Work Completed for Compliance with the 2008 Willamette Project Biological Opinion, USACE funding: 2010

Brian Cannon
Ryan Emig
Thomas A. Friesen
Marc Johnson
Paul Olmsted
R. Kirk Schroeder
Cameron S. Sharpe[1]
Craig A. Tinus
Luke Whitman

Oregon Department of Fish and Wildlife
Upper Willamette Investigations
Corvallis Research Lab
28655 Highway 34
Corvallis, Oregon 97333

Prepared for the U.S. Army Corps of Engineers, Portland District
Task Order: NWPPM-10-FH-05

Final Draft October 2011

[1] Corresponding author

Table of Contents

List of Tables 3
List of Figures 5
Executive Summary 6
Introduction 8
Methods 11
Results and Discussion 16
Task 1.1: Distribution, Abundance, and Proportion of Hatchery and Natural-Origin Chinook Salmon 16
Task 1.2: Monitor fin-clipped & unclipped fish passing Leaburg and Upper Bennett dams 29
Task 2.1: Collection, spawn timing, and H/W composition for broodstock management 38
Task 2.2: Determine Survival of Outplanted Fish and Abundance of Spawners 44
Task 3.1: Determine the extent of summer steelhead reproduction in the wild. 50
Task 3.2: Evaluate release strategies for summer steelhead to increase migration and reduce impacts on wild fish [RPA 6.1.6] 50
Acknowledgments 51
References 52
Appendix 1 55
Run Size and Spawner Escapement Estimates 55
Appendix 2 60
Summary of Tasks 60
Appendix 3 63
2011 Lower Bennett Dam Fish Ladder Power Supply Project 63
Appendix 4 65
Project concepts approved for funding in 2011: Final proposals and progress to date 65
Appendix 5 109
Project Concepts for work in 2011 Not Approved for Funding in 2011 109
Appendix 6 125
Willamette River Steelhead Genetic Stock Identification: 125
Appendix 7 128
Dates of Trap Operation and Collections 128

List of Tables

Table 1. Spring Chinook salmon redds counted in the four major watersheds of the upper Willamette River basin, 2002–2010. 17

Table 2. Summary of spawning surveys for spring Chinook salmon in the North Santiam River, 2010, and redd densities (redds/mi) for 2002–2010. Spawning in areas downstream of Stayton may include some fall Chinook salmon. 17

Table 3. Composition of naturally-spawning spring Chinook salmon estimated from carcasses recovered in the North Santiam River, 2010. 18

Table 4. Summary of Chinook salmon spawning surveys in the McKenzie River, 2010, and redd densities (redds/mi) for 2005–2010. Redd densities for 2000-2004 are provided in Cannon et al. 2009. 19

Table 5. Composition of naturally spawning spring Chinook salmon from carcasses recovered in the McKenzie River, 2010. 21

Table 6. Summary of Chinook salmon spawning surveys in the South Santiam and Middle Fork Willamette rivers, 2010, and redd densities (redds/mi) for 2002–2010. 21

Table 7. Average difference (%) and range (%) between successive counts of spring Chinook salmon redds for three classes of surveys (size of stream and survey method), 2010. 23

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). 24

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. 25

Table 10. Estimated percent pre-spawning mortality for Chinook salmon in the Willamette Basin based on the recovery of female carcasses, 2001–2010. Only areas and years with > 10 recoveries are included. Date of first survey is in parentheses. 27

Table 11. Pre-spawning mortality of fin-clipped and unclipped spring Chinook salmon carcasses based on recovery of female carcasses, 2010. Note that we consider these to be multiple comparisons and the apparently significant difference in the North Santiam River is spurious after adjusting the significance level to account for the three simultaneous comparisons. 27

Table 12. Number of locally and remotely released coded-wire tagged hatchery spring Chinook salmon that were recovered as carcasses from Willamette Basin spawning

grounds. Expanded sample sizes (in parentheses) are based on the percentage of each release group that was tagged. 30

Table 13. Spring Chinook salmon counted at Leaburg Dam, McKenzie River, April through October 2010.......... 31

Table 14. Spring Chinook passage at Leaburg Dam, 2002–2010. 31

Table 15. Spring Chinook salmon counted at Upper Bennett Dam, North Santiam River, 2010. Fish observed going downstream were subtracted from the upstream counts. No counts were conducted at Lower Bennett Dam. 35

Table 16. Estimated Spring Chinook passage at Bennett Dam, 2001-2010. 35

Table 17. Collection, spawning and outplanting of fin-clipped and unclipped spring Chinook salmon entering Willamette basin hatcheries and collection facilities, 2010. Mark status by gender of adults collected for broodstock at McKenzie is unknown. 39

Table 18. Disposition of fish in excess of broodstock and outplanting needs. 40

Table 19. Composition of unclipped spring Chinook salmon spawned at Willamette basin hatcheries, based on the presence or absence of thermal marks in otoliths, 2002–2010 . 45

Table 20. Adult spring Chinook salmon outplanted, redd counts, fish per redd, and percent pre-spawning mortality in upper Willamette basin tributaries, 2010. 46

Table 21. Temperature data for select fish passage and outplanting sites in 2010. All temperatures are ° C recorded every 15 minutes for the period from 9 June 2010 through 15, October 2010. LNFk indicates Little North Fork Santiam. 50

List of Figures

Figure 1. The Willamette Basin with major dams, hatcheries, and fish collection facilities. 10

Figure 2. Distribution of spring Chinook salmon redds in the McKenzie River basin, 2002–2010. 20

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. 26

Figure 4. Timing of spring Chinook salmon passage at Leaburg Dam, 2010. 32

Figure 5. Passage timing of unmarked (top) and hatchery (bottom) spring Chinook salmon over Willamette Falls and Leaburg Dam, 2010. 33

Figure 6. Adult spring Chinook passage at Leaburg Dam in 2010. "LB" and "RB" indicate passage at left bank and right bank, respectively. 34

Figure 7. Timing of spring Chinook salmon passing Upper Bennett Dam, North Santiam River, 2010. Total adults include only those of known fin-clip status. 36

Figure 8. Passage timing of unmarked (top) and hatchery (bottom) spring Chinook salmon over Willamette Falls and Upper Bennett Dam, 2010. 37

Figure 9. Spring Chinook salmon returns to Upper Willamette hatcheries by month, 2010. 41

Figure 10. Fork length distribution of fin-clipped (top) and unclipped (bottom) spring Chinook salmon used for broodstock in upper Willamette Basin hatcheries, 2010. 42

Figure 11. Fork lengths of clipped and unclipped broodstock at upper Willamette hatcheries, 2010. 43

Executive Summary

- *Task 1.1: Distribution, Abundance, and Proportion of Hatchery and Natural-Origin Chinook Salmon:* Counts of spring Chinook redds were similar in 2010 compared to the 2002–2009 averages for the Middle Fork Willamette, McKenzie and the North Santiam rivers and significantly higher in the South Santiam River Preliminary analyses indicate that the proportions of hatchery fish recovered as carcasses from the spawning grounds varied significantly among all four surveyed sub-basins (South Santiam > M. Fork Willamette > North Santiam > McKenzie).

- *Task 1.2: Monitor fin-clipped & unclipped fish passing Leaburg and Upper Bennett dams.* Adult fish passage at Leaburg and Upper Bennett dams was continuously monitored in 2010. We estimated that 2,696 spring Chinook (52% unclipped) passed above Leaburg Dam and 5,956 passed above upper Bennett Dam (14% unclipped). Passage at Leaburg Dam of fin-clipped fish was strongly bimodal with peaks in June (coincident with passage of the majority of unclipped fish) and September (coincident with a smaller proportion of unclipped fish). This bimodal peak suggests that hatchery fish might be removed in September to reduce the proportion of hatchery origin spawners while simultaneously reducing the impacts of handling wild fish.

- *Task 2.1: Collection, spawn timing, and Hatchery/Wild (H/W) composition for broodstock management.* Collection, spawn timing, and H/W composition for broodstock management were successfully monitored at all facilities in 2010.

- *Task 2.2: Determine Survival of Outplanted Fish and Abundance of Spawners.* Patterns of pre-spawning mortality were similar to results in 2009 with mortality below project dams significantly higher than that above project dams. We did not detect significant differences in mortality between clipped and unclipped spring Chinook. In comparisons of pre-spawning mortality among sub-basins above project dams, pre-spawning mortality was uniformly low in the Breitenbush and N. Santiam above Detroit, S. Santiam above Foster, and in the S. Fork McKenzie. Pre-spawning mortality was uniformly higher above project dams in the N. Fork Mid. Fork Willamette, Fall Creek and the Little N. Fork Santiam. No comprehensive surveys were conducted in the Middle Fork Willamette.

- *Task 3.1: Determine the extent of summer steelhead reproduction in the wild:* We developed a formal study plan to analyze and interpret genetic results from a collection of 299 tissue samples from unclipped juvenile steelhead at Willamette Falls, five from the mainstem Willamette River, and two from the South Santiam River in 2010 in addition to a single sample from an unclipped adult steelhead at the Minto fish collection facility. Samples were preserved and cataloged and then shipped to the NOAA Fisheries Manchester, Washington (WA) laboratory for analysis.

- *Task 3.2: Evaluate release strategies for summer steelhead to increase migration and reduce impacts on wild fish.* Study plans to evaluate advantages and disadvantages of volitional release strategies were completed and presented in the 2009 annual report to USACE (Cannon et al. 2010). Funding to process the tissue samples was not available in 2010, and no progress was made in executing the proposed work.

Introduction

The National Marine Fisheries Service (NMFS) 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 in the ESU 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 hatcheries 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 spawner abundance—a critical consideration for those populations 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). Recent work, however, has shown that hatchery fish tend to have lower reproductive success than wild fish even when broodstocks are largely comprised of wild fish (Araki et al. 2007), and productivity parameters are depressed when large numbers of hatchery salmonids mix with wild fish (Chilcote et al. 2011). The objective of this project is to conduct baseline monitoring of returning adult fish and to 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-10-FH-05, covering activities of May 2010–April 2011 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 down-stream 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 (H/W) composition for broodstock management.

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

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.

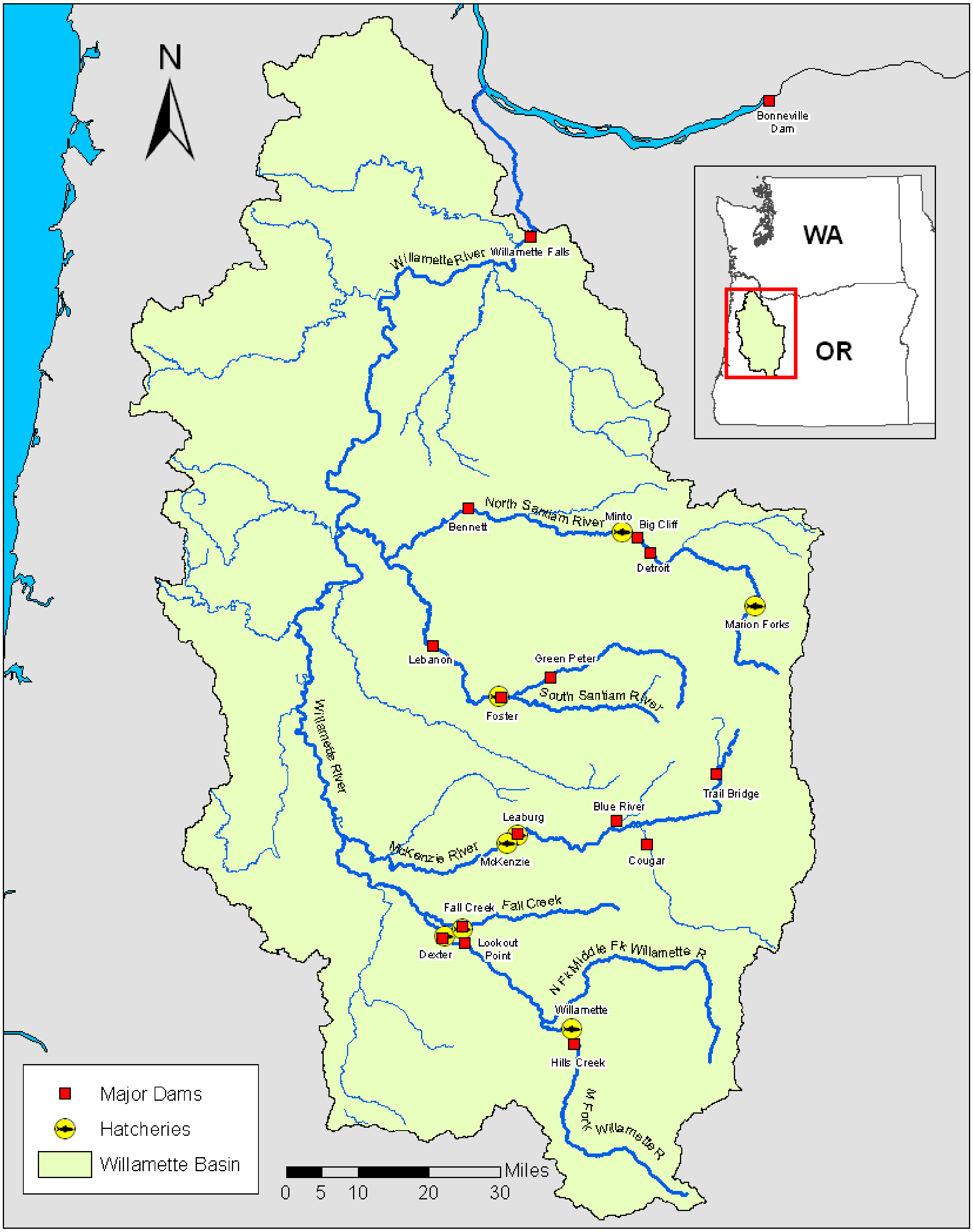


Figure 1. The Willamette Basin with major dams, hatcheries, and fish collection facilities.

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 2010 by boat and on foot to count spring Chinook salmon carcasses and redds following protocols established by Schroder et al. (2007) counting redds from late August through October to encompass the peak times of spawning based on data from surveys conducted in past years.

We used rafts with elevated viewing towers on large river sections. On some river sections the raft stayed on one side of the river over 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 that we used small rafts with viewing platforms lacking elevated towers. For walking surveys, 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 observer enumerated and recorded global positioning system (GPS) coordinates for all redds for each river section.

All carcasses that could be recovered by hand or with long-handled gaffs were examined for adipose fin clips to determine the proportion of hatchery fish on spawning grounds. We measured carcasses (centimeters, fork length), determined gender, and estimated the proportion of remaining eggs to document pre-spawning mortality. Carcasses in water too deep to permit recovery or too scavenged or decomposed to permit inspection were recorded as unprocessable carcasses. We collected otoliths and scale samples from processable carcasses without fin-clips to differentiate unclipped hatchery fish from naturally-produced fish (*see Proportion of hatchery spawners*, below). We used hand-held detectors manufactured by Northwest Marine Technology, Inc. (Tumwater, WA) to determine if carcasses with adipose fin clips had a coded wire tag (CWT), and in the Middle Fork Willamette River to determine if unclipped carcasses had a CWT. Fish with CWTs and without fin clips might be simply be misclipped fish, fish with regenerated adipose fins or fish from “double-index release groups” (intentionally released without a fin clip for fishery management purposes). 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 laboratory to establish origin of the tagged fish.

Variability of redd counts (Task 1.1.2). In 2010, we assessed differences in redd counts between surveyors during foot and raft surveys by following up normal raft (N = 9) and walking (N = 2) surveys with a second survey (“resurvey”) by our most experienced surveyors. Resurveys were conducted the same day or within one day of the original survey.

Proportion of hatchery spawners (Task 1.1.3). Restoration of spring Chinook salmon under the Endangered Species Act (ESA),) and the implementation of ODFW's Native Fish Conservation Policy, requires monitoring the number of hatchery and wild fish that comprise the spawning populations in the Willamette basin. The Willamette Project 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, have been 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 inadvertently released without a fin- clip at a rate that 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 a more precise automated fin-clipping system. Other factors that contribute to the return of unclipped hatchery fish include the release of unclipped hatchery fish with coded wire tags (double-index), and natural regeneration of partially clipped adipose fins.

We estimated the proportion of naturally-origin (wild) and hatchery-origin fish on spawning grounds in the Willamette basin by examining otoliths collected from carcasses on the spawning grounds in 2010. We collected samples from adult spring Chinook carcasses without fin-clips on spawning grounds and at hatcheries in four sub-basins (McKenzie, North and South Santiam, and Middle Fork Willamette). Otoliths were collected 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 of thermal marks. The proportion of hatchery origin spawners (PHOS) was derived from the counts of fin clipped fish (AD), unclipped thermally-marked fish TM and total count of fish examined TOT (PHOS = [AD + TM]/TOT). We also used the otoliths to adjust estimates of the proportion of natural-origin brood (PNOB) in the hatcheries using the counts of nonthermally-marked unclipped broodstock ($WILD_B$), and the total number of broodstock (TOT_B): $PNOB = WILD_B/TOT_B$.

Pre-spawning mortality (Task 1.1.4).—We surveyed major tributaries of the Willamette basin by boat and on foot in 2010 to estimate pre-spawning mortality based on the proportion of unspawned female salmon carcasses observed. These surveys were conducted in a manner identical to the spawner surveys (described above) but began in the summer prior to any spawning to permit observation of any early mortality that occurred as salmon reached spawning tributaries. Female carcasses were also checked for spawning success during the regular spawning surveys and redd counts through early October so that pre-spawning mortality could be assessed over the entire run. For every female salmon carcass that could be recovered during the pre-spawning and spawning surveys the gut cavity was cut open to visually judge the relative abundance of eggs. Female carcasses with intact or relatively intact skeins were considered unspawned.

Straying of hatchery fish (Task 1.1.5). In the Willamette basin a stray is defined as any hatchery fish that does not return to its hatchery of origin and is found on natural spawning grounds. In addition to estimating PHOS (described above) in each subbasin we estimated the contribution to PHOS of strays from outside the subbasin into which the juveniles were originally released.

A portion of the juvenile hatchery Chinook in the Willamette Basin are released with coded-wire tags (CWTs). Specific information on CWT releases are from the Regional Mark information System (RMIS) available online at http://www.rmpc.org/ but, on average, 687,000 CWT spring Chinook are released into the Willamette each year (2000 – 2010; Shaun Clements, ODFW, pers. comm.) and more than 100,000 tagged fish are released per hatchery per year. We used handheld tag detectors to check for tags in carcasses recovered during surveys (*see Task 1.1.1*). The binary codes of CWTs were read at ODFW's Clackamas laboratory 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 to the percentage of fish in that release group that were tagged. For example, if one CWT from a McKenzie release was recovered in the South Santiam when 1/10th of the of the McKenzie fish received CWTs intended to identify that release then we assumed an additional nine McKenzie fish from that release strayed into the South Santiam.

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.

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 that automatically scans and records fish movement and creates video files from these images (FishTick, SalmonSoft, Inc., Portland, OR). The captured video images were reviewed and species, presence or absence of an adipose fin clip, direction of movement (upstream or downstream) were noted so that the net upstream movement of spring Chinook by hatchery or wild origin could be estimated. Fish passage was recorded continuously during the year except for brief outages over several days in January— when no fish were believed to be moving—and a partial day in May when a computer hard drive failed. We estimated the number of fish that may have passed during these outages based on simple linear extrapolation of fish counts recorded during the time when the video equipment was operating normally on the same day.

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 21

January –12 Dec, 2010 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 moving downstream were subtracted from the total counts. Video monitoring was operated continuously and no adjustments to counts were necessary. Monitoring at Lower Bennett Dam was not conducted in 2010 because the video system at that facility is still being developed (see section 1.2.4).

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 for each of the Willamette spring Chinook hatcheries to collect broodstock. Chinook salmon are also trapped at Leaburg Dam and Leaburg Hatchery and then 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. Scales and otoliths were collected from all unclipped fish. For fin-clipped Chinook, scale samples were collected from every fifth fish. We collected tissue samples (small portion of a fin) from outplanted fish, and recorded gender along with presence or absence of a fin clip.

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

Subtasks 1–6 (combined). We monitored the success of outplanted spring Chinook salmon upstream of Project dams by conducting 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 2010. We collected tissue samples from both clipped and unclipped juvenile steelhead at the Pacific Gas and Electric (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.

To obtain tissue samples for genetic analysis, 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 ethanol. The cut margin of the caudal lobe was dipped in iodine, and the fish were allowed to fully recover from anesthesia prior to release. The tissue samples were subsequently shipped to NOAA Fisheries' Northwest Fisheries Science Center for analysis.

Results and Discussion

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

We used a combination of spawning ground surveys, hatchery records, and dam counts to derive estimates of run-size and spawner escapement for hatchery- and natural-origin Chinook in the four basins of interest. Details are provided below and in Appendix 6.

Spawning Ground Surveys Downstream of Corps Dams (Task 1.1.1). Counts of spring Chinook redds were similar in 2010 compared to the 2002–2009 averages for the Middle Fork Willamette, McKenzie and the North Santiam rivers and significantly higher in the South Santiam River (Table 1).

The North Santiam River was surveyed during the period of July 7–October 19. Redd construction was first observed on September 2 and peak spawning occurred in late September to early October. As in previous years, the redd density in 2010 was highest in the section immediately downstream of Minto Dam to Fishermen's Bend (Table 2). Redd counts and densities were higher in 2010 compared to 2009 (Tables 1, 2). Of the carcasses we recovered in the North Santiam in 2010, 68% had fin clips (Table 3); lower than the 2002–2009 average (76%).

We surveyed the McKenzie River from July 21 to October 13. The first redd was observed on September 1, similar to previous years. Peak spawning occurred in late September to early October. The total number of redds in 2010 (1,276) was the second highest count since comprehensive surveys began in 2002 (Table 1). Redd densities were variable from 2000–2009 within survey sections (Table 4). Redd densities downstream of Leaburg Dam were also the highest in 2010 since the comprehensive surveys began in 2002 (Table 4). The percentage of redds counted in the mainstem upstream of Forest Glen was lower in 2007–2010 than in 2002–2006, but the percentage of redds in that reach does appear to have been increasing over the last three years (2007-2010: Figure 2).

The percentage of fin-clipped carcasses upstream of Leaburg Dam in 2010 (Table 5) was the highest since 2002 when marked hatchery fish began to return as adults. Downstream of Leaburg Dam, 87% of the carcasses were fin-clipped in 2010, the highest percentage since comprehensive surveys began.

Other rivers surveyed in 2010 included the South Santiam (July 15–October 12) and Middle Fork Willamette (August 4–October 13) rivers. Active redd building began in early September, with peak counts observed in late September to early October. Redd density in 2010 in the upper section (Pleasant Valley to Waterloo) of the South Santiam was the highest since 2002 (Table 6). Redd density in the Middle Fork Willamette was

Table 1. Spring Chinook salmon redds counted in the four major watersheds of the upper Willamette River basin, 2002–2010.

Run Year	Middle Fork Willamette[a]	McKenzie	South Santiam[c]	North Santiam
2010	91	1,276	799[d]	461
2009	72	698	483	281
2008	134	869	209	226
2007	9	1,487	483	494
2006	184[b]	793	510	254
2005	9	1,147	530	325
2004	9	1,129	373	360
2003	14	1,187	619	673
2002	64	922	914	306
2002 - 2009 Average	62	1,029	515	365
2002 - 2009 SE	23	91	71	53

[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.
[d] Redd count in 2010 is more than 2 SE higher than 2002-2009 average

Table 2. Summary of spawning surveys for spring Chinook salmon in the North Santiam River, 2010, and redd densities (redds/mi) for 2002–2010. Spawning in areas downstream of Stayton may include some fall Chinook salmon.

Survey section	Length (mi)	2010		Redds/mi								
		Carcass	Redds	2010	2009	2008	2007	2006	2005	2004	2003	2002
Minto–Fishermen's Bend	10.0	148	295	29.5	18.8	10.7	32.3	14.8	20.6	17.7	55.5	16.2
Fishermen's Bend–Mehama	6.5	30	48	7.4	3.8	1.5	11.1	4.9	3.1	2.8	6.5	9.4
Mehama–Stayton Island	7.0	15	6	0.9	0.6	0.6	2.1	3.1	2.0	12.6	4.7	6.1
Stayton Island–Stayton	3.3	2	18	5.5	0.3	0.3	6.1	3.9	7.3	7.9	3.6	3.0
Stayton–Greens Bridge	13.7	18	33	2.4	1.8	0.0	--	0.4	0.3	0.2	0.1	0.4
Greens Br.–mouth	3.0	0	4	1.3	3.0	0.3	--	--	0.0	0.0	1.7	4.7
Little North Santiam[a]	17.0[b]	38	57	3.4	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; see McLaughlin et al. 2008 for 2002–2007 release data.

[b]14.4 miles surveyed in 2007.

Table 3. Composition of naturally-spawning spring Chinook salmon estimated from carcasses recovered in the North Santiam River, 2010.

Reach Section	Fin-clipped	Unclipped	% Unclipped
Minto–Fishermen's Bend	111	37	25
Fishermen's Bend–Mehama	21	9	30
Mehama–Stayton Island	12	3	20
Little North Fork Santiam	13	25	66
Total upstream of Stayton Island	157	74	32
Stayton Island–mouth	18	2	10
Total	175	76	30

Table 4. Summary of Chinook salmon spawning surveys in the McKenzie River, 2010, and redd densities (redds/mi) for 2005–2010. Redd densities for 2000-2004 are provided in Cannon et al. 2009.

Survey section	Length (mi)	2010		Redds/mi[a]					
		Carcass	Redds	2010	2009	2008	2007	2006	2005
McKenzie River									
Spawning channel	0.1	5	42	4.2	1.5	3.2	6.8	13.8	12.8
Olallie–McKenzie Trail	10.3	18	190	18.4	10.5	11.9	10.4	14.1	31.1
McKenzie Trail–Hamlin	9.9	24	95	9.6	4.3	2.2	6	1.8	4.2
Hamlin–S. Fork McKenzie	0.3	6	6	20	6.7	6.7	93.3	6.6	--
South Fork–Forest Glen	2.4	4	36	15	7.5	3.3	26.7	10.8	12.1
Forest Glen–Rosboro Bridge	5.7	61	210	36.8	15.3	16.1	30.5	6.7	3.7
Rosboro Br.–Ben and Kay Park	6.5	40	130	20	6.9	10.3	16.6	8.9	12.5
Ben and Kay–Leaburg Lake	5.9	--	--	0	0	0.6	--	--	0.3
South Fork McKenzie									
Cougar Dam–Road 19 Bridge	2.3	20	28	12.2	17	26.5	16.5	23.9	22.2
Road 19 Bridge–mouth	2.1	10	24	11.4	13.8	11	37.6	14.8	16.7
Horse Creek									
Pothole Cr–Separation Cr	2.8	5	20	7.1	0.7	14.3	22.5	9.3	5.4
Separation Creek–mouth	10.7	37	182	17	10.6	13	33.3	16.1	19.2
Lost Creek									
Spring – Limberlost[b]	2.8	0	7	2.5	4.3[b]	1.8[b]	35.7	3.2	15.4
Limberlost–Hwy 126[c]	2	0	28	14	12	10.5	53.6	30	78.5
Hwy 126–mouth[c]	0.5	0	15	30	2	14	--	0	14
Lower McKenzie River									
Leaburg Dam – Leaburg Landing[d]	6	201	263	43.8	27.8	39.2	23.5	12	12.5

[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 (Cannon et al. 2010).

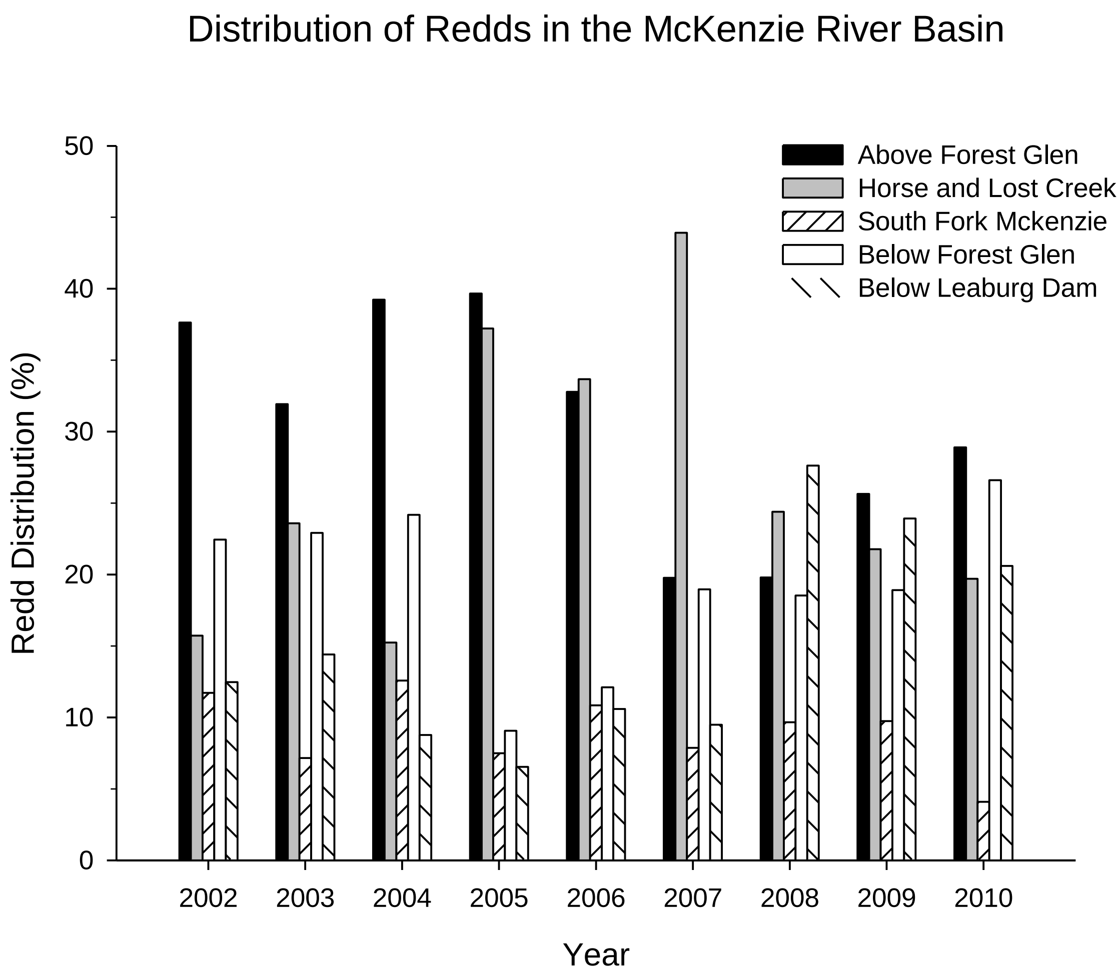


Figure 2. Distribution of spring Chinook salmon redds in the McKenzie River basin, 2002–2010.

Table 5. Composition of naturally spawning spring Chinook salmon from carcasses recovered in the McKenzie River, 2010.

Section	Hatchery	Wild	PHOS
Upstream of Leaburg Dam			
McKenzie spawning channel	3	2	60%
Olallie–Forest Glen	8	44	15%
Forest Glen–Leaburg Lake	66	35	65%
South Fork McKenzie	15	15	50%
Horse Creek	6	36	14%
Lost Creek	0	0	--
Total upstream of Leaburg Dam	98	132	43%
Total downstream of Leaburg Dam	180	27	87%
Total	278	159	64%

Table 6. Summary of Chinook salmon spawning surveys in the South Santiam and Middle Fork Willamette rivers, 2010, and redd densities (redds/mi) for 2002–2010.

Reach	Reach Length (mi)	2010 Carcasses	2010 Redds	Redd Density (redds/mile)								
				2010	2009	2008	2007	2006	2005	2004	2003	2002
South Santiam River												
Foster–Pleasant Valley	4.5	987	667	148	95.8	40.2	92.9	103	113	75.1	132	194
Pleasant Valley–Waterloo	10.5	240	117	11.1	5	2.7	6.2	4.4	2.2	3.3	1.5	1.8
Middle Fork Willamette River												
Dexter–Jasper	9	93	22	2.4	4	14.9	1	20.4[a]	1	1	1.5	7.1

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

lower in 2010 than in 2009, and lower than the highest levels of 2008 and 2006 (Table 6).

Variability of redd counts (Task 1.1.2) Variability of redd counts (Task 1.1.2).— We conducted nine boat and two walking surveys to determine differences in redd counts and to determine which surveyors needed more training. Three sections were resurveyed on the North Santiam River, one section on the South Santiam River, five sections on the McKenzie River, and two sections on Still Creek (Sandy River basin). Differences in redd counts where rafts with elevated towers were used and both sides were surveyed ranged from 4.7–81.4%. Surveying only one side of the river resulted in a redd count difference ranging from 7.1–322.2%. Differences in redd counts on walking surveys ranged from 29.2–67.1%.

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. After discussions with surveyors that had very large differences in redds counts, it was determined that one crew was unfamiliar with the survey section and the other crew did not follow prescribed survey protocol. The section on the South Santiam River from Foster Dam to Pleasant Valley boat ramp is one of the more difficult (high density of redds) sections to count redds and had the lowest difference between surveys (7%). The differences of the walking surveys among surveyors were most likely the result of undercounting or overcounting in sections with multiple redds and redd superimposition.

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 over-count 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 accumulated throughout the entire spawning season. We think that omission errors were 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.

Table 7. Average difference (%) and range (%) between successive counts of spring Chinook salmon redds for three classes of surveys (size of stream and survey method), 2010.

Survey type	n	Difference (%)	Range (%)
Boat - same side	5	127.0	7.1-322.2
Boat - both sides	4	19.8	4.7-81.4
Walking- medium stream	2	48.2	29.1-67.1

Proportion of hatchery spawners (Task 1.1.3).—During surveys in 2010, we sampled unclipped Chinook salmon carcasses collecting 163 otoliths in the McKenzie River, 88 in the North Santiam River, 175 in the South Santiam River (112 downstream of Foster Dam and 63 upstream), 85 in the Middle Fork Willamette River, and 149 in Fall Creek. Fish were initially categorized as naturally produced based on absence of an adipose fin clip. Final estimates of the proportion of hatchery-origin spawners, run size and spawner abundance were derived after otolith analyses allowed adjustments based on the proportions of unclipped hatchery-origin fish.

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 2010 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). We compared the proportions of hatchery-origin fish among sub-basins using the Unplanned G-Test for Homogeneity, (Sokal and Rohlf 1981, P. 728). Overall, there were highly significant differences among sub-basins ($G = 284.3$, $df = 3$, G-critical = 7.815, $P \leq .001$). After ranking the sub-basins by proportion of hatchery fish we performed pairwise G-tests, using an adjusted critical value for the G-statistic to account for the multiple simultaneous tests, and determined that proportions of hatchery fish were significantly different from each other for all sub-basins ($P \leq 0.05$ for S. Santiam vs. M. Fork Willamette, M. Fork Willamette vs. N. Santiam and N. Santiam vs. McKenzie: $G = 31.16$, 10.63, and 25.26, respectively; $df = 1$, G-critical = 7.815). Proportions of hatchery fish were ranked as South Santiam > M. Fork Willamette > N. Santiam > McKenzie.

The estimated number of wild fish in the McKenzie River upstream of Leaburg Dam was lower in 2010 compared to 2005–2009 (Table 9). We estimated a relatively low number of wild Chinook in the North Santiam in 2010, 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).

River (section), run year	Fin-clipped	Unclipped[a] 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)
2010	76	7 (4)	147	64 (53)
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)
2010	146	20(27)	54	(24)
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	305	5(7)	68	18 (19)
2008	51	1 (2)	53	(50)
2009	168	12 (4)	296	(62)
2010	1,115	59 (53)	53	(4)
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)
2010	244	41 (23)	135	(32)

[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.

Pre-spawning mortality (Task 1.1.4).— The 2010 estimates of pre-spawning mortality for spring Chinook salmon were similar to 2009 estimates for the McKenzie and Middle Fork Willamette rivers, whereas 2010 estimates were higher than 2009 for the North and South Santiam rivers (Table 10). All but one of the female carcasses collected in the Middle Fork Willamette in 2010 had not spawned (99% pre-spawning mortality), although 22 redds were counted. We derived an estimated pre-spawning mortality for the Middle Fork Willamette by assuming the 22 redds were from 22 females that had spawned successfully.

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.

	Dam count				Estimated number		
Run Year	Unclipped	Fin-clipped[a] Adjusted	Fin-clipped[a] Unadjusted	Unclipped with thermal marks (%)[b]	Wild	Hatchery[a]	Percent wild[a] (Adjusted)
			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	2,785	61 (49)
2005	2,579	377	515	5.6	2,435	521	82 (79)
2006	2,002	369	641	1.6	1,970	401	83 (75)
2007	2,651	490	525	0.8	2,630	511	84 (83)
2008	1,349	197	252	3.4	1,303	243	84 (81)
2009	1,219[c]	332	487	6.3	1,143	407	74 (67)
2010	1,357	1,007	1,298	4.5	1,296	1,069	55 (51)
			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
2010	434	2,688	--	24.1[d]	329	2,793	11

[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.

[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.

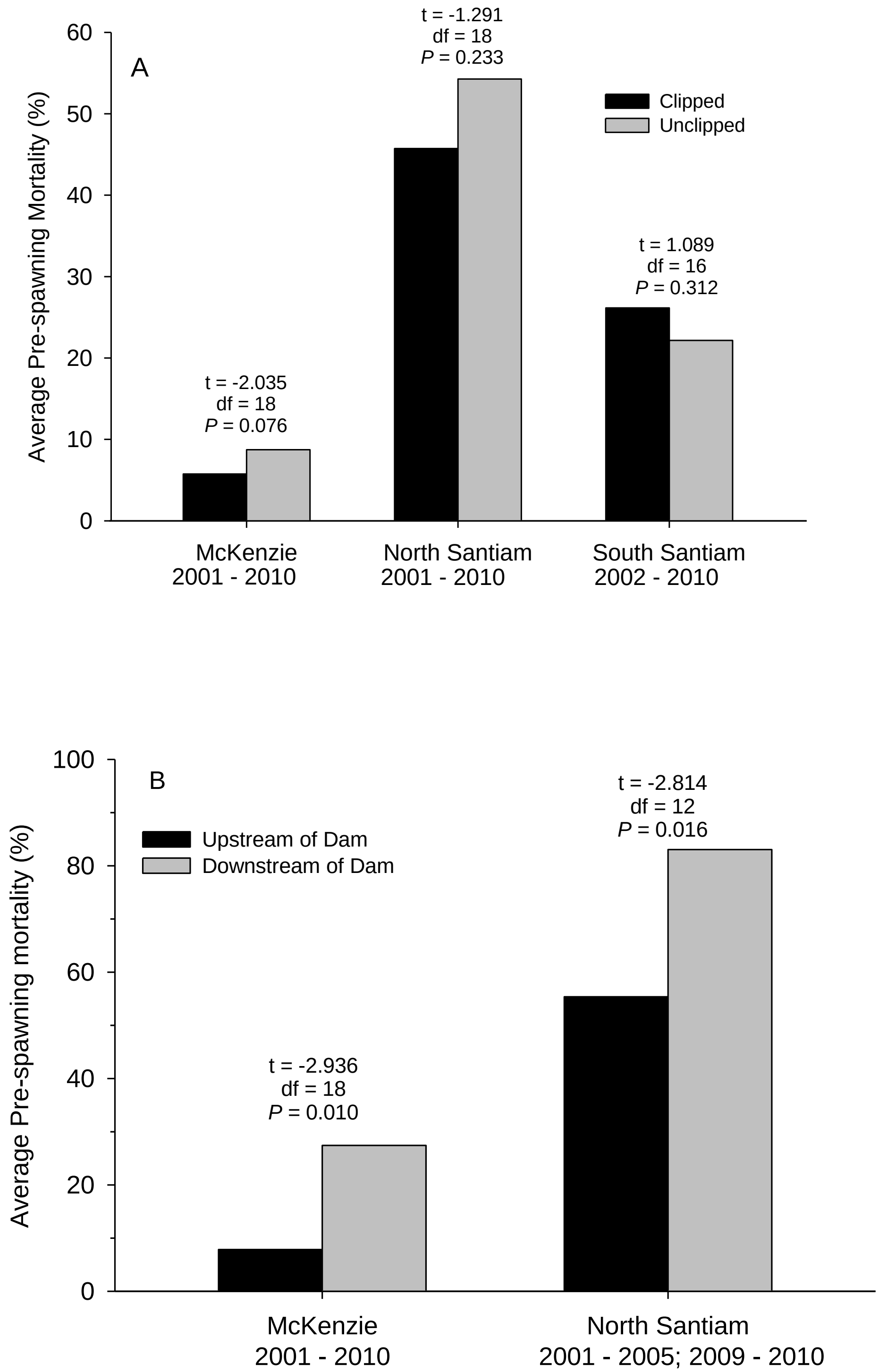


Figure 3. Average pre-spawning mortality of adult spring Chinook salmon in Willamette Basin rivers based on recovery of female carcasses for (A) upstream and downstream of dams, and (B) clipped and unclipped fish. Note different Y-axis scale.

Table 10. Estimated percent pre-spawning mortality for Chinook salmon in the Willamette Basin based on the recovery of female carcasses, 2001–2010. Only areas and years with ≥ 10 recoveries are included. Date of first survey is in parentheses.

Location	2010	2009	2008	2007	Mean 2001–2006[a]
Middle Fork Willamette	89[b] (Aug 4)	77 (Jul 9)	17 (Jul 14)	95 (Jul 10)	86
McKenzie above Leaburg	6 (Aug 9)	6 (Aug 6)	1 (Aug 26)	5 (Aug 15)	10
McKenzie below Leaburg	25 (Jul 29)	23 (Jul 14)	9 (Aug 20)	37 (Jul 31)	30
North Santiam above Bennett[c]	48 (Jul 21)	30 (Jul 22)	30 (Jul 15)	41 (Jul 3)	61
South Santiam above Lebanon	51 (Jul 19)	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] Only one recovered female had spawned, but we counted 22 redds; to estimate pre-spawning mortality, we assumed these redds accounted for 22 successful spawners.

[c] Does not include Little North Fork Santiam.

Table 11. Pre-spawning mortality of fin-clipped and unclipped spring Chinook salmon carcasses based on recovery of female carcasses, 2010. Note that we consider these to be multiple comparisons and the apparently significant difference in the North Santiam River is spurious after adjusting the significance level to account for the three simultaneous comparisons.

	Not spawned		Spawned		G-test Results		
Location	clipped	unclipped	clipped	unclipped	G	df	*P*
McKenzie	30 (24%)	15 (68%)	172	65	0.62	1	0.430
North Santiam above Bennett	37 (35%)	11 (61%)	70	7	4.32	1	0.038
South Santiam above Lebanon	188 (24%)	11 (20%)	595	44	0.47	1	0.494

We did not detect any differences in pre-spawning mortality between clipped and unclipped fish in any of the sub-basins (Table 11 and Figure 3A). While it appeared that there was a tendency for clipped fish to survive to spawning at a higher rate the differences were not significant statistically. However, estimated pre-spawning mortality was significantly higher downstream of dams than it was upstream of dams in the McKenzie (unpaired t-test: t = -2.936, df = 18, P = 0.010) and North Santiam rivers (unpaired t-test: t = -2.814, df = 12, P = 0.016) (Figure 3B), which is similar to reported findings for the Clackamas and Sandy rivers (Schroeder et al. 2007).

Several factors can potentially affect estimates of pre-spawning mortality derived from recovery of female carcasses. Survey efforts can vary spatially and temporally from year to year. These differences can affect recovery of salmon carcasses: scavengers and high river flow can affect the length of time that carcasses remain in river sections where they can be located and recovered by surveyors. Late season carcasses can be difficult to recover after flows begin to increase, and since these fish are more likely to be successful spawners, there is the potential for systematic bias. We believe that pre-spawning mortality estimates of outplanted fish are affected by the following factors: the time of the year that fish are released upstream of dams, the quality of release sites, and water temperature. Therefore, estimates of pre-spawning mortality should be viewed in relative terms (e.g., high, medium, low) rather than as absolute values.

In other work to examine pre-spawning mortality a study was conducted in the North Santiam to estimate distribution and survival of outplanted female spring Chinook. A detailed report under separate cover is in preparation (Emig and Friesen*, in preparation*). The objectives of the study were to: (1) Determine spawning distribution differences between clipped and unclipped adults outplanted in the N. Santiam and Breitenbush rivers above Detroit Dam, (2) evaluate pre-spawning mortality between clipped and unclipped adults, and (3) evaluate the relationship of time of outplanting to the distribution and spawning success of adults.

We used radio telemetry to monitor movement and distribution of a subsample of outplanted Spring Chinook in July through October 2010. We tagged 50 clipped fish and 52 unclipped fish for release on the North Santiam and Breitenbush rivers in July and August. For daily mobile tracking, we installed fixed detection sites on the Breitenbush River at River Mile (RM)) 3.75 and on the North Santiam River at Horn Creek (RM 86.5). Ninety-eight fish were released with radio tags. A total of 5 fish were tracked to spawning and 2 of these were unclipped. Due to the low spawning success of our radio tagged Chinook, we were not able to make strong inferences about spawning distribution: we did not detect a difference in the distribution of clipped and unclipped fish. Migration of clipped and unclipped Chinook was similar except that the North Santiam River unclipped fish had a significantly greater travel distance (Kruskall-Wallis ANOVA: H = 5.240, df = 1, P = 0.022) and unclipped fish as a whole migrated faster. Movement was observed in several patterns: 1) upstream only, 2) upstream, downstream followed by upstream movement, 3) downstream migration represented by fall back into the reservoir, and 4) migration from the Breitenbush River into the North Santiam River. Five fish migrated to the vicinity of Marion Forks Hatchery and only one

Chinook, a clipped fish, migrated above Horn Creek. Three fish fell back into Detroit Reservoir. Four fish migrated from the Breitenbush River through Detroit Reservoir and into the North Santiam River. Of the 24 individuals that had a known fate, we found seven clipped pre-spawn mortalities compared to only three unclipped pre-spawn mortalities. We did not detect any significant differences in the distribution or spawning success between fish released in July and August. We also recovered 43 shed tags in the Breitenbush and North Santiam rivers, and 31 tags were never detected, went missing during the season, or were unrecoverable.

Straying of hatchery fish (Task 1.1.5). We recovered 115 coded-wire tags from spring Chinook salmon carcasses on the spawning grounds in 2010 (Table 12). Of the tagged fish recovered, most were from releases into the sub-basin where tags were recovered (94%: 108 of 115 recovered CWT carcasses). We are not aware of any rigorously defined limit to the percentage of out-of-basin strays that may pose additional risk to endemic populations but that type of straying appears to be a rare event in Willamette sub-basins. We propose to continue monitoring the phenomenon because, given the need to monitor hatchery fish escapement in general, that exercise does not represent any significant increase in effort for our monitoring program.

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 2010, with the first spring Chinook recorded on April 20. Of the spring Chinook passing Leaburg Dam, 52% were unclipped, including jacks (Table 13). The total number of adult spring Chinook passing Leaburg was higher than in 2009, an outcome attributed to the abundance of hatchery spring Chinook in 2010.The proportion of unclipped spring Chinook passing Leaburg Dam in 2010 (52%) was lower when compared to the 2002–2009 average of 72% (Table 14). The number of unclipped adults (1,299) in 2010 increased by about 10% from 2009 but was much lower than the 2005-2009 average (2,046). In contrast, the number of fin-clipped adults at Leaburg Dam increased by about 266% compared to 2009 and was about 230% higher than the 2005–2009 average.

Passage of adult spring Chinook salmon at Leaburg Dam in 2010 occurred from April to October. Peak numbers occurred in June and July (Figures 4 and 5) and transit time from Willamette Falls to Leaburg Dam was approximately one month for unclipped fish. Transit time appears to be more protracted for clipped fish (Figure 5). A secondary peak passage of fin-clipped Chinook occurred in September (306), which represented 24% of the total passage of fin-clipped adults. It appears that the left bank ladder was the one primarily used by fin-clipped fish in September (Figure 6). This September peak has been observed in other years and could present an opportunity to selectively operate the fishway trap: hatchery Chinook could be removed during this period which could potentially reduce the impact on wild fish.

Table 12. Number of locally and remotely released coded-wire tagged hatchery spring Chinook salmon that were recovered as carcasses from Willamette Basin spawning grounds. Expanded sample sizes (in parentheses) are based on the percentage of each release group that was tagged.

		Juvenile Release Location						
River of tag recovery, run year	*n* for sub-basin	Locally released	Lower Columbia netpens	Molalla	North Santiam	South Santiam	MF Willamette	Clackamas
McKenzie								
2007	4(26)	3(23)	--	--	--	--	1(3)[b]	--
2008	10(77)	10(77)	--	--	--	--	--	--
2009	7(59)	3(23)	1(13)[a]	--	--	--	3(23)	--
2010	13(144)	12(137)	--	--	--	1(7)	--	--
North Santiam								
2007	3(27)	2(23)	--	--	--	1(4)	--	--
2008	1(5)	1(5)	--	--	--		--	--
2009	7(35)	7(35)	--	--	--	--	--	--
2010	7(35)	7(35)	--	--	--	--	--	--
South Santiam								
2007	18(86)	17(75)	--	--	1(11)	--	--	--
2008	4(9)	1(6)	3(3)	--	--	--	--	--
2009	10(78)	10(78)	--	--	--	--	--	--
2010	72(534)	67(511)	--	3(11)	--	--	1(7)	1(5)
M. Fork Willamette								
2007	2(15)	2(15)	--	--	--	--	--	--
2008	2(11)	2(11)	--	--	--	--	--	--
2009	4(29)	4(29)	--	--	--	--	--	--
2010	23(169)	22(162)	--	--	--	1(7)	--	--

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

[b] Released in Fall Creek

Table 13. Spring Chinook salmon counted at Leaburg Dam, McKenzie River, April through October 2010.

	Video monitoring				
Month	Unclipped adults	Fin-clipped adults	Unclipped jacks	Fin-clipped jacks	Total
April	2	1	0	0	3
May	138	14	0	0	152
June	608	206	6	1	821
Jul	441	337	10	5	793
Aug	55	68	2	3	128
Sep	50	306	13	0	369
Oct	5	17	1	0	23
Total	1,299	949	32	9	2,289

Table 14. Spring Chinook passage at Leaburg Dam, 2002–2010.

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
2009	1,208	487	10	10	1,715	71
Average[a]	3,103	1,567	5	6	4,678	72
2010	1,357	1,298	32	9	2,696	52

[a] Average includes 2002–2009 for adults and 2004–2009 for jacks. Jacks were not counted in 2002–2003.

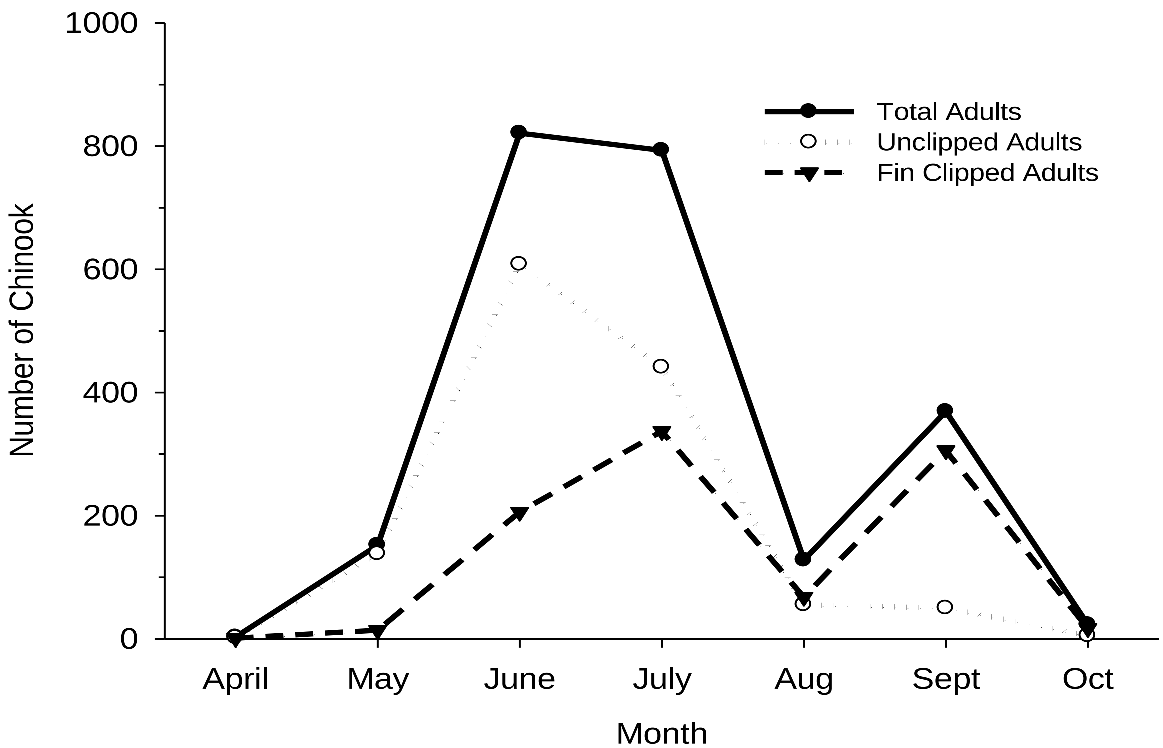
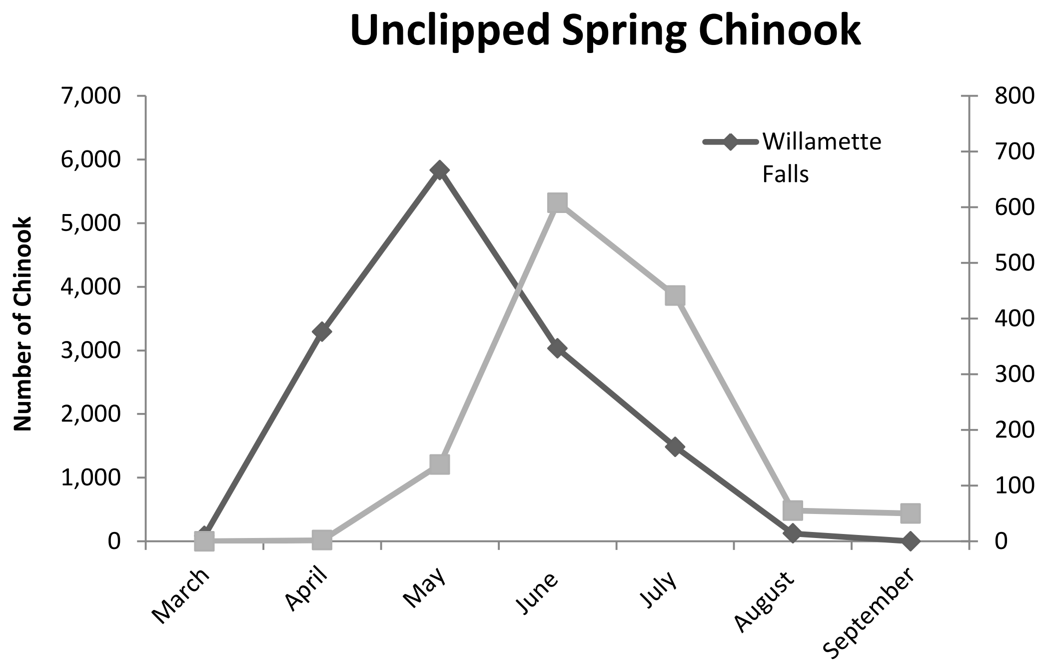


Figure 4. Timing of spring Chinook salmon passage at Leaburg Dam, 2010.



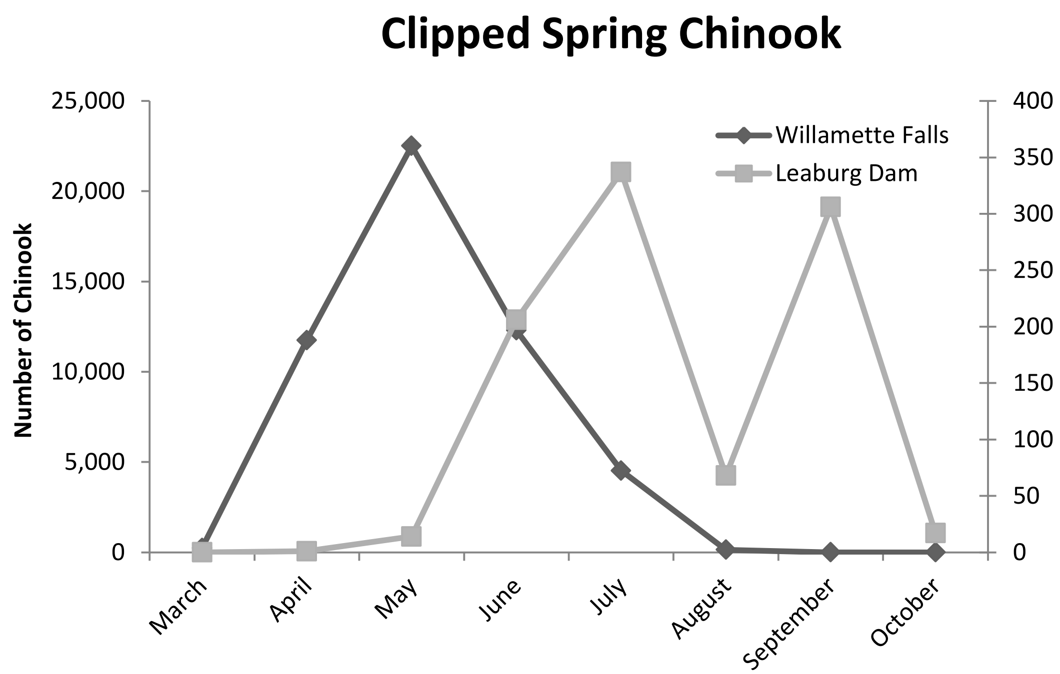


Figure 5. Passage timing of unmarked (top) and hatchery (bottom) spring Chinook salmon over Willamette Falls and Leaburg Dam, 2010. Left axis is count over Willamette Falls; right axis is count past Leaburg Dam.

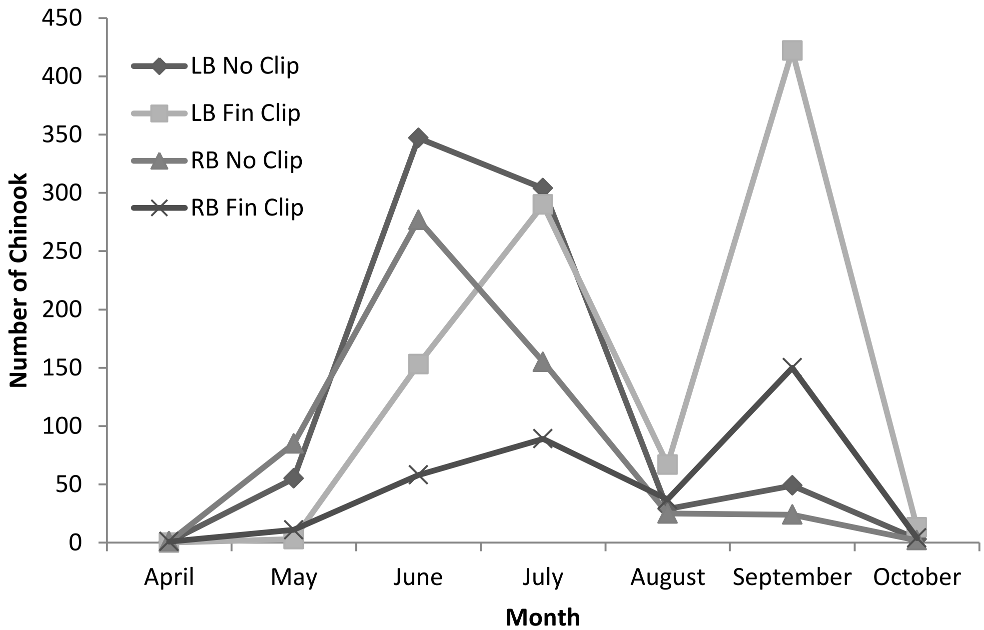


Figure 6. Adult spring Chinook passage at Leaburg Dam in 2010. "LB" and "RB" indicate passage at left bank and right bank, respectively.

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 from April–October 2010 (Table 15). The first spring Chinook was observed during the week of April 11-17. Peak migration for the spring Chinook passing Upper Bennett occurred in June (Figure 7). A larger percentage of the passage occurred during late June and early July due to abnormally high flows and turbidity in the first two weeks of June. There was a higher proportion of unknown marks during June, presumably due to high flows and poor visibility. Poor lighting at times compromised the video resolution and made it difficult to distinguish species or identify fin-clips. Improvements to the equipment were made in 2010, including new lights and a brighter backdrop board, and will continue to be made in 2011. Transit time from Willamette Falls to Bennett Dam was approximately one month for both clipped and unclipped fish (Figure 8).

Total Chinook passage at Bennett dam in 2010 was slightly below the recent 10-year average (Table 16). Importantly, and in contrast to other tributaries in the Willamette basin, counts of fin-clipped Chinook in the North Santiam at upper Bennett dam did not exceed the 10-year average. Overall, the numbers of spring Chinook to upper Bennett dam were higher when compared to 2009 and similar to the 10-year averages.

Table 15. Spring Chinook salmon counted at Upper Bennett Dam, North Santiam River, 2010. 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
April	0	7	0	0	7
May	96	516	65	8	685
June	202	1,403	713	28	2,346
July	133	745	209	14	1101
Aug	1	3	9	1	14
Sep	2	14	2	0	18
Oct	0	0	0	0	0
Total	434	2,688	998	51	4,171

Table 16. Estimated Spring Chinook passage at Bennett Dam, 2001-2010.

Year	Unclipped	Fin-Clipped	Estimated Escapement	Percent unclipped	Willamette Falls Counts	Willamette Falls Percentage
2001	415	5,974	6,389	6.5%	53,973	12%
2002	1,289	6,764	8,053	16.0%	83,136	10%
2003	1,208	11,372	12,580	10.6%	87,749	14%
2004	1,502	12,029	13,531	11.1%	96,725	14%
2005	923	3,960	4,883	18.9%	36,633	13%
2006	*	*	*	*	37,041	*
2007	*	*	*	*	23,099	*
2008	*	*	*	*	14,672	*
2009	369	2,139	2,508	14.7%	28,514	9%
Average	951	7,040	7,991	13.0%	51,282	12%
2010	828	5,128	5,956	13.9%	67,059	9%

[a] Counts in years 2000-2005 were based on a 4 day a week manual trap operation with estimation for the entire week. Counts in years 2009 and 2010 were based on 7 day a week video monitoring.
* Trap was not fully operational in 2006-2008. Partial counts were obtained but not reported.

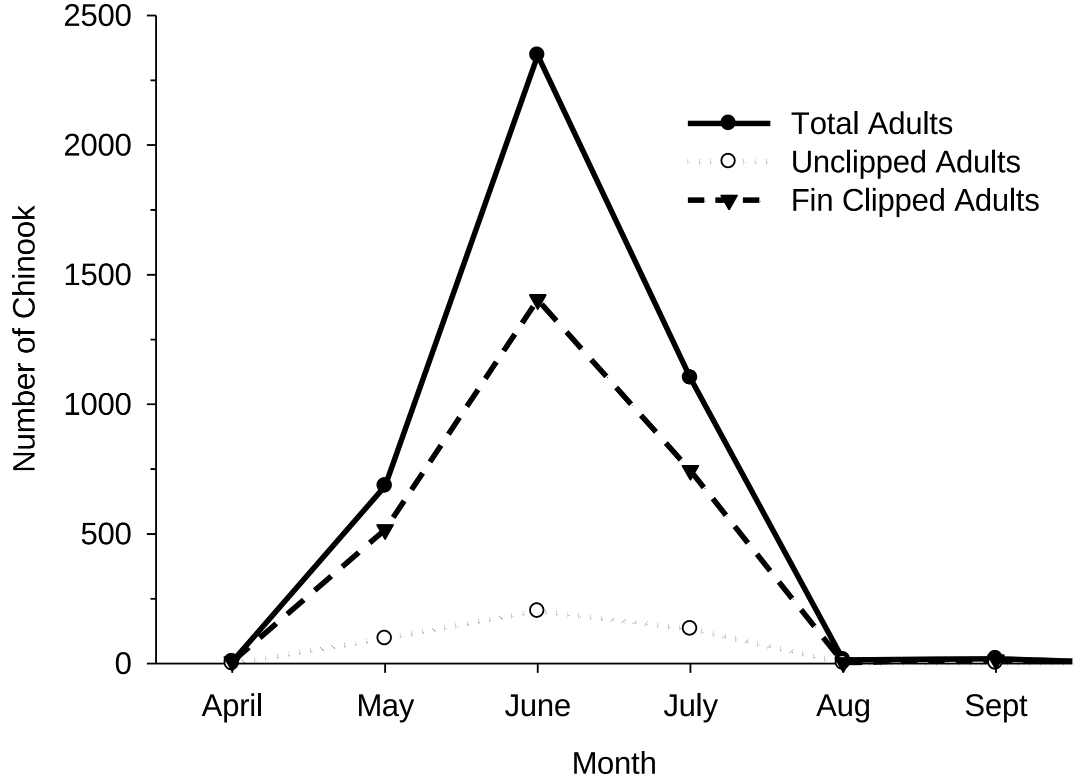
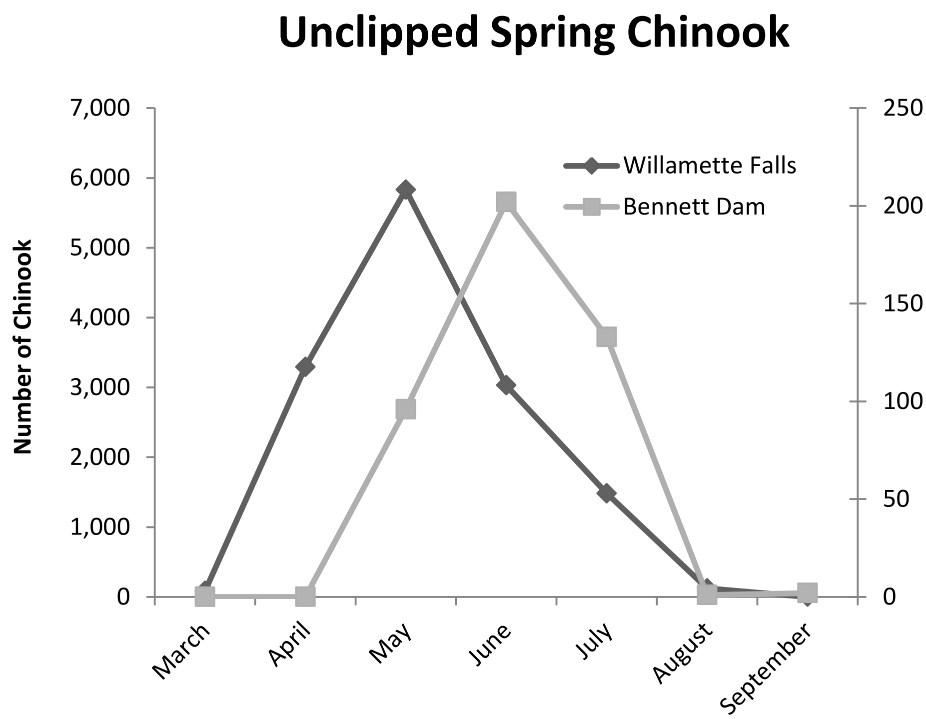


Figure 7. Timing of spring Chinook salmon passing Upper Bennett Dam, North Santiam River, 2010. Total adults include only those of known fin-clip status.



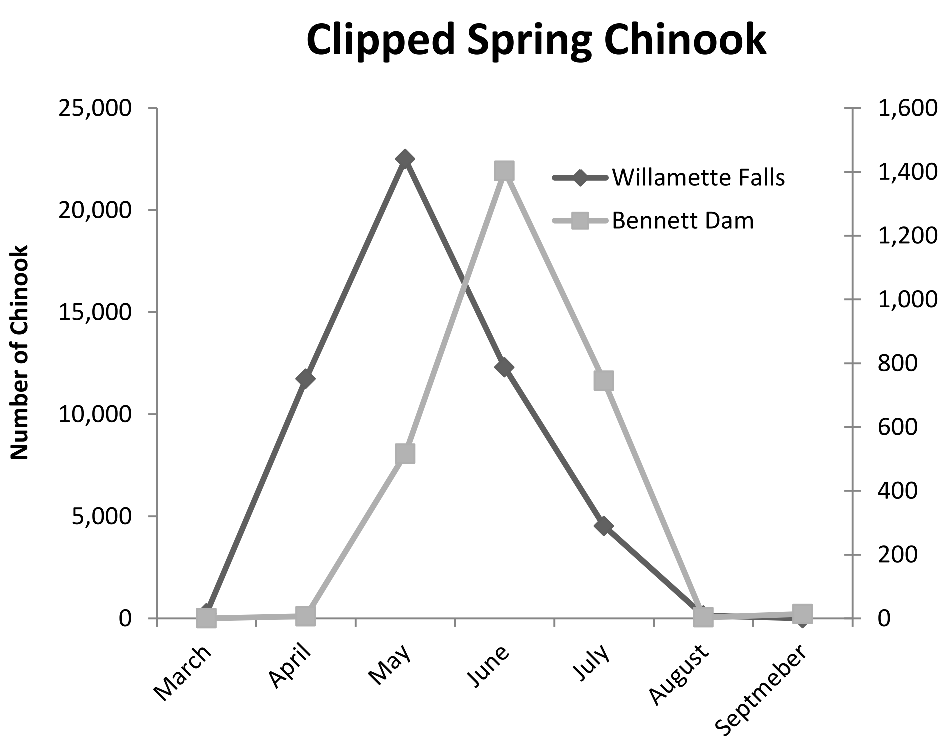


Figure 8. Passage timing of unmarked (top) and hatchery (bottom) spring Chinook salmon over Willamette Falls and Upper Bennett Dam, 2010. Left axis is count over Willamette Falls; right axis is count past Bennett Dam.

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, the ODFW South Willamette Watershed District, and the Corps. Preliminary planning was conducted. It was determined that video monitoring at Lower Bennett could be operational by late spring 2011. The first step is to provide electricity to the site, which is scheduled for completion this spring. The next step is to build the imaging center within the fish ladder that is already present. Lower Bennett is projected to be functional and counting fish by May 2011 (S. Mamoyac, ODFW, pers. comm.). Facility development details are provided in Appendix 2. Installation of video monitoring equipment at Lebanon Dam on the South Santiam River is under consideration by ODFW and the Corps but no improvements, or progress, have been made to date.

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 2010 (Appendix 7). The number of fish counted at the traps did not exactly always 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 2010, 7.5% of the adults and 3.7% of the jacks were unclipped (Tables 17 and 18). These values exclude fish of unknown clip status.

Spring Chinook salmon collected by the hatcheries or fish collection facilities were used primarily for broodstock or reintroduction above the dams (Table 17). The total number of Chinook may include fish handled multiple times 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%), when compared with the two other hatcheries (1–3%). The Santiam hatcheries also 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 17). 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 9). The trap data provide a general time of return but the traps are not operated continuously and therefore trap data do not completely reflect return timing. Peak returns appeared to be unimodal (a single peak in July) at Dexter and South Santiam and bimodal (peaks in July and September) at McKenzie and Marion Forks.

Table 17. Collection, spawning and outplanting of fin-clipped and unclipped spring Chinook salmon entering Willamette basin hatcheries and collection facilities, 2010. Mark status by gender of adults collected for broodstock at McKenzie is unknown.

Hatchery	Action	Marked Males	Unmarked Males	Marked Females	Unmarked Females	Marked Jacks	Unmarked Jacks	Total
Marion Fks/Minto	Collect	2,314	466	1,908	204	52	4	4,892
	Outplant	1,398	437	1,280	182	6	4	3,297
	Spawn	207	27	236	20	2	0	490
McKenzie	Collect	3,944		2,835		195		6,847
	Outplant	622	155	423	64	7	4	1,052
	Spawn	737	57	779	19	4	0	1,596
S. Santiam	Collect	4,625	487	3,457	231	163	10	8,800
	Outplant	0	488	0	232	0	10	720
	Spawn	340	0	354	0	14	0	694
Willamette / Dexter	Collect	3,350	39	2,621	14	145	0	6,024
	Outplant	1,468	59	1,178	48	106	0	2,673
	Spawn	708	36	741	19	4	1	1,488

Table 18. Disposition of fish in excess of broodstock and outplanting needs.

Hatchery	Action	Unspawned males	Spawned Males	Unspawned Females	Spawned Females	Jacks	Sub-jacks	Total
Marion Fks/Minto	Disposal	0	0	0	0	0	0	0
	Donate	305	0	37	0	14	0	356
	Sell	317	0	251	0	22	0	590
	Enrichment	65	234	33	256	3	0	591
McKenzie	Disposal	0	0	0	0	0	0	0
	Donate	1,108	0	752	0	67	0	1,927
	Sell	581	0	368	0	25	0	974
	Enrichment	0	0	0	0	0	0	0
S. Santiam	Disposal	50	0	65	0	5	379	499
	Donate	1,741	0	1,139	0	115	0	2,995
	Sell	0	0	0	0	0	0	0
	Enrichment	582	340	366	354	43	29	1,714
Willamette/ Dexter	Disposal	227	15	252	15	5	0	514
	Donate	197	0	3	0	14	0	214
	Sell	352	0	148	0	9	0	509
	Enrichment	18	744	44	744	0	0	1,550

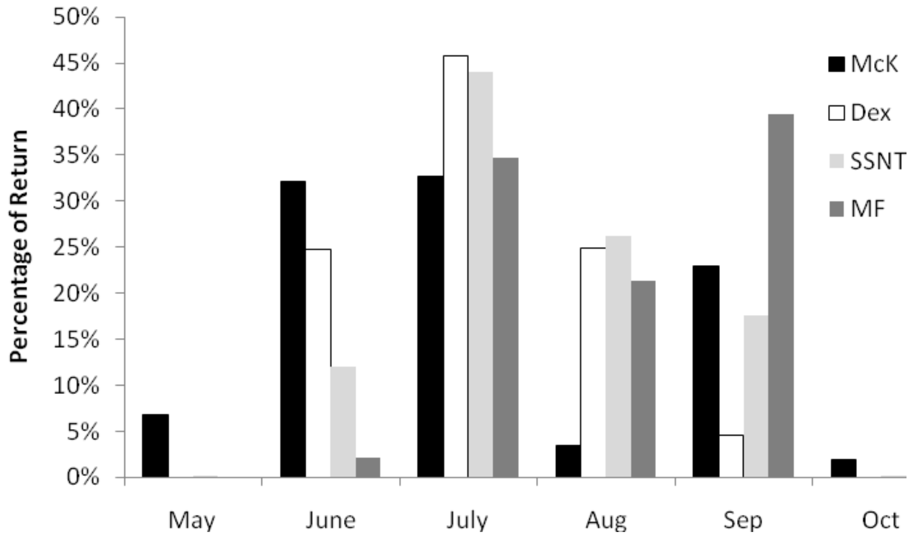


Figure 9. Spring Chinook salmon returns to Upper Willamette hatcheries by month, 2010.

Collection of biological data from spawned and outplanted broodstock and otoliths collection from broodstock (Task 2.1.1 and 2.1.2).—We measured 1,679 fin-clipped and unclipped spring Chinook used for broodstock in 2010. Otoliths were collected in 2010 from unclipped spring Chinook spawned at Willamette basin hatcheries to determine the number and percentage of wild fish incorporated into the broodstocks (Table 19). We collected 72 otolith samples from McKenzie Hatchery, 44 from Minto Pond, and 65 from Willamette Hatchery. No otoliths were collected at the South Santiam Hatchery because no unclipped fish were incorporated in the broodstock. After confirming hatchery or wild origin based on thermal marks (N = 1,617 and 62, respectively) we found no statistically significant differences when all size data were pooled (Mann-Whitney U Statistic = 45,638, T = 475,901, P = 0.230; Figure 10). However, pairwise comparisons within and among hatcheries revealed that North Santiam (Marion Forks) hatchery-origin broodstock tended to be larger than all other groups (Kruskal-Wallis one-way ANOVA on ranks; H = 437, df = 6, P = <0.001 followed by Dunn's Multiple Comparison Procedure; Figure 11).

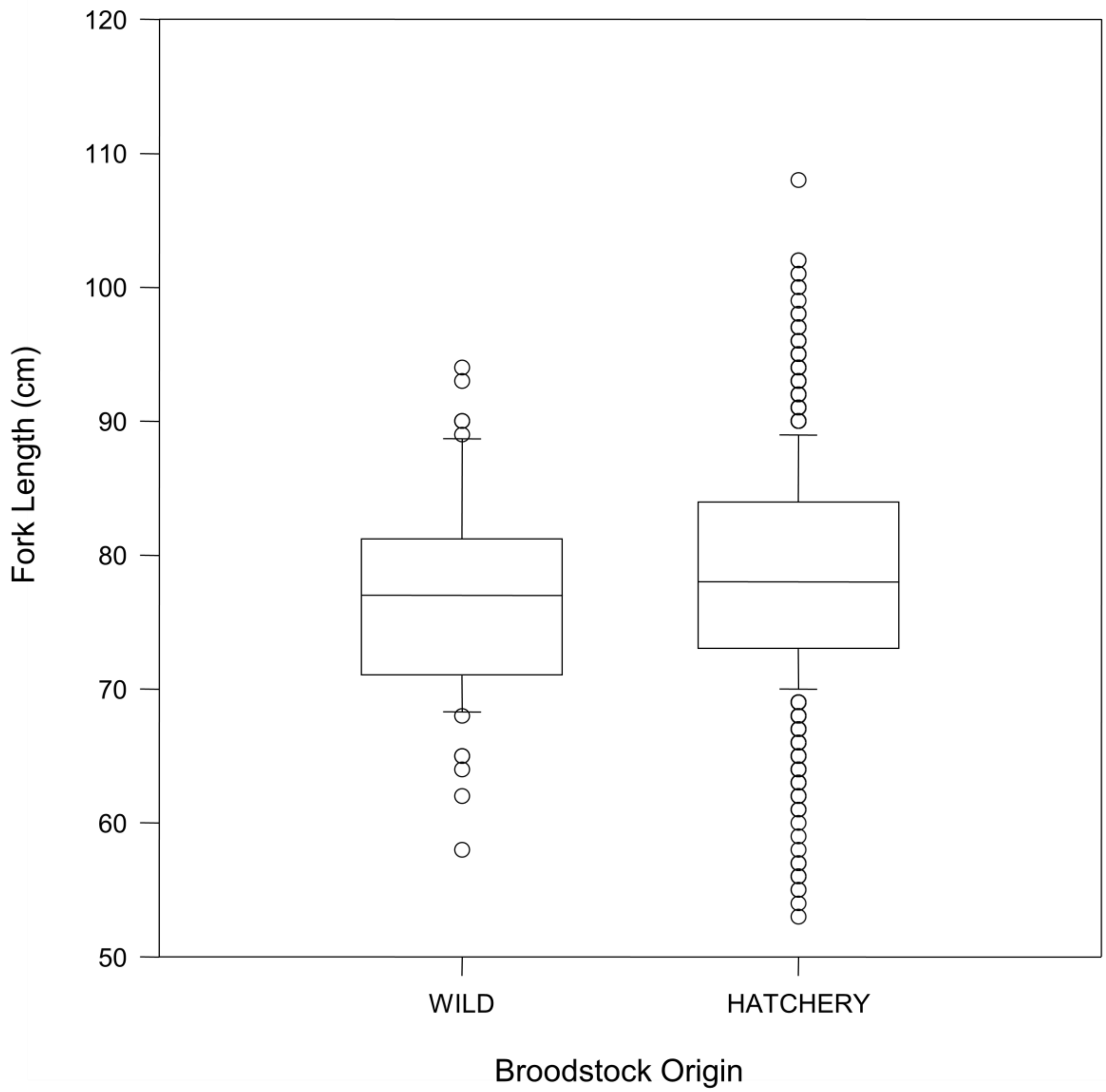


Figure 10. Comparison of fork lengths of wild- and hatchery-origin Chinook salmon used for broodstock in upper Willamette Basin hatcheries, 2010.

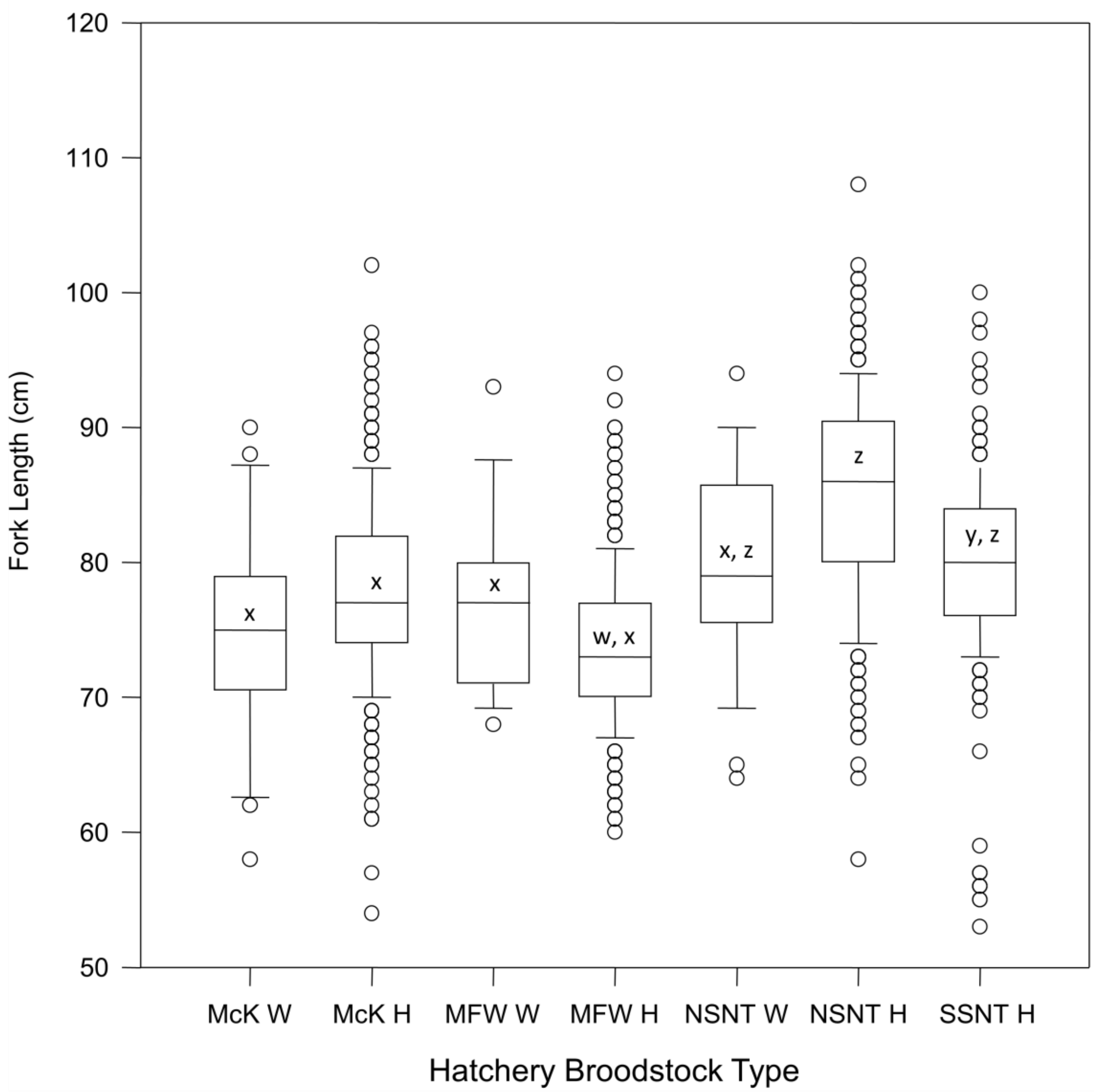


Figure 11. Fork lengths of wild (W) and hatchery (H) broodstock at upper Willamette hatcheries, 2010. McK, MFW, NSNT and SSNT indicate McKenzie, Willamette, Marion Forks (North Santiam) and South Santiam hatcheries, respectively. The horizontal line in each box indicates the median. The top and bottom of each box indicates the 75th and 25th percentile, respectively. The top and bottom whiskers indicate the 90th and 10th percentiles, respectively. Individually plotted points indicate outliers. Letters in common inside each box indicate no significant differences between medians (Dunn's Multiple Comparison Procedure following the Kruskall-Wallis one-way ANOVA on ranks).

Tissue samples (fin clips) were collected from spring Chinook outplanted upstream of the upper Willamette Basin dams. Samples were not collected from Chinook outplanted upstream of Fall Creek Dam. Fin clips were collected from virtually all outplanted Chinook at McKenzie (100%), Willamette (>99%) and South Santiam hatcheries, (98%). Ninety percent of outplants in the North Santiam were sampled. The tissue samples are being stored in ethanol at ODFW facilities in anticipation of analyses for pedigree and other genetic studies.

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 (upper and lower) can be used to estimate spring Chinook numbers on the North Santiam River. Use of video monitoring equipment will give a count of clipped and unclipped Chinook passing the Bennett dams, which will help with evaluation of the composition of potential broodstock in any given year. Video monitoring equipment is in place at Upper Bennett Dam and was used in 2010 (see Figures 7 and 8). At this time, Lower Bennett Dam does not have video monitoring equipment but construction of a station is underway. 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 into historic habitats and subsequently increase natural production upstream of Willamette Project dams, adult spring Chinook salmon have been collected at trapping facilities and transported to previously determined release sites. In 2010, 7,287 fish (primarily of hatchery origin: see Table 17) 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 downstream of Detroit Dam (Table 20). This section describes surveys conducted in reaches upstream of project dams (Table 21) to document spawning activity of the outplanted fish. Refer to Task 1.1 for a discussion of surveys conducted below dams.

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). Seven hundred and eighty three (346 female) adult fish were released into the Breitenbush River at Cleator Bend Camp Ground (Rm 12) on five occasions between July 16 and September 22. An additional 51 radio-tagged female adults (25 clipped, 26 unclipped) were released in the Breitenbush River on July 14 and August 6 at the Detroit water intake (Rm 2) for a total outplant of 834 fish. The Breitenbush River was regularly surveyed on five occasions from August 31 to October 18 to recover carcasses and count redds. Redd construction was first observed on August 31 and peak spawning occurred in late September and early October. Recovery of 29 female carcasses indicates that pre-spawn mortality was low (7%).

Table 19. Composition of unclipped spring Chinook salmon spawned at Willamette basin hatcheries, based on the presence or absence of thermal marks in otoliths, 2002–2010. 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.

River	Year	Unclipped Wild	Unclipped Hatchery	Fin-clipped	Percent wild in broodstock	Percent wild of Run	Percent wild 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	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
	2010	21	55	1,520	1.3	1.5	1.6
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
	2010	27	22	445	5.5	3	6.4
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	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
	2010	0	0	708	0	0	0
Middle Fork Willamette	2002	5	53	1,602	0.3	3.1	42
	2003	5	59	1,465	0.3	8.8	76.3
	2004	16	28	1,807	0.9	8.2	81
	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	25.5	45.4
	2009	61	57	1,807	3.2	27.8	76.5
	2010	15	41	1453	1.0	17.4	75.0

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

Table 20. Adult spring Chinook salmon outplanted, redd counts, fish per redd, and percent pre-spawning mortality in upper Willamette basin tributaries, 2010.

Section	Fish outplanted	Females	Redds	Adults/ redd	Females/ redd	Pre-spawn mortality (%)
Breitenbush above Detroit	834[a]	397[a]	193	4.3	2.1	7
North Santiam above Detroit	1,650[b]	746	310	5.3	2.4	8
South Santiam above Foster	728	231	152	4.8	1.5	5
South Fork McKenzie	762	320	190	4.0	1.7	8
Middle Fork Willamette[c]	1,356	613	15	--	--	--
North Fork M Fk Willamette	1,423	573	193	7.4	3.0	55
Fall Creek	534	246	61	8.8	4.0	47
Little North Fork Santiam	132	44	57	2.3	0.8	46

[a] Includes 98 radiotagged females released above Detroit Reservoir.
[b] Includes 261 adults (146 females) released into Detroit Reservoir.
[c] Outplants on the Middle Fork Willamette were above Hills Creek Reservoir. No comprehensive surveys conducted for Chinook.

In the North Santiam River above Detroit Dam, 1,389 adults (600 females; 49 unclipped and 49 clipped w/radio tags) were released at Cooper's Ridge Road (Rm 62) on nine dates between July 7 and September 20. An additional 261 adults (146 females) were released in Detroit Reservoir at Mongold boat ramp on September 15 and 28 for a total outplant of 1,650 adults. Each reach of the North Santiam River above Detroit was surveyed on at least three and up to six occasions from July 9–October 11. The first redd was observed on August 24 with the peak counts in late September and early October. Of the 310 redds counted in the North Santiam River, 58% occurred in Horn and Marion Creeks bordering Marion Forks Hatchery. Pre-spawning mortality was low (8%) based on the recovery of 73 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: the Calkins boat ramp at the head of the reservoir (Rm 40), Riverbend State Park (Rm

44), and Gordon Road (Rm 54). Seven hundred and twenty adults (232 females) and ten jacks were outplanted throughout the run on 24 separate occasions (May 14–September 15); however, upstream release at the Gordon Road site did not begin until mid July. Most fish were Floy (Floy Tag, Inc., Seattle WA) tagged to assess distribution and spawning success.

Each reach upstream of Foster Dam on the South Santiam River was surveyed at least twice and up to five times from August 16–October 12. The first redd was observed on September 14. The highest concentration of redds was counted in the section starting at the Gordon Road release site upstream to the end of accessible habitat (Table 21). Pre-spawning mortality was low (5%) based on the recovery of 55 female Chinook carcasses, three of which were unspawned.

South Fork McKenzie River above Cougar Dam.—Fin-clipped and unclipped fish were outplanted into the South Fork McKenzie River above Cougar Dam on 12 dates between July 19 and October 5 (Table 22). Outplant locations were the Slide Creek boat ramp into the reservoir (Rm 8.5), Hard Rock Campground (Rm 11.5), and FS Road 430 bridge near Homestead Campground (Rm 18). Outplants were from the McKenzie Hatchery (259 males, 250 females and one jack) and via the Cougar Dam Trap and Haul operation (179 males, 70 females and 3 jacks).

Spawning surveys were conducted October 6–14 from the head of the reservoir to Elk Creek. Carcass recovery was poor in the South Fork McKenzie upstream of Cougar Dam, and only 25 females were recovered—of which two had died before spawning (8% pre-spawn mortality). The recovery rate of female carcasses in the South Fork McKenzie (5%) was similar to that in the Breitenbush River (7%), but was lower than that in South and North Santiam rivers and Fall Creek upstream of dams (13–36%). The latter streams are smaller and easier to walk. Carcasses can be difficult to retrieve in the South Fork McKenzie because of scavenging by animals, swift current, and deep pools.

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 in 2010 (July 13–August 11). On the North Fork Middle Fork, 1,423 adults (573 females) and 56 jacks were released at Rm 18.5 (Table 20). Spawning and carcass surveys were conducted by ODFW biologists in support of an adult condition study conducted by the University of Idaho (UI) and Oregon State University (OSU). Over 60% of the 193 redds counted were within a few miles upstream of the release site. We estimated that pre-spawning mortality was 55% in the North Fork Middle Fork, based upon the recovery of 139 female carcasses.

A total of 1,350 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); approximately 16% were females. Spawning surveys were conducted by USFS and ODFW's Bull Trout Project personnel mainly for bull trout. Spawning surveys above Hills

Creek Dam do not encompass the full extent of Chinook spawning distribution. A total of 11 redds were counted and an additional four possible redds were noted. Carcasses were not observed during these surveys.

Fall Creek above Fall Creek Dam. A total of 534 unclipped spring Chinook salmon collected at Fall Creek Dam were outplanted approximately three miles above the head of the reservoir (Table 21). In addition, six jacks were released upstream. Fish were released throughout the run (April 22–October 13). ODFW personnel conducted surveys to collect carcasses, assisted by UI investigators. Pre-spawning mortality was estimated to be 47% in Fall Creek based on recovery of female carcasses, which is lower that estimated from radio telemetry (63%). Previous years' pre-spawn mortality estimates were 9.4% in 2008 and 84.8% in 2009. River temperatures in 2010 remained below 22°C with peak temperatures occurring in mid-August, later than in previous years. Assuming that each redd represented one surviving female, then mortality estimated from the number of redds (61) was 47% of all released females.

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 2010, 132 unclipped fish (88 males, 44 females) were outplanted on three dates between July 2 and July 20. 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 at least four and up to six occasions from August 4–October 13. The redd count in 2010 (57) was similar to the 2005–2009 average (58). Recovery of tagged adults was low (8), making it difficult to determine the fate of outplanted fish. Eleven tagged fish returned to the Minto Collection Facility and no tagged fish were found in the North Santiam downstream of Minto. Recovery rate of the outplanted female carcasses was low (7%), similar to surveys upstream of dams in South Fork McKenzie (5%) and Breitenbush (7%). Our estimate of pre-spawning mortality based on the recovery of 19 female carcasses was 46%.

Table 21. Spring Chinook salmon survey sections and redd counts above Willamette Valley Project dams, 2010.

Stream	Section	Miles surveyed	Redds
Breitenbush River	NF Breitenbush: Mink Cr. to mouth	1.5	3
	SF Breitenbush: Debris jam to mouth	1.5	12
	SF Breitenbush to Hills Cr.	2.0	47
	Hills Cr. To Scorpion Cr.	1.7	43
	Scorpion Cr. to Fox cr.	1.4	9
	Fox Cr. to Humbug Cr.	1.4	34
	Humbug Cr. to Byars Cr.	1.5	16
	Byars Cr. To Upper Arm Picnic Area [a]	2.4	25
North Santiam River	Parrish Lake Rd. to Straight Cr.	3.5	---
	Straight Cr. to Bugaboo Cr.	2.6	0
	Bugaboo Cr. To Horn Cr.	1.7	43
	Horn Creek: Mouth to weir	0.5	104
	Marion Creek: Mouth to weir	0.5	75
	Horn Cr. to Minto Cr.	1.2	49
	Minto Cr. to Pamelia Cr.	2.8	39
South Santiam River	Falls to Soda Fk.	0.5	25
	Soda Fk to Little Boulder Cr.	1.8	17
	Little Boulder Cr. to Trout Cr.	2.0	41
	Trout Cr. to second trib below	1.4	6
	2nd trib to Gordon Rd.	1.8	23
	Gordon Rd. to Moose Cr.	2.6	11
	Moose Cr to Cascadia	2.5	11
	Cascadia to High Deck Rd.	1.6	10
	High Deck Rd. to Shotpouch Bridge	1.7	0
	Shotpouch Bridge to Riverbend Campground	2.2	4
	Riverbend Campground to Reservoir	1.5	4
South Fork McKenzie R.	Elk Creek to Frissel Campground	2.7	3
	Frissel Campground to Twin Springs	2.1	17
	Twin Springs Campground to Homestead C.G.	2.0	32
	Homestead C.G. to Dutch Oven Campground	2.1	30
	Dutch Oven Campground to Reservoir	6.9	108
Fall Creek	Falls to Gold Cr.	1.0	2
	Gold Cr. to Hehe Cr.	3.5	23
	Hehe Cr. to FS Rd. 1828 Bridge	1.8	12
	FS Rd. 1828 Bridge to Bedrock Campground	2.7	3
	Bedrock Campground to Johnny Cr. Bridge	1.3	1
	Johnny Cr. Bridge to Site "C"	4.7	1
	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	5
	FS Rd. 1944 to Kiahanie Bridge	5.4	38
	Kiahanie Bridge to CHS release site	4.5	80

[a] Byar Cr to Wind Cr and Wind Cr to Upper Arm Picnic Area sections combined in 2010.

Temperature monitoring. Temperature data were collected for outplant sites on Little North Fork, Breitenbush, and North Santiam (Cooper's Bridge) rivers; and at the fish ladders on the Upper and Lower Bennett dams. In general, temperatures were unremarkable. Upper Bennett fish ladder was slightly cooler than the lower Bennett fish ladder. The river bottom of the Narrows on the Little North Fork (~ 12m max. depth) was 3°C cooler than the river thalweg at maximum recorded temperature.

Table 22. Temperature data for select fish passage and outplanting sites in 2010. All temperatures are ° C recorded every 15 minutes for the period from 9 June 2010 through 15, October 2010. LNFk indicates Little North Fork Santiam.

Location	Mean temperature °C	Range (min. – max.)
LNFk narrows river bottom	15.0	10.6 - 20.7
LNFk river thalweg outplant site	15.0	10.5 - 23.3
Breitenbush outplant site	11.0	7.0 - 14.9
N. Santiam Cooper's Bridge	11.0	6.4 - 15.5
Upper Bennett Dam fish ladder	14.1	8.3 - 20.0
Lower Bennett Dam fish ladder	14.5	8.5 - 20.4

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

We collected 299 tissue samples from unclipped juvenile steelhead at Willamette Falls, five from the mainstem Willamette River, and two from the South Santiam River in 2010. In addition, we obtained one sample from an unclipped adult steelhead at the Minto fish collection facility. After preserving and cataloging the samples, they were shipped to the NOAA Fisheries lab in Manchester, WA for analysis (see Van Doornik and Teel 2010).

A formal study plan to estimate natural production of summer- and winter-run steelhead has been developed and is included in this document as Appendix 6.

Task 3.2: Evaluate release strategies for summer steelhead to increase migration and reduce impacts on wild fish [RPA 6.1.6]

Study plans to evaluate advantages and disadvantages of volitional release strategies were completed and presented in the 2009 annual report to USACE (Cannon et al. 2010). Funding to address the issue was not available in 2010 and no progress was made on executing the proposed work.

Acknowledgments

Many individuals and groups helped with this study. We thank hatchery managers Brett Boyd, Greg Grenbemer, Kurt Kremers, Dan Peck, and their crews for collecting data from fish captured at their facilities and conducting the otolith marking at their hatcheries. We also thank Kurt Kremers, the McKenzie Hatchery staff, and Mike Hogansen for providing count data for Chinook salmon at Leaburg Dam. Mike Hogansen also provided data on genetic sampling. We thank Greg Taylor and Doug Gartletts of the U.S. Army Corps of Engineers for providing spawning survey data for Fall Creek. We would like to recognize seasonal biologists Chris Abbes, Amy Anderson, Bart Debow, David Duckett, Wes Edwards, Brian Franklin, Greg Gillam, Todd Gillen, Khoury Hickman, Michelle MacArthur, Meghan Horne-Brine, David Jones, Dave Metz, Jon Pender, Tim Plawman, Eva Riedlecker, Kevin Stertz, Andrew Walch, and Jessie Wolfe, who collected much of the field data during spawning ground surveys.

References

Araki, H., B. Cooper and M.S. Blouin. 2007. Genetic effects of captive breeding cause a rapid, cumulative fitness decline in the wild. Science. 318:100-103.

Blouin, M. S. 2003. DNA-based methods for pedigree reconstruction and kinship analysis in natural populations. Trends in Ecology and Evolution 18:503–511.

Busack, C. A. and K. P. Currens. 1995. Genetic Risks and Hazards in Hatchery Operations: Fundamental Concepts and Issues. American Fisheries Society Symposium 15:71-80.

Cannon, B., R. Emig, T. A. Friesen, F. Monzyk, R. K. Schroeder, and C. A. Tinus 2010. Work Completed for Compliance with the 2008 Willamette Project Biological Opinion, USACE funding: 2009. Annual report to USACE. 66 pp.

Chilcote, M.W., K.W. Goodson and M.R. Falcy. 2011. Reduced recruitment performance in natural populations of anadromous salmonids associated with hatchery-reared fish. Canadian Journal of Fisheries and Aquatic Sciences. 68:511-522.

Cuenco, M. L., T. W .H. Backman, and P. R. Mundy. 1993. The use of supplementation to aid in natural stock restoration. Pages 269–294 *in* Genetic Conservation of Salmonid Fisheries, J.G. Cloud and G.H. Thorgaard, editors. Plenum Press, New York.

Dunham, J., B. Rieman, and K. Davis. 2001. Sources and magnitude of sampling error in redd counts for bull trout. North American Journal of Fisheries Management 21:343–352.

Emig, R. and T. Friesen. In Preparation. Spawning distribution and success of clipped and unclipped adult spring Chinook above Detroit Dam. Draft Report to USACE. 13 pp.

Firman, J., M. Buckman, R. Schroeder, and K. Kenaston, M. Hogansen, and B. Cannon. 2005. Work Completed for Compliance with the Biological Opinion for Hatchery Programs in the Willamette Basin, USACE funding: 2004. Oregon Department of Fish and Wildlife, Task Order NWP-OP-FH-02-01, Salem.

Hard, J. J., R. P. Jones, M. R. Delarm, and R. S. Waples. 1992. Pacific salmon and artificial propagation under the Endangered Species Act. Technical Memorandum NMFS F/NWC-2, NOAA, Northwest Fisheries Science Center, Seattle.

Kenaston, K., K. Schroeder, F. Monzyk, and B. Cannon. 2009. Interim Activites for Monitoring Impacts Associated with Hatchery programs in the Willamette Basin, USACE funding: 2008. Task Order NWPOD-08-FH-05, Annual Report. Oregon

Department of Fish and Wildlife, Corvallis.

Kostow K. E., and S. Zhou. 2006. The effect of an introduced summer steelhead hatchery stock on the productivity of a wild winter steelhead population. Transactions of the American Fisheries Society 135:825-841.

Levin P. S., and J. G. Williams. 2002. Interspecific effects of artificially propagated fish: an additional conservation risk for salmon. Conservation Biology 16:1581-1587.

Muhlfeld C. C., M. L. Taper, D. F. Staples, and B. B. Shepard. 2006. Observer error structure in bull trout redd counts in Montana streams: implications for inference on true redd numbers. Transactions of the American Fisheries Society 135:643–654.

NOAA (National Oceanic & Atmospheric Administration). 2008. Consultation on the “Willamette River Basin flood control project”. NOAA National Marine Fisheries Service, Northwest Region. NOAA Fisheries Log Number F/NWR/2000/02117, Seattle.

NMFS (National Marine Fisheries Service). 1999a. Endangered and threatened species: threatened status for two ESUs of steelhead in Washington and Oregon. Federal Register 64:14517-14528.

NMFS. 1999b. Endangered and threatened species: threatened status for three Chinook salmon evolutionarily significant units (ESUs) in Washington and Oregon, and endangered status of one Chinook salmon ESU in Washington. Federal Register 64:14307-14328.

NMFS. 2008. 2008-2023 Willamette River Basin Project Biological Opinion. NOAA’s National Marine Fisheries Service, Northwest Region, Seattle, WA. F/NWR/2000/02117.

Schroeder, R. K., K. R. Kenaston, and L. K. Krentz. 2005. Spring Chinook salmon in the Willamette and Sandy rivers 2005: with 1996–2004 summaries. Oregon Department of Fish and Wildlife, Fish Research Report F-163-R-10, Annual Progress Report, Salem.

Schroeder, R. K., K. R. Kenaston, and L. K. McLaughlin. 2007. Spring Chinook salmon in the Willamette and Sandy rivers 2006–2007. Oregon Department of Fish and Wildlife, Fish Research Report F-163-R-11/12, Annual Progress Report, Salem.

Sokal, R.R. and F.J. Rohlf. 1981 Biometry, second ed. 859pp.

Steward, C. R. and T. C. Bjornn. 1990. Supplementation of salmon and steelhead stocks with hatchery fish: a synthesis of published literature. Technical Report 90-1. Idaho Cooperative Fish and Wildlife Research Unit. University of Idaho, Moscow, ID.

Van Doornik, D. M, and D. J. Teel. 2010. Genetic analysis of Willamette River steelhead of unknown run origin. Final Report to U.S. Army Corps of Engineers, Order No. W66QKZ01256317 and Oregon Department of Fish and Wildlife. NOAA Fisheries, Northwest Fisheries Science Center, Manchester, WA.

Waples, R. S. 1999. Dispelling some myths about hatcheries. Fisheries 24(2):12-21.

Zymonas, N.D., J.V. Tranquilli, and M. Hogansen *in prep*. Monitoring and Evaluation of Impacts to Bull Trout (*Salvelinus confluentus*) and Spring Chinook (*Oncorhynchus tshawytscha*) in the South Fork McKenzie River from Construction of Water Temperature Control Facilities at Cougar Dam, Oregon. Final project report. Oregon Department of Fish and Wildlife, Corvallis, Oregon.

Appendix 1

Run Size and Spawner Escapement Estimates

Table A1-1. Number of natural origin spring Chinook incorporated into the broodstock, and estimates of the natural origin run size and spawners in the North Santiam River basin, upstream and downstream of Bennett dams, 2002–2010.

		Run[a]				Spawners[c]		
Year	Brood-stock	above Bennett	below Bennett	Harvest[b]	Total	above Bennett[c]	below Bennett[c]	above Minto[d]
2002	4	431	29	15	479	103	10	41
2003	2	224	6	8	240	62	2	10
2004	12	615	26	35	688	146	5	10
2005	18	501	49	19	587	189	18	5
2006	197	441	22	22	682	195	12	89
2007	158	645	24	27	854	335	9	0
2008	154	644	6	**b**	804	403	3	4
2009	5	470	54	17	546	236	25	0
2010	27	771	34	28	860	238	12	147

[a] Number of Chinook accounted for at Minto fish trap excluding broodstock (outplanted upstream of Detroit Dam, released upstream of Minto barrier, transported to Little North Fork or lower North Santiam, and excess used for nutrient enrichment of streams, given to food banks, or killed for coded wire tags or disease culling), plus estimated number of Chinook in river using redds and 2.5 spawners per redd expanded by estimates of pre-spawning mortality. To prevent double-counting fish transported to Little North Fork, the number of transported fish that contributed to the spawning population was estimated by the percentage of recovered carcasses with tags (all transported fish were tagged).

[b] Harvest in 2004 estimated from creel surveys using number released times 12.2% mortality of catch and release (Lindsay et al. 2004), other years were estimated from the wild fish run and effect of catch and release from Lindsay et al. 2004 (encounter rate times mortality rate). Fishery was closed in 2008 because of the low run of unclipped Chinook over Willamette Falls. Creel data in 2003 was not used because the number of released wild fish in the survey was very high relative to the estimated size of the wild run.

[c] Run estimate of natural origin fish (from redds) and pre-spawning mortality. Broodstock would be added to give all potential spawners.

[d] Estimated from number of unclipped fish released upstream of Minto barrier, percentage of natural origin fish from otolith analysis of fish sampled at the hatchery and in the North Santiam downstream of Minto, and estimated spawners based on the proportion of spawners to escapement in the area upstream of Bennett Dam. Surveys have not been conducted upstream of Minto barrier.

Table A1-2. Number of natural origin spring Chinook incorporated into the broodstock, and estimates of the natural origin run size and spawners in the McKenzie River basin, upstream and downstream of Leaburg Dam, 2002–2010.

		Run[b]					Spawners[e]	
Year	Brood-stock[a]	above Leaburg	below Leaburg	Other[c]	Harvest[d]	Total	above Leaburg	below Leaburg
2002	13	3,611	166	2	106	3,898	3,222	139
2003	14	4,899	146	23	70	5,152	4,108	70
2004	24	4,438	81	7	193	4,743	3,950	32
2005	20	2,435	119	2	72	2,648	2,051	84
2006	100	1,970	107	12	61	2,250	1,948	102
2007	81	2,630	106	6	79	2,902	2,496	66
2008	90	1,303	108	6	**d**	1,507	1,289	99
2009	60	1,154	158	4	39	1,415	1,070	123
2010	21	1,296	68	3	39	1,427	1,214	51

[a] Unclipped fish were trapped at Leaburg Dam and taken to McKenzie Hatchery to increase the proportion of natural origin fish incorporated in the broodstock in 2006 (92), 2007 (106), and 2008 (90).

[b] Above Leaburg from counts of unclipped Chinook at Leaburg Dam, below Leaburg from redds downstream of dam and 2.5 spawners per redd expanded by estimates of pre-spawning mortality. Natural origin composition estimated from the otolith analysis of recovered carcasses in river.

[c] Includes mortalities, outplants, and other fish from the hatchery that were not used for broodstock.

[d] Harvest in 2003 and 2004 estimated from creel surveys using number released times 12.5% mortality of catch and release (Lindsay et al. 2004), other years were estimated from the wild fish run and the mean harvest rate in 2002–2003 of wild fish. Fishery was closed in 2008 because of the low run of unclipped Chinook over Willamette Falls. Number of released wild fish reported in creel survey was high in 2004 relative to the estimated wild run.

[e] Above Leaburg from estimated wild run based on Leaburg Dam count and pre-spawning mortality; below Leaburg estimated from run estimate of natural origin fish (from redds) and pre-spawning mortality below Leaburg. Broodstock would be added to give all potential spawners.

Table A1-3. Number of natural origin spring Chinook incorporated into the broodstock, and estimates of the natural origin run size and spawners in the South Santiam River basin, 2002–2010.

						Spawners[d]	
Year	Broodstock	Trap[a]	Fish in river[b]	Harvest[c]	Total	below Foster	above Foster
2002	26	562	447	34	1,069	332	416
2003	25	313	279	20	637	200	220
2004	78	1,278	601	66	2,023	171	360
2005	71	756	407	41	1,275	279	507
2006	137	65	239	15	456	209	51
2007	89	23	253	12	377	232	16
2008	268	169	294	**c**	731	271	62
2009	2	351	873	41	1,267	775	166
2010	0	557	179	24	760	82	294

[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] Harvest in 2004 estimated from creel surveys using number released times 12.2% mortality of catch and release (Lindsay et al. 2004), other years were estimated from the wild fish run and effect of catch and release from Lindsay et al. 2004 (encounter rate times mortality rate). Fishery was closed in 2008 because of the low run of unclipped Chinook over Willamette Falls. Creel data in 2003 was not used because the number of released wild fish in the survey was very high relative to the estimated size of the wild run.

[d] Below Foster (all years) and above Foster (2007–2010) from run estimate of natural origin fish (from redds) and pre-spawning mortality. Spawners upstream of Foster in 2002–2006 were estimated from the proportion of spawners to escapement in survey areas downstream of Foster Dam because no regular redd surveys were conducted upstream of Foster.

Table A1-4. Number of natural origin spring Chinook incorporated into the broodstock, and estimates of the natural origin run size and spawners in the Middle Fork Willamette River, and the number of natural origin spring Chinook counted at Fall Creek Dam, 2002–2010. Redd count in 2006 includes redds counted by Corps of Engineers biologists in side channels not surveyed by ODFW.

Year	Broodstock	Trap[a]	Fish in river[b]	Harvest[c]	Total[d]	Spawners[e]	Fall Creek
2002	5	77	43	4	129	7	73
2003	5	9	7	1	22	2	103
2004	16	41	38	3	98	4	592
2005	19	31	13	2	65	3	119
2006	45	33	266	11	355	251	335
2007	161	90	127	12	390	6	209
2008	105	154	153	0	412	126	268
2009	62	34	90	6	192	20	250
2010	15	6	48	2	71	5	534

[a] Natural origin fish handled at Dexter trap excluding fish used for broodstock or recycled. Includes fish outplanted and fish that died at the 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] Estimated from the wild fish run and effect of catch and release from Lindsay et al. 2004 (encounter rate times mortality rate). Fishery was closed in 2008 because of the low run of unclipped Chinook over Willamette Falls. Creel data in 2003–2004 was not used because the number of released wild fish in the survey was very high relative to the estimated size of the wild run.

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

[e] Run estimate of natural origin fish (from redds) and pre-spawning mortality. Broodstock would be added to give all potential spawners.

Appendix 2

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)

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]

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.

STEELHEAD

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

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

Task 3.2: Evaluate release strategies for summer steelhead to increase migration and reduce impacts on wild fish [RPA 6.1.6]. [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 3

2011 Lower Bennett Dam Fish Ladder Power Supply Project

Site Work, Earthwork, and Related Operations

1. Excavate and trench 3’ deep for 587’ from “City of Salem” fuel building to south edge of Lower Bennett dam fish ladder. Trench will start on North side of fuel building below planned external fuel building junction box and extend adjacent to paved surface through grass area to fish ladder gravel road access gate for 87’ and continue 500’ from access gate following south side of graveled road surface to south edge of fish ladder. Excavating and trenching will go through a 20-25’ roadway swale area with standing water 2-5” deep. Include additional cost of labor to dewater and trench across swale area.

2. Furnish and place 2” and 3” PVC electrical conduit and sweeps to cover the total distance of 587’ to junction box location on south edge of fish ladder. The 3” PVC electrical conduit will be for the 240 V 80 amps 4 gauge aluminum service wire. The 2” PVC electrical conduit will be for the multi-strand fiber optic signal cable (670’) and two 12 V DC coaxial lines.

Two 12 V DC coaxial lines (~25’) will plug into the fish ladder modem box inside the junction box to power the 12 V DC underwater camera and two 12 V DC 36 LED lights. The 240 V 80 amps service and fiber optic signal cable will be for the future viewing room in the replaced fish ladder (ladder replacement date unknown).

4. Both the 2” and 3” electrical conduit to be placed in 3’ deep trench. All PVC electrical conduits will meet ODFW bedding requirements. Backfill and machine wheel compact the trench. Furnish and place crushed rock over roadway where excavation may affect the running surface.

Electrical work

1. **Fuel building 240 V 100 amp power line**: Replace 60 amps breaker with 100 amps breaker in “City of Salem” office electrical panel (Cutler Hammer PRL3a) and replace existing 60 amps wire with 100 amps wire from panel through existing 2” PVC conduit to fuel building (~100’). Set new 100 amps load center (copper buss) on inside of fuel building.

Run 80 amps circuit thru 20’ EMT from 100 amps fuel building load center to furnished and installed junction box on North side of fuel building. Install sweep elbow to ground from junction box.

2. **Fish Ladder 240 V 80 amp circuit (Future)**: Pull 240 V 80 amps wire (size wire for load--4 gauge Al) from fuel building to fish ladder junction box location (3" conduit ~587'). A pull box (similar to 1730 "Christie") will be installed to aide pulling of power wire (~273' from fuel building). The 240 V 80 amps circuit will be for the future fish ladder viewing room (ceiling lights, video camera, 300 W work light, and 1000 W heater with fan). The future view room in the new fish ladder will be all 110 V AC power.

3. **Fish Ladder 12 V DC Power line (Present):** Pull two 12 V DC coaxials to pull box and continue to fish ladder junction box location (2" conduit ~587'). Present load to fish ladder will be around 4 amps. One coaxial (RG8X) will provide 12 V DC power to the underwater camera ("Watec" color CCD WAT-232) and will transmit a signal back to a computer at the fuel building. Another coaxial will provide 12 V DC power to the pair of 36 LED underwater lights.

4. **Fish Ladder fiber optic cable (Future):** Pull fiber optic cable to pull box and continue to fish ladder junction box (2" conduit~587'). The fiber optic cable will be pulled in the same 2" PVC electrical conduit that contains the two 12 V DC coaxials. The fiber optic cable will be used in the future to transmit the 110 V camera video signals back to the fuel building computer. The length of the fiber optic cable must be calculated to eventually travel to the future view room camera (~670').

LB Power Supply Project Contacts:

Ryan Terrill (ODFW Eng.) 503-947-6210

Mike Hogansen (ODFW Leaburg) 541-653-6975

Jack Haggard (Code Electric) 503-581-8684 email: jack@code_electric.com

Doug Mansfield (Rocky Mtn. Electric) 503-428-7993

Richard Fuhrman (Fieldcam) 281-474-1388 www.fieldcam.com email: fdi@flash.net

Appendix 4

Project concepts approved for funding in 2011: Final proposals and progress to date

RESEARCH PROPOSAL

I. BASIC INFORMATION

Survivorship, return rate, and phenotypic characteristics among hatchery, wild, and hatchery-wild crosses of spring Chinook salmon in the context of reintroduction

PROJECT LEADERS: Cameron S. Sharpe
Oregon Department of Fish and Wildlife
28655 Hwy 34
Corvallis, OR 97333
(541) 757-4153

Thomas A. Friesen
Oregon Department of Fish and Wildlife
28655 Hwy 34
Corvallis, OR 97333
(541) 757-5151

STUDY CODE: TBD

ANTICIPATED DURATION: May 1, 2011 – December, 2016

DATE OF SUBMISSION: February 10, 2011

II. PROJECT SUMMARY

A. Goals

The goal of this project is to assess the potential for developing hatchery Chinook salmon stocks that produce juveniles similar to “wild type” fish and are therefore most appropriate for future reintroduction to their historic habitats.

B. Objectives

This project adopts the guidance of Peven and Keefe (2010) and specifically addresses an overarching objective to “rear and release high quality hatchery fish to minimize impacts on naturally produced fish and promote conservation and recovery of listed species”. The proposed work addresses two specific management objectives: (1) Rear and release hatchery spring Chinook salmon to mimic size and behavior of naturally produced yearling migrants, (2) Reduce genetic effects of hatchery fish spawning with naturally produced fish.

Project-specific objectives are provided in section III B, below.

C. Methodology
Hatchery crosses have already occurred and were accomplished using standard hatchery protocols. Approximately equal numbers of offspring for hatchery x hatchery (HxH), hatchery x wild (HxW) and wild x wild (WxW) offspring will be reared and released from the Marion Forks Hatchery. All groups will be treated identically with respect to incubation, rearing, and release procedures. Accordingly, all groups will be subjected to similar environmental conditions prior to liberation, allowing for an examination of intrinsic (genetic) differences among groups. Coded wire tagging will occur using the automated marking/ tagging trailers. In-hatchery performance (survival, growth, smoltification) will be monitored monthly. Smolt-to-adult survival estimates will be obtained through tag recoveries (in fisheries, spawner surveys, and hatcheries) as reported to the Regional Mark Processing Center (RMPC) via the online Regional Mark Information System (RMIS).

D. Relevance to Biological Opinion
The proposed work directly addresses RPA 6.2.1, 6.2.2, and 6.2.4.

III. PROJECT DESCRIPTION

A. Background

1. Problem Description
Reasonable and prudent alternative (RPA) 6.2.4 of the 2008 Biological Opinion prepared by the National Marine Fisheries Service (NMFS) for continued operation of the U.S. Army Corps of Engineers Willamette Valley Project states that "*The Action Agencies will use more natural (i.e. "wild-type") growth rates and size at release for all juvenile spring Chinook reared and released at hatcheries, as feasible. Actions shall be taken to release hatchery fish that are more similar to their natural-origin counterparts to the extent feasible…The effect of this measure will be to make the hatchery Chinook more similar to their natural-origin counterparts, thus making them more appropriate for supplementation and reintroduction purposes."*

2. Literature Review
Wild fish, defined here as naturally produced fish regardless of hatchery ancestry, may be genotypically and phenotypically different from hatchery fish, defined here as fish that spend any portion of their juvenile life history under culture. Alternatively, the wild and hatchery fish in this case may be entirely homogeneous, given past hatchery and fish management practices in the basin. The work proposed in this document, in combination with ongoing work directed at describing genetic diversity among and between hatchery and wild fish in the Willamette sub-basins (Banks and Johnson 2009)

is intended to inform decisions on if and how to alter hatchery management practices in the region.

We propose to test for differences in survivorship (SARs), sex ratio, age at maturation, date of return, straying rates and other phenotypic traits (size, condition, etc.) among the cross groups. Several of these traits have been shown to differ between spring Chinook progeny from wild and hatchery origin parents, even when raised in a common hatchery environment (Knudsen et al. 2006).

Moyer et al. (2007) reported evidence for a genetic effect on survivorship in coho salmon, though no evidence was found to indicate that survivorship could be explained by hatchery/wild parentage. Instead, survivorship might better be explained by within group variability of immune-defense, as a function of individual major histocompatibility complex genotypes (Arkush et al. 2002, Turner et al. 2007). This hypothesis is currently being tested in coho salmon with existing samples by the O'Malley Laboratory at Oregon State University. Tissue samples collected through our proposed study would allow similar analyses for North Santiam spring Chinook salmon, potentially advancing our understanding of the potential to use genetic tools for improving survivorship such as screening potential crosses or manipulating crosses to reflect more natural mate selection processes (Hankin et al. 2009).

B. Objectives

1. Create experimental crosses of hatchery (H) and wild (W) spring Chinook at the Marion Forks Hatchery generating approximately equal numbers of HxH, HxW and WxW offspring *(This objective was accomplished in the 2010 spawning season but is included here to provide a complete record of the work)*.
2. Insert coded wire tags to permit identification of fish to cross type upon capture as juveniles or adults.
3. Monitor survival to different life history stages (hatch, fry, parr, smolt), growth, and smoltification by representatively sampling juveniles during rearing.
4. Monitor smolt to adult survival following recovery in fisheries, spawning grounds and at the hatchery.

C. Methodology

1. Description of proposed study

Much of the proposed work involves sampling of juvenile fish during rearing at the hatchery. Fish will be anaesthetized approximately 10 at a time in buffered (NaHCO3) MS-222 solution (~ 60 mg/l). For each specimen, we will note presence or absence of fin clips and CWTs, fork length (FL) to the nearest mm, and weight to the nearest 0.1 gm. Later in the season we will note whether fish are a parr, pre-smolt, or smolt as an index (SI) of smoltification. The criteria for parr include well-developed parr marks and heavy spotting across the dorsal surface. Pre-smolts have faint parr marks, less prominent dorsal spotting, silvery appearance, and no dark caudal fin margin. Smolts have deciduous scales, silver appearance, and a dark band on the outer margin of the caudal fin.

Tasks for the project-specific objectives are:
Task1.1 Create experimental crosses of hatchery (H) and Wild (W) spring Chinook at the Marion Forks Hatchery generating approximately equal numbers of HxH, HxW and WxW offspring *(This task was accomplished in the 2010 spawning season but is included here to provide a complete record of the work)*
Task2.1 At ponding, insert coded wire tags using automated tagging trailer(s). Tagged fish are to be routed to the appropriate ponds (circulars) such that there are four replicates of each of the proposed treatments (HxH, HxW, & WxW) of approximately 20,000 fish each.
Task2.2 Determine tag loss rates for each treatment x replicate combination using standard CWT Quality Assurance/Quality Control procedures.
Task3.1 Estimate and compare green egg-eyed egg, eyed egg-ponding/tagging (parr) and parr-smolt survival for each treatment x replicate combination.
Task3.2 Estimate and compare growth trajectories (length, weight, condition factor) and smoltification for each treatment x replicate combination.
Task3.3 Estimate incidence of precocious maturation by sacrifice and visual inspecting of a representative sample of yearling fish just prior to release.
Task4.1 Monitor recoveries of CWTs in fisheries, spawning ground surveys, and at hatcheries as adults return.
Task4.2 Reconstruct the experimental broods after adults return and compare SAR for each treatment x replicate combination.

2. Justification of Proposed Study Area

An adequate number of naturally produced adults returned to the Santiam facility in 2010 to serve as parents for the study. Also, the Marion Forks facility is configured with a large enough number of rearing vessels so that release groups can be reared in replicate which permits a robust statistical design.

3. Statistical Justification of Required Sample Sizes

For the work monitoring growth we propose to obtain monthly samples with a sample size of 30 fish/release/replicate. We expect to achieve 80% statistical power to detect a 15% difference between replicates and release groups should differences arise.

For comparisons of SAR we aim to detect differences in survivorship among three groups of tagged spring Chinook salmon released from Marion Forks Hatchery using contingency table analyses to detect differences in survivorship among the groups, with the null hypothesis (H_0) of no difference in survivorship among groups.

In a previous study of upper Willamette River (UWR) spring Chinook, R2 Consultants (Hendrix et al. 2006) utilized a surrogate term for survivorship, defined as *Recovery Rate*, where:

$$Recovery\ Rate = \frac{Total\ number\ recovered}{Total\ number\ tagged}$$

They found that *Recovery Rate* ranged between 0.1% and 2% for various UWR spring Chinook release groups. Similarly, survivorship estimates ranging from 0.15% to 1.51% have been reported for Marion Forks Hatchery spring Chinook (ODFW Draft HGMP). Nevertheless, it is impossible to predict the survivorship, or recovery rate (hereafter used interchangeably) for spring Chinook in this study, moreover the effect that alternate parentages may have over survivorship. However, for this exercise, we will consider a hypothetical recovery rate of 1% for the HxH group, and examine sample size requirements associated with various survivorship effects associated with groups that include a wild parent (WxW and HxW). We used the program G*Power3.1.2 to perform these analyses (Faul et al. 2007).

As an initial example, we consider a test for a 10% (small) effect on recovery rate associated with having at least one parent being of wild origin. If the HxH recovery rate is 0.01, then recovery rates for alternate parentages would have to fall above 0.011 or below 0.009 to constitute a 10% deviation from 0.01. Using typical α and β values of 0.05 and 0.20, which respectively represent the critical value for rejecting the null hypothesis and the probability of a false negative error, we calculate a minimum sample size of 964 recovered (tagged) adults to detect a 10% effect on survivorship associated with having a wild parent. Accordingly, this adult sample size would imply a tagging effort of 96,400 juveniles, given an approximate mean 1% survivorship rate. It is noteworthy, however, that minimum sample size decreases rapidly with increased effect size (Table 1).

Effect on survivorship from having one or more wild parent	Survivorship of HxH offspring	α	β	df	Minimum *n*
10%	0.01	0.05	0.20	2	964
15%	0.01	0.05	0.20	2	429
20%	0.01	0.05	0.20	2	241
30%	0.01	0.05	0.20	2	108

Our analyses indicate that minimum sample sizes required for our proposed study may vary largely with the (unknown) effect size associated with alternate parentages. However, it appears that if effect size exceeds a 15% increase or decrease in survivorship among groups we can reasonably expect to detect these differences.

More complex scenarios might involve differential survivorship between HxW and WxW groups which, in the context of a Chi-square test, would simply alter the effect value. Length, genetic and other data may also serve to explain some variance in survivorship within and among groups. These relationships might best be examined through an analysis of variance (ANOVA) or permutation tests, as appropriate.

4. Method of Analysis

Survival to different life history stages is to be compared among replicates and release groups using contingency table analyses (G-tests: Sokal and Rohlf 1981) with observed values obtained by direct counts of dead fish or eggs and expected values derived from original abundances of fish in each replicate or release group or both (after replicates are set up at the time of coded wire tagging).

Growth parameters are to be compared using 1-way ANOVA up to the time of coded wire tagging and 2-way ANOVA with release group and replicate as the factors in the analysis thereafter.

Smolt to adult returns rates are to compared using contingency table analyses (details in section C-3, above).

5. Description of Treatments to be Tested

In the proposed study, we aim to detect differences in hatchery performance (growth, survival to different life history stages) and survivorship (SAR) among three groups of tagged spring Chinook salmon released from Marion Forks Hatchery. These groups are defined by the origins of their parents, being both hatchery (HxH), both wild (WxW), or a cross of each (HxW).

6. Numbers and Species and Sources

Spawning occurred in 2010 and 18 naturally-produced females were spawned with 18 naturally produced males (WxW cross); 18 hatchery females were spawned with the same naturally-produced males (HxW cross), and 18 hatchery females were spawned with 18 hatchery males (HxH cross). We compared sizes of clipped and unclipped males and females an did not detect significant differences within genders (Figure 1): unclipped males did not differ in size from clipped males (t-test; $t = 0.590$ with 46 degrees of freedom; $P = 0.558$) and unclipped females did not differ in size from clipped females (t-test; $t = 1.144$ with 62 degrees of freedom; $P = 0.257$).

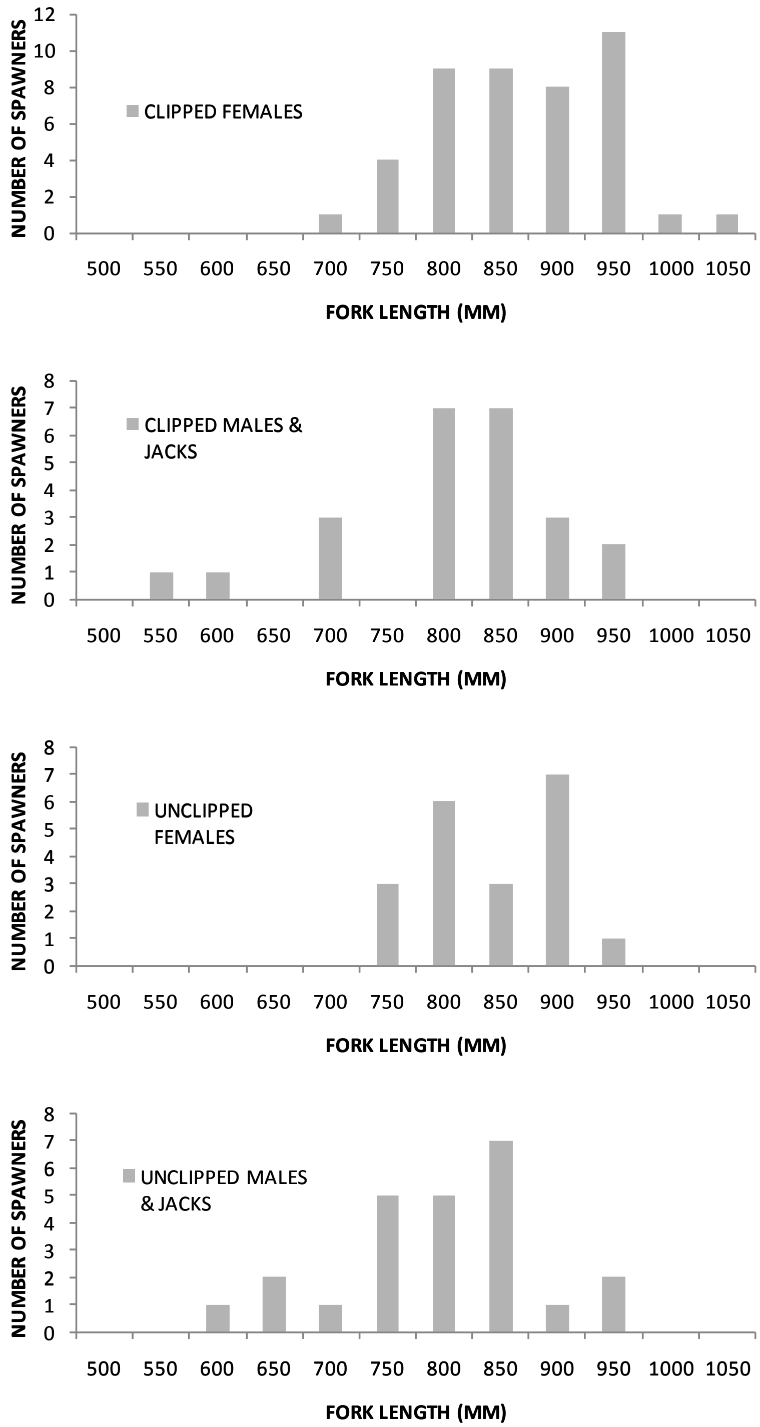


Figure 1. Size distributions of clipped and unclipped spring Chinook used for broodstock in the hatchery x Wild cross experiments. Origin of unclipped spawners will be confirmed after otolith analyses are complete.

We do not anticipate lethal sampling of juveniles during rearing but we are exploring options to monitor physiological parameters associated with smoltification and precocious maturation (NaK-ATPase and 11-ketotestosterone, respectively) which will require lethal sampling in the later stages of rearing.

7. Limitations of Proposed Methodology

We anticipate no limitations to the methods proposed for monitoring in-hatchery performance; those protocols are well established and will provide accurate and precise measures of growth trajectories and survivorship with a statistically robust ability to detect differences between replicates, treatments or both.

We have greater concern over our ability to compare SARs because our analyses indicate that minimum sample sizes required for our proposed study may vary largely with the (unknown) effect size associated with alternate parentages. However, it appears that if effect size exceeds a 15% increase or decrease in survivorship among groups we can reasonably expect to detect these differences (details in section C-3, above).

8. Expected Results and Applicability

We foresee two possible outcomes: one where we detect no apparent differences among cross types during hatchery rearing and post release and the alternative where differences are apparent. The former outcome might suggest that a large proportion of the naturally produced fish used as broodstock for the WxW and HxW crosses were in fact F1 offspring of hatchery spawners and a single generation in the wild did not confer any advantages or disadvantages to in-hatchery or post release performance. That outcome has important implications that, when coupled with ongoing and proposed research on patterns of genetic diversity in the Willamette, will drive far-reaching management actions aimed at deciding what fish to use where for recovery of natural production. If hatchery and wild spring Chinook in the Willamette are genotypically and phenotypically homogeneous then decisions on what stocks might be used for reintroductions become somewhat simplified: any fish will do.

Alternatively, if differences are apparent among cross types we predict that the pattern of differences will be such that the WxW offspring (and possibly HxW offspring) will perform relatively poorly in the hatcheries but may exhibit higher survival post-release. If that outcome is apparent then one might hypothesize that naturally produced fish, regardless of recent hatchery ancestry, are exhibiting wild-type performance whereby they are maladapted for the hatchery environment and, relatively speaking, better adapted for survival in the natural environment. From a practical perspective this outcome would suggest that incorporation of wild fish into hatchery broodstocks will be challenging and special care will be necessary in designing and executing such programs: the fish will be difficult to rear. Perhaps, however, we will find that those challenges will be balanced somewhat by increased survival post-release.

9. Schedule

Objectives and Tasks	M	A	M	J	J	A	S	O	N	D	J	F	M	A
						2011							2012	
1. Create experimental crosses of hatchery (H) and Wild (W) spring Chinook *(This objective was accomplished in the 2010 spawning season but is included here to provide a complete record of the work)* .														
2. Insert coded wire tags to permit identification of fish to cross type upon capture as juveniles or adults.														
Task2.1 At ponding, insert coded wire tags using automated tagging trailer(s).														
Task2.2 Determine tag loss rates for each treatment x replicate combination														
3. Monitor survival to different life history stages (hatch, fry, parr, smolt), growth, precocious maturation, and smoltification by representatively sampling juveniles during rearing.														
Task3.1 Estimate and compare green egg-eyed egg, eyed egg-ponding/tagging (parr) and parr-smolt survival for each treatment x replicate combination.														
Task3.2 Estimate and compare growth trajectories (length, weight, condition factor) and smoltification for each treatment x replicate combination.														
Task3.3 Estimate incidence of precocious maturation by sacrifice and visual inspecting of a representative sample of yearling fish just prior to release.														
4. Monitor smolt to adult survival following recovery in fisheries, spawning grounds and at the hatchery.														
Task4.1 Monitor recoveries of CWTs in fisheries, spawning ground surveys, and at hatcheries as adults return.								Outyears 2013 - 2015						
Task4.2 Reconstruct the experimental broods after adults return and compare SAR for each treatment x replicate combination.								Outyears 2013 - 2015						

D. Facilities and Equipment

1. Requirements

None. The fish are to be reared on site in existing facilities at Marion Forks Hatchery as part of the normal programmed releases. Marking and tagging will occur as part of the normal hatchery operations. All sampling equipment is already on hand.

2. Justification of Special or Expensive Requirements

N/A

E. Impacts

1. Other Ongoing or Proposed Research

A portion of the fish being used for the experiment (HxH crosses) described in this document will also serve as a control for a companion project examining SAR effects of release at different sizes and times (described in a separate proposal).

2. Projects

NA

3. Biological Effects

NA. The bulk of the work involves non-lethal sampling of hatchery fish on site at the hatchery.

F. Collaborative Arrangements and/or Sub-Contracts

None

IV. LIST OF KEY PERSONNEL AND PROJECT DUTIES

Cameron Sharpe	Project Lead: field supervision, reporting, analysis
Craig Tinus	Assistant Project Lead: field supervision, analysis
Tom Friesen	ODFW Program Lead; administration

V. TECHNOLOGY TRANSFER

The results of the experiment will be reported in the existing annual report series to the USACE and, depending on the outcomes, may be published in the peer-review literature.

VI. LIST OF REFERENCES

Arkush, K.D., A.R. Giese, H.L. Mendonca, A.M. McBride, G.D. Marty, P.W. Hedrick. 2002. Resistance to three pathogens in the endangere winter-run Chinook salmon (*Oncorhynchus tshawytscha*): effects of inbreeding and major histocompatibility complex genotypes. Canadian Journal of Fisheries and Aquatic Sciences 59:966-975.

Banks, M.A. and M.A. Johnson. 2009. Genetic pedigree analysis of McKenzie River spring Chinook salmon: An evaluation of adult outplanting strategies. Proposal to USACE. 9pp.

Faul, F., E. Erdfelder, A.-G. Lang, A. Buchner (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*, 175-191.

Hankin,D.G, J.Fitzgibbons, and Y. Chen, 2009. Unnatural random mating policies select for younger age at maturity in hatchery Chinook salmon (Oncorhynchus tshawytscha) populations. Canadian Journal of Fisheries and Aquatic Sciences. 66:1505-1521.

Hendrix, N., P. DeVries, R. Dudley. 2006. Willamette Valley anadromous fish hatchery coded wire tag evaluation. Draft Final Report to the U.S. Army Corps of Engineers. 35 p.

Knudsen, C.M., S.L. Schroder, C. A. Busack, M.V. Johnston, T.N. Pearsons, W.J. Bosch, D.E. Fast. 2006. Comparison of life history traits between first-generation hatchery and wild upper Yakima River spring Chinook salmon. Transactions of the American Fisheries Society 135:1130-1144.

Moyer, G.R., M.S. Blouin, M.A. Banks. 2007. The influence of family-correlated survival on Nb/N for progeny from integrated multi- and single-generation hatchery stocks of coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences 64:1258-1265.

Peven, C. and M. Keefe. 2010. Willamette Hatchery Mitigation Program Research, Monitoring, and Evaluation Plan. Final plan to USACE. 172 pp.

Sokal R.R and F.J. Rohlf. 1981. Biometry, second edition. W.H. Freeman and co., San Francisco. 859 pp.

Turner, S.M., M. Faisal, J.A. DeWoody. 2007. Zygosity at the major histocompatibility complex class IIB locus predicts susceptibility to *Renibacterium salmoninarum* in Atlantic salmon (*Salmo salar* L.). Animal Genetics 38:517-519.

RESEARCH PROPOSAL

I. BASIC INFORMATION

Effect of size and time of hatchery Chinook releases on outmigration and adult returns

PROJECT LEADERS: Cameron S. Sharpe
Oregon Department of Fish and Wildlife
28655 Hwy 34
Corvallis, OR 97333
(541) 757-4153

Thomas A. Friesen
Oregon Department of Fish and Wildlife
28655 Hwy 34
Corvallis, OR 97333
(541) 757-5151

STUDY CODE: TBD

ANTICIPATED DURATION: May 1, 2011 – December, 2016

DATE OF SUBMISSION: February 10, 2011

II. PROJECT SUMMARY

D. Goals

The goal of this project is to assess the potential benefits and risks of juvenile hatchery Chinook release strategies on wild spring Chinook and on performance of hatchery Chinook (juvenile outmigration and survival, and adult return rates). Information will be used to make decisions about modifying the hatchery release programs to more closely align hatchery fish to wild fish life histories.

E. Objectives

This project adopts the guidance of Peven and Keefe (2010) and specifically addresses an overarching objective to “rear and release high quality hatchery fish to minimize impacts on naturally produced fish and promote conservation and recovery of listed species”. The proposed work addresses two specific management objectives: (1) Rear and release hatchery spring Chinook salmon to mimic size and behavior of naturally produced yearling migrants and (2) Investigate alternative rearing and release strategies to increase the number of fish returning. Project-specific objectives are provided in section III B, below.

F. Methodology

The proposed work combines an assessment of in-river performance of released fish by tracking migration and survival of individual releases with an assessment of smolt to adult returns (SAR) following recovery of coded wire tagged fish in fisheries, at hatcheries, and during spawner surveys.

E. Relevance to Biological Opinion

The National Marine Fisheries Service concluded in the Willamette Project Biological Opinion (BiOp) that the continued operation and maintenance of the Willamette Valley Project would jeopardize the continued existence of Upper Willamette River spring Chinook salmon (*Oncorhynchus tshawytscha*) and Upper Willamette River steelhead (*O. mykiss*) (NMFS 2008). Several Reasonable and Prudent Alternatives (RPAs) to the action agencies' proposed actions were identified in the BiOp to address downstream fish passage concerns. The proposed work specifically addresses RPA 6.2.4 to adjust spring Chinook release strategies and Proposed Action 2.10.2.9 to experimentally release hatchery juveniles from Marion Forks Hatchery at a size and time more similar to natural origin fish. In addition, the proposed work directly addresses NOAA monitoring guidelines for risks posed by hatchery production Crawford and Rumsey 2010; specifically, recommendation 41: "Every hatchery should monitor the spatial and temporal distribution of juvenile fish released from the program").

III. PROJECT DESCRIPTION

A. Background

1. Problem Description

The 2008 Biological Opinion for the Willamette Valley Projects identifies actions to release hatchery fish that are more similar to natural-origin fish to make them more appropriate for supplementation and reintroduction purposes (RPA 6.2.4). Size and time of release are two important factors that define the migration attributes of hatchery and natural-origin fish. Size at release and growth rate have been shown to affect juvenile migration, survival, and age at adult return (Beckman et al.1999). In addition, time of release can affect survival. Currently juvenile hatchery Chinook tend to migrate rapidly out of the Willamette River (Schroeder et al. In preparation). Therefore, changes in release strategies could affect migration behavior and increase potential interactions with wild juvenile Chinook. Changes in release strategies could also affect adult returns. Work will continue through the 2012 releases at Dexter Pond, and at Marion Forks Hatchery

B. Objectives *(Note that these are reordered from the original "Project Concept" list of objectives but the objectives are identical)*

1. Evaluate the effect of size (length), condition, and time of release on migration rate (km/d) and passage timing to Willamette Falls;
2. Assess migratory behavior and estimate juvenile survival to Willamette Falls;
3. Estimate the proportion of juvenile Chinook that migrate past Willamette Falls and effect of size and time of release. *(NOTE: Objectives 3 and 4 are included in this document because they appeared in the original Project Concept. However, because of the novelty of the JSAT technology to this workgroup and temporal constraints of the existing infrastructure [April – August deployment of lower river listening stations], we are deferring development of a focused study using JSAT technology until future project years)*.
4. Assess migration timing and survival to the Columbia River estuary. *(See note, above).*
5. Compare the return rates of fish released at two different sizes and return rates of similar-sized fish released at two different times;
6. Investigate if fish released at a smaller size return as older age adults.

C. Methodology

1. Description of proposed study

The juvenile monitoring portion of the proposed work will take advantage of the intensive coded wire tagging (CWT) efforts in place in the Willamette basin (Table 1). Relative abundance estimates of hatchery fish migrating past Willamette Falls will be obtained by capturing a representative sample of CWT fish captured at the juvenile bypass in the Sullivan Plant adjacent to Willamette Falls will be sacrificed and the tags read so that hatchery migrants can be apportioned to their hatcheries of origin by release group. CWT procedures are usually associated with monitoring and research involving recovery in adults but are also useful for monitoring juvenile patterns of migration (Sharpe et al. 2007). The relative survival of CWT fish from each release group passing Willamette Falls will be compared using contingency table analyses with observed numbers obtained by reading the tags and expected numbers derived from original abundance of fish in each release group.

Table 1. Programmed CWT releases in Fall 2011 and Spring 2012. Releases specifically addressed in this document are outlined.

Release	Hatchery of Origin	Purpose of Release Group	# Tags (X1000)	Estimated Passage SUJ @ 2% Detection	Estimated Passage SUJ @ 6% Detection
1	Marion Forks	SAR	100	2,000	6,000
2	Marion Forks	WxW	80	1,600	4,800
3	Marion Forks	WxH	80	1,600	4,800
4	Marion Forks	HxH	80	1,600	4,800
5	Marion Forks	Release Time	50	1,000	3,000
6	Marion Forks	Release Time	50	1,000	3,000
7	Marion Forks	Release Time	50	1,000	3,000
8	McKenzie	Release Time	150	3,000	9,000
9	McKenzie	Release Time	200	4,000	12,000
10	McKenzie	Release Time	200	4,000	12,000
11	McKenzie	Release Time	200	4,000	12,000
12	McKenzie	Release Time	200	4,000	12,000
13	McKenzie	Release Time	240	4,800	14,400
14	Willamette	Release Time	100	2,000	6,000
15	Willamette	Release Time	100	2,000	6,000
16	Willamette	Release Time	100	2,000	6,000
17	Willamette	SAR	240	4,800	14,400
		TOTALS	**2,220**	**44,400**	**133,200**

Originally, passage time and survival from Willamette Falls to the estuary was to be obtained by taking advantage of the existing acoustic telemetry listening stations in the estuary. A representative subsample of the fish at the hatcheries were to be surgically implanted with Juvenile Salmon Acoustic Telemetry (JSAT) tags for release with their respective experimental groups. However, the listening arrays below Willamette Falls are only expected to be deployed in April and thereafter so their utility for tracking the fate of the majority of the juveniles for this project (releases in November, February, and March) is likely limited. It is expected that because the JSAT technology shows promise for addressing uncertainties related to migration and survival in the lower Columbia and estuary we will continue to consider the approach.

The SAR portion of the proposed work will take advantage of the existing Regional Mark Information System (RMIS) operated by the Pacific States Marine Fisheries Commission where records of tag recoveries in fisheries, at hatcheries and during spawning ground surveys can be queried by tag code. Those queries will occur as adults return from the experimental releases (from 2012 through 2016).

2. Justification of Proposed Study Area

The work proposed is focused on the releases from the Marion Forks and McKenzie hatcheries but because the juvenile abundance estimates are based on CWT recoveries at Willamette falls the estimates are necessarily going to address migrants from hatchery releases from all facilities releasing CWT fish throughout the entire watershed. Marion Forks was selected as one of the focused study populations because a portion of the fish from another study at that facility (Hatchery x Wild Crosses, described elsewhere) can be used for both studies, increasing efficiency. McKenzie Hatchery was selected because of a serendipitous opportunity to obtain at low cost a very large number of coded wire tags for use specifically in fish from that facility.

3. Statistical Justification of Required Sample Sizes

In excess of two million CWT fish from the 2010 brood are to be released into the Willamette between November 2011 and April 2012 (Table 1). We expect that between 2% and 6% of the released fish are likely to pass through the Sullivan Plant juvenile bypass, based on earlier work in 2010 (Schroeder et al., in prep). Therefore, between 44,400 and 133,200 could theoretically be available for the work described in this document. Clearly, a relatively small proportion of these fish need to be sampled to achieve the project objectives.

We performed a power analysis (using the statistical software G*Power v. 3.1.2: Faul et al. 2009) to determine the sample size required to detect a 15% difference in relative survival to Willamette Falls with a statistical power of 0.80. We based the power analysis on the numbers of fish released from Marion Forks Hatchery because those represent the smallest number of fish to be released for these experiments. If sampling intensity at the Sullivan Plant juvenile bypass is high enough to detect differences among release groups from Marion Forks then we will automatically be oversampling fish from McKenzie hatchery releases and will achieve a statistical power greater than 0.80.

We determined that we need a total sample size of 485 CWT Marion Forks fish to achieve the desired statistical power. If entrainment of Marion Forks fish to the Sullivan Plant juvenile facility is low (2%) approximately 4,600 Marion Forks fish will pass through there and we need to sample 10.5% of them (485/4,600). If entrainment of Marion Forks fish to the Sullivan Plant juvenile facility is high (6%) approximately 13,800 Marion Forks fish will pass through there and we need to sample 3.5% of them (485/13,800). We propose to sample at the more conservative rate (10.5%; approximately weekly sampling in November, February, March and April) to ensure adequate statistical power to accomplish the research objectives.

4. Method of Analysis

We propose to use contingency table analyses (G-tests: Sokal and Rohlf 1981) to estimate survival to Willamette Falls and SAR with observed values obtained after reading the CWTs recovered from juveniles at Willamette Falls and from adults recovered in fisheries, at hatcheries, and during spawner surveys. Expected values under the null hypothesis (equal survival) will be derived from the original abundance of fish from each release group. For example, if 500 tags are recovered from two release groups and the numbers released from each group were equal then expected values will be 250 for each group. Travel time for juveniles from their hatcheries to Willamette Falls will be compared using 2-way ANOVA. Because we will know when fish are released from a particular hatchery and will get representative recoveries of those fish when they are captured at Willamette Falls the difference (days) between release and recapture will be the metric for comparison. Factors for the ANOVA will be release group (e.g. Early vs. Late) and replicate.

5. Description of Treatments to be Tested

This experiment is to be conducted using spring Chinook salmon from two facilities: Marion Forks Hatchery on the North Santiam and the McKenzie Hatchery/Dexter Ponds on the McKenzie River. The work at Marion Forks requires merging the study described in this document with a portion of a concurrent study investigating in-hatchery and post-release performance of experimental crosses of hatchery and wild-origin fish. The control for the Hatchery x Wild cross experiment is a release group of approximately 80,000 Hatchery x Hatchery crosses. Those 80,000 fish will be paired with an additional 50,000 production fish (which should be genetically and phenotypically identical to the Hatchery x Hatchery group) for release as late as is feasible given rearing constraints at the facility (probably late March or early April). Another two groups (50,000 each) of production fish, each uniquely tagged, will be released as early as is feasible, probably in late February or early March. The design therefore includes replicated releases of smaller early-release fish and larger late-release fish for a total of 150,000 specific to this experiment plus an additional 80,000 shared with the Hatchery x Wild cross experiment.

The work at McKenzie Hatchery complex takes advantage of the intensive coded wire tagging effort driven by the need for complete marking should an automatic hatchery-wild sorting device be constructed to exclude hatchery fish from the upper watershed. We propose to tag the entire release with six different tag codes to permit replicated releases of (1) small fish released early (November: one of 200,000 and one of 150,000 fish), (2) small fish released later (February; 2 groups of 200,000 each), and (3) large fish released late (March; one group of 240,000 and one of 200,000 fish).

6. Numbers and Species and Sources

See “Description of Treatments to be Tested”, above.

7. Limitations of Proposed Methodology

We are not aware of any limitations to the proposed methodology. Far more juvenile specimens are available than are necessary to achieve the desired statistical power and the infrastructure to sample and process adult returns is well-established and already in place at minimal additional cost to the USACE. Project staff have experience both sampling fish at the Sullivan Plant and assembling diverse CWT data through the RMIS system.

8. Expected Results and Applicability

We expect to estimate with accuracy and precision the travel time and relative survival (to Willamette Falls and to the adult life history stage) of juvenile fish from multiple hatchery releases. The diversity of release strategies to be compared should inform managers on appropriate strategies to adopt into the future. We will also be directly estimating the effects of rearing and release strategies on survival to adults and the comparisons among releases should similarly inform decisions on how in the future, for example, we might adjust sizes of hatchery programs (downward) while still maintaining adequate adult returns for harvest.

An additional benefit of the proposed work is that we expect that in the future it may become possible to expand the use of the juvenile bypass facilities at Willamette falls to permit absolute estimates of juvenile migrants passing Willamette Falls from both natural production and hatchery releases. We anticipate that the experience gained from accomplishing the work proposed in the document will substantially inform us of how that important objective might be accomplished in the future.

9. Schedule

					2011							2012		
Objectives and Tasks	M	A	M	J	J	A	S	O	N	D	J	F	M	A
Objectives 1 and 2. 1:Evaluate the effect of size (length), condition, and time of release on migration rate (km/d) and passage timing to Willamette Falls. 2:Assess migratory behavior and estimate juvenile survival to Willamette Falls														
Insert CWT in McKenzie and Marion Forks spring Chinook														
November McKenzie Release														
February McKenzie Release														
February Marion Forks Release														
March McKenzie Release														
March Marion Forks Release														
Sullivan Plant Sampling														
Read CWTs														
Analysis and preparation of Progress Report														
Objectives 3 & 4. 3: Estimate the proportion of juvenile Chinook that migrate past Willamette Falls and effect of size and time of release. 4: Assess migration timing and survival to the Columbia River estuary.	NOTE: Objectives 3 and 4 are included in this document because they appeared in the original Project Concept but we do not anticipate any work towards them because of financial constraints including elimination of existing infrastructure in the estuary for acoustic telemetry													
Objectives 5 & 6. 5: Compare the return rates of fish released at two different sizes and return rates of similar-sized fish released at two different times. 6: Investigate if fish released at a smaller size return as older age adults														
Monitor recoveries of CWTs in fisheries, spawning ground surveys, and at hatcheries as adults return	Outyears 2013 - 2015													

D. Facilities and Equipment

1. Requirements

None.

2. Justification of Special or Expensive Requirements

N/A

E. Impacts

1. Other Ongoing or Proposed Research
As noted in section C5, above, the work proposed here relies in part on a separate study (Hatchery x Wild Crosses) to be conducted at Marion Forks Hatchery.

2. Projects
NA

3. Biological Effects
NA

F. Collaborative Arrangements and/or Sub-Contracts
We anticipate coordinating with PGE to sample juveniles at the Sullivan Plant. Two of us (TF and CT) coordinated with PGE at that facility in earlier work and we do not anticipate any issues with continuing to do so.

IV. LIST OF KEY PERSONNEL AND PROJECT DUTIES

Cameron Sharpe	Project Lead: field supervision, reporting, analysis
Craig Tinus	Assistant Project Lead: field supervision, analysis
Tom Friesen	ODFW Program Lead; administration

V. TECHNOLOGY TRANFER

The results of the experiment will be reported in the existing annual report series to the USACE and, depending on the outcomes, may be published in the peer-review literature.

VI. LIST OF REFERENCES

Beckman, B.R., Dickhoff, W.W., Zaugg, W.S., Sharpe, C., Hirtzel, S., Schrock, R., Larsen, D.A., Ewing, R.D., Palmisano, A., Schreck, C.B., and Mahnken C.V.W. 1999. Growth, smoltification, and smolt to adult return of spring Chinook salmon (Oncorhynchus tshawytscha) from hatcheries on the Deschutes River, Oregon. Transactions of the American Fisheries Society 128:1125 1150.

Crawford, B.A., S.M. Rumsey. 2010 Guidance for Monitoring Recovery of Pacific Northwest Salmon & Steelhead listed under the Federal Endangered Species Act: Guidance to salmon recovery partners concerning prioritizing monitoring efforts to assess the viability of salmon and steelhead populations protected under the Federal Endangered Species Act.

Faul, F., E. Erdfelder, A.-G. Lang, A. Buchner (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*, 175-191.

Peven, C. and M. Keefe. 2010. Willamette Hatchery Mitigation Program Research, Monitoring, and Evaluation Plan. Final plan to USACE. 172 pp.

Sharpe, C.S., B. Beckman, K. Cooper, and P.L. Hulett. 2007. Growth modulation during juvenile rearing can reduce rates of residualism in the progeny of wild steelhead broodstock. North American Journal of Fish Management. 27:1355–1368.

Sokal R.R and F.J. Rohlf. 1981. Biometry, second edition. W.H. Freeman and co., San Francisco. 859 pp.

RESEARCH PROPOSAL

I. BASIC INFORMATION

Genetic Diversity of Willamette River Spring Chinook Salmon Populations

PROJECT LEADERS: Marc A. Johnson
Oregon Department of Fish and Wildlife
28655 Highway 34
Corvallis, OR 97333
(541) 757-5152

Thomas A. Friesen
Oregon Department of Fish and Wildlife
28655 Highway 34
Corvallis, OR 97333
(541) 757-5151

STUDY CODE: TBD

ANTICIPATED DURATION: April 1, 2011 – March 31, 2012

DATE OF SUBMISSION: February 10, 2011

II. PROJECT SUMMARY

G. Goals

The goal of this project is to provide estimates of population genetic diversity within and among natural (wild)- and hatchery- origin populations of spring Chinook salmon *Oncorhynchus tshawytscha* (hereafter Chinook) from multiple sub-basins of the Willamette River. Results obtained from this project will serve to inform potential management actions that could include, but may not be limited to, adult outplanting, wild broodstock integration, and hatchery stock transfers. Additionally, genotypic data generated through this project will be used to evaluate the feasibility and resolution of genetic stock identification (GSI) methods for Willamette River spring Chinook.

H. Objectives

1. Collect tissue samples from natural- and hatchery-origin adult spring Chinook from major eastern sub-basins of the Willamette River above Willamette Falls.
2. Genotype a representative sample of each hatchery and wild population using a suite of ten polymorphic microsatellite loci.
3. Estimate genetic diversity within and among sampled populations, using conventional population genetics measures, including heterozygosity, F_{ST} and allelic richness.
4. Evaluate potential genetic effects of management actions, including integration of natural origin broodstock.

I. Methodology

Fin tissue samples will be collected from adult spring Chinook at hatcheries, fish collection facilities and spawning grounds throughout the Willamette basin. On spawning grounds, samples will be collected from expired adults (carcasses), and whenever appropriate, existing sample collections will be utilized. Whole genomic DNA will be isolated from tissue samples using standard laboratory procedures, and previously developed polymerase chain reaction (PCR) primers will be used to amplify ten polymorphic microsatellite loci from all samples. PCR products will be separated via polyacrylamide gel electrophoresis, and genotypes will be scored and recorded with Applied Biosystems, Inc.® software. Widely used genetic analysis software, including FSTAT (Goudet 1995), PHYLIP (Felsenstein 2005) and ONCOR (Kalinowski 2007), will be used to generate estimates of population genetic diversity, depict genetic relationships among populations, and evaluate the potential for GSI methods for Willamette spring Chinook.

F. Relevance to Biological Opinion

The goal of this project is to provide estimates of population genetic diversity within and among natural origin and hatchery populations of spring Chinook from multiple sub-basins of the Willamette River. Results obtained from this project will serve to inform potential management actions that could include, but may not be limited to, adult outplanting, wild broodstock integration, and hatchery stock transfers. Additionally, genotypic data generated through this project will be used to evaluate the feasibility and resolution of genetic stock identification (GSI) methods for Willamette River spring Chinook.

III. PROJECT DESCRIPTION

A. Background

1. Problem Description

In cooperation with the U.S. Army Corps of Engineers (USACE), the Oregon Department of Fish and Wildlife (ODFW) operates four spring Chinook hatcheries within the upper Willamette River (UWR) basin. These four hatcheries (Marion Forks, South Santiam, McKenzie and Willamette hatcheries) serve to mitigate for impacts of Willamette Valley Project Dams on commercial and sport fisheries by producing adult Chinook returns sufficient as to sustain impacted fisheries and perpetuate hatchery broodstock programs. In recent years, increased involvement with spring Chinook conservation efforts has prompted UWR hatcheries to adopt additional goals consistent with conservation program objectives. Namely, UWR hatcheries have developed and begun to implement plans to integrate natural origin fish into hatchery broodstock populations. Also, UWR hatcheries have restricted stock transfers among sub-basins, utilizing only locally founded broodstock in an effort to minimize the impacts of hatchery strays on wild populations.

Integration of natural-origin spring Chinook into UWR hatchery broodstock populations is consistent with recommendations of the 2008 NMFS Willamette Valley Project Biological Opinion (RPA 6.2.2) and aims to reduce the rate of genetic divergence between hatchery and natural origin populations. Genetic divergence results from the evolutionary processes of selection and random drift, and can be expected to develop quickly in absence of geneflow. As natural selection is believed to shape locally adapted phenotypes in natural populations, hatchery populations that are highly diverged from their wild founder populations would presumably be less suitable for reintroduction (outplanting) programs. Moreover, outbreeding depression in hatchery x wild crosses can be exacerbated when hatchery stocks are highly diverged. However, the degrees of genetic divergence present between hatchery and natural origin UWR spring Chinook populations remain largely unknown. Accordingly, the proportion of natural origin broodstock (pNOB) required to achieve panmixia (between hatchery and natural origin populations) cannot be empirically determined. Without this information, there is no basis for quantitatively evaluating the aims or effects of integration programs on broodstock population genetic diversity.

Prior to 1999, stock transfers among UWR spring Chinook hatcheries were not uncommon (Johnson and Friesen 2010). Myers et al. (2006) proposed that such stock transfers had served, in part, to homogenize UWR spring Chinook populations, with the possible exception of natural origin McKenzie River spring Chinook. However, a comprehensive and systematic examination of genetic structure among UWR spring Chinook populations has not yet been performed, and relationships among sub-basin populations remain poorly understood.

2. Literature Review

In their analysis of Lower Columbia and Willamette river salmon populations, Myers et al. (2006) examined molecular genetic data for several Willamette basin spring Chinook populations. Their study included samples from natural origin populations of the McKenzie, North Santiam and Clackamas rivers, as well as hatchery fish from McKenzie, Marion Forks, and Clackamas hatcheries. However, the authors found no geographic pattern to the genetic structure observed among Willamette spring Chinook populations, which they attributed to the use of juvenile samples for some populations. Indeed, it is understood that high relatedness among siblings, often included among juvenile samples, can greatly bias genetic distance estimates and interpretations of population genetic structure (Waples 1998).

Still to date the most comprehensive examination of Willamette spring Chinook population genetic structure, Myers et al. (2006) considered populations from only two UWR sub-basins, and included data from juvenile samples without adjusting for sibling effects. Accordingly, few reliable population genetic data exist for Willamette spring Chinook stocks. Genetic information, therefore, cannot presently be used for the development and evaluation of most UWR integration and outplanting programs. Moreover, it is uncertain whether GSI approaches would be feasible for studies of Willamette spring Chinook migration, harvest, etc.

Genotypic data for Willamette spring Chinook populations would not only allow for the inference of extant population genetic structure, but could also be used to model the effects of alternate integration rates on hatchery-wild population genetic divergence rates. Genetic data could also inform managers and action agencies of the degree of genetic “distinctiveness” between hatchery and natural origin Chinook used in adult outplanting programs.

B. Objectives

This study is designed to characterize the genetic structure currently present among spring Chinook populations of the Willamette River basin, while examining potential effects of hatchery management practices (broodstock integration and adult outplanting). Our first objective (Objective 1) will be to collect tissue samples from hatchery and natural origin spring Chinook from major eastern Willamette River tributaries. These samples will then be characterized at a suite of ten polymorphic microsatellite loci (Objective 2) to provide genotypic data. We will then analyze the spring Chinook genotypic data (Objective 3) to provide estimates of population diversity and divergence, depict the genetic relationships among all sampled populations, and provide baseline genetic data to guide and evaluate management actions. Our analyses will also enable us to address a fundamental question related to Willamette spring Chinook management. Specifically, we propose to evaluate the effect of variable integration rates (pNOB) on spring Chinook population genetic diversity (Objective 4). Finally, we will use genotypic data to generate estimates of confidence for population assignment by GSI.

By meeting these four objectives, we will address the following questions:

1. Does population genetic structure of Willamette spring Chinook reflect geographic relationships among populations?

2. Are hatchery populations significantly diverged from natural-origin founder populations? If so, to what degree?

3. Do natural origin populations present higher genetic diversity than hatchery populations (or *vice versa*)?

4. What are the theoretical relationships between (a range of) integration rates and predicted genetic distance between hatchery- and natural-origin spring Chinook populations, given present levels of divergence?

5. What is the level of confidence that can be expected for GSI of Willamette spring Chinook?

C. Methodology

2. Description of proposed study

<u>Task 1</u> *Tissue sample collections*

Fin-clip tissue samples will be collected from marked and unmarked adult spring Chinook at Willamette basin hatcheries and broodstock collection facilities. The sex, length and mark status (adipose fin clip) will be systematically recorded for each fish sampled. Otoliths will be collected from all unmarked fish, so as to confirm natural-origin. Tissue samples will be stored in 95% ethanol until processed in the laboratory.

Additional samples will be collected from carcasses of unmarked adult Chinook recovered from spawning grounds. Again, morphometric data and otoliths will be collected, and tissue samples will be stored in 95% ethanol. Whenever possible, a total of 100 samples will be collected from each population, with a projected total sample size of n=800. Two seasonal staff will be dedicated to this project, collecting Chinook tissue samples and associated morphometric data at hatcheries and spawning grounds.

<u>Task 2</u> *DNA isolation and microsatellite genotyping*

All laboratory work will be performed in the Marine Fisheries Genetic Laboratory (MFGL) at Hatfield Marine Science Center, Oregon State University. Whole genomic DNA will be isolated from tissue samples using a glass fiber filtration-elution protocol (Ivanova et al. 2006). This template DNA will then be used to amplify ten polymorphic microsatellites from the Genetic Analysis of Pacific Salmon (GAPS) baseline via the polymerase chain reaction (PCR).

GAPS markers are routinely utilized in the MFGL, and have been standardized across many west coast salmonid genetics laboratories (Seeb et al. 2007). Accordingly, by using GAPS markers, our data may be used in future coast-wide meta-analyses or GSI programs. PCR products will be separated through polyacrylamide gel electrophoresis on an ABI 3730 XL DNA Analyzer and microsatellites will be scored using GeneMapper® (Applied Biosystem, Inc.) software.

Task 3 Data analysis

Using a suite of population genetics and statistical software, we will estimate genetic diversity within and among all populations sampled, infer genetic relationships among populations and model the influence of variable integration rates on multiple parameters for the broodstock and donor populations. Analytical methods are further detailed in “Methods of Analysis”, below.

2. Justification of Proposed Study Area

This study will examine genetic structure of spring Chinook populations from major sub-basins of the upper Willamette River, including samples from both hatchery- and natural-origin populations. A comprehensive analysis of this nature has not yet been performed, and will provide valuable baseline genetic information while directly addressing critical management issues (RPAs 6.2 and 6.2.2).

3. Statistical Justification of Required Sample Sizes

Reliable estimates of population genetic parameters (e.g. F_{ST}, heterozygosity, allelic richness.) can be derived from a range of population sample sizes, and no definitive guidelines exist for minimum sample sizes in population genetics studies. However, Kalinowski (2005) suggests that when F_{ST} is suspected to be at or below 0.01, sample sizes of 100 or more may serve to significantly reduce the coefficient of variance on genetic distance estimates.

Myers (2006) provided only chord distances among several Willamette spring Chinook populations, not F_{ST} values. However, it is reasonable to assume that past stock transfers and ongoing broodstock integration programs have contributed toward low F_{ST} values in the Willamette. Accordingly, we propose to collect and analyze 100 samples from each population, whenever available. Intensive sampling efforts will be made on spawning grounds by two seasonal staff, so as to obtain the maximum possible number of natural origin samples. We project to collect and analyze a total of 800 spring Chinook tissue samples through this study.

It should be noted that the effects of variable sample sizes on population genetic diversity may be addressed through rarefaction procedures, so as to generate allelic richness estimates that may be directly compared among populations (Kalinowski 2004).

4. Methods of Analysis

4.1 Genetic diversity

Using the program FSTAT, we will estimate genetic diversity for each spring Chinook population, as described through mean values of heterozygosity and allelic richness.

4.2 Population genetic structure

We will use the program GENETIX (Belkhir et al. 2004) to calculate pairwise F_{ST} values for sampled populations. Briefly, F_{ST} is a measure of genetic variance that is apportionable among populations (Wright 1951). GENETIX will also be used to perform permutation tests to assess the significance of all pairwise F_{ST} estimates, using a critical value of $p = 0.05$.

We will use microsatellite genotypic data to construct phylogenetic trees depicting relationships among all sampled populations, using the PHYLIP software package (Felsenstein 2005). Bootstrapping will be used to assess node confidence of phylogenetic trees. We will use the program GENETIX to produce a principal components representation of population genetic structure, as an alternate means of structure representation.

4.3 Effects of integration on broodstock genetic diversity and F_{ST}

Using genotypic data for hatchery- and natural-origin populations, we will model the effects of variable integration rates on genetic diversity for both populations, as well as genetic distance and F_{ST} between the recipient and donor populations.

4.5 Evaluate potential of genetic stock identification for Willamette spring Chinook

If adequate genetic structure exists among Willamette spring Chinook populations, GSI could serve as a valuable research and management tool. We will use the program ONCOR (Kalinowski 2007) to implement the “leave one out” test (Anderson et al. 2008) to assess the power of GSI for accurately assigning individuals to their source population, given extant structure among Willamette spring Chinook populations.

5. Description of Treatments to be Tested

Not applicable – no treatments used in this study.

6. Numbers and Species and Sources

This study will utilize tissue samples from hatchery- and natural-origin adult spring Chinook. Samples will be collected from natural origin carcasses during spawner-redd surveys, and from (live) natural- and hatchery-origin fish at hatcheries, using non-lethal sampling techniques.

7. Limitations of Proposed Methodology

The most noteworthy limitation to this study will be our ability to obtain adequate sample sizes from some natural-origin populations, such as the Middle Fork Willamette population. For some analyses, we expect to be able to accommodate for differences in sample sizes. In cases where inadequate sample sizes could compromise our results or conclusions, we intend to identify biases and exclude data if necessary.

The use of only putatively neutral microsatellites could also be viewed as a shortcoming of this study. While neutral markers represent excellent tools for inferring measures of demographic connectivity and population genetic divergence resultant from random drift, they do not inform us of the distribution of genetic diversity that may underlie phenotypic variation. Population genomics approaches (Luikart et al. 2003) strive to address such aspects of diversity, yet they require much more intensive (and costly) efforts than our proposed study.

8. Expected Results and Applicability

Through this study we will provide genetic diversity estimate for hatchery- and natural-origin spring Chinook populations from the Willamette River basin. We will also infer the genetic relationships among all sampled populations and provide pair-wise population genetic divergence estimates.

We will develop a model for the effects of variable integration rates on genetic diversity of broodstock and natural-origin populations, and we will quantitatively evaluate the potential of GSI approaches for Willamette spring Chinook studies. This information will address a critical uncertainty for Willamette spring Chinook hatchery management (Johnson and Friesen 2010) and will aid in the implementation of RPAs 6.2 and 6.2.2.

9. Schedule

Objective	Task	Start Date	End Date
Collect tissue samples	Collect tissue samples from marked and unmarked fish at hatcheries and collection facilities	01 May 2011	31 October 2011
	Collect tissue samples from unmarked carcasses on spawning grounds	01 September 2011	31 October 2011
Genotype samples	Isolate genomic DNA, amplify and score microsatellites	01 October 2011	30 November 2011
Data analysis	Estimate population genetic diversity and structure Model effects of integration rates on F_{ST} and genetic distance Assess confidence of GSI for Willamette spring Chinook	01 December 2011	31 March 2012
Model effects of broodstock integration	Using genotypic data, model the effects of a range of pNOB values on population genetic diversity and distance	01 December 2011	31 March 2012

D. Facilities and Equipment

1. Requirements
None

2. Justification of Special or Expensive Requirements
N/A

E. Impacts

1. Other Ongoing or Proposed Research

We do not anticipate that our proposed study will negatively impact any other proposed or ongoing research.

Findings from our research will complement those of the Cougar Reservoir genetic pedigree study, currently being conducted through a collaborative effort between Oregon State University and Oregon Department of Fish and Wildlife. Specifically, our findings will provide estimates of genetic divergence between hatchery- and natural-origin Willamette spring Chinook populations outside the South Fork McKenzie River basin. Information provided by our research may assist with the development of adult outplanting procedures above multiple Willamette Project dams.

2. Projects

None

3. Biological Effects

Non-lethal sampling methods will be used during sample collections.

F. Collaborative Arrangements and/or Sub-Contracts

We will subcontract with the Marine Fisheries Genetics Laboratory at Oregon State University on a fee-for-service basis to obtain all microsatellite genotype data.

IV. LIST OF KEY PERSONNEL AND PROJECT DUTIES

Marc A. Johnson	Principal Investigator: data collection and analysis
Thomas A. Friesen	Co-principal Investigator; administration

V. TECHNOLOGY TRANFER

Results of this study will be provided in a report to the USACE and presented at the annual Willamette Fisheries Science Review.

VI. LIST OF REFERENCES

Anderson E.C., R.S. Waples, and S.T. Kalinowski. 2008. An improved method for estimating the accuracy of genetic stock identification. Canadian Journal of Fisheries and Aquatic Sciences 65:1475-1486

Belkhir K., P. Borsa, L. Chikhi, N. Raufaste, and F. Bonhomme. 2004. GENETIX 4.05, logiciel sous Windows TM pour la génétique des populations. Laboratoire Génome, Populations, Interactions, CNRS UMR 5000, Université de Montpellier II, Montpellier (France).

Felsenstein, J. 2005. PHYLIP (Phylogeny Inference Package) version 3.6. *Distributed by the author. Department of Genome Sciences, University of Washington, Seattle.*

Goudet, J. 1995. FSTAT (vers. 1.2): a computer program to calculate F-statistics. Journal of Heredity 86: 485-486.

Ivanova N.V., Dewaard J.R., and Hebert, P.D.N. 2006. An inexpensive, automation-friendly protocol for recovering high-quality DNA. Molecular Ecology Notes 6:998-1002.

Johnson, M.A. and T.A. Friesen. 2010. Spring Chinook Salmon Hatcheries in the Willamette Basin: Existing Data, Discernable Patterns and Information Gaps. Final Report to the U.S. Army Corps of Engineers, Task Order NWPPM-09-FH-05.

Kalinowski, S.T. 2007. ONCOR: A computer program for genetic stock identification. Available at http://www.montana.edu/kalinowski/Software/ONCOR.htm.

Kalinowski, S.T. 2005. Do polymorphic loci require large sample sizes to estimate genetic distances? Heredity 94:33-36.

Kalinowski, S.T. 2004. Counting alleles with rarefaction: private alleles and hierarchical sampling designs. Conservation Genetics 5(4):539-543.

Luikart G, P.R. England, D. Tallmon, S. Jordan, and P. Taberlet. 2003. The power and promise of population genomics: From genotyping to genome typing. Nature Reviews Genetics 4:981-994.

Myers, J., C. Busack, D. Rawding, A. Marshall, D. Teel, D.M. Van Doornik, and M.T. Maher. 2006. Historical population structure of Pacific salmonids in the Willamette River and lower Columbia River basins. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-73, 311 p.

NMFS. 2008. Endangered Species Act 7(a)(2) Consultation Biological Opinion & Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation: Consultation on the "Willamette Basin Flood Control Project". NOAA-Fisheries F/NWR/2000/02117.

Seeb, L. W., A. Antonovich, M.A. Banks, T.D. Beacham, M.R. Bellinger, S.M. Blankenship, M. Campbell, N.A. Decovich, J.C. Garza, C.M. Guthrie III, T.A. Lundrigen, P. Moran, S.R. Narum, J.J. Stephenson, K.J. Supernault, D.J. Teel, W.D. Templin, J.K. Wenburg, S.F. Young, and C.T. Smith. 2007. Development of a standardized DNA database for Chinook salmon. Fisheries 32(11):540-552.

Waples, R.S. 1998. Separating the wheat from the chaff: patterns of genetic differentiation in high gene flow species. Journal of Heredity 89:438-450.

Wright, S*.* 1951. The genetical structure of populations*.* Annals of Eugenics 15:323-354.

RESEARCH PROPOSAL

I. BASIC INFORMATION

Adult Chinook Salmon Monitoring in the South Fork McKenzie River Relative to Water Temperature Control and Upstream Passage Facilities at Cougar Dam

PROJECT LEADERS

Nik Zymonas
Oregon Department of Fish and Wildlife
28655 Highway 34
Corvallis, OR 97333
(541) 757-5100

Thomas A. Friesen
Oregon Department of Fish and Wildlife
28655 Highway 34
Corvallis, OR 97333
(541) 757-5151

STUDY CODE:

ANTICIPATED DURATION: March 1, 2011 – February 29, 2012

DATE OF SUBMISSION: February 18, 2010

II. PROJECT SUMMARY

J. Goals

The goals of this project are to characterize spawning by Chinook salmon (*Oncorhynchus tshawytscha*) in the South Fork McKenzie River considering the influences of upstream fish passage and hatchery out-planting, and to facilitate fish passage operations at Cougar Dam.

K. Objectives

The objectives of this project are: (1) to provide information on spawning distribution, abundance, and hatchery-origin vs. wild-origin of adult Chinook salmon; and (2) to collect biological data on fish captured in the upstream passage facility and assist in its operation. Results will be used to help gauge the status of the Chinook salmon population in the South Fork McKenzie River. Interacting influences of water temperature control at Cougar Dam (beginning in 2005), upstream passage (2010), and controlled levels of hatchery out-planting (1993) are expected to strongly affect this population. This information will be used to guide a suite of management decisions regarding establishment of a sustainable Chinook salmon population that utilizes the extended reach of high-quality habitat upstream of Cougar Reservoir. Collection of biological data and corresponding genetics samples will support a separate study currently in progress.

L. Methodology

Spawning surveys, including redd counts and carcass surveys, will be conducted upstream and downstream of Cougar Reservoir to monitor distribution and abundance of spawning and to determine relative proportions of wild- and hatchery-origin spawners. ODFW staff will collect biological data and genetic samples and assist with operation of the Cougar Dam trap.

G. Relevance to Biological Opinion

This project partially addresses a number of actions associated with fish passage in the 2008 Willamette Project Biological Opinion (BiOp; NMFS 2008). Specifically, RPA 5.4 states:

> <u>Cougar Dam RM&E</u>: The Action Agencies will fund and carry out an extended biological RM&E program associated with the Cougar Dam WTC. The RM&E program will begin in 2011, after completion of the RM&E program included in the previously authorized Cougar Trap project. The RM&E program will evaluate effects of the WTC operation on the downstream ecosystem (including TDG), fish passage through the reservoir, dam, and regulating outlet, and effectiveness of the trap-and-haul program. It will also quantitatively assess biological benefits realized from these protective and restorative measures. By September 2010, the Action Agencies will prepare a revised Cougar Dam WTC Monitoring and Evaluation Plan, based on the original plan developed as part of a previous consultation, subject to review and comment by the Services, and consistent with the RM&E process described below in RPA measure 9 (RM&E). The Action Agencies must obtain NMFS' review of the plan prior to initiating any research-related activities anticipated in this RPA. The

proposals must identify anticipated take levels of each species and life stage for each year. The Services will inform the Action Agencies whether they agree with the revised plan, proposed studies, draft reports, and NEPA alternatives. The Action Agencies will begin to carry out the extended RM&E program by March 1, 2011.

Further, Table 9.4-1 specifies that monitoring and evaluation of the Cougar Dam adult trap will occur in 2010 through 2012. Although initial monitoring was conducted in 2010, operation of the trap was delayed and maintenance requirements resulted in atypical dam operation early in the spawning run. This project also partially addresses elements of RPAs 4.1 (adult Chinook salmon outplanting), 4.4 (annual revision of Willamette Fish Operations Plan), 4.7 (adult fish release sites above dams), 4.12 (long-term fish passage solutions), 4.13 (Willamette Configuration Operations Plan), 6.1.5 (management of hatchery-origin spring Chinook upstream of Cougar Dam), 6.2.3 (continue adult Chinook outplanting program), 9.3 (fish passage RM&E), and 9.5.1 (hatchery programs RM&E).

III. PROJECT DESCRIPTION

A. Background

1. Problem Description

The Willamette Project consists of 13 dams and associated reservoirs, five fish hatcheries and 42 miles of riverbank revetments. The Willamette Project is jointly managed by the U.S. Army Corps of Engineers (USACE), Bonneville Power Administration, and Bureau of Reclamation, collectively known as the Action Agencies. The South Fork McKenzie River has one dam, Cougar Dam.

Following construction of Cougar Dam in 1963, the Fish Commission of Oregon evaluated upstream passage of adult Chinook salmon and downstream passage of juveniles (Ingram and Korn 1969). They found that few adult Chinook moved upstream to Cougar Dam because water temperatures in the South Fork McKenzie River were colder in the late spring and summer than they were before the dam was built and that juvenile Chinook suffered high mortality in the downstream passage facilities. By 1966, it was evident that maintaining a naturally producing run of Chinook above Cougar was not feasible with the existing facilities. A steering committee decided to close the fish passage facilities and use artificial propagation to mitigate the loss of Chinook production upstream of Cougar Dam. Although artificial propagation compensated for loss of Chinook production upstream of the dam, changes in the water temperature regime affected fish production downstream of the dam. Chinook eggs developed faster and fry emerged from the gravel earlier because water temperatures were warmer in the fall and early winter than before Cougar Dam was built. Earlier emergence of Chinook fry reduces survival by exposing them to winter and spring freshets, forcing them to forage during the season of lowest stream productivity, and increasing their vulnerability to predators.

In August 2001, the Corps of Engineers began construction to modify the water intake structure of Cougar Dam so that water can be withdrawn from various levels in the reservoir. Drawing water from various levels allows project operators to mimic the historical water temperature regime downstream of the dam. The electrical generation system was upgraded, including replacing the turbine runners with “fish friendlier” runners that utilize minimum gap technology. The water temperature control facility was placed in operation in May 2005 and modifications to the electrical generation system completed in 2006. The public, state agencies, and federal agencies have expressed continuing support for restoration of biologically functional connectivity between areas below Corps dams and historical natural production areas upstream of these Corps projects. An upstream fish passage facility, including a fish ladder, holding and sorting facility, and vehicular transport, was constructed beginning in April 2009 and put into operation on July 27, 2010.

The Corps of Engineers expended a considerable amount of time and money to complete temperature control, turbine runner modifications, and upstream passage facilities at Cougar Dam. These modifications are expected to positively affect fish habitat downstream of the dam and reconnect habitat upstream and downstream of the dam. There is intense interest from the public, State, and Federal agencies to increase natural production of ESA-listed Upper Willamette River Chinook salmon in the Willamette Basin by releasing adults upstream of Corps projects. Installing temperature control and fish passage facilities at Corps dams should improve downstream habitat conditions for anadromous fish in the Willamette Basin. However, decisions regarding temperature control and downstream passage at Cougar Dam and other Project dams should be based on reliable biological information. Evaluation is needed to assess effectiveness and guide operation of water temperature control and fish passage facilities.

The 2008 Willamette Project Biological Opinion (NMFS 2008) outlined the impacts from operation of the Project, including hatchery operations, on 13 species of ESA-listed Pacific salmonids and their habitats including Upper Willamette River (UWR) Chinook salmon and winter steelhead (NMFS 1999a; NMFS 1999b). The Biological Opinion also detailed specific actions, termed Reasonable and Prudent Alternatives (RPAs) that would “…allow for survival of the species with an adequate potential for recovery, and avoid destruction or modification of critical habitat.” The objectives described here address a number of actions associated with fish passage, hatchery management, and water quality in the Willamette Project Biological Opinion (section 9.4), including RPAs 4.1 (adult Chinook salmon outplanting), 4.4 (annual revision of Willamette Fish Operations Plan), 4.7 (adult fish release sites above dams), 4.12 (long-term fish passage solutions), 4.13 (Willamette Configuration Operations Plan), 5.4 (Cougar Dam RM&E), 6.1.5 (management of hatchery-origin spring Chinook upstream of Cougar Dam), 6.2.3 (continue adult Chinook outplanting program), 9.3 (fish passage RM&E), and 9.5.1 (hatchery programs RM&E). This project complements other research projects underway in the South Fork McKenzie River (e.g., Juvenile Downstream Migration, In-Reservoir Studies), and similar projects associated with other Willamette Project dams (e.g., adult Chinook telemetry studies).

2. Literature Review

The McKenzie River basin historically produced substantial runs of Chinook salmon, with the South Fork McKenzie River perhaps supporting the greatest production among streams in the basin (Mattson 1948). In 1958, the run totaled 4,300 adult Chinook salmon (USFWS 1959). Within the South Fork McKenzie River drainage, the majority of Chinook salmon production occurred upstream of the present site of Cougar Reservoir (USDI 1960; Ingram and Korn 1969).

Following construction of Cougar Dam in 1963, the Fish Commission of Oregon evaluated upstream passage of adult Chinook salmon (*Oncorhynchus tshawytscha*) and downstream passage of juveniles, finding these facilities to be ineffective (Ingram and Korn 1969). Passage at the dam was discontinued, eliminating production in 25 miles of formerly accessible habitat. Furthermore, the altered temperature regime downstream of the dam delayed upstream migration of adults into the remaining four-mile reach of accessible spawning habitat and reduced survival of eggs and juveniles (Homolka and Downey 1995).

Changes in fisheries management as well as structural and operational modifications at Cougar Dam have affected the Chinook salmon population and habitat in the SFMR over the past two decades. ODFW has out-planted hatchery adult Chinook salmon since 1993, and some proportion of their progeny survive downstream passage and return as adults (Taylor 2000; Beidler and Knapp 2005; Zymonas et al. *in prep*). The reservoir was drawn down during construction of a water temperature control facility in 2002–2004, and erosion of accumulated sediment led to extended periods of high turbidity within the residual pool and downstream that may have reduced suitability of spawning habitat near the dam (USACE 2003; Anderson 2007). Temperature control began in 2005, aligning the temperature regime of the downstream reach with a natural pattern (Rounds 2007), but the run of adults in 2011 will still include predominantly only the first generation of individuals to hatch under the new temperature regime. Altered thermal regimes and out-planting may affect salmon by means of genetic selection as well as competition (Ford et al. 2006; Angilletta et al. 2008). The Corps constructed an upstream fish passage facility in 2009–2010, and operation of this facility began on July 27, 2010. A total of 252 adult Chinook salmon was transported upstream, including 88% wild fish and a surprisingly large percentage of males (72%). By passing a large number of wild fish upstream of the dam for the first time in more than 40 years, operation of the passage facility altered spawning distribution and abundance as well as ratios of wild to hatchery spawners both upstream and downstream of the project (Zymonas et al. *in prep*). Effectiveness monitoring, an essential component of fish passage programs (Calles and Greenberg 2009), was stipulated in ESA planning (NOAA 2007; NOAA 2008); monitoring data from 2010 was not collected under representative of normal operating conditions because the opening of the facility was delayed.

We propose to monitor Chinook salmon spawning abundance, distribution, and hatchery influence by conducting redd counts and carcass surveys. Standard protocols will be used (Anderson et al. 2007). These surveys will build upon an existing dataset that includes redd and carcass surveys downstream of Cougar Dam since 2001 and upstream of Cougar Reservoir since 2005 (Kenaston et al. 2009; Zymonas et al. *in prep*).

An ongoing genetics pedigree study will help to assess effects of fish passage, but such studies benefit from individual tagging (Williamson et al. 2010).

B. Objectives

1. Provide information on spawning distribution, abundance, and hatchery vs. wild origin of adult Chinook salmon both upstream of Cougar Reservoir and downstream of Cougar Dam.
2. Collect biological data on fish captured in the upstream passage facility and assist in its operation

C. Methodology

1. Description of proposed study

Tasks for the project-specific objectives are:

Task 1.1 Conduct redd count surveys (census) weekly from mid-August through October. Spatial extent includes the South Fork McKenzie River from the mouth to Cougar Dam and from the head of Cougar Reservoir to the Elk Creek confluence. Other potential spawning locations (upstream from Elk Creek confluence, French Pete Creek, East Fork, etc...) will be surveyed at least once. Collect GPS locations to provide information on redd distribution.
Task 1.2 Conduct complete carcass surveys (census) weekly from mid-August through October. Spatial extent includes the South Fork McKenzie River from the mouth to Cougar Dam and from the head of Cougar Reservoir to the Elk Creek confluence. Collect GPS locations to provide information on carcass distribution (coarse indicator of spawning location). To determine hatchery vs. wild origin, record presence or absence of adipose fin and collect otoliths. Collect genetics tissue samples from carcasses encountered downstream of the dam (samples will be collected from all live fish transported upstream).
Task 2.1 Cooperatively assist with collection of biological data (species, length, weight, condition, presence of marks or tags, insertion of new tags, collection of genetics tissue samples) and disposition of fish captured at the Cougar Dam fish passage facility during the scheduled period of operation (Mar – Oct).

2. Justification of Proposed Study Area

The proposed study area encompasses the entire area relevant to this project.

3. Statistical Justification of Required Sample Sizes

We will conduct a complete census of available habitat.

4. Method of Analysis

The purpose of this project is to provide primary survey data. Summarized data, summary statistics, and graphical analyses will be provided. These data will be constituent to detailed analyses in conjunction with data from other concurrent and future projects.

5. Description of Treatments to be Tested

The proposed work is not an experimental study.

6. Numbers and Species and Sources

The proposed work includes genetics tissue sampling of all adult Chinook salmon captured at the Cougar Dam fish passage facility. Number of fish subjected to this nonlethal sampling depends entirely on run size. Additional tagging or marking may be conducted to assist other concurrent studies.

7. Limitations of Proposed Methodology

Our protocols are well established and should provide reasonably accurate measures of spawning distribution and abundance. Redd count surveys are known to involve a degree of imprecision from observer error and confounding effects of “test digs” and redd superimposition, but our protocol of conducting repeated counts over the entire duration of the spawning period, including at least one survey prior to onset of spawning, should maximize precision. Carcass surveys generally provide a sample of spawning adults, as predators, scavengers, and flows may remove or displace carcasses. Efforts to remove adipose fins from hatchery juveniles may incur a low rate of failure, but collection and subsequent analysis of otoliths from carcasses with unclipped adipose fins will maximize accuracy of determining wild vs. hatchery origin.

8. Expected Results and Applicability

We expect to obtain redd counts and carcass counts for adult Chinook salmon in the South Fork McKenzie River in 2011. These efforts will provide information on spawning distribution, abundance, and hatchery vs. wild origin of adult Chinook salmon. We also expect to collect biological data on all fish captured in the upstream passage facility at Cougar Dam and facilitate optimal operation of the facility. Information collected through this work will be highly applicable to management decisions, including the several RPAs identified above as well as ODFW fish management planning. These efforts will also facilitate other ongoing studies (e.g., ODFW / OSU genetics pedigree study) and provide important information to gauge response of the Chinook salmon population to past and future structural and operation changes at Cougar Dam and Reservoir.

9. Schedule

Redd count and carcass surveys (tasks 1.1 and 1.2): weekly from mid-August through October.

Assist with collection of biological data and disposition of fish captured at the Cougar Dam fish passage facility (Task 2.1): daily (depending on fish abundance) during scheduled period of operation (Mar – Oct).

D. Facilities and Equipment

1. Requirements
Regular coordination with USACE personnel in operating the upstream passage facilities.

2. Justification of Special or Expensive Requirements
N/A

E. Impacts

1. Other Ongoing or Proposed Research
Collection of genetics tissue samples and biological data will facilitate the ODFW / OSU genetics pedigree study (described in a separate proposal).

2. Projects
None.

3. Biological Effects
None.

F. Collaborative Arrangements and/or Sub-Contracts
None.

IV. LIST OF KEY PERSONNEL AND PROJECT DUTIES

Nik Zymonas	Project Lead: field supervision, reporting, analysis
Mike Hogansen	Assistant Project Lead: field supervision, analysis
Tom Friesen	ODFW Program Lead; administration

V. TECHNOLOGY TRANSFER

We will summarize monitoring results in an annual report to the USACE.

VI. LIST OF REFERENCES

Anderson, C. 2007. Influence of Cougar Reservoir drawdown on sediment and DDT transport and deposition in the McKenzie River basin, Oregon, water years 2002–04: U.S. Geological Survey Scientific Investigations Report 2007–5164, 42 p.

Angilletta, M. J., A. Steel, K. Bartz, J. G. Kingsolver, M. Scheuerell, B. Beckman, and L. Crozier. 2008. Big dams and salmon evolution: changes in thermal regimes and their potential evolutionary consequences. Evolutionary Applications 1: 286-299.

Beidler, W. and S. Knapp. 2005. A synopsis of information relating to the success of adult hatchery Chinook salmon releases above migration barriers in the Willamette River System. Oregon Department of Fish and Wildlife, Corvallis, Oregon.

Calles, O. and Greenberg, L. 2009. Connectivity is a two-way street - The need for a holistic approach to fish passage problems in regulated rivers. Rivers Research and Applications. 25: 1268-1286.

Ford, M.J., H. Fuss, B. Boelts, E. LaHood, J. Hard, and J. Miller. 2006. Changes in run timing and natural smolt production in a naturally spawning coho salmon (*Oncorhynchus kisutch*) stream after 60 years of intensive hatchery supplementation. Canadian Journal of Fisheries and Aquatic Sciences 63: 2343-2355.

Homolka, K., and T.W. Downey. 1995. Assessment of thermal effects on spawning and fry emergence, upper McKenzie River, 1992. Fish Division Information Report 95-4. Oregon Department of Fish and Wildlife, Portland.

Ingram, P. and L. Korn. 1969. Evaluation of Fish Passage Facilities at Cougar Dam In the South Fork McKenzie River in Oregon. Fish Commission of Oregon.

Johnson, D.H., B.M. Shrier, J.S. ONeal, J.A. Knutzen, X. Augerot, T.A. ONeil, and T.N. Pearsons, editors. 2007. Salmonid Field Protocols Handbook - Techniques for Assessing Status and Trends in Salmon and Trout Populations. American Fisheries Society, Bethesda, Maryland.

Kenaston, K. Schroeder, F. Monzyk, and B. Cannon 2009. Interim Activities for Monitoring Impacts Associated with Hatchery Programs in the Willamette Basin, USACE funding: 2007. NWPOD-08-FH-02. January. Oregon Department of Fish and Wildlife, Salem, Oregon.

Mattson, C.R.. 1948. Research Briefs of the Oregon Fish Commission, 1(2):21-32, Spawning Ground Studies of Willamette River Spring Chinook Salmon, Jan 01, 1948.

NMFS (National Marine Fisheries Service). 1999a. Endangered and threatened species: threatened status for two ESUs of steelhead in Washington and Oregon. Federal Register 64: 14517-14528.

NMFS (National Marine Fisheries Service). 1999b. Endangered and threatened species: threatened status for three Chinook salmon evolutionarily significant units (ESUs) in Washington and Oregon, and endangered status of one Chinook salmon ESU in Washington. Federal Register 64: 14307-14328.

NMFS (National Marine Fisheries Service). 2008. 2008-2023 Willamette River Basin Project Biological Opinion. NOAA - National Marine Fisheries Service, Northwest Region, Seattle, WA. F/NWR/2000/02117.

Rounds, S.A. 2007. Temperature effects of point sources, riparian shading, and dam operations on the Willamette River, Oregon: U.S. Geological Survey Scientific Investigations Report 2007-5185, 34 p.

Taylor, G.A. 2000. Monitoring of downstream fish passage at Cougar Dam in the South Fork McKenzie River, Oregon 1998-00. Oregon Department of Fish and Wildlife, Springfield, Oregon.

USACE (U.S. Army Corps of Engineers). 2003. Water temperature control, McKenzie River Sub-basin, Oregon, Cougar Dam and Reservoir. Draft supplemental information report. USACE, Portland District, Oregon.

USDI (U. S. Dept. of the Interior – Bureau of Commercial Fisheries). 1960. Downstream migrant studies, South Fork McKenzie River, 1957, 1959, 1960. Portland, Oregon

USFWS (U.S. Fish and Wildlife Service). 1959. Cougar Dam and Reservoir Project, Oregon. A detailed report on the fish and wildlife resources. USFWS, Portland, Oregon.

.

Zymonas, N.D., J.V. Tranquilli, and M. Hogansen *in prep*. Monitoring and Evaluation of Impacts to Bull Trout (*Salvelinus confluentus*) and Spring Chinook (*Oncorhynchus tshawytscha*) in the South Fork McKenzie River from Construction of Water Temperature Control Facilities at Cougar Dam, Oregon. Final project report. Oregon Department of Fish and Wildlife, Corvallis, Oregon.

Appendix 5

Project Concepts for work in 2011 Not Approved for Funding in 2011

Portland District - Corps of Engineers
FY 11 WILLAMETTE VALLEY PROJECT
CONCEPT PAPER

STUDY CODE: TBD

Effect of rearing environment on pre-release smolt physiology in UWR spring Chinook populations: indicators of post-release performance

MANAGEMENT PURPOSE: Monitor and evaluate the quality of smolts produced by different rearing strategies within Willamette basin hatcheries. The proposed monitoring will allow us to assess the effects of different rearing and release timing strategies on growth and smolt development and their relation to post release performance.

These physiological/life-history indices will provide early, predictable, and replicated comparative data, before the acquisition of full SARs in 2018-2020, for evaluating the different rearing/release strategies and the effect of parental origin. In addition, these metrics are independent of any potential alteration in ocean conditions that can produce variation in SARs that are unrelated to freshwater rearing. However, once SARs are obtained we will be able to correlate physiological indices of growth and smolting to SARs to evaluate key factors responsible for potential differences in survival between release groups. The data from this project would also inform the analysis of proposed PIT tag releases from the experimental groups.

FISH PROGRAM FEATURE: Hatchery

BIOLOGICAL OPINION ACTION: RPA 6.2.4

BACKGROUND: Reasonable and prudent alternative (RPA) 6.2.4 of the 2008 biological opinion prepared by the National Marine Fisheries Service (NMFS) for continued operation of the Army Corps of Engineers Willamette Valley Project states that "*The Action Agencies will use more natural (i.e. "wild-type") growth rates and size at release for all juvenile spring Chinook reared and released at hatcheries, as feasible. Actions shall be taken to release hatchery fish that are more similar to their natural-origin counterparts to the extent feasible."* However, the relationship between spawn timing, seasonal growth rates, and post-release phenotypes is unclear.

CRITICAL UNCERTAINTIES:

- Effect of growth rate, and timing of growth, on post release performance/maturation
- Relationship between rearing environment and post release performance.
- Relationship between hatchery phenotype and fitness of wild spawned hatchery offspring

OBJECTIVES:

The objectives are to: 1) Monitor spring growth and smolt development at selected sites and 2) Provide comparative metrics of smolt quality between rearing sites. Specifically, we will determine whether there are differences in growth, smolt development, and early male maturation between groups of spring Chinook salmon released in the Willamette Basin.

Potential groups:
Experimental groups

- Upper Willamette spring Chinook salmon reared at Willamette Hatchery and subsequently released into the Middle Fork Willamette River at two different sizes and two different times for three consecutive brood years (BY) 2010-2012 (released in years 2011-2013).
- Experimental groups (H×H, H×W, and W×W crosses) of spring Chinook that are being reared at Marion Forks (2010 BY) and released into the North Santiam River in 2012.

Regular production

- South Santiam Spring and Fall Release
- McKenzie Spring Releases

Proposed metrics:

- Early male maturation (11KT, potentially GSI)
- Growth (IGF1, batch sampling)
- Adiposity (?) (% moisture)
- Smolting (Na/K ATPase, K)

SCHEDULE: 2011 – 2013

CONTACT: Dave Leonhardt (503) 808-4786

Portland District - Corps of Engineers
FY 11 WILLAMETTE VALLEY PROJECT
DRAFT PROPOSAL

STUDY CODE: TBD

Strategies for hatchery summer steelhead releases

MANAGEMENT PURPOSE: This study will evaluate the benefits and risks of implementing RPA 6.1.6; the volitional release of hatchery summer steelhead and removal of non-migrants.

FISH PROGRAM FEATURE: Hatchery

BIOLOGICAL OPINION ACTION: RPA 6.1.6

BACKGROUND:

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 concern 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 (Table 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 (Figure 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).

APPROACH:

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 given PIT tags 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 and February–April 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.

SCHEDULE: 2011 – 2012

CONTACT: Dave Leonhardt (503) 808-4786

Table 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.*

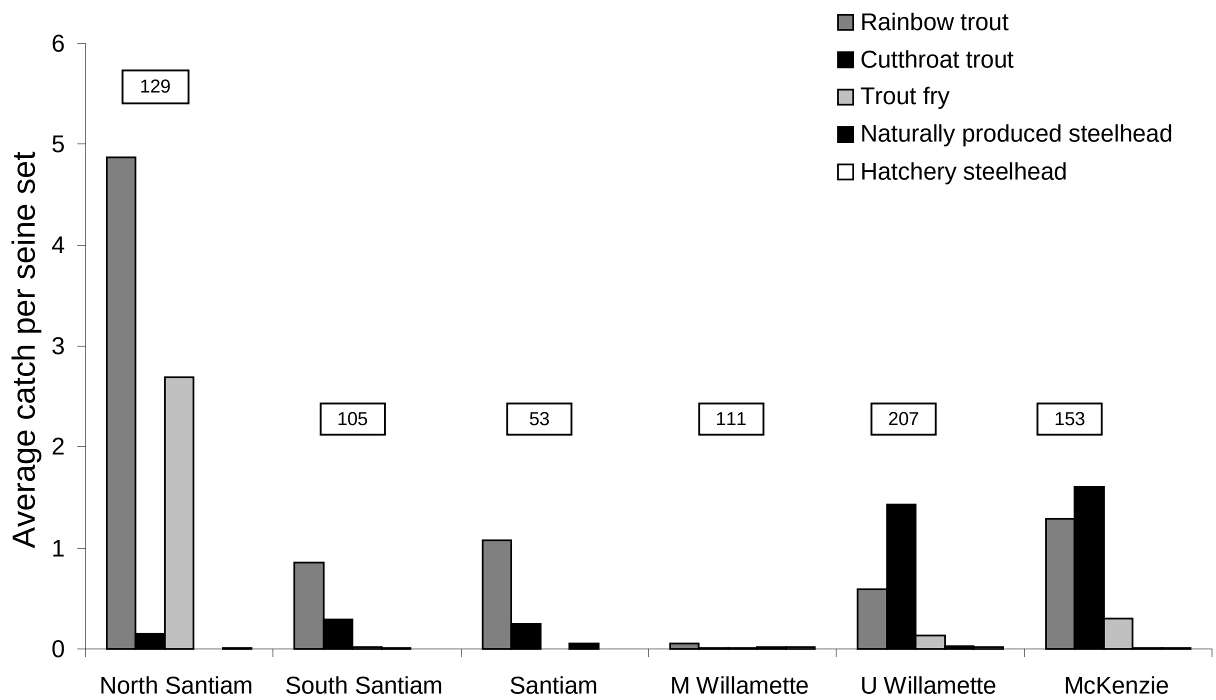


Figure 1. Average catch per seine set of trout in Willamette Basin beach seining, 2004–2009. Numbers in boxes are the average number of seine sets in each sampling area.

REFERENCES

Carmichael, R. W., D. L. Eddy, M. W. Flesher, G. C. Grant, J. R. Ruzycki, and G. R. Vonderohe. 2005a. Lower Snake River compensation plan: Oregon summer steelhead evaluation studies. Oregon Department of Fish and Wildlife, Fish Research Report, Contract 1411-01-J071, Annual Progress Report, Salem.

Carmichael, R. W., D. L. Eddy, M. W. Flesher, G. C. Grant, J. R. Ruzycki, and G. R. Vonderohe. 2005b. Lower Snake River compensation plan: Oregon summer steelhead evaluation studies. Oregon Department of Fish and Wildlife, Fish Research Report, Contract 1411-01-J071, Annual Progress Report, Salem.

Flesher, M. W., G. R. Vonderohe, G. C. Grant, D. L. Eddy, and R. W. Carmichael. 2005. Lower Snake River compensation plan: Oregon summer steelhead evaluation studies. Oregon Department of Fish and Wildlife, Fish Research Report, Contract 1411-01-J049 and 1411-03-J050, Annual Progress Report, Salem.

Flesher, M. W., S. M. Warren, D. L. Eddy, L. R. Clarke, and R. W. Carmichael. 2009. Lower Snake River compensation plan: Oregon summer steelhead evaluation studies. Oregon Department of Fish and Wildlife, Fish Research Report, Contract 14110-4-J071, 14110-5-J055, and 14110-6-J011, Annual Progress Report, Salem.

Gale, W. L., C. R. Pasley, B. M. Kennedy, and K. G. Ostrand. 2009. Juvenile steelhead release strategies: a comparison of volitional- and forced-release practices. North American Journal of Aquaculture 71:97–106.

Gee, S. A., G. R. Vonderohe, M. W. Flesher, D. L. Eddy, G. C. Grant, and R. W. Carmichael. 2007. Lower Snake River compensation plan: Oregon summer steelhead evaluation studies. Oregon Department of Fish and Wildlife, Fish Research Report, Contract 1411-01-J049 and 1411-03-J050, Annual Progress Report, Salem.

Tipping, J. M. 2006. Adult returns of volitionally migrating and pond-sedentary hatchery-reared steelhead smolts. North American Journal of Aquaculture 69:1–4.

Tipping, J. M., A. L. Gannam, T. D. Hillson, and J. B. Poole. 2003. Use of size for early detection of juvenile hatchery steelhead destined to be precocious males. North American Journal of Aquaculture 65:318–323.

Viola, A. E., and M. L. Schuck. 1995. A method to reduce the abundance of residual hatchery steelhead in rivers. North American Journal of Fisheries Management 15:488–493.

Portland District - Corps of Engineers
FY 11 WILLAMETTE VALLEY PROJECT
CONCEPT PAPER

STUDY CODE: TBD

Reducing the proportion of hatchery spring Chinook spawning in the McKenzie River.

MANAGEMENT PURPOSE: Reduce the number of hatchery spring Chinook that “stray” (do not return to McKenzie Hatchery) to minimize the direct genetic impact of hatchery fish spawning with naturally produced fish, and to reduce the potential ecological effects of hatchery fish spawning in the wild. Alternative strategies will be implemented to increase homing to McKenzie or Leaburg hatcheries and to increase harvest of returning hatchery fish. Strategies will be evaluated for effectiveness of homing with minimal impacts on naturally produced Chinook.

FISH PROGRAM FEATURE: Hatchery

BIOLOGICAL OPINION ACTION: Primarily 6.1.4

BACKGROUND: The proportion of spawners that are of hatchery origin has ranged from 16–35% of spawners upstream of Leaburg Dam and 50–94% of spawners downstream of the dam, with a combined total of 20–46%. Leaburg Dam is located 3 km upstream of McKenzie Hatchery and some hatchery Chinook first ascend the fishways at the dam and fall back either to spawn or eventually swim into McKenzie Hatchery or Leaburg Hatchery. Reducing the proportion of hatchery fish that spawn in the wild is critically important in the McKenzie River, which presently has the largest population of natural origin spring Chinook upstream of Willamette Falls. The Biological Opinion identified the need to reduce hatchery fish spawning in the wild to the “lowest extent possible (0–10%)”, primarily through an action (6.1.4) to sort hatchery fish at Leaburg Dam. However, it is uncertain if that action will be implemented, and hatchery strays downstream of the dam would likely need to be reduced as well to reach the target stray rate for the total population. Action 6.1.4 directs Action Agencies to take alternative actions to reduce hatchery straying to less than 10% of the total population spawning in the wild. Actions that decrease the number and percentage of hatchery fish that spawn in the wild may include alternative hatchery operations such as increased attraction flow or chemical imprinting to increase homing to the hatchery or alternative release strategies to delay hatchery fish in areas of the river downstream of the hatchery in an attempt to increase the harvest of hatchery fish. Because of the delay between implementation and resulting returns (4–5 years), actions should be implemented and evaluated simultaneously to increase the chances of identifying effective actions.

CRITICAL UNCERTAINTIES:

- Implementation of sorting facilities at Leaburg Dam
- Efficacy of alternative release or rearing practices to increase homing

OBJECTIVES:

The overall objective is to reduce straying of hatchery Chinook to <10%. Objectives of the study will be to:

1. Assess the effectiveness of chemical imprinting in decreasing the proportion of stray hatchery fish (assess homing of Chinook exposed to chemical imprinting).
2. Assess the effectiveness of increased attraction flow at McKenzie and Leaburg hatcheries in decreasing the proportion of stray hatchery fish (without increasing the proportion of natural-origin fish volitionally entering the hatcheries).
3. Assess the effectiveness of alternative direct release locations and/or acclimation release sites in increasing harvest of hatchery fish and in decreasing the proportion of hatchery fish that stray upstream of Leaburg Dam.

SCHEDULE: 2011 – 2012

CONTACT: Dave Leonhardt (503) 808-4786

Portland District - Corps of Engineers
FY 11 WILLAMETTE VALLEY PROJECT
RESEARCH SUMMARY

Spawning Distribution and Success of Hatchery and Unclipped Adult Spring Chinook above Detroit Dam

MANAGEMENT PURPOSE: Determine whether outplanted adult Chinook in the North Santiam and Breitenbush rivers differ in their migration behavior, distribution, and survival between unclipped (natural origin) and hatchery adults. Decisions about outplant strategy (timing, location and number of release sites, etc.) may differ depending on performance behavior of fish. One hypothesis is that hatchery Chinook behave differently than unclipped Chinook because hatchery fish are apparently homing to their rearing water. It is unknown if unclipped adult Chinook will behave differently. Also the proportion of Chinook that fall back into the reservoir after release can be evaluated for both groups of fish.

FISH PROGRAM FEATURE: Hatchery

BIOLOGICAL OPINION ACTION: RPA’s 4.1, 4.7, 6.2.3, 9.5.1

BACKGROUND:
The outplanting of adult Chinook above WVP dams began in 1996, with the original intent of providing nutrient enrichment (direct and indirect) to ESA-listed bull trout. When it was discovered that outplanted Chinook were spawning successfully, the re-establishment of populations in historic habitats above the dams was made a key activity for the action agencies in the WVP BiOps. Since this has been identified as a method for increasing both UWR Chinook and UWR steelhead population viability, the performance and success of the plan will need to be monitored as the best methods for outplanting fish are developed. Information on outplants to date has been with hatchery fish only, which may behave differently than unclipped fish. Behavior of hatchery fish may be influenced by hatchery adults homing to their rearing waters on the North Santiam (Horn Creek and Marion Creek). For adults outplanted below the hatchery, very little spawning has occurred in the North Santiam River upstream of Horn Creek. Spawning has been documented above Horn Creek when adults are released above Horn Creek at Parish Lake Road.

Key uncertainties that need to be addressed are:
- Spawning distribution differences between hatchery and unclipped adults
- Pre-spawning mortality
- Fallback into the reservoir

OBJECTIVES:
1. Determine spawning distribution differences between hatchery and unclipped adults outplanted in the North Santiam and Breitenbush rivers above Detroit Dam.

2. Evaluate pre-spawning mortality between hatchery and unclipped adults.

3. Evaluate the effect of outplanting date on distribution and spawning success of adults.

APPROACH:
Excess hatchery spring Chinook from broodstock will be outplanted in the North Santiam and Breitenbush rivers above Detroit Reservoir during 2010 to address RPA 4.1. Researchers will radio tag 25 hatchery and 25 unclipped female fish and release paired groups into each river, conducting two trials (100 fish total).

Radio-tagged fish will be tracked using mobile and fixed receivers, monitoring movement and distribution in each river. Spawning location, pre-spawn mortality, and fallback rates into the reservoir will be monitored in relation to fish origin and outplanting date. Spawning surveys will be conducted in conjunction with radio tracking to monitor pre-spawn mortality and spawning of tagged fish. The spawning surveys will coincide with the monitoring of all outplants above Detroit Reservoir (RPA 9.5.1). Temperature will be monitored at the release sites to help assess causes of pre-spawning mortality.

SCHEDULE: Implemented in 2010-11; proposed for continuance in 2011-12.

CONTACT: Dave Leonhardt (503) 808-4786

Portland District - Corps of Engineers
FY 11 WILLAMETTE VALLEY PROJECT
CONCEPT PAPER

STUDY CODE: TBD
Assessment of the morphometry, skin reflectance, and condition of hatchery and wild Chinook juveniles.

MANAGEMENT PURPOSE: Assess the degree of similarity between hatchery and wild reared Chinook juveniles and smolts with respect to morphometry, skin reflectance, and condition while controlling for genetic effects. Information will be used as baseline data to inform WATER decisions regarding the desired state of hatchery produced fish relative to wild counter parts.

FISH PROGRAM FEATURE: Hatchery

BIOLOGICAL OPINION ACTION: Directly addresses RPA 6.2.4

BACKGROUND: The 2008 Biological Opinion for the Willamette Valley Projects, in addition to the 2010 Hatchery Genetic Management Plan (HGMP), identifies actions to release hatchery Chinook more similar to natural origin fish, to make them more appropriate for supplementation and reintroduction purposes (RPA 6.2.4). However, the degree of phenotypic similarity is currently undocumented, as are the relative effects of genetic and rearing environment differences on degree of similarity. This study takes advantage of an ongoing genetic study where wild–wild, wild–hatchery, and hatchery–hatchery Chinook crosses are available in a common environment to assess similarity during the juvenile rearing phase. These data will then be compared with hatchery and unmarked out-migrating smolts intercepted at Willamette Falls, where timing (relative distribution of out-migration) can also be quantified. Additionally, juvenile Chinook captured in annual sub-basin seining and at basin hatcheries will be included in the data set.

CRITICAL UNCERTAINTIES:

1. Degree of phenotypic differentiation among juvenile hatchery Chinook
2. Degree of phenotypic differentiation among juvenile wild Chinook
3. Degree of phenotypic differentiation between wild and hatchery Chinook
4. Relative contribution of genetic and environmental influences in phenotypic variation.

OBJECTIVES:

1. Describe the morphometry from digital photographs using tpsDig2 imaging software and MorphoJ analysis software of both wild and hatchery Chinook.
2. Describe the relative condition using a modified Fulton’s K condition factor of hatchery and wild Chinook.
3. Describe relative skin reflectance as a proxy for physiological smoltification state using SigmaScan imaging software.

SCHEDULE: 2011-2012

CONTACT: Dave Leonhardt (503) 808-4786

Portland District - Corps of Engineers
FY 11 WILLAMETTE VALLEY PROJECT
CONCEPT PAPER

STUDY CODE: TBD

Effect of mate choice on Chinook salmon fitness

MANAGEMENT PURPOSE: Provide recommendations regarding spawning strategies (in hatchery) and incorporation of wild fish into broodstocks for the reintroduction of spring Chinook salmon above barriers.

FISH PROGRAM FEATURE: Hatchery

BIOLOGICAL OPINION ACTION: RPA X.X

BACKGROUND: Two studies have documented a decrease in fitness of steelhead and coho salmon spawning in the wild following a single generation of hatchery rearing (Araki et al. 2008; Therialut et al. *In press*). In addition, other pedigree studies have noted similar decreases in lifetime fitness or partial life history fitness in Chinook and steelhead. The study by Therialt et al. (*In press*) suggests that differences in the very early life history (prior to first feeding) were responsible for the decrease in fitness.

The most likely candidate for causing the observed effect is mate choice. It is well known that mate choice is not random. A number of studies have proposed that both males and females choose partners based on traits that are related to fitness. The favored hypotheses relates to the MHC complex. It is thought that vertebrates choose mates that will maximize the diversity of MHC alleles or the formation of optimal allele combinations, and hence provide a more robust immune system in the offspring. Other mechanisms, such as gamete compatibility have also been proposed and should be investigated.

If the factors involved in mate choice could be identified, and were related to the observed decrease in RRS, this would represent a significant advance in our ability to use hatchery fish for conservation purposes.

CRITICAL UNCERTAINTIES:

- The factors driving mate choice are unknown
- The role of mate choice in spawning success (vs. non-choice mechanisms) is unknown
- Relative benefit of wild fish incorporation into broodstock (vs. modified spawning protocol)

OBJECTIVES:

Our objective is to evaluate the likely mechanism causing a reduction in the RRS of wild spawning hatchery fish. We propose to focus on mating strategies by taking advantage of the resources at the Oregon Hatchery Research Center and the Willamette basin hatcheries. The study design is currently being reviewed by ODFW, NOAA, and OSU.

SCHEDULE: 2011 – 2012

CONTACT: Dave Leonhardt (503) 808-4786

Appendix 6

Willamette River Steelhead Genetic Stock Identification:

Scientific inquiry and study design for 2011

BACKGROUND

Beginning in the late 1960s, the Oregon Department of Fish and Wildlife (ODFW) initiated a summer steelhead (*Oncorhynchus mykiss*) hatchery program to mitigate for winter steelhead habitat losses caused by Willamette Project dam constructions, and to provide an enhanced sport fishery in the Willamette River basin. Summer steelhead are not native to the basin, and Skamania stock steelhead from Washington State were used to found hatchery broodstocks. Marked summer steelhead have commonly been observed on natural spawning grounds, raising concerns about negative ecological interactions and genetic introgression with native winter steelhead. These concerns have in part been addressed by the Reasonable and Prudent Alternative 9.5.2 developed by NOAA Fisheries (NMFS 2008), which recommends the implementation of a study to "*determine the extent of summer steelhead reproduction in the wild*" by collecting "*tissue samples from juvenile steelhead for genetic analysis to determine if offspring are of winter- or summer-run origin*".

In 2009, ODFW collected tissue samples from steelhead at three locations of the Willamette River. Juvenile (smolt) samples (*n*=240) were collected along the mainstem river at Willamette Falls, and adult samples were collected at Foster Trap (South Santiam River; *n*=50) and Minto Trap (North Santiam River; *n*=11). Both adult and juvenile samples were of unknown stock (summer or winter run), and sub-basin of origin was unknown for all juvenile samples. These "unknown" samples were then provided to the Northwest Fisheries Science Center (NOAA Fisheries) for analyses, together with additional archival samples of known winter (*n*=145) and summer (*n*=173) run stocks.

By first genotyping all samples at 15 microsatellite loci, then incorporating archival sample genotypes into an existing steelhead genotype baseline, Van Doornik & Teel (2010) performed genetic stock assignments for all unknown steelhead samples collected in 2009. Their findings indicated that all unknown adult samples were of winter run (as previously suspected) and that 8% of juvenile samples assigned to summer run. Although their results provided convincing evidence for limited natural production of introduced summer steelhead in the Willamette River basin, the sub-basin(s) supporting natural production of this stock were not identified.

Potentially, summer steelhead smolts of unknown geographic origin could be probabilistically assigned to their most genetically similar hatchery populations, providing some indication for sub-basin of origin. However, only weak genetic structure exists among Willamette summer steelhead populations included in the microsatellite baseline used by

Van Doornik & Teel (2010), as evidenced by a low overall theta (θ=0.009; Weir & Cockerham 1984) and low bootstrap support for some cladistic nodes within the summer steelhead reporting group (Van Doornik & Teel 2010). It can therefore be expected that statistical power would be prohibitively low for population-specific assignments within the summer steelhead reporting group. As a consequence, sampling juvenile steelhead at a "single-point" along the mainstem Willamette River would not likely provide information needed to identify which sub-basin(s) naturally produce summer steelhead.

Original project objectives also included the development of quantitative estimates for genetic introgression between Willamette summer and winter run steelhead. However, these estimates were not made because requisite analyses would require reference samples of "pure" summer or winter run lineages, which are not readily available (see Pritchard et al. 2007). Nevertheless, the high reporting group assignment probabilities reported by Van Doornik & Teel (2010) are indicative of negligible levels of summer-winter introgression or the absence of hybrids among samples.

QUESTIONS

1) Which sub-basins of the Willamette River support natural production of summer steelhead?
2) Within each sub-basin of the Willamette River, what percentage of natural steelhead production is represented by summer run stock?
3) Do sub-basins differ through the proportion of natural production steelhead assigning to summer run?

APPROACH

To determine which Willamette sub-basins support natural production of summer steelhead, ODFW will sample for unmarked, juvenile steelhead in each sub-basin of interest (e.g., North Santiam, South Santiam, Molalla, and McKenzie rivers). Sampling will begin at the seasonal onset of steelhead smoltification, in late February to allow the visual discrimination of steelhead smolts from resident rainbow trout. Collection methods will include standard seining techniques, as well as electrofishing if deemed necessary. Steelhead smolts will be anaesthetized with MS-222, measured for length, and a small section (2 × 2 mm) of the lower lobe of the caudal fin will be collected from each fish and stored in a labeled tube containing 95% ethanol. Fish will be allowed to recover, then released near their location of collection.

A target of n=50 samples will be collected from each sub-basin to permit some quantitative analyses of genetic stock identification results (e.g. percent of sub-basin samples assigning to summer run) in addition to qualitative results (presense/absence of summer steelhead among sub-basin samples). Sampling will be conducted for a period of two months, and will focus on multiple locations within each sub-basin, so as to sample multiple families and, potentially, life histories.

All samples will be genotyped at the 15 microsatellites previously used by Van Doornik and Teel (2010), so as to facilitate population assignments with the existing genetic baseline data and the software ONCOR (Kalinowski et al. 2008).

EXPECTED RESULTS

Previous work has provided evidence for limited natural production of introduced summer steelhead within the greater Willamette River basin. From the current study we intend to identify which sub-basins of the Willamette River support natural production of summer steelhead. Our data will provide indices of relative production for summer and winter run steelhead, which may be compared among sub-basins pending adequate sample sizes.

CITATIONS

Kalinowski S.T., K.R. Manlove, M.L. Taper. 2008. ONCOR: a computer program for genetic stock identification, v.2. [http://www.montana.edu/kalinowski/Software/ONCOR.htm] Department of Ecology, Montana State University, Bozeman, MT, USA

NMFS. 2008. Endangered Species Act Section 7(a)(2) Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation: Consultation on the “Willamette River Basin Flood Control Project”.

Pritchard, V.L., K. Jones, D.E. Cowley. 2007. Estimation of introgression in cutthroat trout populations using microsatellites. *Conservation Genetics* 8:1311-1329

Van Doornik, D.M., D.V. Teel. 2010. Genetic analysis of Willamette River steelhead of unknown run origin. Final Report to U.S. Army Corps of Engineers and Oregon Department of Fish and Wildlife. 20 p.

Weir, B.S., C.C. Cockerham. 1984. Estimating *F*-statistics for the analysis of population structure. *Evolution* 38: 1358–1370

Appendix 7

Dates of trap operation and collections

Facility	Date	Males	Females	Jacks	Subjacks
	6/8/2010	7	3		
	6/16/2010	352	148	9	
	6/17/2010	313	183	5	
	6/22/2010	324	186		
	6/30/2010	179	199		
	7/8/2010	251	375	16	
	7/13/2010	216	144	12	
	7/14/2010	11	14		
Dexter	7/16/2010	30	11		
	7/20/2010	208	155	12	
	7/22/2010	361	301	31	
	7/23/2010	176	115	10	
	7/27/2010	352	283	21	
	7/27/2010	26	20		
	8/5/2010	392	372	28	
	8/11/2010	21	19		
	9/2/2010	170	107	1	
TOTALS		**3389**	**2635**	**145**	
	6/16/2010	22	6		
	6/21/2010	20	11		
	6/23/2010	33	12		
	6/28/2010	174	104		
	6/30/2010	121	109	7	
	7/2/2010	13	10		
	7/6/2010	61	43		
	7/12/2010	348	261	11	
Marion Forks	7/19/2010	217	187	5	
	7/19/2010	34	12		
	7/27/2010	219	206	5	
	7/27/2010	35	17	1	
	8/5/2010	164	129	8	
	8/5/2010	47	21		
	8/16/2010	143	58	4	
	8/23/2010	147	86	3	
	8/30/2010	241	121	5	
	9/2/2010	147	87	1	

Facility	Date	Males	Females	Jacks	Subjacks
	9/6/2010	257	211		
	9/13/2010	153	164	4	
	9/15/2010	35	48	2	
	9/16/2010	28	39		
	9/20/2010	57	70		
	9/22/2010	12	32		
	9/28/2010	26	36		
	10/6/2010	20	32		
TOTALS		**2774**	**2112**	**56**	**0**
McKenzie	5/20/2010	231	227	7	
	5/28/2010	163	134		
	6/1/2010	102	101	3	
	6/3/2010	99	68	5	
	6/7/2010	254	194	5	
	6/16/2010	157	125	8	
	6/21/2010	81	49	2	
	6/25/2010	365	262	21	
	6/30/2010	233	182	15	
	7/1/2010	169	140	15	
	7/9/2010	286	224	23	
	7/12/2010	83	84	14	
	7/14/2010	128	99	5	
	7/15/2010	181	127	5	
	7/19/2010	23	13		
	7/22/2010	102	78	8	
	7/30/2010	48	61	5	
	8/6/2010	33	25	5	
	8/13/2010	17	17	2	
	8/18/2010	12	11	4	
	9/1/2010	174	33	16	
	9/9/2010	299	59	8	
	9/13/2010	168	50	2	
	9/16/2010	131	93	8	
	9/20/2010	213	193	4	
	9/22/2010	60	61	2	
	9/27/2010	37	74	1	
	10/4/2010	15	6		
TOTALS		**3864**	**2790**	**193**	**0**

Facility	Date	Males	Females	Jacks	Subjacks
South Santiam	5/14/2010	1	1		
	5/18/2010	1			
	5/21/2010	3	1	1	
	5/25/2010	5	5		
	6/1/2010	3	1		
	6/11/2010	1		1	
	6/17/2010	3	4		
	6/23/2010	329	241	2	
	6/25/2010	276	202	2	4
	6/30/2010	295	325	17	3
	7/2/2010	204	221	12	1
	7/8/2010	621	449	31	6
	7/12/2010	218	134	10	14
	7/14/2010	316	208	8	15
	7/16/2010	198	125	3	13
	7/22/2010	185	109	2	12
	7/23/2010	152	103	4	9
	7/26/2010	169	99	3	5
	7/29/2010	149	137	1	22
	8/2/2010	40	35	2	10
	8/5/2010	113	60	10	33
	8/10/2010	313	212	11	70
	8/12/2010	274	169	3	31
	8/19/2010	288	241	22	70
	8/31/2010	501	299	18	61
	9/8/2010	144	95	6	11
	9/9/2010	116	56	1	9
	9/14/2010	134	95		7
	9/22/2010	52	55	3	2
	9/29/2010	8	6		
	10/26/2010				
TOTALS		**5112**	**3688**	**173**	**408**