Cr.	2.8	12
South Santiam River	Half mile above Soda Fk. to Soda Fk.	0.5	5
	Soda Fk to Little Boulder Cr.	1.8	9
	Little Boulder Cr. to Trout Cr.	2.0	8
	Trout Cr. to second trib below	1.4	0
	2nd trib to Gordon Rd.	1.8	40
	Gordon Rd. to Moose Cr.	2.6	9
	Cascadia to High Deck Rd.	1.6	0
	High Deck Rd. to Shotpouch Bridge	1.7	8
	Shotpouch Bridge to Riverbend Campground	2.2	5
	Riverbend Campground to Reservoir	1.5	0
South Fork McKenzie R.	Elk Creek to Frissel Campground	2.7	3
	Frissel Campground to Twin Springs	2.1	21
	Twin Springs Campground to 430 Rd. Bridge	2.0	38
	430 Rd. Bridge to Dutch Oven Campground	2.1	82
	Dutch Oven Campground to Reservoir	6.9	130
Fall Creek	Falls to Gold Cr.	1.0	5
	Gold Cr. to Hehe Cr.	3.5	12
	Hehe Cr. to FS Rd. 1828 Bridge	1.8	3
	FS Rd. 1828 Bridge to Bedrock Campground	2.7	5
	Bedrock Campground to Johnny Cr. Bridge	1.3	0
	Johnny Cr. Bridge to Site "C"	4.7	11
	Site "C" to Reservoir	1.3	0
North Fork M Fk Willamette	Pullout (RM 33.6) to Minute Cr.	1.5	0
	Minute Cr. to FS Rd. 1944	3.9	11
	FS Rd. 1944 to Kiahanie Bridge	5.4	59
	Kiahanie Bridge to CHS release site	4.5	123

Idaho (UI) and Oregon State University (OSU). Over 60% of the 193 redds we counted were within a few miles upstream of the release site (Table 21). We estimated that pre-spawning mortality was 42% in the North Fork Middle Fork, but recovery rate of carcasses was low (7% of the female Chinook carcasses released).

A total of 921 fin-clipped and six unclipped adults were outplanted into the Middle Fork Willamette River above Hills Creek Dam on five dates (July 14–September 10) and approximately 16% were females. Spawning surveys were conducted by USFS personnel. Access was restricted due to a forest fire; surveys were conducted only once late in the season (October 28). A total of 11 redds were counted and an additional four possible redds were noted. Carcasses were not observed during this survey.

Fall Creek above Fall Creek Dam.—A total of 354 spring Chinook salmon collected at Fall Creek Dam were outplanted approximately three miles above the head of the reservoir. Fish were released throughout the run (April 22–October 13) and (86%) of the released fish were unclipped. ODFW personnel conducted surveys to collect carcasses, assisted by UI investigators. Although survey effort was more extensive in the early part of the season, surveys continued into early October. Pre-spawning mortality was estimated to be 85% in Fall Creek based on recovery of female carcasses, which is similar to that estimated from radio telemetry (90%). Assuming that each redd represented one surviving female, then mortality estimated from the number of redds (36) would be 78% of all released females. Based on data from radio-tagged and PIT-tagged fish, high levels of mortality occurred in Fall Creek in July and August and may have been related to high water temperatures in July (Mann et al. 2010). Over 80% of the Chinook had been released by late July and would have been exposed to these high temperatures. Ratios of fish/redd and females/redd were also high in Fall Creek, indicating high pre-spawning mortality (Table 20).

Little North Fork Santiam River.—Unclipped adult spring Chinook collected at Minto Pond have been outplanted into the Little North Fork Santiam to increase natural production. In 2009, 232 unclipped fish (133 males, 87 females, and 12 jacks) were outplanted on four dates between July 21 and September 23. Most fish were outplanted in July (142) with the remainder held until September. All fish were marked with a Floy® tag, and were released into a deep pool at the Narrows (rm 8) where survival has been good in previous years. Sections upstream and downstream of the release site were surveyed on 15 dates. The redd count was lower in 2009 (26) than the 2005–2008 average since the release site was moved to the Narrows, considered to be a better site than the previous site. Almost 90% of the recovered carcasses were tagged or had tag scars indicating that the outplanted fish comprised most of the adults in the Little North Fork in 2009. Outplanted fish remained in the Little North Fork Santiam River based on recovery of tagged fish; only one fish returned to Minto Pond and no tagged fish were found in the North Santiam downstream of Minto. Recovery rate of the outplanted female carcasses was 25%, slightly higher than that in surveys upstream of dams in Fall Creek (22%) and North Santiam (19%). Our estimate of pre-spawning mortality based on the recovery of 27 female carcasses was 81% and most of the observed mortality occurred in early August when water temperature was high.

Task 3.1: Determine the extent of summer steelhead reproduction in the wild.

We collected 250 tissue samples from unclipped juvenile steelhead at Willamette Falls and 59 samples from unclipped adult steelhead at the Foster and Minto fish collection facilities in spring 2009. After preserving and cataloging the samples, they were shipped to the NOAA Fisheries Manchester, WA lab for analysis. Contracting issues prevented the work from being completed immediately; these are being resolved and we proposed to continue both sample collection and analysis in 2010.

Because the development of a formal study plan depended largely on the analysis of the tissue samples collected in 2009, we deferred this task (portions of subtasks 1-4 and 7) until the analysis can be completed. However, biologists from NOAA Fisheries, USFWS, and ODFW have informally discussed potential sampling approaches for 2010. In addition, NOAA geneticists agreed to analyze about 300 archived steelhead scale samples collected by ODFW throughout the Willamette basin during the 1980s and 1990s, effectively doubling the sample size and greatly improving the spatial and temporal scale of the study.

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Appendix 1

Summary of Tasks

Summary of anadromous fish monitoring and hatchery sampling tasks addressed in this report. RPA=reasonable and prudent alternative (NMFS 2008).

SPRING CHINOOK SALMON

Task 1.1: Determine abundance, distribution, & percent hatchery-origin fish on spawning grounds [RPA 9.5.1(2)]

Conduct surveys downstream of federal dams in the North Santiam, South Santiam, McKenzie, MF Willamette basins

1. Conduct spawning surveys to count redds
2. Assess variability in redd counts among crews with re-surveys
3. Conduct spawning surveys to collect carcasses for differentiating hatchery fish from wild fish (fin clips & otoliths)
4. Estimate pre-spawning mortality
5. Assess straying of hatchery fish between basins using coded-wire tags recovered from carcasses

Task 1.2: Monitor clipped & unclipped fish passing Leaburg and Upper Bennett dams [RPA 9.5.1(2)]

Collect information on run size & composition of run (using data from Task 1.1), removal of hatchery fish

1. Operate video recording equipment and count clipped and unclipped fish passing Leaburg Dam
2. Operate adult fish trap in the Leaburg Dam fishway when feasible to remove clipped fish [RPA 6.1.4, interim measure]
3. Operate video recording equipment and count clipped and unclipped fish passing upper Bennett Dam
4. Investigate feasibility of video monitoring at Lower Bennett and Lebanon dams

Task 2.1: Collection, spawn timing, and H/W composition for broodstock management [RPA 9.5.1(1) & 6.2.2]

Hatchery monitoring of returns and broodstocks

1. Record data on return date, numbers of clipped & unclipped fish, disposition (collect biological data on outplants and spawned fish)
2. Collect otoliths on unclipped fish used for broodstock to determine proportion of wild fish
3. Operate Leaburg fishway trap to collect unclipped fish to supplement broodstock [see Task 1.2(2)]
4. Develop monitoring of fin-clipped and unclipped fish at Bennett dams for index of broodstock management (under Task 1.2)

<u>Task 2.2: Determine survival of outplanted fish and abundance of spawners [RPA 9.5.1(3) & 6.2.3; Proposed Action 2.10.1]</u>

Conduct surveys upstream of federal dams in the North Santiam, South Santiam, McKenzie, MF Willamette basins

1. Record numbers, clip information, date, release locations for outplanted Chinook
2. Collect tissue samples from outplanted Chinook to determine spawning success and parentage analysis of returning adults
3. Conduct spawning surveys to count redds as measure of abundance, survival, and distribution of outplants
4. Conduct spawning surveys to collect carcasses for proportion of hatchery and wild fish in some outplant areas
5. Estimate pre-spawning mortality for outplanted Chinook
6. Assist in collection of information needed for condition study in Middle Fork Willamette River and Fall Cr.

<u>STEELHEAD</u>

<u>Task 3.1: Determine the extent of summer steelhead reproduction in the wild [RPA 9.5.2(1) and 6.1.9].</u>

1. Develop a study plan for genetics study[a] and initiate field collections
2. Work with geneticists (Services, OSU) to develop study plan to determine parentage and introgression
3. Review plan and design with ODFW managers, and with independent review group
4. Initiate field collections of tissue samples in North and South Santiam using traps, electrofishing, seines
5. Collect tissue samples on unclipped steelhead smolts in Willamette at Sullivan Plant and using seines or electrofishing
6. Collect tissue samples on winter-run and summer-run steelhead adults if needed to increase reference samples
7. Collect tissue samples from adult resident and hatchery rainbow trout - potential parentage sources

<u>Task 3.2: Evaluate release strategies for summer steelhead to increase migration and reduce impacts on wild fish [RPA 6.1.6].</u> [a]

1. Develop study plans to implement volitional releases and monitor outmigration, and initiate field work
2. Develop plans to implement volitional emigration from release facilities and evaluate factors influencing volitional emigration
3. Develop plans to monitor outmigration of summer steelhead releases past Willamette Falls
4. Develop plans to monitor presence, distribution, and size of residual hatchery steelhead in tributaries and main stem.

[a] *The scope of this task is dependent on sampling designs to conduct study; full implementation is not covered in this report.*

Appendix 2

Hatchery Operations Tables

Hatchery Operations

Note: Numbers of fish handled at the traps may not match the final disposition numbers because of counting errors or misclassification of fin clips.

APPENDIX TABLE 2-1.—Dates of operation and numbers of spring Chinook salmon collected in the North Santiam River (at Minto), 2009.

	Adult		Jack	
Date	fin-clipped	unclipped	fin-clipped	unclipped
15-Jun	106	0	0	0
20-Jul	367	108	44	5
27-Jul	94	28	24	1
11-Aug	98	16	0	0
18-Aug	72	12	8	0
25-Aug	66	9	3	0
1-Sep	108	14	0	0
4-Sep	120	0	13	0
9-Sep	359	10	19	4
10-Sep	44	13	0	0
14-Sep	244	12	19	0
16-Sep	36	2	0	1
18-Sep	98	21	6	1
23-Sep	107	30	3	0
5-Oct	10	0	0	0
Total	1,929	275	139	12

APPENDIX TABLE 2-2.— Dates of operation and numbers of spring Chinook salmon collected in the South Santiam River (at Foster), 2009.

	Adult		Jack		Mini jack	
Date	fin-clipped	unclipped	fin-clipped	unclipped	fin-clipped	unclipped
20-May	1	4	2	0	0	0
27-May	52	21	5	0	0	0
3-Jun	11	9	1	1	0	0
10-Jun	48	21	14	2	0	0
15-Jun	145	0	14	0	0	0
19-Jun	13	0	3	0	0	0
24-Jun	3	11	0	0	0	0
29-Jun	45	7	2	0	0	0
2-Jul	287	46	55	1	2	0
6-Jul	203	54	56	0	2	0
9-Jul	27	12	0	0	0	0
14-Jul	71	28	0	1	14	0
15-Jul	77	8	130	0	16	0
30-Jul	53	15	28	1	23	0
4-Aug	166	0	53	0	29	0
10-Aug	56	41	21	2	32	0
12-Aug	0	0	0	0	0	0
19-Aug	63	12	30	1	43	0
26-Aug	47	6	20	0	72	0
2-Sep	219	34	29	4	188	0
8-Sep	224	30	47	2	24	1
9-Sep	0	0	0	0	0	0
15-Sep	260	44	24	0	21	0
16-Sep	0	0	0	0	0	0
22-Sep	85	22	19	4	0	0
23-Sep	0	0	0	0	0	0
29-Sep	10	2	0	1	0	0
6-Oct	1	0	2	0	0	0
Total	2,167	427	555	20	466	1

APPENDIX TABLE 2-3.—Dates of operation and numbers of spring Chinook salmon collected in the Middle Fork Willamette River (at Dexter), 2009.

	Adult		Jack		
Date	fin-clipped	unclipped	fin-clipped	unclipped	Mini-Jack
17-Jun	604	12	3	0	0
24-Jun	420	22	409	0	10
25-Jun	239	9	233	0	13
1-Jul	441	6	126	0	6
9-Jul	81	7	20	0	4
14-Jul	313	0	110	0	0
15-Jul	243	0	69	1	0
17-Jul	278	1	99	1	0
29-Jul	147	3	0	0	0
4-Aug	165	2	53	0	0
5-Aug	178	1	57	0	0
11-Aug	178	0	52	0	0
13-Aug	176	12	26	0	0
17-Aug	36	0	4	0	0
2-Sep	195	3	33	0	0
10-Sep	182	7	20	1	0
Total	3,876	85	1,314	3	33

APPENDIX TABLE 2-4.—Dates of operation and numbers of spring Chinook salmon collected at McKenzie River Hatchery, 2009.

	Adult		Jacks	
Date	fin-clipped	unclipped	fin-clipped	unclipped
28-May	161	3	2	0
3-Jun	321	5	5	0
5-Jun	273	2	7	0
8-Jun	240	5	7	0
15-Jun	309	6	14	0
17-Jun	182	0	8	0
18-Jun	174	0	13	0
19-Jun	255	11	12	0
25-Jun	96	0	9	0
29-Jun	91	0	7	0
2-Jul	83	5	5	0
7-Jul	194	5	14	1
13-Jul	86	3	13	0
20-Jul	58	1	10	0
30-Jul	46	2	15	0
11-Aug	38	1	13	0
21-Aug	24	2	6	0
28-Aug	49	0	8	0
4-Sep	92	6	18	3
9-Sep	195	7	24	0
14-Sep	135	8	15	0
18-Sep	69	4	10	0
21-Sep	42	5	8	0
28-Sep	35	3	3	0
5-Oct	15	3	1	0
Total	3,263	87	247	4

Origin of Hatchery Returns

Estimates of natural origin fish were made to assess the proportion of natural origin spring Chinook used for hatchery broodstocks relative to the size of the run into the river or the number of natural origin spawners. Data available vary by river and several assumptions and expansions were used to make the estimates. In some cases more than one method was used. These estimates should be considered preliminary.

APPENDIX TABLE 2-5.—Number of natural origin spring Chinook incorporated into the broodstock and estimates of the run of natural origin fish and number of natural origin spawners in the McKenzie River basin, 2002–2009.

		Run					Spawner-1[f]		Spawner-2[g]	
Return year	Brood-stock[a]	above dam[b]	below dam[c]	Other[d]	Harvest[e]	Total	above dam	below dam	above dam	below dam
2002	13	3,602	166	2	109	3,892	3,214	139	1,365	57
2003	14	4,899	135	23	70	5,141	4,108	64	1,615	27
2004	24	4,419	89	7	197	4,736	3,933	35	1,710	16
2005	20	2,435	120	2	74	2,651	2,051	85	2,265	94
2006	100	2,189	118	12	69	2,488	2,164	112	1,548	76
2007	81	2,735	110	6	85	3,016	2,595	69	2,803	77
2008	90	1,408	127	6	0	1,631	1,393	115	1,355	110
2009	60	1,143	35	4	36	1,278	1,060	28	1,015	26

[a] Includes natural origin fish in unclipped fish trapped at Leaburg Dam and taken to McKenzie Hatchery in 2006 (92), 2007 (139), and 2008 (91).

[b] Estimated from counts of unclipped fish at Leaburg Dam and the percentage of natural origin carcasses recovered on the spawning ground as determined from otolith analysis.

[c] Estimated from redds downstream of the dam and fish per redd ratio upstream of the dam, adjusted for higher pre-spawning mortality downstream of the dam.

[d] Includes mortalities, and other fish not spawned at hatchery.

[e] Creel surveys were conducted in 2003 and 2004, estimates for other years were from 2003–2004 catch rates relative to fish that could be accounted for (dam count, hatchery return, estimated fish below dam); fishery was closed in 2008 because of the low run. Includes unclipped fish kept plus estimated mortality of released fish.

[f] Total number of potential spawners calculated from estimates of run and pre-spawning mortality; brood stock would be added to give all potential spawners..

[g] Total number of potential spawners estimated from redds assumed to be from wild fish based on percentage of natural origin spawners by section from otolith analysis of carcasses and 2.5 spawners per redd; brood stock would be added to give all potential spawners.

The difference between the two estimates of natural origin spawners was greatest in 2002–2004 (years of high run sizes) when number of spawners estimated from redd counts was about 40% of that estimated from run counts. Several factors can potentially affect estimates of run and spawners, and the effect of any individual factor likely varies by year and could be affected by run size. For example, some of the potential factors affecting estimates include counts of redds (counts may be more accurate in low return years because the incidence of multiple redds and redd superimposition would be lower), counts at Leaburg (more fish may fall back at the dam in high return years than in low return years), and estimates of pre-spawning mortality (surveys often began later in the McKenzie than in other rivers, so it may be underestimated).

APPENDIX TABLE 2-6.—Number of natural origin spring Chinook incorporated into the broodstock and estimates of the run of natural origin fish and number of natural origin spawners in the North Santiam River basin, 2002–2009.

		Run			Harvest[d]				Spawners[e]		Spawners[f]	
Year	Brood-stock	above dam-1[a]	above dam-2[b]	below dam[c]	below dam	total	Total 1	Total 2	above dam	below dam	above dam	below dam
2002	4	604	435	29	25	53	658	517	174	11	103	10
2003	2	271	226	6	13	29	290	261	76	1	62	2
2004	12	489	627	26	17	36	532	689	90	2	146	5
2005	18	667	519	49	27	58	743	626	198	12	189	18
2006	197	650	638	22	27	57	699	717	173	8	195	12
2007	158	852	803	24	35	75	911	902	273	11	335	9
2008	154	903	798	6	**d**	**d**	909	804	342	3	403	3
2009	5	571	475	60	23	50	654	585	254	35	184	28

[a] Estimated from counts of unclipped fish at Upper Bennett Dam (2002–2005), and the percentage of natural origin carcasses recovered on the spawning ground as determined from otolith analysis. Because Upper Bennett trap was not run in 2006–2008, counts of natural origin fish were estimated from the proportion of the 2002 dam count that could be accounted for (fish handled at Minto trap plus the estimated number of fish in the river using redd counts and 2.5 fish per redd expanded by pre-spawning mortality). The 2002 count was used because run size was more similar to 2006–2008 than 2003–2004, and the count was for the entire season. Estimates of total count in 2009 was made from average of dam count accounted for at Minto and estimates of fish in the river, with proportion of hatchery and natural origin fish from partial video counts (Upper Bennett Dam only).

[b] Estimated from total number of fish that could be accounted for (fish handled at Minto trap plus the estimated number of fish in the river using an estimate of spawners at 2.5 fish per redd expanded by pre-spawning mortality).

[c] Calculated from estimated fish upstream of dam (using redds and pre-spawning mortality) and proportion of redds downstream of dam adjusted for the 2002–2005 average of 50% higher pre-spawning mortality downstream of the dam (too few carcasses recovered in 2006–2008 downstream of dam to make estimates).

[d] Creel surveys were conducted in 2003 and 2004, estimates for other years were from 2003–2004 catch rates relative to fish that could be accounted for (dam count, hatchery return, estimated fish below dam); fishery was closed in 2008 because of the low run. Includes unclipped fish kept plus estimated mortality of released fish. Below dam harvest only was included in first total run estimate because fish harvested upstream of the dam would be accounted for in the dam counts.

[fe] Total number of potential spawners upstream of dam calculated from estimated fish in river (run of method 1 minus fish at Minto trap) and pre-spawning mortality; potential spawners downstream of dam from estimated fish upstream of dam, proportion of redds downstream of dam, and measured or estimated pre-spawning mortality; brood stock would be added to give all potential spawners.

[f] Total number of potential spawners in river estimated from redd counts, 2.5 spawners per redd, and percentage of natural origin spawners in carcasses from otolith analysis; brood stock would be added to give all potential spawners.

APPENDIX TABLE 2-7.—Number of natural origin spring Chinook incorporated into the broodstock and estimates of the run of natural origin fish and number of natural origin spawners in the South Santiam River basin, 2002–2008.

Year	Broodstock	Trap[a]	Fish in river[b]	Harvest[c]	Total Run	Spawners[d]
2002	26	562	447	80	1,115	332
2003	25	313	279	74	691	200
2004	78	1,278	601	67	2,024	171
2005	71	756	407	95	1,329	279
2006	137	65	239	34	475	209
2007	89	23	253	28	393	232
2008	268	169	294	**c**	731	271
2009	2	351	873	94	1,320	775

[a] Natural origin fish handled at Foster trap excluding fish used for broodstock or recycled. Includes fish outplanted upstream of Foster Dam and fish that died at hatchery or excess given to food banks or tribes.

[b] Estimated from number of redds, 2.5 spawners per redd, pre-spawning mortality, and percentage of natural origin spawners in carcasses from otolith analysis.

[c] Creel surveys were conducted in 2003 and 2004, estimates for other years were from 2003–2004 catch rates relative to fish that could be accounted for (hatchery return and estimated fish below dam); fishery was closed in 2008 because of the low run. Includes unclipped fish kept plus estimated mortality of released fish.

[d] Total number of potential spawners in river estimated from redd counts, 2.5 spawners per redd, and percentage of natural origin spawners in carcasses from otolith analysis; brood stock would be added to give all potential spawners.

APPENDIX TABLE 2-8.—Number of natural origin spring Chinook incorporated into the broodstock and estimates of the run of natural origin fish and number of natural origin spawners in the Middle Fork Willamette River, and number of natural origin spring Chinook counted at Fall Creek Dam, 2002–2008. Redd count in 2006 included redds counted by Corps of Engineers biologists in side channels not counted by ODFW.

Year	Broodstock	Trap[a]	Fish in river[b]	Harvest[c]	Total Run[d]	Spawners[e]	Fall Cr
2002	5	77	43	34	159	7	63
2003	5	9	31	12	57	2	103
2004	16	41	75	64	196	4	592
2005	19	31	42	25	117	3	119
2006	45	33	266	95	439	251	335
2007	161	90	127	104	482	6	209
2008	105	154	153	**c**	412	126	268
2009	62	28	84	48	222	19	252

[a] Natural origin fish handled at Dexter trap excluding fish used for broodstock or recycled. Includes fish outplanted and fish that died at hatchery or excess given to food banks or tribes.

[b] Estimated from number of redds, 2.5 spawners per redd, pre-spawning mortality, and percentage of natural origin spawners in carcasses from otolith analysis.

[c] Creel surveys were conducted in 2003 and 2004, estimates for other years were from 2003–2004 catch rates relative to fish that could be accounted for (hatchery return and estimated fish below dam); fishery was closed in 2008 because of the low run. Includes unclipped fish kept plus estimated mortality of released fish.

[d] Does not include counts of Chinook at Fall Creek Dam.

[e] Total number of potential spawners in river estimated from redd counts, 2.5 spawners per redd, and percentage of natural origin spawners in carcasses from otolith analysis; brood stock would be added to give all potential spawners. Does not include estimates of spawners in Fall Creek.

Appendix 3

Hatchery Spring Chinook Strays in the McKenzie River

Hatchery Spring Chinook Strays in the McKenzie River

Kirk Schroeder

The Willamette Biological Opinion identified the need to reduce hatchery fish spawning in the wild to “the lowest extent possible (0–10%)”. In the draft recovery plan for Upper Willamette Chinook and steelhead, risk levels to the diversity of populations were “low” or “very low” if the proportion of hatchery fish on spawning grounds was < 10%.

Estimates of spring Chinook salmon spawning in the McKenzie River basin were derived from counts of fish at Leaburg Dam, proportion of hatchery and natural origin fish determined by recovery of carcasses, pre-spawning mortality, and redds. Origin of carcasses was determined by presence or absence of adipose fin clips and induced thermal marks in otoliths of unclipped fish. We used two methods to estimate the number of spring Chinook spawners. The first method was based on counts of fin-clipped and unclipped Chinook at Leaburg Dam. Counts were adjusted by the ratio of fin-clipped to unclipped carcasses recovered upstream to account for documented fallback of fin-clipped fish at the dam (McKenzie Hatchery is 3 km downstream). We weighted the distribution of carcasses among survey sections upstream of the dam by the distribution of redds to account for differences in ability to see and recover carcasses among the survey sections. We used the estimated escapement of Chinook upstream of the dam to estimate the number of spawners by using pre-spawning mortality (determined by the spawning success of female carcasses) to estimate survival to spawning. To estimate the number of spawners downstream of Leaburg Dam, we multiplied the number of redds counted downstream of the dam by the fish/redd ratio estimated upstream of the dam and adjusted the result for higher pre-spawning mortality that occurs downstream of the dam. The second method for estimating spawners used the number of redds counted upstream and downstream of Leaburg Dam and an estimate of 2.5 spawners/redd.

The estimated escapement of Chinook upstream of the dam and the difference in estimated numbers between the two methods was higher in 2002–2004 than in subsequent years (Appendix Table 3-1). Several factors can affect estimates of spawners, and the effect of any individual factor likely varies by year and could be affected by run size. For example, some of potential factors affecting estimates include counts of redds (counts may be more accurate in lower run years because the incidence of multiple redds and redd superimposition would be lower), counts at Leaburg (more fish may fall back at the dam in high run years than in low run years), and estimates of pre-spawning mortality (surveys often began later in the McKenzie than in other years, so it may be underestimated). Although the difference in estimated number of spawners using the two methods was variable, the proportions of hatchery origin spawners estimated from these two estimates were similar and were similar to the proportion of hatchery spawners directly estimated from recovery of carcasses (Appendix Table 3-2).

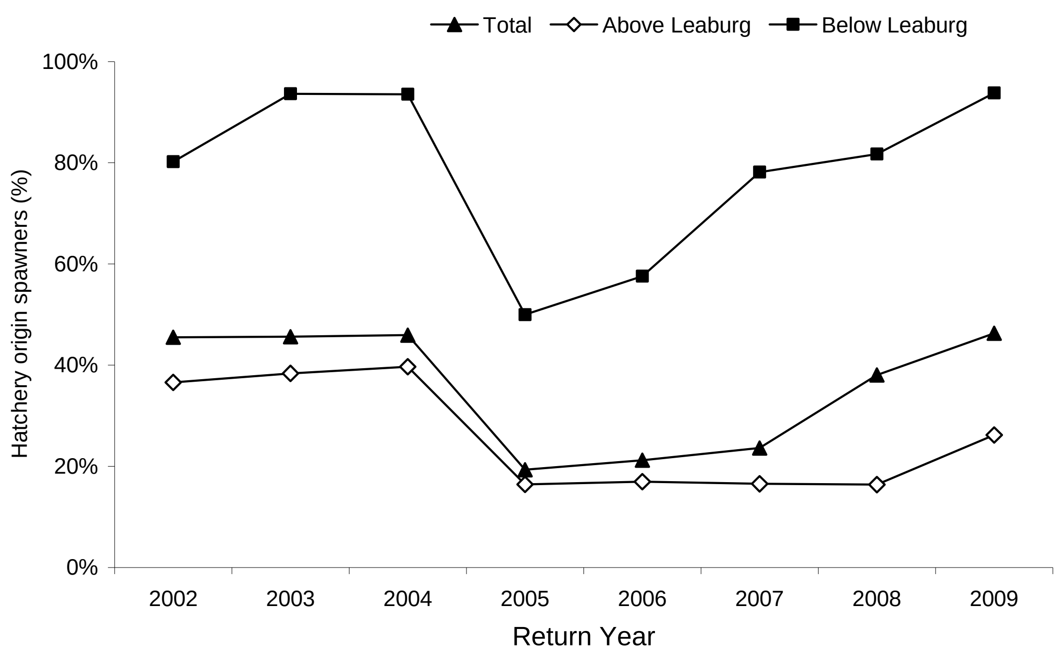
The proportion of hatchery Chinook spawning in the wild averaged over 30% in 2002–2009, with a range of 17–45% (Appendix Table 3-2, Appendix Figure 3-1). The proportion of hatchery spawners in the McKenzie Basin was largely affected by the proportion observed upstream of Leaburg Dam in 2002–2007, but an increase in hatchery fish spawning downstream of the dam in 2008 resulted in an overall increase in the proportion of hatchery spawners for the basin. This was followed by an increase in the proportion of hatchery spawners upstream and downstream of the dam in 2009 (Appendix Figure 3-1). The percentage of spawning upstream of the dam accounted for almost 90% of all redds in 2002–2007, but decreased to 74% in 2008–2009 when we observed an increase in hatchery Chinook spawning downstream of the dam.

APPENDIX TABLE 3-1.—Number of spring Chinook spawners in the McKenzie River upstream and downstream of Leaburg Dam, estimated by two methods: 1) upstream of dam = dam count adjusted by pre-spawning mortality, downstream of dam = fish/redd from upstream of dam times redds downstream of dam, adjusted by pre-spawning mortality downstream of dam; 2) redds times an estimated 2.5 fish/redd.

	Upstream of Leaburg Dam-1		Downstream of Leaburg Dam-1		Upstream of Leaburg Dam-2		Downstream of Leaburg Dam-2	
Year	Natural origin	Hatchery origin	Natural origin	Hatchery origin	Natural origin	Hatchery origin	Natural origin	Hatchery origin
2002	3,214	1,761	139	565	1,315	653	57	231
2003	4,108	2,669	64	953	1,615	925	27	400
2004	3,933	2,506	35	509	1,710	865	16	232
2005	2,051	439	85	85	2,265	415	94	94
2006	2,164	440	112	152	1,548	225	76	104
2007	2,595	505	69	247	2,803	563	77	276
2008	1,393	260	115	515	1,355	218	110	490
2009	1,060	377	28	418	1,015	313	26	392

APPENDIX TABLE 3-2.—Percentage of hatchery origin spawners (pHOS) in the McKenzie River upstream of Leaburg Dam determined by three methods, downstream of dam determined by recovery of carcasses, and total. 1 = dam count adjusted by pre-spawning mortality, 2 = redds times an estimated 2.5 fish/redd, 3 = carcass recovery.

	Upstream of Leaburg Dam			Downstream	Total		
Year	1	2	3	of Leaburg Dam	1	2	3
2002	35	32	37	80	41	38	45
2003	39	36	38	94	46	45	46
2004	39	34	40	94	43	39	46
2005	18	15	16	50	20	18	19
2006	17	13	17	58	21	17	21
2007	16	17	17	78	22	23	24
2008	16	14	16	82	34	33	38
2009	26	24	26	94	42	40	46

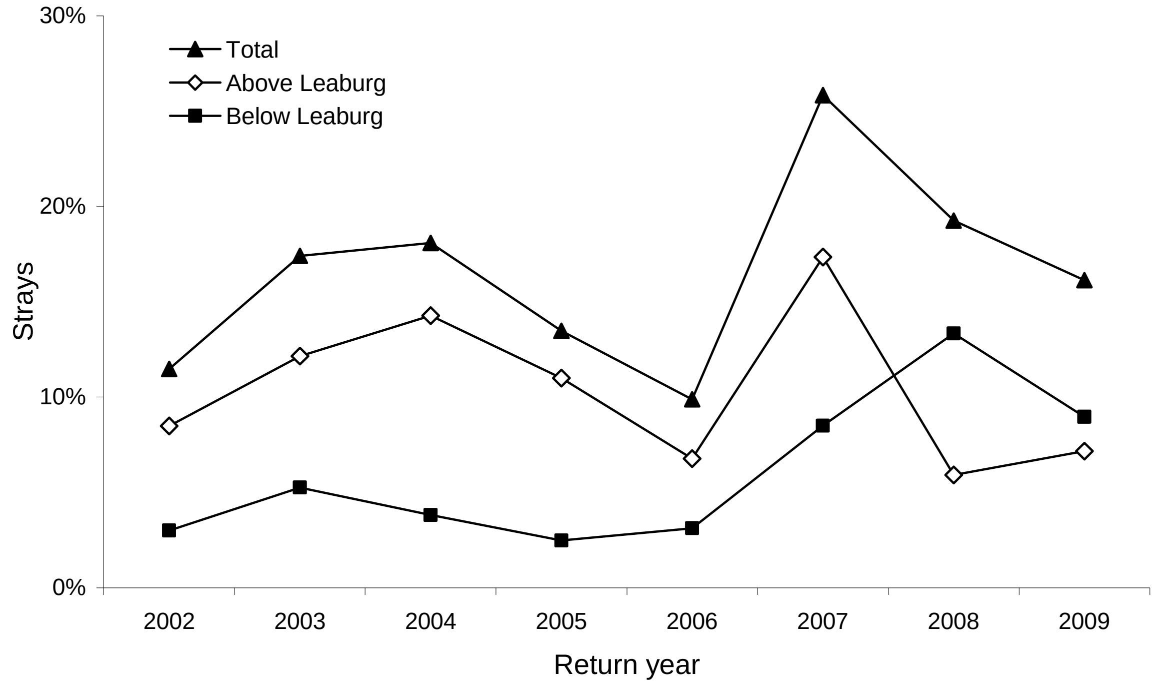


APPENDIX FIGURE 3-1.—Percentage of hatchery origin spawners in the McKenzie River estimated from the presence of fin-clips or thermal marks in otoliths of recovered carcasses, 2002–2009.

We looked at the percentage of the hatchery Chinook in the McKenzie River that did not return to the hatchery (strayed) and spawned in the river. Because the concern of hatchery Chinook spawning in the wild is primarily genetic, we calculated the percentage of strays based on estimates of spawners instead of estimated run size (i.e., we did not factor in pre-spawning mortality or fishery harvest). In 2002–2007, hatchery strays upstream of Leaburg Dam represented a higher proportion of the basin total than downstream of the dam (Appendix Table 3-3 and Appendix Figure 3-2). However, hatchery strays downstream of the dam comprised a higher percentage of the basin total in 2008 and 2009.

APPENDIX TABLE 3-3.—Hatchery spring Chinook spawners in the wild, as a percentage of hatchery fish returning to McKenzie Hatchery and hatchery fish spawning upstream and downstream of Leaburg Dam. Spawners were estimated from redds and 2.5 fish/redd.

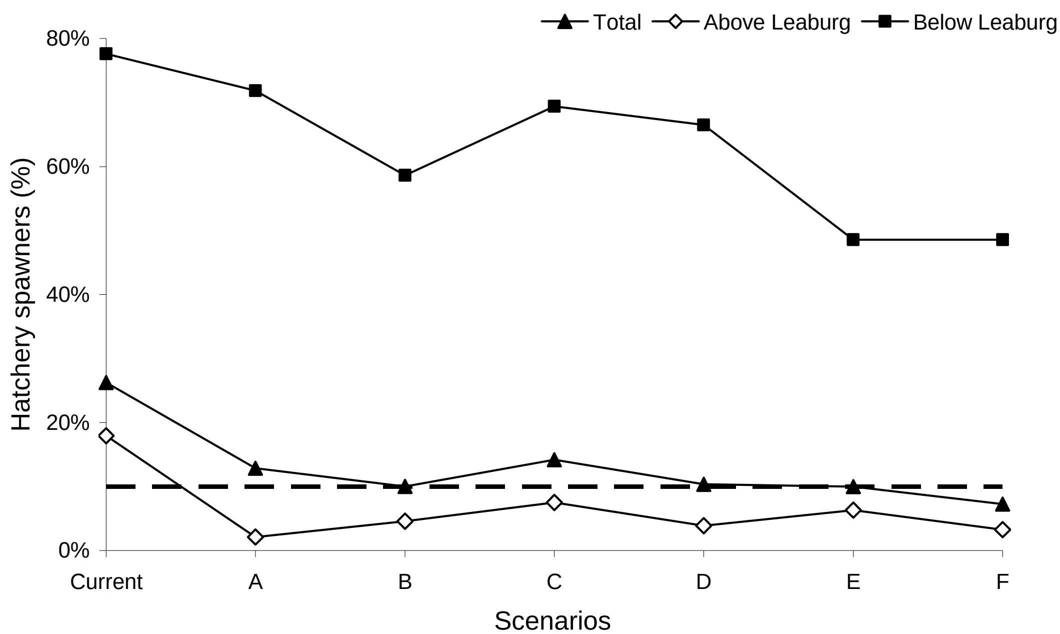
	Hatchery spawners			Percentage		
Year	Upstream of Leaburg Dam	Downstream of Leaburg Dam	McKenzie Hatchery	Upstream of dam	Downstream of dam	Total
2002	653	231	6,810	8.5	3.0	11.5
2003	925	400	6,288	12.1	5.3	17.4
2004	865	232	4,965	14.3	3.8	18.1
2005	415	94	3,267	11.0	2.5	13.5
2006	225	104	2,994	6.8	3.1	9.9
2007	563	276	2,405	17.3	8.5	25.8
2008	218	490	2,968	5.9	13.3	19.3
2009	312	392	3,661	7.1	9.0	16.1



APPENDIX FIGURE 3-2.—Percentage of hatchery spring Chinook in the McKenzie Basin that did not return to the hatchery based on counts of hatchery fish returning to McKenzie Hatchery and the estimated number hatchery fish spawning upstream and downstream of Leaburg Dam using redd counts and 2.5 fish/redd.

Reducing the percentage of hatchery Chinook that spawn in the wild will require actions that remove hatchery fish (harvest or removing hatchery fish at Leaburg Dam), increase homing to McKenzie Hatchery, increase production of wild fish (e.g., wild fish production from reintroductions in the basin), reduce releases of hatchery Chinook in the basin, or a combination of actions. Several scenarios were modeled to illustrate the potential effects of actions on the percentage of hatchery fish spawning in the wild (Appendix Figure 3-3). Current conditions were based on the average number of spawners in 2005–2009. Scenarios were modeled using reductions of hatchery spawners upstream and downstream of Leaburg Dam, and three levels of wild spawners upstream of Leaburg Dam: (1) current levels (Appendix Figure 3-3, **A–B**), (2) an increase to 2,500 fish, which was the 2007 level (Appendix Figure 3-3, **C–D**), or (3) an increase to 3,000 fish, which is 80% of the 2002–2005 average (Appendix Figure 3-3, **E–F**).

If the number of wild spawners remained at current levels, a large reduction in hatchery spawners upstream of Leaburg Dam (90%) would reduce the proportion of hatchery fish in the basin by 50%, but would not reach the target of 10% (Appendix Figure 3-3, **A**). This scenario represents an action such as implementation of a passive sorting mechanism at Leaburg Dam that would have a disproportionate effect on the population upstream of the dam. Other actions that reduce the number of hatchery spawners upstream of the dam such as increased homing in hatchery fish, reduction in hatchery releases, or alternative release strategies should also reduce the number of hatchery spawners downstream of the dam. For example, a slightly lower reduction in hatchery spawners upstream of the dam than Scenario **A** (75%) along with a 50% reduction in hatchery spawners downstream of the dam would bring the proportion of hatchery spawners in the basin to 10% (Appendix Figure 3-3, **B**). An increase in wild spawners would also reduce the proportion of hatchery spawners in the basin if the increase resulted from actions that target wild fish such as successful re-establishment of a self-sustaining natural population upstream of Cougar Dam (Appendix Figure 3-3, **C–F**). The target of 10% hatchery spawners in the basin at could be achieved with certain reductions in hatchery spawners (Appendix Figure 3-3, **D–F**). However, if the increase in wild spawners resulted from effects such as improved ocean conditions that also increased the return of hatchery Chinook to the basin, the effect on the proportion of hatchery spawners in the basin would likely be minimal.



APPENDIX FIGURE 3-3.—Effects on the proportion of hatchery origin spring Chinook spawners in the McKenzie River basin from current conditions (2005–2009) of implementing actions to reduce hatchery spawners upstream and downstream of Leaburg Dam, with three levels of wild spawners upstream of Leaburg Dam: (1) Current level of wild spawners plus 90% reduction upstream and 10% downstream (**A**) or 75/50 reductions (**B**), (2) 2,500 wild spawners upstream plus 50/50 reductions (**C**) or 75/30 reductions (**D**), and (3) 3,000 wild spawners plus 50/50 reductions (**E**) or 75/50 reductions (**F**). Dashed line is the target proportion of hatchery spawners at 10%.

These results suggest that aggressive actions to reduce the number of hatchery spawners in the basin will be necessary to achieve the desired level of 10% or less. However, interim measures could be implemented that would have a higher likelihood of reducing hatchery spawners upstream of the dam than downstream (e.g., releasing hatchery fish farther downstream to reduce the chance returning adults would stray upstream of the dam). We estimated that almost 97% of natural origin spawners in the McKenzie Basin were upstream of Leaburg Dam in 2002–2009; therefore, decreasing the proportion of hatchery spawners in this portion of the basin would lower genetic risks to the McKenzie wild Chinook.

Appendix 4

Task 3.2 – Evaluating Summer Steelhead Release Strategies

Strategies for Hatchery Summer Steelhead Releases (Task 3.2)

Kirk Schroeder and Craig Tinus

One of the RPAs in the Willamette Project Biological Opinion is to improve summer steelhead releases by implementing volitional emigration of 2–4 weeks and removing non-migrants (RPA 6.1.6). The rationale and effect of this RPA is to reduce the percentage of residual hatchery steelhead. Because of concerns about potential negative effects that residual hatchery steelhead may have on naturally-produced salmonids, changes in release strategies have been implemented in several basins to reduce the number of residual fish. For example, non-migrant steelhead were retained in an acclimation pond in the Tucannon River following a volitional emigration period to reduce the number of residual steelhead in the river (Viola and Schuck 1995). In the Imnaha Basin, the density of residual hatchery summer steelhead at index sites close to release locations was generally higher than wild steelhead juveniles, but was lower in the Grande Ronde Basin (e.g., Flesher et al. 2009). Steelhead that remained in acclimation ponds in the Tucannon River were predominantly male (4:1 ratio of males to females) and were a mix of transitional, parr, and precocious male stages (Viola and Schuck 1995). Residual hatchery steelhead captured in the Imnaha and Grande Ronde basins were largely male (Flesher et al. 2005, 2009). The level of precocious males in WDFW hatcheries have been 1–5% (Tipping et al. 2003).

We compiled data collected during seining for spring Chinook salmon to assess the relative abundance of residual hatchery steelhead. Sections of the Santiam Basin and Willamette and McKenzie rivers were sampled with beach seines in 2004–2009, one to three months after hatchery steelhead were released. Sampling in the North Santiam extended upstream to Mehama, but was more extensive downstream of Stayton. In the South Santiam, sampling extended to Pleasant Valley Bridge but was more extensive downstream of Lebanon. Sampling in the McKenzie began at Leaburg Dam but was more extensive downstream of Hendricks Bridge.

The catch of hatchery steelhead was very low throughout the Willamette Basin, as was the catch of naturally-produced steelhead (Appendix Table 4-1). We used a smolt-like appearance to identify steelhead and an adipose fin clip to differentiate hatchery fish from naturally-produced fish. The relative catch of juvenile steelhead (fish per seine set) was much lower than that of rainbow trout in all areas except the Willamette River downstream of the Santiam confluence (Appendix Figure 4-1). Salmonids classified as rainbow trout included adult and juvenile fish, and among the juvenile fish some were likely naturally-produced steelhead that would smolt the following spring or later. Fish classified as trout were generally too small to be accurately identified as rainbow trout or cutthroat trout, and in the North Santiam, upper Willamette, and McKenzie rivers, these fish were more abundant than juvenile steelhead.

These data suggest that the presence of residual hatchery steelhead is limited in the areas and time of year we sampled. Therefore, the underlying rationale RPA 6.1.6 may not be valid, and effect of implementing this RPA may not yield expected benefits.

A potential negative effect of implementing a strategy to release only volitional migrants into free-flowing water downstream of Willamette projects and putting remaining fish elsewhere is a reduction in adult returns. In addition, the cost of implementing the proposed release strategy may outweigh the benefits. One study comparing adult returns of volitionally migrating and forced (after five weeks) non migrating steelhead showed no difference in adult returns between the two groups in four years and a significantly higher return of the forced released release in one year (Tipping 2006). Although releases of forced non migrating steelhead from Winthrop National Fish Hatchery did not migrate or survive as well within the Columbia River as either the volitional or forced released groups, no difference in adult returns was reported between volitional and forced release strategies (Gale et al. 2009). Other studies have shown that steelhead from forced releases return better than fish from volitional releases (Wagner 1968; Evenson and Ewing 1992). In Northeast Oregon, the return rate of steelhead from forced releases was slightly higher than for volitional releases for the May release groups, but the April release groups showed no difference (data from Carmichael et al. 2005a, 2005 b; Flesher et al. 2005, 2009; Gee et al. 2007).

Because available data from Willamette Basin rivers suggested the abundance of residual steelhead was low and because of potential effects and costs of an alternate release strategy, we propose to develop specific studies to evaluate the efficacy of implementing RPA 6.1.6. Initial experimental studies can be designed to compare juvenile body size, migratory behavior, and proportions of volitional migrants and non migrants (forced from the pond at the end of the volitional release period). The experimental study may also include a third group of juvenile steelhead that is forced from a pond at the beginning of the volitional release period. Juvenile steelhead within each test group will be PIT tagged to assess the time and date they left the ponds and migration timing to Willamette Falls. Sample size of PIT-tagged releases depends on the detection probability of the PIT tag detectors at Willamette Falls. Tests conducted in November 2009 and February–April 2010 will be used to help determine adequate sample sizes for the experimental releases. Coded-wire tags can be used for the experimental releases to evaluate effect of release strategy on adult returns. If possible, individual raceways will be used to replicate the experimental release groups. Juvenile steelhead will be sampled before and during release to measure size and condition factor. We will also assess the sex ratio of a subsample of non migrants from the volitional release pond. Data on size and condition factor will be collected for two months before the beginning of scheduled releases to test for any differences of the release groups.

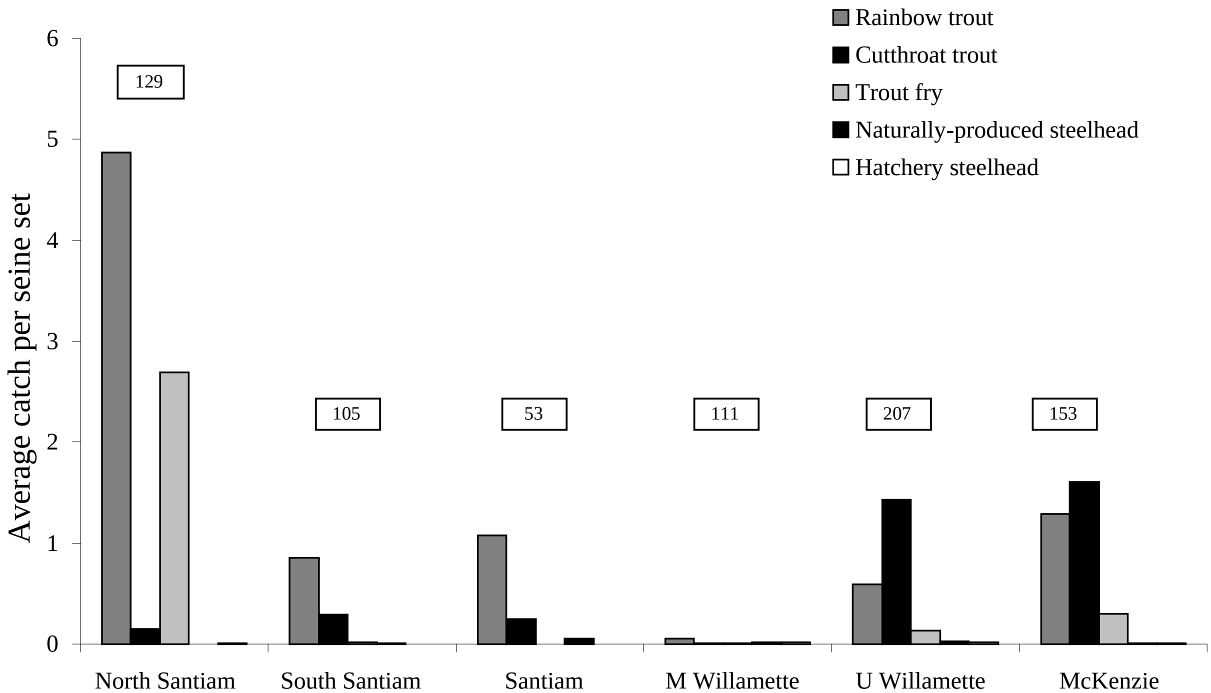
Data will be evaluated to assess the benefits and costs of alternative release strategies. For example, decisions about a release strategy may depend on the proportion (or number) of juvenile steelhead that remain in a pond after a volitional release period, and on the proportion of precocious males or parr among the non migrants. Results of the experiment may also be used to implement alternative rearing strategies to control early maturation (Sharpe et al. 2007). Gale et al. (2009) suggest the best strategy for reducing precocity may be to control environmental cues that trigger this rather than removing non migrants at the end of the rearing period. If juvenile steelhead that reach a large size early are more likely to become precocious males, then grading and removing those fish early may reduce the number of precious males that get released (Tipping et al. 2003). However, they reported that the benefits of this strategy may be minimal because of costs and the large number of non-precocious fish that would also be removed.

APPENDIX TABLE 4-1.—Catch of trout in Willamette Basin beach seining samples, 2004–2009. Steelhead were those with smolt-like appearance, and an adipose fin clip was used to differentiate hatchery and naturally-produced fish. Some rainbow trout juveniles could be juvenile (parr) steelhead.

						Steelhead		
Area, year	Start date	Sets	Rainbow trout	Cutthroat trout	Trout fry	Naturally-produced	Hatchery	Capture date[a]
North Santiam								
2004	Jun 29	25	108	2	64	0	0	
2005	Jul 12	18	159	8	155	0	0	
2006	Jun 8	145	820	14	189	0	0	
2007	Jun 4	272	508	6	144	1	18	Jun 25[b], 26
2008	Jul 2	138	396	14	415	2	0	
2009	Jun 8	178	1,006	26	25	0	0	
South Santiam								
2004	Jun 3	28	10	10	0	0	0	
2005	Jul 14	13	22	2	0	0	0	
2006	May 30	160	250	122	6	2	1	Jun 15
2007	Jun 11	121	101	27	6	5	2	Jun 19, 22
2008	Jul 2	169	9	17	1	0	0	
2009	May 27	138	87	23	0	0	0	
Santiam								
2004	Jun 1	22	17	3	0	0	0	
2005	Jun 6	34	39	6	0	1	0	
2006	May 25	94	61	28	1	2	1	Jun 19
2007	May 23	66	86	16	0	10	0	
2008	Jul 2	41	33	8	0	2	0	
2009	Jun 2	61	110	27	0	4	0	
Middle Willamette								
2004	May 26	61	5	1	0	0	0	
2005	May 25	53	7	0	0	0	0	
2006	Jun 13	39	0	1	0	0	2	Jun 14, 26
2007	May 16	90	3	0	0	9	4	May 16, 17, 31
2008	Jun 2	203	4	0	2	1	1	Jun 4
2009	May 4	217	14	5	11	2	0	
Upper Willamette								
2004	May 19	95	47	30	23	6	2	May 19
2005	May 26	156	55	284	23	14	1	Jun 13
2006	May 24	199	262	552	2	0	7	Jun 1, 15, 16, 21, 29
2007	May 14	197	191	471	22	1	3	Jun 14, Jul 18
2008	May 27	370	65	253	93	4	3	May 27, Jun 10, 17
2009	May 7	222	54	130	3	0	2	May 7, 18
McKenzie								
2004	May 20	88	69	165	24	4	0	
2005	Jun 9	110	130	287	7	0	0	
2006	Jun 6	195	441	346	5	0	0	
2007	Jun 19	153	321	269	62	0	10	Jun 27, Jul 9, 11, 16
2008	Jul 9	236	151	222	198	0	0	
2009	Jun 4	137	104	90	26	0	0	

[a] Date(s) when hatchery steelhead were caught.

[b] 17 of 18 hatchery steelhead were caught in one seine set on June 25.



APPENDIX FIGURE 4-1.—Average catch per seine set of trout in Willamette Basin beach seining, 2004–2009. Numbers in boxes are the average number of seine sets in each sampling area.

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