Interim Activities for Monitoring Impacts Associated with Hatchery Programs in the Willamette Basin, USACE funding: 2008

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Task Order: NWPOD-08-FH-05

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Introduction

The National Marine Fisheries Service (NMFS) has listed spring Chinook salmon (*Oncorhynchus tshawytscha*) in the Upper Willamette River Evolutionarily Significant Unit (ESU) as threatened under the Endangered Species Act (ESA; 64 FRN 14308; 64 FRN 14517). Associated with this listing, any actions taken or funded by a federal agency must be evaluated to assess whether these actions are likely to jeopardize the continued existence of threatened and endangered species, or result in the destruction or impairment of critical habitat. Several hatcheries operate within the ESU and may impact wild populations of listed species. Although all of the artificial propagation programs that potentially affect listed salmonids in the Upper Willamette River ESUs are operated by the Oregon Department of Fish and Wildlife (ODFW), 50–100% of the funding for these operations comes from the U.S. Army Corps of Engineers (the Corps).

Possible risks of artificial propagation programs have been well documented. Hazards 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 play a positive role for wild salmonids by bolstering populations, especially those on the verge of extirpation, by providing a genetic reserve as well as providing opportunities for nutrient enrichment of streams (Steward and Bjornn 1990; Cuenco et al. 1993). The objective of this project is to evaluate the potential effects of hatchery programs on naturally spawning populations of spring Chinook within the Upper Willamette River ESU.

ODFW submits this report in fulfillment of Task Order NWPOD-08-FH-05 (per Task 3). This report covers activities of July 2008–May 2009 that were implemented by ODFW on behalf of the Corps to assist with meeting the requirements of the reasonable and prudent alternatives and measures prescribed in the Willamette Project Biological Opinion (BiOp) of July 2008 (NOAA 2008). Although a strategy to implement actions identified on the BiOp has not yet been completed, the Corps provided interim funding to continue certain monitoring activities and initiate long-term planning as detailed below:

<u>Task 1 (a–f)</u>. Monitor straying of hatchery fish on natural spawning grounds in the North Santiam, South Santiam, McKenzie, and Middle Fork Willamette rivers to determine the distribution, abundance and proportion of hatchery and natural-origin fish spawning by: (1) conducting spawning ground surveys downstream of projects and upstream of Detroit and Foster reservoirs; (2) conducting re-surveys to assess variability in redd counts among crews; (3) estimating pre-spawning mortality; (4) estimating the percentage of hatchery-origin spawners using otolith analysis; (5) monitoring fin-clipped and unclipped fish passing Leaburg and upper Bennett dams.

<u>Task 2 (a–c)</u>. Monitor fin-clipped and unclipped fish entering hatcheries and collection facilities (i.e., record number, origin, length, date of return); determine origin using otolith analysis; collect tissue samples for genetic analysis.

<u>Task 4</u>. Work with Corps and/or contractors to develop coordinated monitoring plan for Corps-funded hatchery programs based on requirements in the 2008 BiOp.

Approach

Spawning Ground Surveys (Task 1)

Foot and boat surveys were conducted to make visual counts of spawners, redds, and to collect biological information including origin of spawners using fin clips and analysis of otoliths; and to evaluate pre-spawning mortality. Re-surveys were conducted in selected sections to assess variability in redd counts among survey crews.

Spring Chinook Passage (Task 1)

The fish ladders at Leaburg Dam have viewing stations with video cameras in place. The species and mark status of all fish that passed the ladders were recorded. Video monitoring equipment was installed in the fish ladder at Upper Bennett Dam and was operated on a provisional basis in 2008.

Hatchery Broodstocks (Task 2)

Hatcheries conventionally include some naturally-produced spring Chinook in their broodstock. Proposed broodstock collection guidelines for incorporation of wild fish are 10–20% of the wild run for McKenzie Hatchery, 20–50% for North and South Santiam hatcheries, and 100% for Willamette Hatchery (NOAA 2008). Final recommendations will be adopted when Hatchery and Genetic Management Plans are approved. Guidelines are on a sliding scale dependent on the size of the run as indexed at Willamette Falls or other counting facilities. Data were collected from all spring Chinook spawned at hatcheries in the upper Willamette to determine their origin. Biometric data were collected from Chinook that were spawned at hatcheries.

Research, Monitoring, and Evaluation Planning (Task 4)

ODFW personnel were involved in numerous planning efforts in the 2008–2009 reporting period including membership on technical committees, review of proposed RME activities, development of RME proposals, and initiation of an ODFW RME proposal to evaluate BiOp actions.

Task 1. Distribution, Abundance, and Proportion of Hatchery and Natural-Origin Chinook

Spawning Ground Surveys Downstream of Corps Dams (Task 1.a.a)

We surveyed most of the major tributaries in the Willamette Basin upstream of Willamette Falls in 2008 by boat and on foot to count spring Chinook salmon carcasses and redds. We counted redds during 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, otoliths were collected 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, and in the McKenzie River to determine if unclipped carcasses had a tag (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 surveyed four basins upstream of Willamette Falls from July through October in 2008. Spring Chinook redds counted in the upper Willamette River basin were lower in 2008 than the 2002–2007 average, except in the Middle Fork Willamette River (Table 1).

Table 1. Spring Chinook salmon redds counted in four watersheds of the upper Willamette River basin, 2002–2008.

Watershed	2008	2007	2006	2005	2004	2003	2002
Middle Fork Willamette	134	9	111[a]	9	9	14	64
McKenzie	869	1,487	793	1,147	1,129	1,187	922
South Santiam[b]	209	483	510	530	373	619	914
North Santiam	226	494	254	325	360	673	306

[a] *234 redds were counted in a survey by COE biologists including 73 in two small side channels.*
[b] *Includes Thomas and Crabtree creeks 2002-2005.*

The North Santiam River was regularly surveyed July 15–October 13 to recover carcasses and count redds. 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 2008 was highest in the section immediately downstream of Minto Dam (Table 2), but redd counts and densities were lower than previous years (Tables 1–2). Of the carcasses we recovered in the North Santiam in 2008, 26% had fin clips (Table 3); lower than the 2004–2007 average (71%).

Table 2. Summary of spawning surveys for spring Chinook salmon in the North Santiam River, 2008, and comparison to redd densities in 1998–2007. Spawning in areas downstream of Stayton may include some fall Chinook.

	Length	2008		Redds/mi										
Survey section	(mi)	Carcass	Redds	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998
Minto–Fishermen's Bend	10.0	21	107	10.7	32.3	14.8	20.6	17.7	55.5	16.2	17.9	23.0	15.6	11.8
Fishermen's Bend–Mehama	6.5	2	10	1.5	11.1	4.9	3.1	2.8	6.5	9.4	5.7	5.8	3.1	4.3
Mehama–Stayton Is.	7.0	0	4	0.6	2.1	3.1	2.0	12.6	4.7	6.1	10.0	**a**	--	0.6
Stayton Is.–Stayton	3.3	2	1	0.3	6.1	3.9	7.3	7.9	3.6	3.0	6.7	**a**	--	10.0
Stayton–Greens Bridge	13.7	1	0	0.0	--	0.4	0.3	0.2	0.1	0.4	0.1	--	0.0	0.4
Greens Br.–mouth	3.0	0	1	0.3	--	--	0.0	0.0	1.7	4.7	--	--	--	4.7
Little North Santiam[b]	17.0[c]	21	103	6.1	4.4	2.0	3.6	3.0	1.8	1.8	1.1	1.3	1.0	2.2

[a] *Data were recorded for Mehama–Stayton and density was 0.9 redds/mi.*
[b] *157 unclipped adult spring Chinook were released on Aug 29, Sep 1–2 ,5, 8, 25– 26; for release data in 2002-2007 see McLaughlin et al. 2008.*
[c] *14.4 miles were surveyed in 2007.*

Table 3. Composition of naturally spawning spring Chinook salmon from carcasses recovered in the North Santiam River, 2008.

Section	Unclipped	Fin-clipped
Minto–Fishermen's Bend	15	6
Fishermen's Bend–Mehama	0	2
Mehama–Stayton Island	0	0
Little North Fork Santiam	20	1
Total upstream of Stayton Island	***35***	***9***
Downstream of Stayton Island	0	3
Total	***35***	***12***

The McKenzie River was regularly surveyed August 20–October 22 to recover carcasses and count redds. Active redd building began in early September, with the first redd observed on September 3, similar to previous years. Peak spawning occurred in late September to early October. The total number of redds in 2008 (869) was 42% lower than in 2007 and was lower than all previous years except 2006 (Table 1). The percentage of redds counted in the main stem upstream of Forest Glen was similar in 2008 and 2007, but was lower than in 2002–2005 (Figure 1). The percentage of redds counted downstream of Forest Glen in 2008 was generally similar to previous years except 2005 and 2006. The percentage of redds counted downstream of Leaburg Dam was about 2.7 times higher than in previous years, with most of the redds occurring in side channels close to Leaburg Hatchery. Redd densities decreased in 2008 compared to 2007 in all survey sections except the section upstream of McKenzie Trail, the section downstream of Leaburg Dam, and in the upper reach of the South Fork McKenzie downstream of the dam (Table 4).

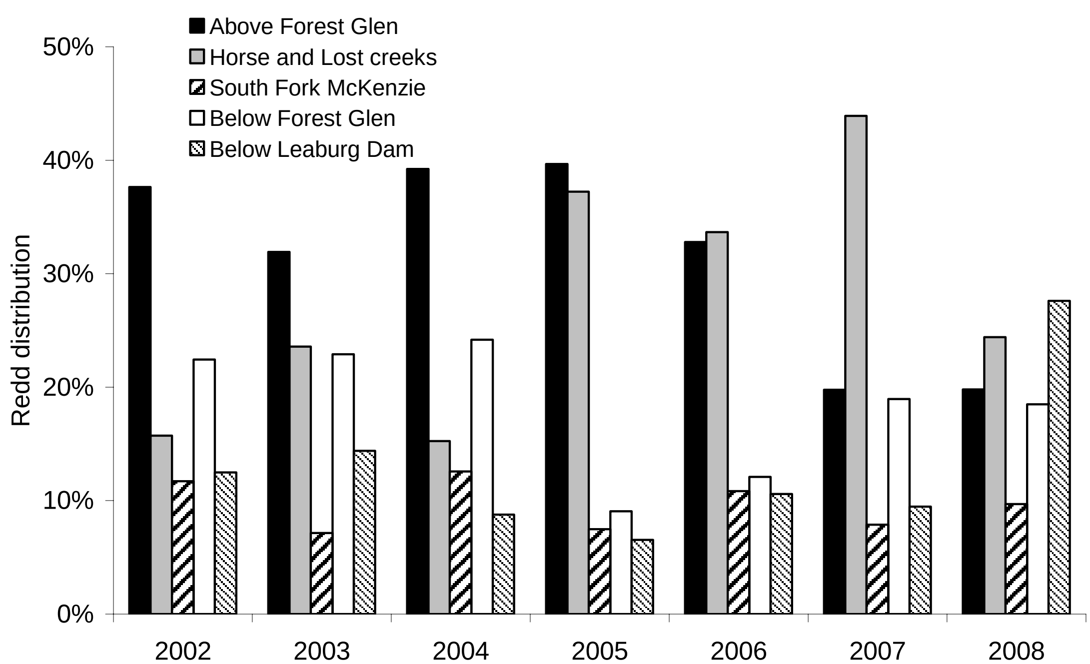

Figure 1. Distribution of spring Chinook salmon redds in the McKenzie River basin, 2002–2008.

Table 4. Summary of Chinook salmon spawning surveys in the McKenzie River, 2008, and comparison to redd densities (redds/mi, except redds/100 ft for spawning channel) in 1996–1998 and 2000–2007.

Survey section	Length (mi)	2008 Carcass	2008 Redds	Redds/mi[a] 2008	2007	2006	2005	2004	2003	2002	2001	2000	1998	1997	1996
McKenzie River:															
Spawning channel	0.1	4	17	3.2	6.8	13.8	12.8	18.6	7.2	15.4	--	--	--	1.0	2.6
Olallie–McKenzie Trail	10.3	22	123	11.9	10.4	14.1	31.1	22.1	24.7	16.3	17.7	5.6	--	11.4	7.0
McKenzie Trail–Hamlin	9.9	10	22	2.2	6.0	1.8	4.2	9.4	4.0	5.2	4.9	1.6	--	--	2.1
Hamlin–S. Fork McKenzie	0.3	2	2	6.7	93.3	6.6	--	--	10.0	36.7	--	--	--	--	--
South Fork–Forest Glen	2.4	7	8	3.3	26.7	10.8	12.1	12.1	19.2	16.7	0.8	2.1	--	--	0.8
Forest Glen–Rosboro Br.	5.7	32	92	16.1	30.5	6.7	3.7	36.1	26.8	14.9	13.2	5.8	--	--	6.1
Rosboro Br.–Ben and Kay	6.5	15	67	10.3	16.6	8.9	12.5	10.3	7.4	16.2	6.3	3.2	--	--	4.9
Ben and Kay–Leaburg Lake	5.9	2	2	0.6	--	--	0.3	--	12.0	2.9	3.2	--	--	--	1.8
South Fork McKenzie:															
Cougar Dam–Road 19 Br.	2.3	25	61	26.5	16.5	23.9	22.2	49.1	31.7	36.5	--	--	--	--	--
Road 19 bridge–mouth	2.1	9	23	11.0	37.6	14.8	16.7	13.8	5.7	11.4	8.1	7.6	--	--	2.9
Horse Creek:															
Pothole Cr.–Separation Cr.	2.8	4	40	14.3	22.5	9.3	5.4	5.4	18.6	--	--	--	--	--	--
Separation Cr.–mouth	10.7	31	139	13.0	33.3	16.1	19.2	10.3	13.6	12.1	7.4	--	--	--	5.3
Lost Creek:															
Spring–Limberlost	2.8	0	5	1.8	35.7	3.2	15.4	6.4	9.3	--	--	--	--	--	--
Limberlost–Hwy 126[b]	2.0	2	21	10.5	53.6	30.0	78.5	13.5	21.0	--	--	--	--	--	--
Hwy 126–mouth[b]	0.5	0	7	14.0	--	0.0	14.0	4.0	30.0	32.0	--	--	--	--	--
McKenzie River:															
Leaburg Dam–Leaburg Landing[c]	6.0	79	235	39.2	23.5	12.0	12.5	16.5	28.5	19.2	12.3	--	15.3	19.8	10.3

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

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

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

The percentage of fin-clipped carcasses upstream of Leaburg Dam (Table 5) was similar in 2008 (13%) to that in 2005–2007 (15%), but was lower than in 2003 (28%) and 2004 (34%). A higher percentage of carcasses downstream of Leaburg Dam were fin-clipped in 2008 (82%) and 2007 (76%) than in 2005 and 2006 (52%).

Table 5. Composition of naturally spawning spring Chinook salmon from carcasses recovered in the McKenzie River, 2008.

Section	Unclipped	Fin-clipped
McKenzie spawning channel	4	0
Olallie–Forest Glen	39	2
Forest Glen–Leaburg Lake	35	14
S Fork McKenzie	30	4
Horse Creek	34	1
Lost Creek	2	0
Total upstream of Leaburg Dam	***144***	***21***
Downstream of Leaburg Dam	15	67

Other rivers that were regularly surveyed in 2008 were South Santiam (July 23–October 20) and Middle Fork Willamette (July 14–October 14). 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 lower in 2008 than in previous years, except 1998, whereas redd density in the Middle Fork Willamette was the highest observed to date (Table 6).

Table 6. Summary of Chinook salmon spawning surveys in the South Santiam and Middle Fork Willamette rivers, 2008, and comparison to redd densities in 1998, and 2002–2007.

River, section	Length (mi)	Carcasses	Redds	Redds/mi 2008	2007	2006	2005	2004	2003	2002	1998
South Santiam											
Foster–Pleasant Valley	4.5	95	181	40.2	92.9	102.9	112.7	75.1	132.0	194.4	36.0
Pleasant Valley–Waterloo	10.5	10	28	2.7	6.2	4.4	2.2	3.3	1.5	1.8	1.8
Middle Fork Willamette											
Dexter–Jasper	9.0	31	134	14.9	1.0	12.3	1.0	1.0	1.5	7.1	1.1

Spawning Ground Surveys Upstream of Corps Dams and Outplanting (Task 1.a.b)

North Santiam

Surplus fin-clipped spring Chinook salmon collected at Minto Pond were outplanted into the North Santiam and Breitenbush rivers upstream of Detroit Dam (Table 7). A total of 91 adult fish were released into the Breitenbush River at Cleator Bend (rm 12), and 125 into the North Santiam River at Coopers Ridge Road (rm 62). Because of the low run, males were outplanted early and most females were held at Minto Pond to insure broodstock needs were met. The females were treated to prevent disease; therefore, they could not be outplanted later into recreational fishery waters upstream of Detroit Dam. As a result, only 7 females were released into the Breitenbush and 13 into the North Santiam, and we did not conduct spawning surveys.

South Santiam

In the South Santiam River, 523 fin-clipped and 163 unclipped spring Chinook salmon from the South Santiam Hatchery were outplanted above Foster Dam at Gordon Road (rm 54) on six dates (August 6–October 2). The outplanted fish included 436 males, 248 females, and 5 jacks (hatchery records indicated 2 jacks were outplanted, but tissue samples were taken from 5 jacks). The river was surveyed from Moose Creek (rm 52) to Soda Fork (rm 62) on two dates (September 13 and September 20). Of the 133 redds counted (Table 7), 100 were located upstream of the release site within 2.3 miles.

McKenzie

In an effort to re-establish populations, 874 fin-clipped spring Chinook salmon collected at McKenzie Hatchery were outplanted into the South Fork McKenzie River above Cougar Dam on eleven dates (July 16–September 8). Fish were released at FS Road 1980 near French Pete Campground (July only) and FS Road 430 near Homestead Campground. The outplanted fish consisted of 573 adult males, 288 females, and 13 jacks. Spawning surveys were conducted on October 16–17 from the head of the reservoir to above Frissel Campground (16.2 mi), and 128 redds were counted (Table 7).

Middle Fork Willamette

In an effort to re-establish populations above Lookout Point Dam, 460 fin-clipped and 53 unclipped spring Chinook salmon were outplanted into the North Fork Middle Fork Willamette on four dates (July 31–September 11). The outplanted fish included 271 males, 180 females, and 62 jacks. Spawning surveys were conducted by Corps biologists on October 3, 18, and 25 on 12 miles of the river from below the release site (rm 16.2) to Road 1944 bridge, and 113 redds were counted (Table 7).

Fall Creek

A total of 298 spring Chinook salmon trapped at Fall Creek Dam were outplanted above Fall Creek reservoir in 2008. Most of these fish (90%) were unclipped. A total of 16.3 miles of stream above Fall Creek were surveyed and 90 redds were observed (Table 7).

Little North Santiam

Unclipped adult spring Chinook collected at Minto Pond have been outplanted into the Little North Fork Santiam to increase natural production. In 2008, 157 unclipped fish (105 males and 52 females) were outplanted on seven dates (Aug 29–Sep 26). All fish were marked with a red Floy® tag, and were released into a deep pool at the Narrows (rm 8) where survival has been good in previous years. The number of fish outplanted in 2008 was similar to 2006–2007 (130) but less than in 2004–2005 (350) because more unclipped fish have been retained for hatchery broodstock. The stream was surveyed on five days and a total of eight sections (17 mi) upstream and downstream of the release site were surveyed at least once. The number of redds in 2008 was more than in previous years (Table 7; *see also* Table 2), and 64% were upstream of the release site. Of the 20 salmon carcasses recovered in the Little North Fork, 8 were tagged or outplanted from Minto, suggesting most of the redds were from Chinook salmon that had not been outplanted.

Table 7. Summary of spring Chinook outplanted in 2008. Includes only those basins where spawning surveys were conducted to assess the success of the outplant program.

Section	Fish outplanted	Redds	Adults/redd	Females/redd	Redds/mi
South Santiam above Foster	686	133	5.2	1.9	13.3
South Fork McKenzie	874	128	6.8	2.3	7.9
North Fork Middle Fork Willamette	513	113	4.5	1.6	9.1
Fall Creek	298	90	3.3	1.2	18.3
Little North Fork Santiam	157	103	a	a	6.2

[a] *Not calculated because of unknown amount of natural escapement.*

Variability in Redd Counts—Resurveys (Task 1.b)

Variability in redd counts exists between 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 experience of surveyors. 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 are when redds are not counted because they are not recognized, and false identifications are when natural disturbances in stream substrate such as water scour are incorrectly counted as a redd. Both types of errors are common but because observers often commit both, they tend to cancel each other out.

We re-surveyed 36 sections in 2008 usually within one day of the first survey to assess differences in redd counts between surveyors. Surveys were classified by size of stream and survey technique. We used rafts with elevated viewing towers on large river sections, and on some sections the raft stayed on one side of the river the entire length of the section to count redds, whereas on other sections the raft would cross the river to count redds on both sides. Similar techniques were used on medium-sized rivers except we used small rafts that had a viewing platform but did not have an elevated tower. Surveys conducted by walking were 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. Streams were re-surveyed in a similar manner in 2005, except that kayaks were used on some medium-sized rivers in addition to small rafts (Schroeder et al. 2005).

The average difference between successive redd counts was 20–57% in 2008, higher than in 2005, but the coefficient of variation in 2008 was lower, with the exception of walking surveys in medium streams (Table 8). The pattern of variability in redd counts between survey types was similar in 2008 and 2005 (Figure 2), with the greatest variability occurring where a boat was used to count redds on both sides of a river. Discussions with surveyors afterward confirmed that the boat sometimes was on the wrong side of the river from where most redds were located. However, the results for surveys where redds were counted along only a single side of a river indicate substantial variation in ability to recognize redds among individual surveyors.

We investigated methods to account for observer errors or variability among surveyors. One method is based on a double surveyor method that uses sightings by each surveyor to calculate population and variance estimates (Magnusson et al. 1978). However, the methodology has limitations because it is based primarily on surveyors missing a sighting (not counting a redd) but does not completely account for false sightings (counting substrate disturbance as a redd or overcounting redds where multiple spawning has occurred on a single gravel patch).

A second method uses adjustment factors for individual surveyors that compensate for individual variation in ability to recognize redds. We used data from 20 re-surveys to derive adjustment factors for 11 surveyors relative to one or more other surveyors to standardize redd counts. We applied the adjustment factors to redd counts in the North Santiam and McKenzie rivers and found that differences between the adjusted and raw counts were relatively small (Table 9). Because redd counts were made by a mix of many different observers, those who tended to overcount redds were apparently compensated by those who undercounted.

We plan to continue examining methods for quantifying variability in redd counts and for addressing the variability by using a combination of additional training, scheduling surveys to allow for direct comparisons among individuals, and mapping redds to better identify key spawning patches.

Table 8. Average difference (%) and coefficient of variation (cv) between successive counts of spring Chinook salmon redds for four classes of surveys (size of stream and survey method) in the Willamette and Sandy basins, 2008 and 2005.

	2008			2005		
Survey type	n	Difference (%)	cv (%)	n	Difference (%)	cv (%)
Boat – same side	15	33.4	60.4	3	21.3	74.8
Boat – both sides	9	57.0	43.0	4	49.8	80.5
Walking – medium stream	3	43.5	56.3	3	33.3	27.9
Walking – small stream	9	19.7	65.5	5	19.0	81.1

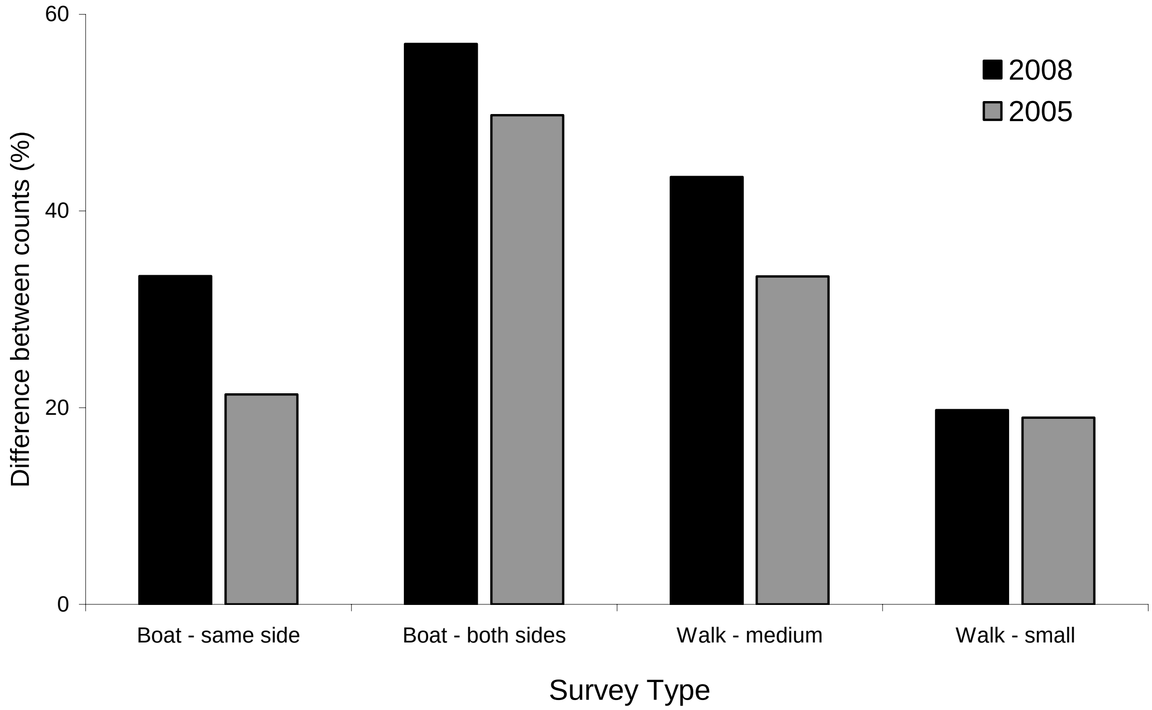

Figure 2. Average difference (%) between successive counts of spring Chinook salmon redds by different surveyors for four types of surveys (size of stream and survey method) in the Willamette and Sandy basins, 2008 and 2005.

Table 9. Estimates of redds in the North Santiam and McKenzie rivers in 2008 from the sum of peak counts in survey sections using two methods: (1) raw counts, and (2) section counts individually adjusted by surveyor factors (differences between surveyors) to a standardized count.

	Redds	
River	Raw	Standardized
North Santiam	226	191
McKenzie	864	849[a]

[a] *No adjustment was made for surveys in the South Fork McKenzie.*

Pre-spawning Mortality (Task 1.c)

Pre-spawning mortality of spring Chinook salmon in the Willamette basin was lower in 2008 than in 2007, with the exception of South Santiam (Table 10). Mortality in 2008 was generally similar to low levels observed in 2006, and lower than mortality in 2001–2005. Because survey intensity varies among rivers and between years, and because recovery of carcasses is generally more difficult later in the season when all carcasses would be successful spawners, pre-spawning estimates should be viewed in relative terms (e.g., high, medium, low) rather than as absolute estimates.

We examined potential effects of water temperature and flow on pre-spawning mortality. Data suggest that mortality increases with an increase in maximum water temperature in July or August (7-day average maximum). Although data are limited, the relationship between pre-spawning mortality and maximum water temperature in the North Santiam River before (2001–2005) and after the fish ladder was rebuilt appeared to decline about 50–60% in the latter years. In other words, although the trend in mortality increased over a range of 7-day maximum temperatures in both periods, the mortality at either end of the range was lower after the fish ladder was improved. Relationships between water temperature or flow and pre-spawning mortality are likely to be complex, and identifying a specific temperature or flow metric and the duration or timing for those metrics is difficult. In addition, the effect of a specific metric on mortality may be influenced by factors such as size and timing of the adult return.

Table 10. Estimates of the percent pre-spawning mortality of Chinook salmon in the Willamette Basin, based on recovery of female carcasses, 2001–2008. **Only for areas and years with $\geq$ 10 recoveries.** Date of first survey is included in parenthesis. Data in boldface indicate surveys began late or ended prior to the end of the peak spawning time.

River	2008	2007	2006	2001–2005[a]
Fall Creek above dam	**0 (Sep 5)**		**0 (Sep 18)**	56
Middle Fork Willamette	17 (Jul 14)	95 (Jul 10)	**6 (Oct 2)**	94
McKenzie above Leaburg	1 (Aug 26)	5 (Aug 15)	**1 (Sep 12)**	12
McKenzie below Leaburg	9 (Aug 20)	37 (Jul 31)	5 (Sep 5)	35
N Santiam above Bennett	30 (Jul 15)	41 (Jul 3)	16 (Jul 27)	62
S Santiam above Lebanon	8 (Jul 23)	8 Jul 16)	12 (Jul 26)	39

[a] *Detailed data for 2001–2005 can be found in Schroeder et al. 2007.*

Mortality of fin-clipped fish in 2008 was higher than that of unclipped fish in the South Santiam and in the McKenzie downstream of Leaburg Dam, although sample sizes were small, and there was no difference in mortality between the groups in the upper McKenzie and North Santiam rivers (Table 11). The difference in mortality between clipped and unclipped fish over several years was significant (paired t-test; $P < 0.05$) only in the North Santiam River with unclipped fish having higher mortality (Figure 3a). In contrast, the estimated pre-spawning mortality was significantly higher (unpaired t-test; $P < 0.05$) downstream of dams than upstream in the McKenzie and North Santiam rivers (Figure 3b), similar to that observed in the Clackamas and Sandy rivers (Schroeder et al. 2007).

Table 11. Pre-spawning mortality (percentage in parentheses) of fin-clipped and unclipped spring Chinook salmon carcasses based on recovery of female carcasses, 2008.

	Not spawned		Spawned	
River	clipped	not clipped	clipped	not clipped
McKenzie above Leaburg	0 (0%)	1 (1%)	16	75
McKenzie below Leaburg	5 (10%)	0 (0%)	43	7
North Santiam above Bennett	2 (29%)	4 (31%)	5	9
South Santiam above Lebanon	4 (14%)	0 (0%)	24	23

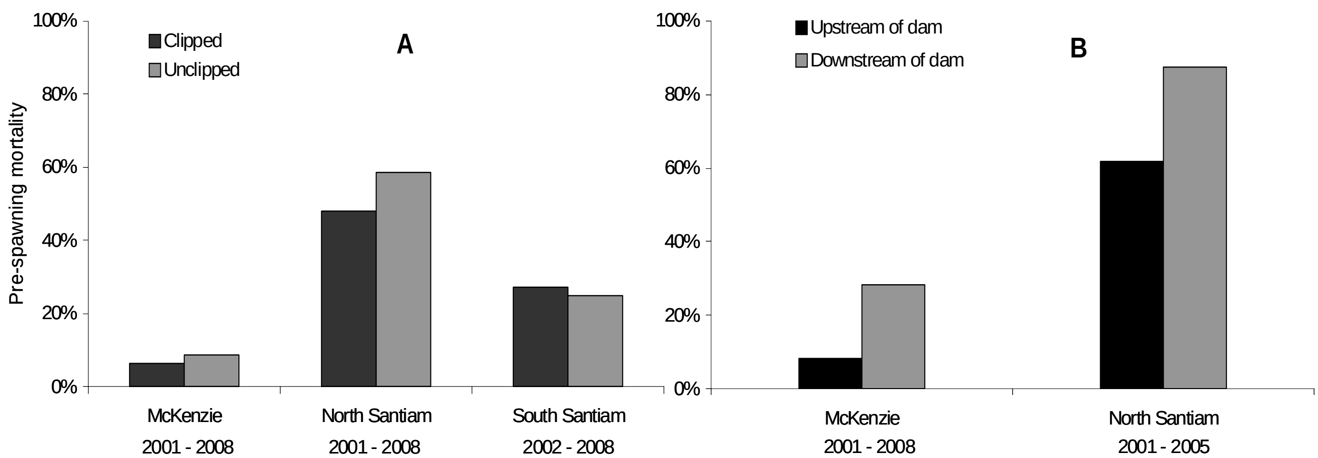

Figure 3. Average pre-spawning mortality based on recoveries of female carcasses for **(A)** clipped and unclipped adult Chinook salmon in the McKenzie, North and South Santiam rivers, and **(B)** upstream and downstream of dams in the McKenzie and North Santiam rivers.

Proportion of Hatchery Spawners (Task 1.d)

Restoration of spring Chinook salmon under the Endangered Species Act and the implementation of ODFW's Native Fish Conservation Policy require information on hatchery and wild fish in spawning populations. In response to this need and to implement a selective fishery, all hatchery spring Chinook salmon in the Willamette basin, beginning with the 1997 brood, were marked with adipose fin clips. Although the intention is to externally mark all juvenile hatchery fish, some are missed during marking. To help separate returning hatchery fish without fin clips from wild fish, otoliths have been thermally marked on all hatchery spring Chinook released into the Willamette basin beginning with the 1997 brood year.

Methods

We collected otoliths from adult spring Chinook without fin clips on spawning grounds in most of the major tributaries in the Willamette Basin in 2008. Otoliths were removed from carcasses without fin clips and placed into individually numbered vials.

We estimated the proportion of naturally produced ("wild") fish on spawning grounds in the Willamette basin from otoliths collected in 2008 (Table 12). Wild fish were determined by absence of a fin clip and absence of an induced thermal mark in the otoliths. We previously documented a significant difference between the distribution of redds and the distribution of carcasses recovered among survey areas within some watersheds (Firman et al. 2005), and used the distribution of redds among survey areas to weight the number of unclipped carcasses in each area. We then used results of otolith analysis to estimate the number of wild fish that would have spawned within a survey area. However, in 2008 we applied the weighting only to the McKenzie River because redd and carcass distribution was not significantly different in the other rivers.

Table 12. Otoliths collected in 2008 from unclipped adult spring Chinook in the Willamette River Basin that were analyzed for presence of thermal marks.

Location	Number
McKenzie River	155
North Santiam River	34
South Santiam River below Foster	54
South Santiam River above Foster	15
Middle Fork Willamette River	17
Fall Creek	42

Results

The percentage of wild spring Chinook in 2008 was highest in the McKenzie River and was similar to previous years, but the percentage of wild fish in the other basins was higher than in other years (Table 13). The percentage of carcasses that were wild increased in all basins in 2008, with large increases occurring in the North and South Santiam and Middle Fork Willamette rivers.

Table 13. 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 Middle Fork Willamette in all years and all basins in 2008 except McKenzie).

River (section), run year	Fin-clipped	Unclipped[a] Hatchery	Unclipped[a] Wild	Percent 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)
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)
South Santiam (Foster–Waterloo)				
2002	1,386[d]	38[d] (14)	225[d]	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)
Middle Fork Willamette (Dexter–Jasper[e])				
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)

[a] *The proportion of hatchery and wild fish was determined by presence or absence of thermal marks in otoliths. Number in parentheses is percentage of unclipped fish that had a thermal mark (unclipped hatchery fish).*
[b] *Percentage not weighted for redd distribution is in parentheses.*
[c] *Including Little North Fork Santiam.*
[d] *Corrected number.*
[e] *Including Fall Creek except 2007. Data on clipped fish in spawning population were incomplete for 2006.*

The estimated number of wild fish in the McKenzie River upstream of Leaburg Dam in 2008 was almost half (51%) that in 2007 (Table 14). However, because the number of hatchery fish upstream of the dam decreased more than that of the wild fish, the percentage of wild fish upstream of the dam was similar in 2008 to previous years (Table 14). Estimates for the North Santiam were not available because fish traps at Bennett Dam have not been operated in 2006 or 2007, and video recording of spring Chinook passage at upper Bennett Dam in 2008 was incomplete.

Table 14. Estimated number of wild and hatchery adult spring Chinook salmon in the McKenzie River upstream of Leaburg Dam. 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]
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)

[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 distribution of redds among survey areas.*

Few coded-wire tags were recovered from spring Chinook salmon on the spawning grounds in 2007 and 2008 (Table 15), 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. As in previous years, some fish strayed between the North and South Santiam either from local releases or from off-station releases (South Santiam stock released into Molalla River). Strays of Middle Fork Willamette stock released in the lower Columbia comprised 33% of the tagged fish recovered in the South Santiam in 2008.

Table 15. Number of spring Chinook salmon that were composed of hatchery fish released within the basin (local) or released in other basins, 2007–2008, determined from coded-wire tags in carcasses on spawning grounds. The sample size was expanded (in parentheses) for the percentage of each release group that was tagged.

		Origin of release				
River, run year	n	Local	Lower Columbia netpens	Molalla	North Santiam	Fall Cr (M. Fk. Willamette)
McKenzie						
2007	4 (26)	3 (23)				1 (3)
2008	10 (63)	10 (63)				
North Santiam						
2007	3 (50)	2 (48)		1 (2)		
2008	1 (2)	1 (2)				
South Santiam						
2007	17 (122)	16 (98)			1 (24)	
2008	4 (9)	1 (6)	3 (3)			
M. Fk. Willamette						
2007	2 (23)	2 (23)				
2008	2 (11)	2 (11)				

Spring Chinook Passage at Leaburg Dam, McKenzie River (Task 1.e)

Passage of spring Chinook salmon through the fishways at Leaburg Dam was monitored with video recording equipment. Fin-clipped (hatchery) fish composed 17% of the Chinook passing Leaburg Dam (Table 16), similar to 2007 and 2005, but lower than the average in 2002–2004 and 2006 (37%). Counts of fin-clipped and unclipped adults decreased in 2008 compared to recent years. Counts of fin-clipped adults was 85% lower in 2008 than in 2002–2007 (Table 15), slightly higher than the decrease in the count of fin-clipped adults at Willamette Falls in the same period (79%). The count of unclipped adults decreased in 2008 from the 2002–2007 average at Leaburg Dam (61%) and at Willamette Falls (64%). Numbers of unclipped adults peaked in July, whereas the peak count of fin-clipped adults was in September, with a smaller peak in July (Figure 4).

Table 16. Spring Chinook counted at Leaburg Dam, McKenzie River, 2008.

Month	Unclipped adults	Fin-clipped adults	Unclipped jacks	Fin-clipped jacks	Total
May	1	0	0	0	1
June	600	32	0	0	632
Jul	683	81	1	2	767
Aug	82	8	0	6	96
Sep	86	149	0	3	238
Oct	6	20	0	1	27
2008	**1,458**	**290**	**1**	**12**	**1,761**
Average[a]	**3,692**	**1,959**	**5**	**4**	

[a] *2002–2007 for adults and 2004–2007 for jacks because number of jacks or clip of jacks were not recorded in 2002–2003.*

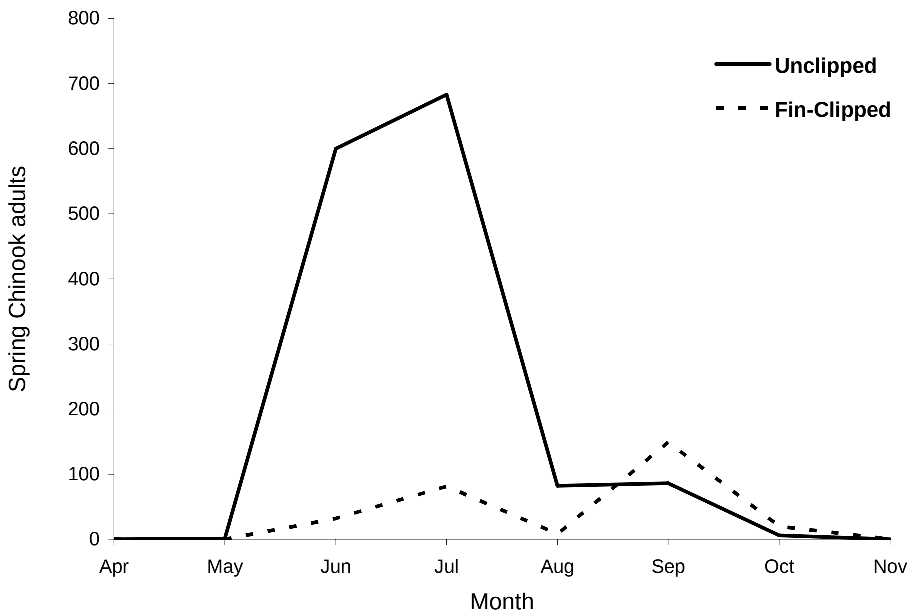

Figure 4. Spring Chinook count at Leaburg Dam, 2008.

Spring Chinook migrated later in 2008 than in previous years (Figure 5a), and it was not until June that significant numbers began to migrate over Leaburg Dam. Although the first peak of fin-clipped Chinook passing Leaburg Dam was later in 2008 than in previous years, a second peak occurred in September as in previous years. However, the proportion of fin-clipped Chinook passing Leaburg Dam in September was higher in 2008 than in previous years (Figure 5a). Passage of unclipped and fin-clipped adult Chinook at Willamette Falls was also later in 2008 than in previous years (Figure 5b). Late passage of spring Chinook salmon in 2008 may have been because of the large snowpack in the Cascade Mountains, resulting in high flows and low water temperatures that extended longer into the spring and early summer than in recent years (Figure 6).

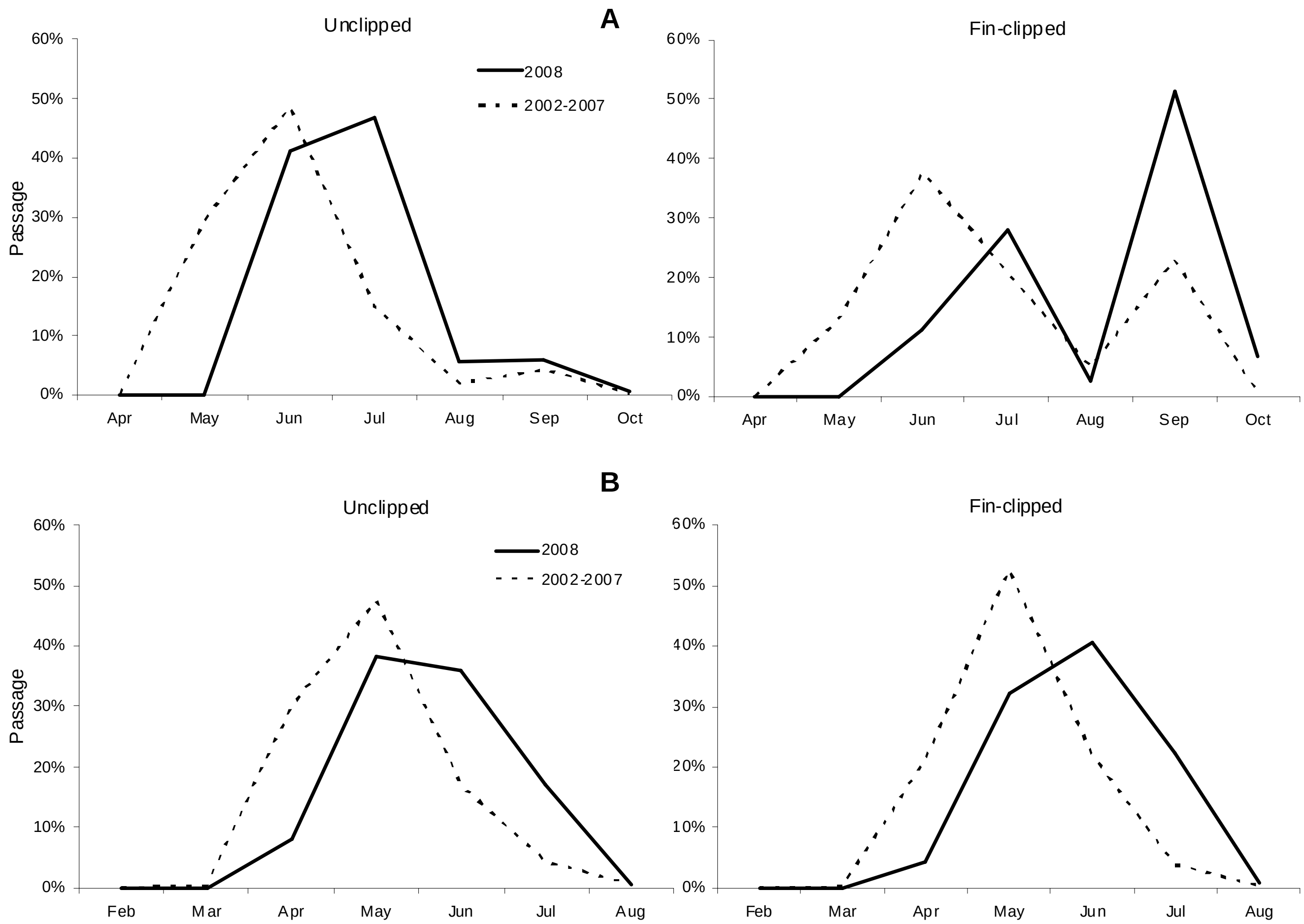

Figure 5. Passage by month of spring Chinook salmon at Leaburg Dam (A) and at Willamette Falls (B) for unclipped and fin-clipped adults, 2008 and 2002–2007. Note different time periods on X-axes for Leaburg Dam and Willamette Falls.

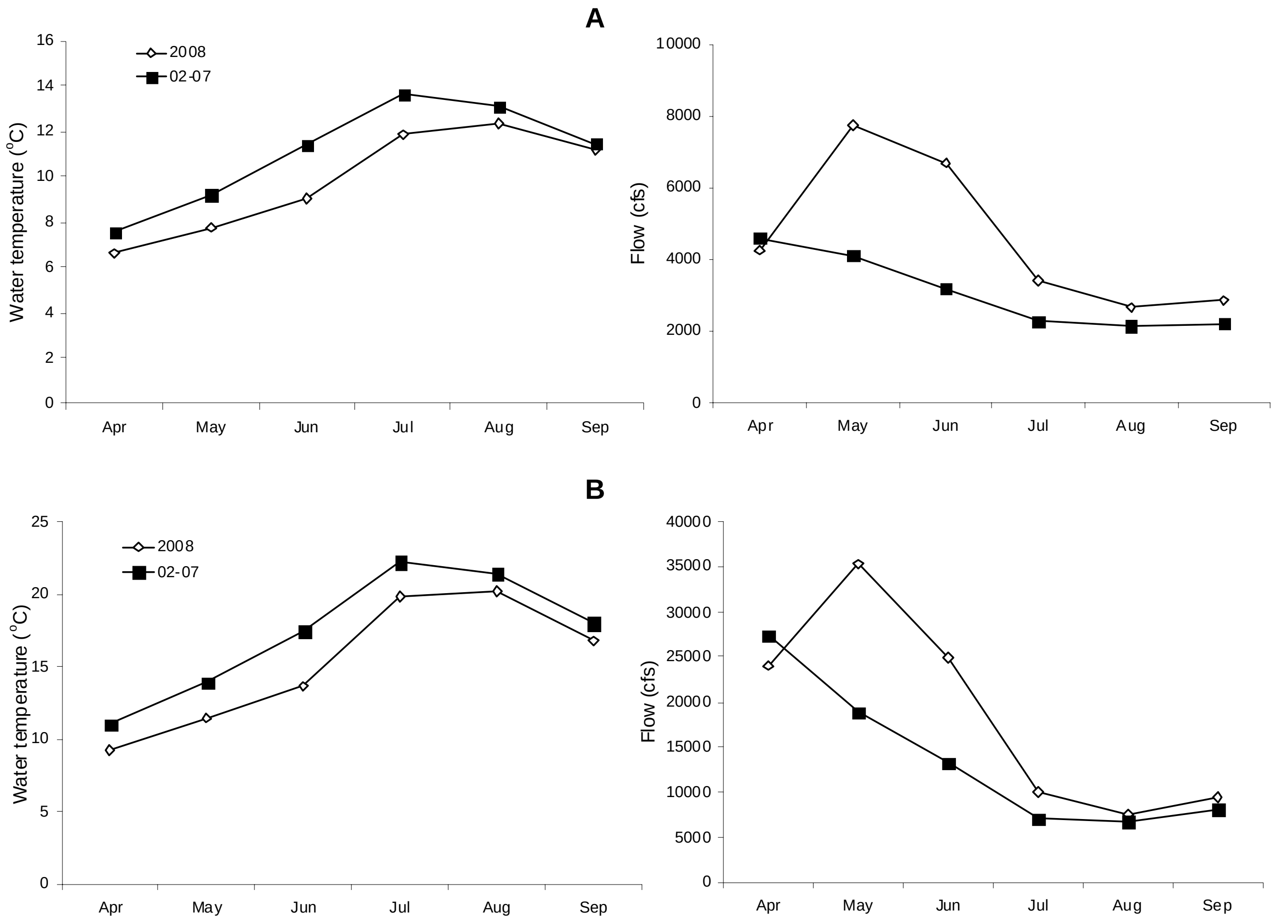

Figure 6. Water temperature (°C) and flow (cfs) of the McKenzie River at Vida (**A**) and the Willamette River at Newberg (**B**), 2008 and 2002–2007 average.

Spring Chinook Passage at Upper Bennett Dam, North Santiam River (Task 1.f)

Video recording equipment was purchased and installed in the upper Bennett Dam fishway in 2008. A chamber was built and installed into the fishway to house the video equipment and to guide fish into a narrowed passage in front of the viewing window (Figure 7). The video recorder was operational beginning May 8, but images were lost because the hard drive failed. The system was functional approximately 80–90% of the June 6–July 31 period. Some of the problems in 2008 included an inadequate power supply (reliance on batteries that had to be regularly changed), inadequate hard drive space to store video images (a second hard drive was purchased and installed), difficulties with lighting and image quality especially at night (ability to distinguish fin-clipped and unclipped fish), and difficulties integrating the video recording equipment with software designed to automatically scan and detect fish images. Therefore, although video recording of fish passage at upper Bennett Dam was initiated in 2008, the count will be incomplete. Plans for 2009 include improving image quality through changes in the camera settings or lighting, improvements in power supply to the site, and integration of the fish counting software into the recording system. Future plans should also include installation of video recording equipment at lower Bennett Dam.

Figure 7. Installation of housing vault at Upper Bennett Dam fishway for video recording system to monitor fish passage.

Task 2. Monitor Return of Chinook to Hatcheries

Number and Biometrics of Hatchery Returns (Task 2.a)

Traps were operated at each of the Willamette hatcheries from May into October in 2008. Dates of operation and numbers of spring Chinook collected are in Appendix Tables 1–4. Although the trap data provide a general time of return (Figure 8), the traps are not operated continuously and therefore do not completely represent return timing.

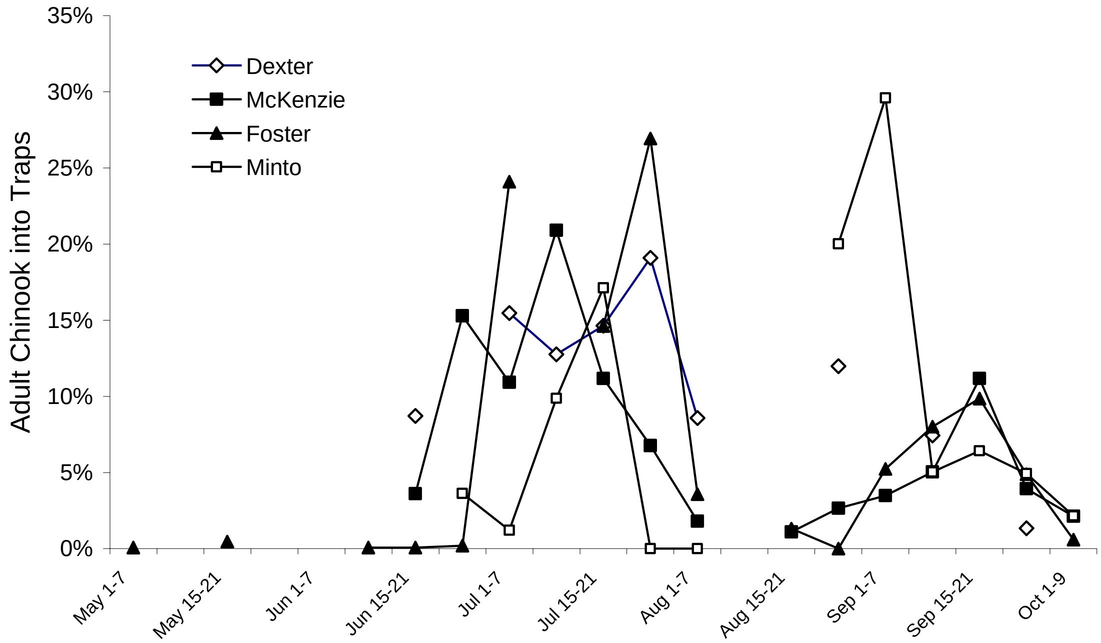

Figure 8. Weekly collection of adult spring Chinook (as percentage of total collected) at traps on the Middle Fork Willamette (Dexter), McKenzie, South Santiam (Foster), and North Santiam (Minto) rivers, 2008. Traps were not continuously operated.

Information about the disposition of adult spring Chinook was compiled from the upper Willamette Basin hatcheries for 2008 (Table 17). The total number of Chinook may include fish handled more than once because of factors such as recycling. Willamette Hatchery data include fish collected at the Dexter facility and taken to the hatchery for spawning and fish directly outplanted. Some Chinook have been collected at Leaburg Dam and either held at McKenzie Hatchery for broodstock (unclipped fish), or outplanted (fin-clipped fish), and these are noted in the tables. Surplus hatchery fish (fin-clipped) were outplanted into historic habitats, and unclipped fish were outplanted into accessible habitats, primarily from Minto Pond into the Little North Fork Santiam (Table 18).

Table 17. Disposition of fin-clipped and unclipped spring Chinook entering hatcheries and collection facilities, 2008. Unspawned includes mortalities, green fish, excess fish (including those killed to recover coded-wire tags), and females culled for BKD.

Hatchery	Disposition	Fin-clipped adults	Unclipped adults	Total adults	Fin-clipped jacks	Unclipped jacks	Total Chinook	Percent unclipped
Marion Forks	Spawned	336	160	496	6	0	502	31.9
	Outplanted	301	164	465	22	0	487	33.7
	Recycled	0	0	0	0	0	0	0.0
	Unspawned	73	34	107	30	0	137	24.8
	Total	***710***	***358***	***1,068***	***58***	***0***	***1,126***	***31.8***
S. Santiam	Spawned	510	284	794	6	0	800	35.5
	Outplanted	521	163	684	5[a]	0	689	23.7
	Unspawned	40	16	56	32[a]	5	93	22.6
	Food Share	1	0	1	0	0	1	0.0
	Total	***1,072***	***463***	***1,535***	***43***	***5***	***1,583***	***29.2***
Willamette	Spawned	1,404	91	1,495	0	5	1,500	6.4
	Outplanted	404	47	451	56	6	513	10.3
	Unspawned	45	180	225	2	0	227	79.3
	Food Share	0	0	0	0	0	0	0.0
	Total	***1,853***	***318***	***2,171***	***58***	***11***	***2,240***	***14.7***
McKenzie	Spawned[b]	1,099	155	1,254	12	0	1,266	12.2
	Outplanted	1,193	4	1,197	19	0	1,216	0.3
	Unspawned[b]	334	12	346	16	0	362	3.3
	Tribes	192	0	192	2	0	194	0.0
	Total	***2,818***	***171***	***2,989***	***49***	***0***	***3,038***	***5.6***

[a] *Hatchery records showed 2 fin-clipped jacks outplanted, but tissue samples taken on all outplanted fish noted 5fin-clipped jacks. Difference of 3 fin-clipped jacks was subtracted from unspawned jack numbers, which were noted as being "released".*

[b] *Includes 69 clipped adults, 1 clipped jack, and 91 unclipped adults trapped at Leaburg Dam and transported to the hatchery. Also includes 57 clipped adults, 1 clipped jack, and 1 unclipped adult trapped at Leaburg Hatchery and transported to McKenzie Hatchery.*

Table 18. Outplants of spring Chinook captured in hatcheries and collection facilities, 2008.

Hatchery	Release location	Fin-clipped adult	Unclipped adult	Fin-clipped jack	Unclipped jack	Total Chinook	Percent unclipped
Marion Forks	N. Santiam above Detroit	125	0	0	0	125	0.0
	Breitenbush River	91	0	0	0	91	0.0
	Little N. Fork Santiam	0	157	0	0	157	100.0
	Above Minto Dam	85	7	22	0	114	6.1
	Total	***301***	***164***	***22***	***0***	***487***	***33.7***
S. Santiam	S. Santiam above Foster	521	163	5	0	689	23.7
Willamette[a]	Salt Creek	0	0	0	0	0	0.0
	N Fk Mid Fk Willamette	404	47	56	6	513	10.3
	Mid Fk Willamette	0	0	0	0	0	0.0
	Mosby Creek	0	0	0	0	0	0.0
	Total	***404***	***47***	***56***	***6***	***513***	***10.3***
McKenzie[a]	S Fk McKenzie above Cougar	861	0	13	0	874	0.0
	Above Trail Bridge Reservoir	0	0	0	0	0	0.0
	Mohawk R	332	0	6	0	338	0.0
	McKenzie R above Leaburg	0	4	0	0	4	100.0
	Total	***1,193***	***4***	***19***	***0***	***1,216***	***0.3***

[a] *Eggs were buried in gravel above Hill Creek Reservoir and Trail Bridge Reservoir.*

Fork lengths of Chinook used for broodstock were measured on hatchery origin and natural origin fish (Figure 9). Hatchery origin was determined by presence of a fin clip or coded-wire tag. We measured 3,591 adult spring Chinook in 2008, and the fork length ranged between 30 and 120 cm (Table 19). We compared median fork lengths between hatcheries for both hatchery and natural origin broodstock using a Kruskal-Wallis one-way ANOVA on ranks followed by Dunn’s pairwise multiple comparison method. The median fork length of hatchery origin broodstock at the South Santiam Hatchery (78 cm) was significantly larger ($P < 0.05$) than at Marion Forks (76 cm) and McKenzie (76 cm) hatcheries, but not at Willamette Hatchery (77 cm) (Figure 9). There was no detectable difference in median fork length between hatcheries for natural origin broodstock. Natural origin Chinook salmon were larger than hatchery origin Chinook salmon at all hatcheries (Table 19; Figure 9), and the median fork lengths of these two groups were significantly different at each hatchery (Mann-Whitney rank sum test, $P < 0.05$).

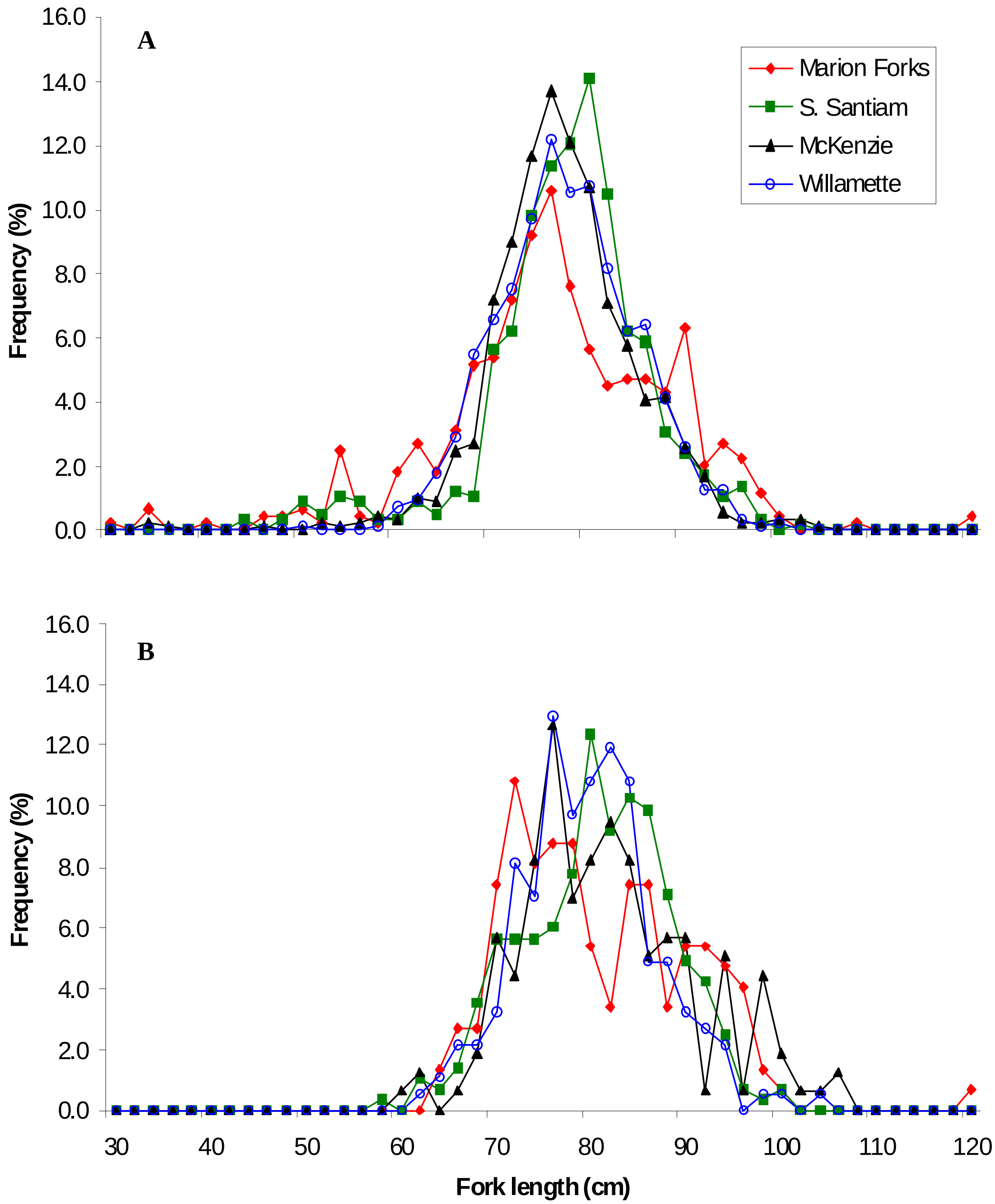

Figure 9. Length frequency distributions of hatchery (A) and natural (B) origin adult broodstock by hatchery, 2008.

Table 19. Fork length (cm) statistics of Chinook salmon at Upper Willamette hatcheries, 2008.

Hatchery	Mark[a]	Measured (n)	Minimum	Maximum	Mean
Marion Forks	Unclipped	148	64	120	80.1
Marion Forks	Fin-clipped	445	30	120	76.2
S. Santiam	Unclipped	283	57	100	80.2
S. Santiam	Fin-clipped	582	43	102	77.3
Willamette	Unclipped	185	62	103	78.9
Willamette	Fin-clipped	855	49	100	77.0
McKenzie	Unclipped	158	60	105	80.9
McKenzie	Fin-clipped	935	33	103	76.4
Marion Forks	All	593	30	120	77.2
S..Santiam	All	865	43	102	78.2
Willamette	All	1,040	49	103	77.3
McKenzie	All	1,093	33	105	77.1

[a] *Fin-clipped includes double index fish.*

Origin of Hatchery Returns (Task 2.b)

Otoliths were collected in 2008 from unclipped spring Chinook spawned at Willamette basin hatcheries to determine the number and percentage of wild fish incorporated into the broodstocks (Table 20). The percentage of wild fish in the unclipped portion of the broodstock in 2008 was three times higher at South Santiam Hatchery than in previous years and was similar to recent years at the other hatcheries (Table 21). Otoliths were collected from Chinook that appeared to have partially clipped adipose fins at North (n = 9) and South Santiam (n = 13) hatcheries, and about 67% of these were natural origin fish. Unclipped Chinook were collected at the Leaburg Dam trap in 2006–2008 and taken to McKenzie Hatchery. Of the unclipped fish spawned at the hatchery, we estimated that the percentage of unclipped hatchery fish was lower for the fish that were transported from Leaburg Dam (5%) than for the fish that volitionally entered the hatchery (58%).

Table 20. Otoliths collected in 2008 from unclipped spring Chinook at hatcheries in the upper Willamette River Basin that were analyzed for presence of thermal marks.

Location	Number
McKenzie Hatchery	162[a]
Minto Pond	161
South Santiam Hatchery	297
Willamette Hatchery	186

[a] *Does not include 10 samples collected from double-index fish (CWT but not fin-clipped).*

Table 21. Composition of spring Chinook salmon without fin clips that were spawned at Willamette basin hatcheries, based on the presence or absence of thermal marks in otoliths, 2002–2008. Because fish with partial or questionable fin-clips were included with unclipped fish, the total of unclipped and fin-clipped fish spawned may not agree with numbers reported by hatcheries. *See* Appendix Tables 5–8 for data used to estimate run and spawners.

	Unclipped[a]		Fin-clipped	Percent wild—		
River, year	Wild	Hatchery	hatchery	in broodstock	of run	of spawners
McKenzie[b]						
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[c]	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[d]	81	48	891	7.9	2.7	2.7–2.9
2008[e]	90	65	1,111	7.1	5.5	5.6–5.8
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[c]	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[d]	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
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[c]	71	19	999	6.5	5.3	20.3
2006[f]	137	46	957	12.0	28.9	39.6
2007[d]	89	13	783	10.1	22.6	27.7
2008[e]	268	16	516	33.5	36.7	49.7
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[g]	27.5[g]
2007	161	67	1,364	10.1	33.4	96.2
2008	105	81	1,314	7.0	25.5	45.4

[a] *Includes fish with partial or questionable fin-clips.*
[b] *Includes unclipped fish trapped at Leaburg Dam and taken to McKenzie Hatchery in 2006 (92), 2007 (139), and 2008 (91).*
[c] *Otoliths were analyzed for 53 fish at McKenzie (of which 18 were wild); 21 at North Santiam (11 wild); and 63 at South Santiam (50 wild).*
[d] *Otoliths were analyzed for 128 fish at McKenzie (of which 84 were wild, but 4 were not spawned); 171 fish at North Santiam (154 wild); and 97 at South Santiam (85 wild).*
[e] *Otoliths were analyzed for 162 unclipped fish at McKenzie (of which 94 were wild); and 294 at South Santiam (277 wild).*
[f] *Otoliths were collected on 152 unclipped fish, of which 114 were wild and 38 were of hatchery origin.*
[g] *Wild fish in broodsotck would be 10.3% of run and 15.2% of spawners using Corps of Engineers redd count.*

Monitor Effects of Hatchery Chinook on Natural Populations (Tasks 1 and 2)

The Hatchery Scientific Review Group developed a basis for reform of hatchery programs to aid salmon hatcheries in meeting conservation and sustainable harvest goals (Mobrand et al. 2005). One measure in hatchery reform is to develop genetic management strategies for every hatchery broodstock as either: (1) well-integrated components of natural populations; or (2) well-segregated from natural populations where the contribution of hatchery fish to natural spawning is kept very low. The effects of captive breeding and supplementation programs on genetic integration and fitness have been modeled (Lynch and O'Hely 2001; Ford 2002), and is approximated from proportions of hatchery and natural origin fish in hatchery broodstocks and in natural spawning populations as an index of the proportion of natural influence (Mobrand et al. 2005). PNI is calculated as:

$$PNI_a = \frac{pNOB_b}{pNOB_b + pHOS_a}$$

where, $pHOS_a$ is the proportion of hatchery origin fish in the natural spawning population in year *a*, and $pNOB_b$ (realized pNOB) is the average proportion of natural origin fish in the broodstock in years *a*-4 and *a*-5. Because the genetic effect of incorporating natural origin spring Chinook into brood stocks is not realized until these fish return as adults (mostly four to five years later), we used a realized pNOB to calculate PNI for Willamette populations. A PNI value greater than 0.5 indicates that the natural environment rather than the hatchery environment drives adaptation and productivity of naturally spawning populations (HSRG 2004). Further reduction of the influence of hatchery fish within a population (PNI > 0.67) has been recommended for populations of moderate or high biological significance or to achieve goals of population viability (HSRG 2008). Proportions for spring Chinook in the Willamette Basin were calculated from data collected under Tasks 1.d and 2.b (Appendix Tables 9–10) to serve as a tool for assessing the influence of hatchery programs.

The proportion of natural influence for spring Chinook populations was very low and ranged from < 0.01 to 0.11 (Table 22). Although the proportion of hatchery origin fish in naturally spawning populations has generally decreased in recent years, the realized proportion of natural origin fish incorporated into broodstocks in the hatchery returns was low, which resulted in low PNI values (Figure 10). The proportion of natural origin spring Chinook incorporated into broodstocks increased in all rivers in 2006–2008 from previous years (*see* Table 21), and the effect on PNI will be fully realized in 2011. However, assuming the proportion of hatchery origin spawners remains at the levels of recent years, PNI would remain below 0.5 (Figure 10).

Table 22. Proportion of natural influence (PNI) of spring Chinook salmon in four rivers of the Willamette Basin, 2002–2008.

River	2002	2003	2004	2005	2006	2007	2008
McKenzie above Leaburg	0.04	0.03	0.03	0.07	0.07	0.07	0.11
McKenzie below Leaburg	0.02	0.01	0.01	0.03	0.02	0.02	0.02
McKenzie combined	0.03	0.03	0.03	0.06	0.06	0.06	0.05
North Santiam	0.01	<0.01	0.01	0.01	0.01	0.01	0.04
South Santiam	0.02	0.02	0.03	0.03	0.03	0.03	0.09
Middle Fork Willamette	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.01

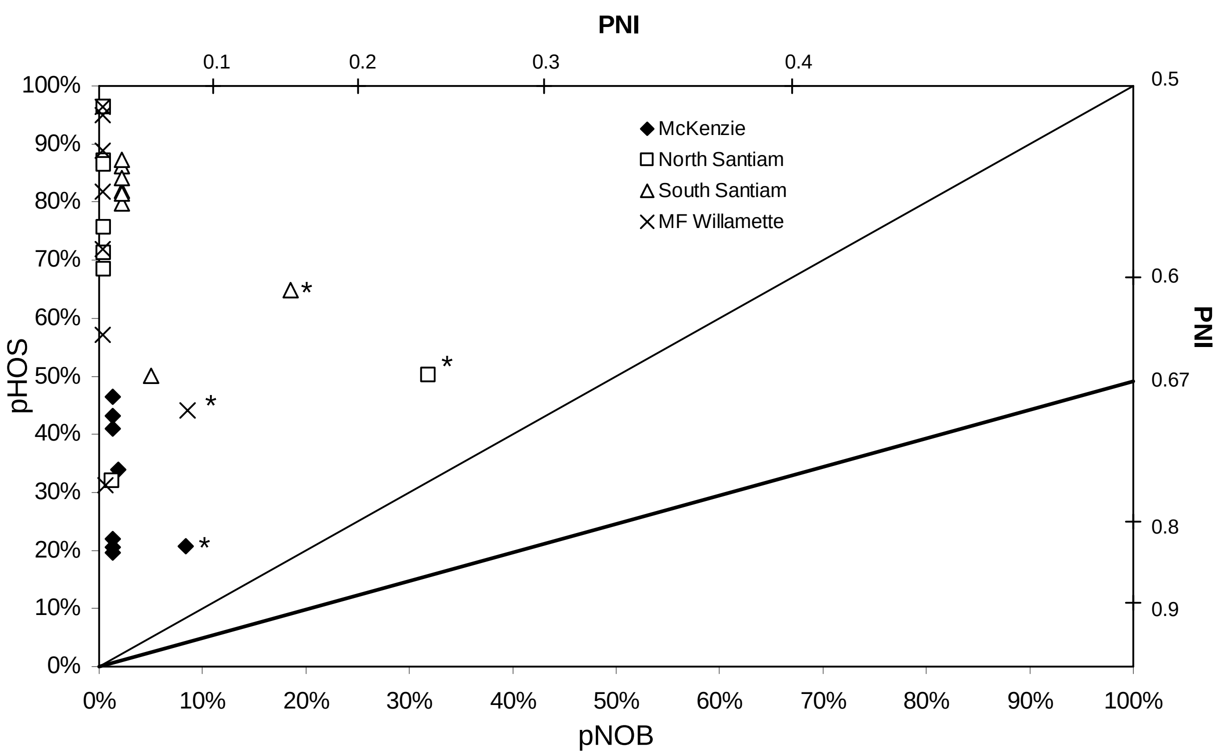

Figure 10. Relationship of the proportion of natural origin fish in the hatchery broodstock (pNOB) and the proportion of hatchery origin fish in the natural spawning population (pHOS) for four populations of spring Chinook in the Willamette Basin, 2002–2008. Proportion of natural influence (PNI) values are given on top and right axes; values > 0.5 indicate that the natural environment drives adaptation and values > 0.67 are recommended to reduce adverse effects of hatchery fish within a population. Data points noted with an asterick (*) indicate expected values when the 2006–2008 increases in pNOB are realized, assuming pHOS is similar to recent years.

PNI can be increased by increasing the proportion of natural origin fish incorporated into hatchery broodstocks or by decreasing the proportion of hatchery origin fish in naturally spawning populations (a reduction in the number of hatchery fish on spawning grounds or a disproportionate increase in the number of natural origin spawners). Several scenarios were calculated for the McKenzie River to illustrate the effects of potential measures in reducing the influence of hatchery fish (Figure 11). Although increasing the number of wild fish into the hatchery broodstock provides an incremental increase in PNI (Figure 11, **A**), this measure alone will not sufficiently reduce the influence of hatchery fish within the population because the number of returning wild fish has been low or the number of hatchery fish on the spawning ground has been high. Hatchery and Genetic Management Plans restrict the number and percentage of wild fish that may be incorporated, and the incorporation of wild fish into broodstocks must be balanced with the effect on wild populations of reducing potential spawners. Therefore, other actions will be necessary to further reduce the influence of the hatchery program such as excluding hatchery fish from spawning grounds upstream of Leaburg Dam (Figure 11, **B**), reducing the proportion of hatchery fish spawning in the wild (Figure 11, **D**), or a combination (Figure 11, **C**). Strategies to reduce the proportion of hatchery fish spawning in the wild might include increasing homing to the hatchery, increasing harvest, or reducing production. An increase in the run size of natural origin fish could result in an increased PNI if the number of hatchery origin fish in spawning areas did not also proportionally increase.

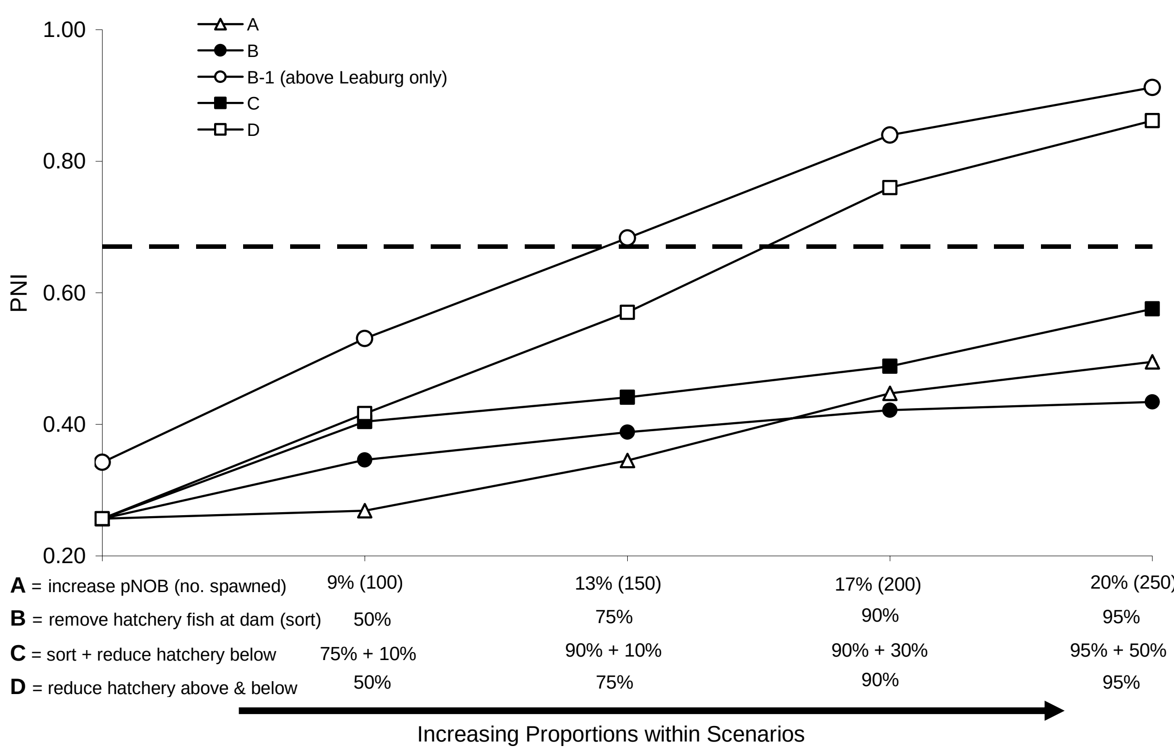

Figure 11. Effects on the proportion of natural influence (PNI) from the present level (Y-axis value) for spring Chinook salmon in the McKenzie River under four scenarios that include: (**A**) increasing the proportion of natural origin fish in broodstock (pNOB), (**B**) sorting and removing hatchery fish at Leaburg Dam, (**C**) sorting at the dam and reducing the proportion of hatchery fish spawning downstream of the dam, and (**D**) reducing the proportion of hatchery fish spawning upstream and downstream of the dam. Scenario **B** for the population segment upstream of Leaburg Dam is included for comparison.

Decisions about what strategy to implement also depend on other fish management actions. For example, estimates in 2002–2008 suggest that over 85% of the spawning and over 95% of natural origin spawners in the McKenzie Basin are upstream of Leaburg Dam. If managing this area as a wild fish sanctuary was deemed sufficient for long-term conservation and recovery, then measures to exclude hatchery fish from this portion of the basin should be a high priority action to implement (Figure 11, **B-1**).

Genetic Samples of Hatchery Outplants (Task 2.c)

Molecular data can be used to study parentage, pedigree reconstruction, and kinship analysis (Blouin 2003; Jones and Ardren 2003), and have been used to estimate the relative reproductive success of hatchery anadromous salmonids in the wild (Araki et al. 2007). Analysis of tissue samples collected from spring Chinook outplanted upstream of dams in the Willamette Basin and from adults returning to the collection sites at or near the dams will be conducted to determine the reproductive success of the outplanted Chinook. These data, in turn, will be used to assess the success of re-establishing self-sustaining populations into historic habitats upstream of dams.

Tissue samples were collected in 2007 and 2008 from hatchery spring Chinook that returned to hatcheries and were outplanted into areas upstream of impassable dams (Table 23 and Appendix Tables 11–13). All Chinook outplanted in the McKenzie Basin were sampled, but the sampling of outplanted fish in other basins ranged from 30–100% (Table 23).

Table 23. Tissue samples collected from hatchery spring Chinook salmon that were outplanted into areas upstream of Corps dams in four Willamette basins, 2007–2008.

Basin, year	Female	Male	Jack	Sampled	Percent of outplants
McKenzie					
2008	288	573	13	874	100%
2007	362	506	13	881	100%
North Santiam					
2008	10	117	1	128	59%
2007	396	365	1	762	77%
South Santiam					
2008	248	436	5	689	100%
2007	136	123	0	259	64%
M Fork Willamette					
2008	82	63	11	156	30%
2007	408	262	0	670	83%

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APPENDIX TABLES

Hatchery Operations

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 1. Dates of operation and numbers of spring Chinook salmon collected in the North Santiam River (at Minto), 2008.

Date	Adult		Jack
	Fin-clipped	Not clipped	
25-Jun	1	5	0
30-Jun	13	20	0
2-Jul	4	9	0
14-Jul	52	54	2
15-Jul	100	84	9
25-Aug	49	19	0
28-Aug	86	36	6
29-Aug	18	7	1
1-Sep	148	44	24
2-Sep	65	13	4
5-Sep	42	6	7
8-Sep	36	18	4
15-Sep	61	8	0
22-Sep	16	28	0
29-Sep	6	3	1
3-Oct	13	3	0
9-Oct	6	1	0
Total	***716***	***358***	***58***

Appendix Table 2. Dates of operation and numbers of spring Chinook salmon collected in the South Santiam River (at Foster), 2008. Because numbers of fish recorded at the trap did not match the total number of fish handled at the hatchery, the count of fin-clipped fish was adjusted at the end of the season by adding 24 fish to get the season for a total of 1,057 fin-clipped fish.

	Adult		Jack		Mini jack	
Date	Fin-clipped	Unclipped	Fin-clipped	Unclipped	Fin-clipped	Unclipped
5-May	0	1	0	0	0	0
20-May	1	6	0	0	0	0
11-Jun	0	1	0	0	0	0
17-Jun	0	1	0	0	0	0
24-Jun	2	1	0	0	1	0
1-Jul	200	90	11	0	6	0
7-Jul	38	36	0	0	23	0
16-Jul	3	3	1	0	3	0
21-Jul	163	52	4	0	74	0
23-Jul	144	46	7	2	128	0
29-Jul	135	82	6	2	72	0
6-Aug	25	29	2	0	37	0
20-Aug	12	8	0	1	147	0
3-Sep	62	17	3	0	47	3
9-Sep	95	26	3	0	57	1
10-Sep	0	0	0	0	0	0
16-Sep	99	50	4	0	32	4
17-Sep	0	0	0	0	0	0
23-Sep	48	26	2	0	7	0
24-Sep	0	0	0	0	0	0
1-Oct	0	0	0	0	0	0
2-Oct	6	3	0	0	0	0
Total	***1,033***	***478***	***43***	***5***	***634***	***8***

Appendix Table 3. Dates of operation and numbers of spring Chinook salmon collected in the Middle Fork Willamette River (at Dexter), 2008.

Date	Adult		Jack	
	Fin-clipped	Not clipped	Fin-clipped	Not clipped
18-Jun	188	2	3	0
1-Jul	332	5	1	0
8-Jul	277	1	0	0
16-Jul	317	2	1	0
23-Jul	310	11	2	0
31-Jul	94	1	0	0
7-Aug	185	2	33	0
27-Aug	89	18	9	2
28-Aug	139	15	9	0
11-Sep	142	20	7	4
25-Sep	29	0	1	0
Total	***2,102***	***77***	***66***	***6***

Appendix Table 4. Dates of operation and numbers of spring Chinook salmon collected in the McKenzie River (at hatchery), 2008. Because numbers of fish recorded at the trap did not match the total number of fish handled at the hatchery, the count was adjusted at the end of the season by subtracting 12 fish to get the season total of 2,807 Chinook.

	Adult	
Date	Fin-clipped	Not clipped
17-Jun	97	5
23-Jun	68	15
27-Jun	88	8
30-Jun	230	22
3-Jul	98	10
7-Jul	181	19
10-Jul	278	35
14-Jul	245	31
16-Jul	205	18
18-Jul	85	7
24-Jul	172	19
4-Aug	48	3
15-Aug	27	4
22-Aug	65	10
5-Sep	89	9
11-Sep	123	19
15-Sep	125	13
19-Sep	139	38
22-Sep	68	14
24-Sep	22	7
1-Oct	44	7
6-Oct	4	5
Total	***2,501***	***318***

Origin of Hatchery Returns

Estimates of the number 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 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, 2002–2008.

		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	84	3,016	2,595	69	2,803	77
2008	90	1,408	127	6	**d**	1,631	1,393	115	1,355	110

[a] *Determined from absence of fin clips and absence of induced thermal marks in otoliths. 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 when number of spawners estimated from redd counts was about 40% of that estimated from run counts. Estimated total returns to the McKenzie were larger in 2002–2004 (15,000–18,500) than in 2005–2008 (5,400–7,000). 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 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, 2002–2008.

		Run			Harvest[e]				Spawners[f]		Spawners[g]	
Year	Brood-stock[a]	above dam-1[b]	above dam-2[c]	below dam[d]	below dam	total	Total-1	Total-2	above dam	below dam	above dam	below dam
2002	4	604	435	28	25	53	657	516	174	11	103	10
2003	2	271	226	6	13	29	290	261	75	1	62	1
2004	12	489	627	23	17	36	529	686	90	2	146	4
2005	18	667	519	48	27	58	742	625	197	12	189	18
2006	197	650	699	22	27	57	699	778	121	5	195	12
2007	158	852	744	24	35	75	911	843	308	12	335	9
2008	154	901	798	6	**d**	**d**	907	804	342	3	403	3

[a] *Determined from absence of fin clips and absence of induced thermal marks in otoliths.*

[b] *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 (no trapping occurred after July 2005 because of construction).*

[c] *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).*

[d] *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).*

[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. 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.*

[f] *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.*

[g] *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.*

Run estimates from Bennett dams were based on expansions from trapping Chinook at the dams 3–4 days/week and expanding to 7 days, which may have an unknown error factor because of observations at the dam that suggested passage was delayed when the trap was operated. A third run estimate was made using the difference between the dam counts and fish accounted for at the Minto trap to estimate the number of fish remaining in the river. These estimates were similar to the Run-1 estimates in 2002–2004 and to the Run-2 estimate in 2005, but were lower in 2006–2008 (4–20%) than the other run estimates.

Appendix Table 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[a]	Trap[b]	Fish in river[c]	Harvest[d]	Total Run	Spawners[e]
2002	26	562	447	80	1,115	332
2003	25	313	279	74	691	200
2004	78	1278	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	**d**	731	271

[a] *Determined from absence of fin clips and absence of induced thermal marks in otoliths.*

[b] *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.*

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

[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 (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.*

[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.*

Appendix Table 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

Year	Broodstock[a]	Trap[b]	Fish in river[c]	Harvest[d]	Total Run[e]	Spawners[f]	Fall Cr[g]
2002	5	77	43	34	159	7	63
2003	5	9	31	12	57	2	105
2004	16	41	75	64	196	4	592
2005	19	31	42	25	117	3	119
2006	45	33	126[h]	56	260[h]	119[h]	335
2007	161	90	127	104	482	6	209
2008	105	154	153	**d**	412	126	267

[a] *Determined from absence of fin clips and absence of induced thermal marks in otoliths.*

[b] *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.*

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

[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 (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.*

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

[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. Does not include estimates of spawners in Fall Creek.*

[h] *Based on ODFW redd count of 111; Corps of Engineers biologists counted 234 redds including 73 in a side channel not surveyed by ODFW. Estimates using the higher redd count would be 266 natural origin fish in the river, harvest of 95 natural origin fish, total run of 439, and natural origin spawners of 251.*

Proportions of Natural and Hatchery Origin Chinook

Appendix Table 9. Number and proportion of natural origin spring Chinook in the hatchery broodstock (pNOB) and the number and proportion of hatchery origin fish in the natural spawning populations (pHOS) upstream and downstream of Leaburg Dam on the McKenzie River.

	Broodstock				Upstream[b]			Downstream[c]			Combined
Year	Natural	Hatchery	pNOB	pNOB[a]	Natural	Hatchery	pHOS	Natural	Hatchery	pHOS	pHOS
2002	13	1,034	0.012	0.013	3,214	1,761	0.35	139	565	0.80	0.41
2003	14	995	0.014	0.013	4,108	2,669	0.39	64	953	0.94	0.46
2004	24	985	0.024	0.013	3,933	2,506	0.39	35	509	0.94	0.43
2005	20	1,062	0.018	0.013	2,051	439	0.18	85	85	0.50	0.20
2006	100	891	0.101	0.013	2,164	440	0.17	112	152	0.58	0.21
2007	81	939	0.079	0.013	2,595	505	0.16	69	247	0.78	0.22
2008	90	1,176	0.071	0.019	1,393	260	0.16	115	515	0.82	0.34
2009				0.021							
2010				0.060							
2011				0.090							
2012				0.075							

[a] *Realized pNOB for calculating PNI. Genetic effect of incorporating natural origin fish into broodstocks is realized when adult hatchery fish return four to five years later, therefore the realized pNOB in year a would be the average pNOB in years a-4 and a-5. For years prior to 2007, the realized pNOB was assumed to be the average of 2002 and 2003.*

[b] *Leaburg Dam counts adjusted for the proportion of fin-clipped and unclipped carcasses collected upstream of the dam and for pre-spawning mortality.*

[c] *Number of spawners was estimated from redd counts, spawners per redd ratio upstream of Leaburg Dam, and pre-spawning mortality downstream of dam (higher than upstream); number of spawners by origin was estimated from origin of recovered carcasses.*

Appendix Table 10. Number and proportion of natural origin spring Chinook in the hatchery broodstock (pNOB) and the number and proportion of hatchery origin fish in the natural spawning populations (pHOS) in the North Santiam, South Santiam, and Middle Fork Willamette rivers.

	Broodstock				Spawning population		
River, year	Natural	Hatchery	pNOB	pNOB[a]	Natural	Hatchery	pHOS
North Santiam							
2002	4	678	0.006	0.005	50	340	0.871
2003	2	616	0.003	0.005	44	1,149	0.964
2004	12	554	0.021	0.005	64	410	0.865
2005	18	486	0.036	0.005	89	221	0.713
2006	197	347	0.362	0.005	58	126	0.685
2007	158	392	0.287	0.005	45	142	0.757
2008	154	348	0.307	0.012	32	15	0.321
2009				0.028			
2010				0.199			
2011				0.325			
2012				0.297			
South Santiam							
2002	26	1,193	0.021	0.022	231	1,443	0.862
2003	25	1,071	0.023	0.022	148	1,015	0.873
2004	78	921	0.078	0.022	83	375	0.819
2005	71	1,018	0.065	0.022	124	490	0.797
2006	137	1,003	0.120	0.022	48	255	0.842
2007	89	796	0.101	0.022	70	308	0.815
2008	268	532	0.335	0.050	53	53	0.500
2009				0.072			
2010				0.093			
2011				0.110			
2012				0.218			
M. Fork Willamette[b]							
2002	5	1,665	0.003	0.003	11	249	0.957
2003	5	1,524	0.003	0.003	4	89	0.956
2004	16	1,835	0.009	0.003	13	64	0.833
2005	19	1,521	0.012	0.003	5	40	0.889
2006	45	1,663	0.026	0.003	12	16	0.571
2007	161	1,431	0.101	0.003	9	23	0.719
2008	105	1,395	0.070	0.006	12	19	0.623
2009				0.010			
2010				0.019			
2011				0.064			
2012				0.086			

[a] *Realized pNOB for calculating PNI. Genetic effect of incorporating natural origin fish into broodstocks is realized when adult hatchery fish return four to five years later, therefore the realized pNOB in year a would be the average pNOB in years a-4 and a-5. For years prior to 2007, realized pNOB was assumed to be the average of 2002 and 2003.*

[b] *Does not include Fall Creek.*

Genetic Sampling

Appendix Table 11. Tissue samples collected from hatchery spring Chinook salmon that were outplanted into areas upstream of dams in the McKenzie Basin, 2007–2008.

Location, date	Female	Male	Jack
	McKenzie 2008		
SF McKenzie – FS Rd 1980			
16-Jul	30	45	1
24-Jul	34	45	0
SF McKenzie – FS Rd 430			
16-Jul	29	45	0
18-Jul	34	42	1
24-Jul	39	38	0
4-Aug	21	17	2
15-Aug	7	10	4
22-Aug	2	57	4
5-Sep	0	72	1
11-Sep	4	85	0
18-Sep	28	43	0
6-Oct	36	39	0
8-Oct	24	35	0
	McKenzie 2007		
SF McKenzie – RM 10.5			
28-Jun	40	31	0
3-Jul	33	34	0
18-Jul	19	28	0
SF McKenzie – FS Rd 430			
29-Jun	31	44	0
18-Jul	29	45	0
30-Jul	22	19	0
3-Oct	44	38	0
SF McKenzie – Reservoir			
2-Jul	37	37	0
SF McKenzie – FS Rd 1980			
14-Sep	0	142	6
3-Oct	41	26	3
Above Trail Bridge Reservoir			
11-Jul	41	37	2
21-Sep	25	25	2

Appendix Table 12. Tissue samples collected from hatchery spring Chinook salmon that were outplanted into areas upstream of dams in the Santiam Basin, 2007–2008.

Location, date	Female	Male	Jack
	North Santiam 2008		
North Santiam – Cooper Br.			
22-Sep	3	34	0
Breitenbush – Cleator Bend			
2-Sep	0	63	0
29-Sep	7	20	1
	North Santiam 2007		
21-Aug	74	100	1
28-Aug	51	54	0
4-Sep	16	43	0
Breitenbush – Cleator Bend			
7-Sep	27	54	0
10-Sep	62	8	0
12-Sep	72	55	0
13-Sep	15	50	0
18-Sep	79	1	0
	South Santiam 2008		
South Santiam – Gordon Rd.			
6-Aug	33	99	0
16-Aug	37	98	0
25-Sep	21	41	2
1-Oct	63	89	2
2-Oct	94	109	1
	South Santiam 2007		
South Santiam – Gordon Rd.			
7-Sep	78	97	0
11-Sep	25	7	0
21-Sep	33	19	0

Appendix Table 13. Tissue samples collected from hatchery spring Chinook salmon that were outplanted into areas upstream of dams in the Middle Fork Willamette Basin, 2007–2008.

Location, date	Female	Male	Jack
	MF Willamette 2008		
North Fork of Middle Fork			
11-Sep	82	63	11
	MF Willamette 2007		
North Fork of Middle Fork – RM 18.5			
27-Jun	25	20	0
10-Jul	89	72	0
North Fork of Middle Fork – RM 16.5			
30-Aug	106	29	0
5-Sep	52	24	0
Middle Fork Willamette			
10-Jul	98	79	0
Salt Creek			
10-Jul	38	38	0