PROGRESS REPORTS

2015

Photo by Sara Akins

FISH DIVISION

Oregon Department of Fish and Wildlife

Spring Chinook Salmon in the Willamette and Sandy Basins

Sandy River Basin Spring Chinook Salmon Spawning Surveys – 2015

Compliance Monitoring for Sandy Hatchery Biological Opinion – June 2016

ANNUAL PROGRESS REPORT

FISH RESEARCH PROJECT
OREGON

PROJECT TITLE: Spring Chinook Salmon in the Willamette and Sandy Rivers

REPORT TITLE: Sandy River Basin Spring Chinook Salmon Spawning Surveys – 2015

PROJECT NUMBER: F-163-R-20/21

PROJECT PERIOD: October 1, 2014–September 30, 2016

Prepared by: Luke Whitman
Brian Cannon
Sara Akins

Oregon Department of Fish and Wildlife
4034 Fairview Industrial Drive SE
Salem, Oregon 97302

This project was funded in part by the Sport Fish and Wildlife Restoration Program administered by the U.S. Fish and Wildlife Service, and by Mitchell Act Funds administered by NOAA Fisheries

CONTENTS

KEY FINDINGS **1**

INTRODUCTION **1**

METHODS **2**
Redd Counts 2
Carcass Recovery 3
Composition of the Spawning Population 3
Trapping 4
Data Management and Analysis 4

RESULTS **5**
Composition of the Spawning Population 5
Effect of Trapping 6
Timing of Spawning 7
Redd Counts and Distribution 7
Prespawn mortality 8

ACKNOWLEDGMENTS **9**

REFERENCES **9**

FIGURES **11**

TABLES **13**

KEY FINDINGS

1. The proportion of hatchery origin spawners (pHOS) for spring Chinook salmon *Oncorhynchus tschwytscha* in the Sandy River Basin was 11.5% in 2015.
2. A total of 105 hatchery fish were removed at the weirs, reducing pHOS from 17% to 9% in the upper Sandy River Basin.
3. Peak spawn timing occurred from September 26 to October 6, within the range of dates from 2002-2015.
4. Spawning distribution was similar to 2002-2007, suggesting that weirs did not affect distribution.
5. Prespawn mortality of wild fish in the Salmon and Zigzag River basins was lower in 2015 than in 2003–2010 in the absence of weirs. Prespawn mortality was lower for wild fish than for hatchery fish.

INTRODUCTION

Spring Chinook salmon *Oncorhynchus tshawytscha* from the Sandy Basin were listed as threatened under the Endangered Species Act in 1999 (NOAA 1999). All hatchery spring Chinook salmon in the Sandy River basin were released with adipose fin clips and thermally marked otoliths beginning with the 1997 brood year. All fin-clipped hatchery spring Chinook salmon were trapped and removed at Marmot Dam in 2002–2007. After Marmot Dam was removed in 2007, it could no longer be used to exclude hatchery fish from spawning areas in the upper Sandy River basin. Following the dam's removal, the percentage of hatchery-origin spawners (pHOS) in spring Chinook salmon increased to 23–77% of the spawning population in 2008–2012, compared to a mean of 11% (4–18%) in 2002–2007, when Marmot Dam was used to sort returning fish. A detailed history of management for Chinook salmon in the Sandy Basin can be found in Schroeder et al. (2013).

Beginning in 2011, the Oregon Department of Fish and Wildlife (ODFW) implemented several measures to reduce the proportion of hatchery Chinook spawning in the wild. These actions included operating weirs and traps to remove adult hatchery Chinook salmon, reducing the number of hatchery smolts released, and acclimating juvenile hatchery Chinook in the Bull Run River with the objective of increasing the number of hatchery fish that home back to their release location, where they can be trapped and removed. In 2013, ODFW began operating a weir near the mouth of the Bull Run River to trap and remove hatchery adults homing back to this river. Also, ODFW began conducting spawning surveys in the Bull Run River in 2013.

This report summarizes data collected during spawning surveys and an assessment of the Sandy hatchery program pertaining to spring Chinook salmon. We report on the following selection of performance standards and monitoring requirements from the Hatchery Genetics Management Plan for the Sandy River basin. Those activities or analyses in bold italics are ongoing and will be reported later as noted.

1. Reduce straying of hatchery spring Chinook in the upper Sandy River (above the confluence of the upper Sandy and Salmon rivers) through construction of off-station acclimation ponds, weirs/traps, and other stray reduction measures.
2. Performance standard for a three-year running average pHOS is of 0.10 of the spawning population in spring Chinook salmon.
3. ODFW will monitor the presence of hatchery fish on the spawning grounds to verify compliance with this standard.
4. Complete census conducted by ODFW, across the Sandy Basin, of the location, number, and timing of naturally spawning hatchery fish.
5. Life-history characteristics of hatchery origin and wild spring Chinook will be monitored through analysis of hatchery returns (***run timing and age composition***), spawning ground surveys, and juvenile outmigrants.
6. Determine distribution and spawning success of naturally-produced spring Chinook salmon. ***Assessment of productivity is long-term because of the generational overlap in returning adults; some analyses require age composition data to assess brood year returns and adult-to-adult survival (see #5).***
7. Monitor the number of mortalities in all adult collection facilities and on spawning grounds for each species to assess the potential effect of trap operation, with an emphasis on prespawn mortality in the naturally produced population.
8. Monitor changes in spawning distribution and estimate prespawn mortality**.**

METHODS

Spawning surveys for spring Chinook salmon in the Sandy River basin consist of carcass recovery and redd counts, following the methods used in previous years (Schroeder et al. 2013). These surveys are designed to recover all observed carcasses in the upper Sandy River basin and to provide a complete census of redds in the primary spawning areas. Data collected from carcasses include prespawn mortality (based on females), hatchery:wild composition (based on the presence or absence of fin clips or thermal marks in otoliths), and age composition and freshwater life history in wild fish (based on analysis of scales). Redd counts are used to estimate spawner escapement (the number of adult fish that reach the spawning grounds), total run size when combined with other metrics, and to describe spawning distribution. Weirs were used to exclude hatchery spawners from the upper Sandy Basin.

Redd Counts

All spawning areas for spring Chinook in the upper Sandy River basin were surveyed on a 7–10 day cycle, with increased effort during peak spawning. This schedule is designed to insure weekly coverage of the primary spawning areas in the Salmon and Zigzag rivers and Still Creek, which have historically accounted for 80–90% of all spring Chinook redds in the upper Sandy Basin (the area of the Sandy Basin above the site of the former Marmot Dam, Figure 1). In 2014, we surveyed the Bull Run River, a tributary in the lower Sandy Basin weekly and the mainstem Sandy River upstream of the Marmot Dam site biweekly (Figure 1). All redds observed were counted in each survey. The same surveyors generally covered the same survey sections so they could better follow changes in spawning activity.

Redds were tallied on a personal digital assistant (PDA) and coordinates of redds were recorded with a global positioning system (GPS) receiver connected to the PDA. Comments were recorded on the PDA to help interpret data at the end of the season.

For purposes of surveys and analysis, streams were divided into "survey sections" based on geographical landmarks such as bridge crossings or campgrounds (Figure 2). These survey sections have been used by ODFW since 1996. As described below, in 2015 we split the traditionally used survey sections in the lower sections of the Salmon, Zigzag, and Bull Run rivers at the location of the weirs to allow additional analyses of potential effect of trapping on distribution of spawners and prespawn mortality.

For the Bull Run River surveys, we used standard sections that were used in previous years by the Portland Water Bureau (PWB). These surveys were added in 2013 because ODFW began operating a weir on the Bull Run River and have continued to do so. ODFW did not conduct these surveys previously because they were being done by PWB and the data was shared for our reports. Surveys by PWB documented little spawning activity and ODFW biologists noted limited available spawning habitat (Schroeder et al. 2013).

Carcass Recovery

We processed all recovered carcasses of spring Chinook salmon for which we could determine the presence of an adipose fin. Carcasses were cut open to verify sex, and retention of eggs in females was used to determine spawning success (prespawn mortality). We scanned all fin-clipped fish with a hand-held detector to check for coded-wire tags (CWT), and collected the snout and biological data (fork length, sex, spawning success) from those with a CWT. Snouts were put into a plastic bag with a waterproof tab providing a unique identifier for each sample. All data were entered into PDAs.

We collected otoliths from all carcasses with an adipose fin (and those with questionable fin clips). We collected scales and tissue samples from all unclipped fish. Otoliths and tissues were put into individually numbered vials, and scales were put into numbered waterproof envelopes. Data were recorded on scale envelopes and entered into a PDA, including references to otolith, tissue vial numbers, and survey section. Biological information included fork length (cm), sex, and spawning success. After processing the carcasses, tails were removed to identify fish that have already been counted and processed, and carcasses were returned to the stream channel.

Composition of Spawning Population

We used carcass sampling to identify hatchery and wild fish based on fin clips and to produce preliminary estimates of pHOS. Otoliths are being analyzed to apportion the unclipped or unknown fish (with a partial adipose fin clip or with an indeterminate fin clip status) into wild and hatchery categories. These results will be ready in March 2016 and will be used to correct pHOS estimates. In the last few years, hatchery fish have accounted for about 3% of the unclipped carcasses, increasing pHOS accordingly. Banding patterns are induced in the otoliths of all hatchery spring Chinook during incubation by raising or lowering the water temperature on a set schedule, which results in increases or decreases in the growth rings of otoliths and creates

a pattern that can be used to differentiate between hatchery and wild fish (Volk et al. 1999). Composition of the spawning population was estimated for survey sections, subbasins, and the Sandy River Basin.

Age was determined by reading scales to count annuli following the methods described by Borgerson et al. (2014). Age composition was estimated by return year and by brood year from scales collected from wild fish recovered during spawning ground surveys.

Trapping

District biologists from ODFW installed weirs and fish traps in the lower Salmon and Zigzag rivers to capture and remove hatchery spring Chinook salmon migrating to spawning areas. Traps were checked once a day in the early part of the season, and trapped fish were passed upstream if they did not have a fin clip or were removed and transported to Sandy Hatchery if they were fin-clipped. Beginning September 10, traps were monitored throughout the evening and night to process fish more frequently. All fish caught in the trap were counted daily by category (fin-clipped or unclipped).

We incorporated additional elements to our surveys to monitor the potential effects of operating weirs in the lower Salmon and Zigzag rivers to remove fin-clipped Chinook salmon:

1. Identified weir locations in our standard survey sections to monitor counts upstream and downstream of the weirs
2. Recorded live fish, carcasses, prespawn mortality, hatchery:wild composition, and redds upstream and downstream of weirs
3. Analyses designed to evaluate potential weir effects included
    a. Distribution and timing of live fish relative to weir locations
    b. Distribution of redds within the Salmon and Zigzag watersheds and within the upper Sandy River basin
    c. Passage timing and subsequent distribution of spawners
    d. General timing of spawning compared to previous years
    e. Hatchery:wild composition of spawning population upstream and downstream of weirs, and within the upper Sandy River basin
    f. Comparison of pHOS among years
    g. Prespawn mortality within watersheds and in the upper Sandy River basin

Data Management and Analysis

All carcass and redd data were recorded on a PDA and these data were uploaded to a database daily. Data checks were conducted in-season and at the end of the season to identify and correct data entry errors or to verify questionable data. Data were summarized by survey section, including survey sections downstream of weirs. The highest redd counts for each section were reviewed to follow the progression of spawning activity during the season. We report peak redd counts, the highest number of redds observed during a single spawning survey for a given section.

When Marmot Dam was in place, the counting station at the dam allowed ODFW to count all adult spring Chinook salmon returning to the upper Sandy River basin. The dam was removed in November 2007; complete counts are no longer available. Simple linear regression of Marmot Dam count to redds counted upstream of the dam was used to estimate run size for 1996–1998 (early surveys) and 2002–2006 (Figure 3). We did not use 2007 because of unknown effects of dam deconstruction, operation of a temporary weir, and additional handling of adult Chinook salmon in a trap-and-haul operation to move fish upstream of the cofferdam. For 2007-2015, run size was estimated from peak redd counts and 2.5 fish per redd. The number of fish per redd is reviewed by Gallagher et al. (2007). The estimate of 2.5 fish per redd is supported by Boydstun and McDonald (2005) and has been used previously to estimate run size in the Sandy and Willamette basins.

Tissue samples are being stored for possible genetic studies on composition of spring and fall Chinook salmon if funding becomes available. These samples may also provide the basis of future studies on the rate and magnitude of genetic change in a population where hatchery fish are successfully excluded from the population.

RESULTS

We conducted spawning surveys for spring Chinook salmon in the Sandy River basin in 2015 from July 14 to October 27. Primary spawning areas in the Salmon and Zigzag watersheds were surveyed 8–13 times through the season, including surveys for prespawn mortality, and generally on a weekly rotation. These are the sections that have historically accounted for most of the redds in the upper basin. Secondary spawning areas in the upper Zigzag River, Little Sandy River, Lost, Clear Fork, Devil's Canyon and Cheeney creeks were surveyed 1–5 times depending on water levels. These secondary areas have contained few, if any, redds historically and depend on early rain events if they are to have enough water for Chinook salmon to spawn. Also, we surveyed the Sandy River upstream of the old Marmot Dam site (4 times) and the Bull Run River (5 times).

Composition of the Spawning Population

The estimate of pHOS in the Sandy River Basin, including the Bull Run River, in 2015 was 11.5 %. This compares to a mean pHOS of 57% in the Sandy River Basin in 2008–2012. For the upper Sandy River Basin (upstream of the old Marmot Dam site), the estimated pHOS in 2015 was 10.7 % (Table 1). This compares to a mean pHOS of 61% in the upper basin in 2008–2011 after the removal of Marmot Dam, and a mean of 11% in 2002–2007 when fin-clipped fish were sorted and removed at the dam (Figure 4).

The percentage of hatchery origin spawners was lowest in the Salmon and Zigzag rivers and Lost Creek, and highest in the Sandy and Bull Run rivers and Clear Fork Creek (Table 1 and 2). The percentage of hatchery spawners in 2015 was 1.0% and 0.0% upstream of weirs in the Salmon and Zigzag rivers, whereas 20.0% and 20.5% of the spawners downstream of the Salmon and Zigzag weirs were hatchery origin (Table 2).

Estimated abundance of spawning spring Chinook salmon in the Sandy Basin was 3,023, with 2,772 wild spawners and 251 hatchery spawners. The number of wild fish returning to the upper Sandy River Basin in 2015 was 63% higher than in 2014 (Figure 5). Spring Chinook salmon from the Sandy and Clackamas basins follow the same life history strategy and these populations follow similar trends in abundance.

Wild adult spawners returning in 2015 were 67.4% age 4 and 26.1% age 5 (Table 3). Each year, a small percentage of spawners will be age 3 and age 6. Wild adults from the 2009 brood year were 46.4% age 4 and 52.5% age 5 (Table 4). Wild adults from the 2010 brood year were 68.7% age 4 and 28.6% age 5, although we expect a small percentage of age 6 adults to return in 2016 (Table 4).

Effect of Trapping

Weirs and fish traps were installed by ODFW biologists in the lower Salmon and Zigzag rivers to capture and remove hatchery Chinook salmon migrating upstream to primary spawning areas. In 2015, the Zigzag River trap was in the same location as in 2013-2014. In 2015, the Salmon River trap was in the same location as in 2014, just below the Highway 26 Bridge.

Trapping began June 1, 2015 in the Salmon River and May 21, 2015 in the Zigzag River (Table 5). ODFW staff checked the weir traps at least once a day in the early part of the season. Traps were inspected daily to insure they were functioning properly and to remove fish that entered the trap. All fish with an intact adipose fin were passed upstream. Fish with a clipped adipose fin were removed and transported to the Clackamas Hatchery for gamete collection or to the Sandy Hatchery for holding until they would be used for nutrient enrichment in the upper Sandy Basin. During most of September when many fish were moving, traps were monitored throughout the evening and night to remove fish more frequently because of concerns that fish might be reluctant to enter a crowded trap. Weirs were removed on October 12 on the Zigzag River and October 21 on the Salmon River, after peak spawning activity in most areas. Adult salmon were trapped at the weirs at a fairly steady rate from late July until the last week of September (Fig. 8).

A total of 105 hatchery Chinook were removed at the traps on the Salmon and Zigzag rivers, and 1,506 unclipped Chinook were trapped and passed upstream (Table 5, Figure 8). In addition, 137 clipped Chinook were removed and 63 unclipped Chinook were passed upstream at the weir on the Bull Run River. The number of hatchery fish removed is much lower than in 2014, probably because the extremely low river flows didn't cause the late returning hatchery fish to migrate farther upstream.

We estimated that removing fin-clipped fish at the weirs reduced the percentage of hatchery fish in the spawning population from 17% to 9% for the primary spawning areas upstream of the Marmot Dam site (Table 6, Figure 9). The percentage of fin-clipped fish upstream of the weirs on the Salmon and Zigzag rivers was low overall (Table 1). These results indicate that trapping in the primary spawning tributaries continues to reduce the number of hatchery spawners.

Timing of Spawning

The date of first spawning in 2015 was August 31 in the Salmon River and September 2 in the Zigzag River (Figure 10). The first date of spawning in the Salmon River was earlier than the observed range and Zigzag River date was within the observed range from 2002-2009, when weirs were not present (Figure 10). The date of first spawning in 2015 in the lower Salmon River was September 8, similar to the mean from 2002–2009 (Figure 10).

Peak spawning date in the Zigzag River Basin occurred between September 26 and October 4, within the range from 2002-2010 (Figure 11). In the Salmon River, peak spawning occurred from October 3-6. This date was within the range from 2002-2010 in all areas of the Salmon River.

Redd Counts and Distribution

The number of redds counted on all surveys in the upper Sandy Basin (above the old Marmot Dam site) was 1,179 in 2015, which was 58% higher than the number counted in 2014. Additionally, 30 redds were counted in the Bull Run River (including Little Sandy River), upstream of the weir.

Density of redds above the weirs was highest in the upper sections of the Salmon River and in Still Creek downstream of Cool Creek (Table 7). These areas have consistently had the highest density of redds in the upper Sandy River basin and placement of the weirs continues to exclude most hatchery fish from them.

Redd densities were higher in 2015 than the last few years in most sections of the Salmon River (Table 7). Redd densities in the lowest survey sections of the Salmon and Zigzag rivers (weir to mouth) were high as well this year, possibly from large numbers of hatchery spawners. Redd density in the survey section of the Zigzag River farthest downstream (weir to mouth), was the highest recorded since 2002. Still Creek continued to have high redd densities, as this tributary is where most spawning takes place in the Zigzag River watershed (Table 7). Variation in redd densities by section may be attributed to a number of causes, such as natural variation and changing habitat.

We compared the redd distribution among several survey sections in the Salmon and Zigzag watersheds. Redd distribution in 2015 was compared to 2002–2007 as a baseline for distribution of natural origin spawners because fin-clipped fish were removed at Marmot Dam. However, in the Salmon River, data from 2004 and 2006 were not used because redd counts were combined for the lower sections when section breaks were not noted on the data sheets.

Surveys cannot distinguish redds produced by hatchery fish from redds produced by naturally produced fish. Thus, in our analysis, we used a surrogate indicator to estimate the percentage of redds in each survey section that are produced by clipped, versus unclipped fish. For each survey section, we calculated the percentage of clipped versus unclipped carcasses found in that section. That percentage was used to estimate the contribution of clipped versus unclipped spawners to redds found in that section.

In the Salmon River, the percentage of total redds increased in the section farthest upstream (Final Falls-Forest Rd 2618) when compared to 2002–2007, especially from unclipped spawners (Figure 12). The percentage of redds downstream of the weir increased as well, primarily from hatchery spawners. These data suggest an overall decrease in the percentage of redds in the middle survey sections.

In the Zigzag River watershed, the percentage of total redds in Still and Camp creeks decreased somewhat when compared to 2002-2007 (Figure 13). As in the Salmon River, the percentage of redds in the section farthest downstream (Still Creek – mouth) increased in 2015 from 2002–2007 and had a higher component of unclipped spawners. This suggests that more unclipped fish were spawning in the Zigzag River below the weir in 2015 than spawned there in 2002-2007, before the weirs were in place.

Overall redd distribution in the Salmon and Zigzag rivers in 2015 remained similar to those observed in 2002-2007, suggesting that weirs did not affect the distribution of spawning salmon (Figures 12 and 13). Redd locations were mapped for the Salmon and Zigzag rivers using GPS coordinates collected on spawning surveys (Figures 14 and 15).

Prespawn Mortality

We compared prespawn mortality in 2015 to that in 2003–2007 to detect any effects the weirs may have on prespawn mortality in wild fish. Data from 2003-2007 was chosen as an appropriate baseline to compare, because the spawning population in the upper basin was primarily wild fish migrating directly to the spawning grounds. We did not use 2002 or 2010 in our comparisons because spawning surveys in those years were not started until September, which reduced the probability of recovering carcasses of fish that died before spawning. One limitation of using the 2003–2007 period as a baseline for mortality in natural origin spawners is that all unclipped spring Chinook salmon were subject to handling at Marmot Dam where they were trapped and passed upstream.

Overall prespawn mortality in the upper Sandy River basin was lower in 2011-2015 than in previous years. Additionally, prespawn mortality in the upper basin in 2015 was lower for unclipped salmon than for fin-clipped salmon, and was lower for unclipped fish in 2015 than in 2003–2007. In general, these results suggest effects of the weirs on the mortality of unclipped salmon is negligible.

Among specific watersheds, prespawn mortality in the Salmon River watershed was lower in 2011-2015 than in 2003–2007 or in 2008–2009, and was higher in the Zigzag River watershed in 2011–2015 than in previous years (Table 8). Recovery of carcasses early in the spawning survey season is often low in the Zigzag River because of poor visibility caused by glacial melt. This can be a problem each year, but this area is surveyed frequently and good numbers of carcasses are still collected.

ACKNOWLEDGMENTS

We thank the seasonal biologists who collected much of the field data for these surveys. Our primary surveyors for the Sandy Basin were Chris Lessick, Erin Fulop, Joshua Coleman, and Jacob McClure, with assistance from Eric Bailey, Daniel Coffman, and Suzette Savoie. We thank ODFW district biologists Todd Alsbury and Ben Walczak for providing a great deal of logistical support, assistance with sampling carcasses at the weirs, and for providing data from trap operations. We thank Burke Strobel and his staff at the City of Portland Water Bureau for their help collecting biological samples from the Bull Run River.

REFERENCES

Borgerson, L., B. Clemens, K. Bowden, & S. Gunckel. 2014. Fish life history analysis project: methods for scale analysis. Information Report 2014-10. Oregon Department of Fish and Wildlife, Salem.

Boydstun, L., and T. McDonald. 2005. Action plan for monitoring California's coastal salmonids. Final report to NOAA Fisheries, Contract Number WASC-3-1295, Santa Cruz, California.

Gallagher, S., P. Hahn, and D. Johnson. 2007. Redd counts. Pages 197–234 in D. Johnson, B. Shier, J. O'Neal, J. Knutzen, X. Augerot, T. O'Neil, and T. Pearsons, editors. Salmonid field protocols handbook: techniques for assessing status and trends in salmon and trout populations. American Fisheries Society, Bethesda, Maryland.

ODFW (Oregon Department of Fish and Wildlife). 2011. Final hatchery and genetic management plan (HGMP). Sandy Hatchery spring Chinook, Oregon Department of Fish and Wildlife, Salem. http://www.dfw.state.or.us/fish/HGMP/docs/2011/Sandy_River_Spring_Chinook_HGMP.pdf

NOAA (National Oceanic and Atmospheric Administration). 1999. 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). 2012. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Sandy River Spring Chinook Salmon, Coho Salmon, Winter Steelhead, and Summer Steelhead, NMFS consultation number: 2011102491.

Schroeder, K., B. Cannon, L. Whitman, and M. Walker. 2013. Sandy Basin spring Chinook salmon spawning surveys – 2012. Annual Progress Report F-163-R-17/18. Oregon Department of Fish and Wildlife, Salem.

Volk, E. C., S. L. Schroder, and J. J. Grimm. 1999. Otolith thermal marking. Fisheries Research 43:205–219.

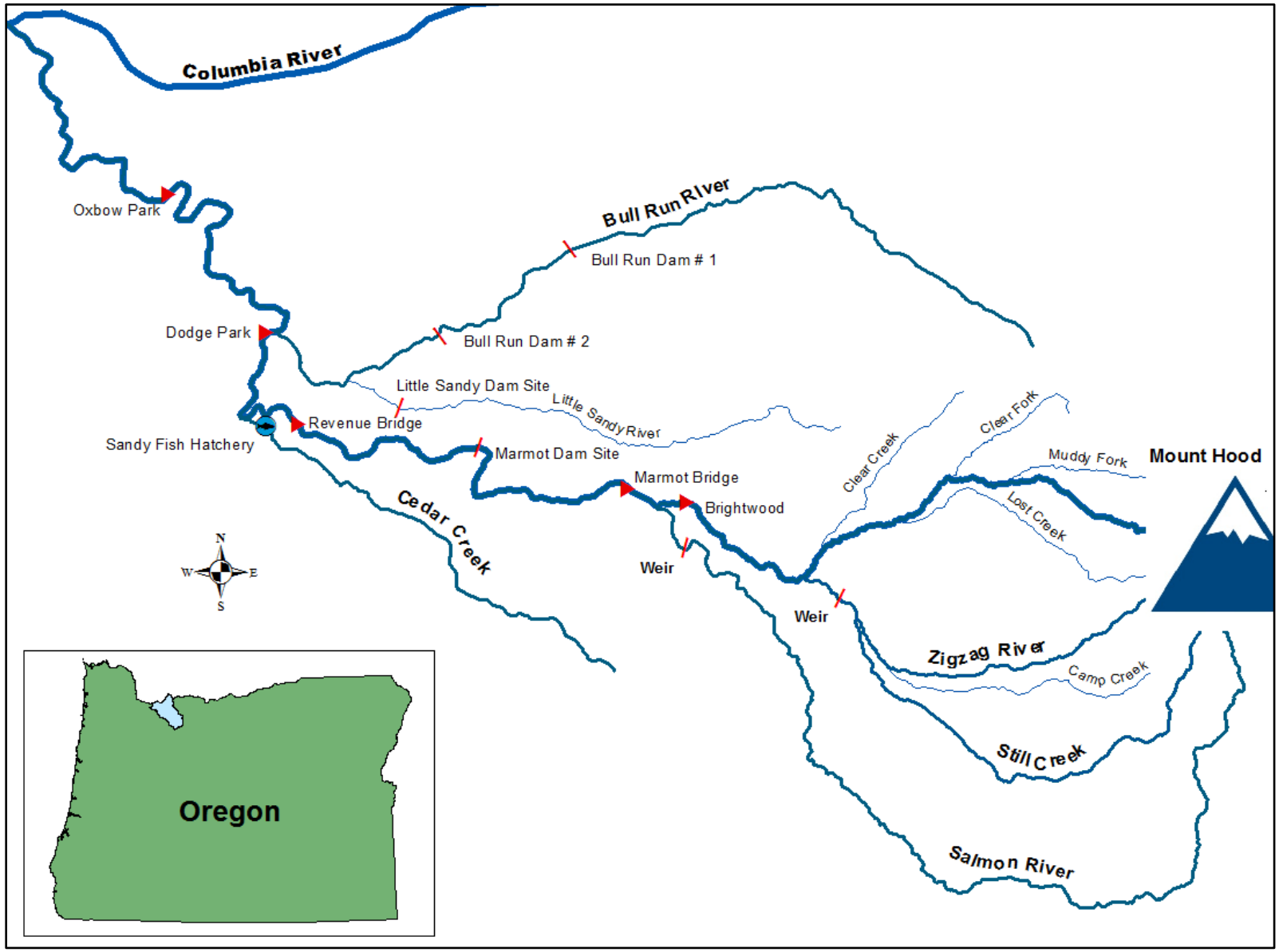

Figure 1. The Sandy River Basin including tributaries with spawning populations of spring Chinook salmon.

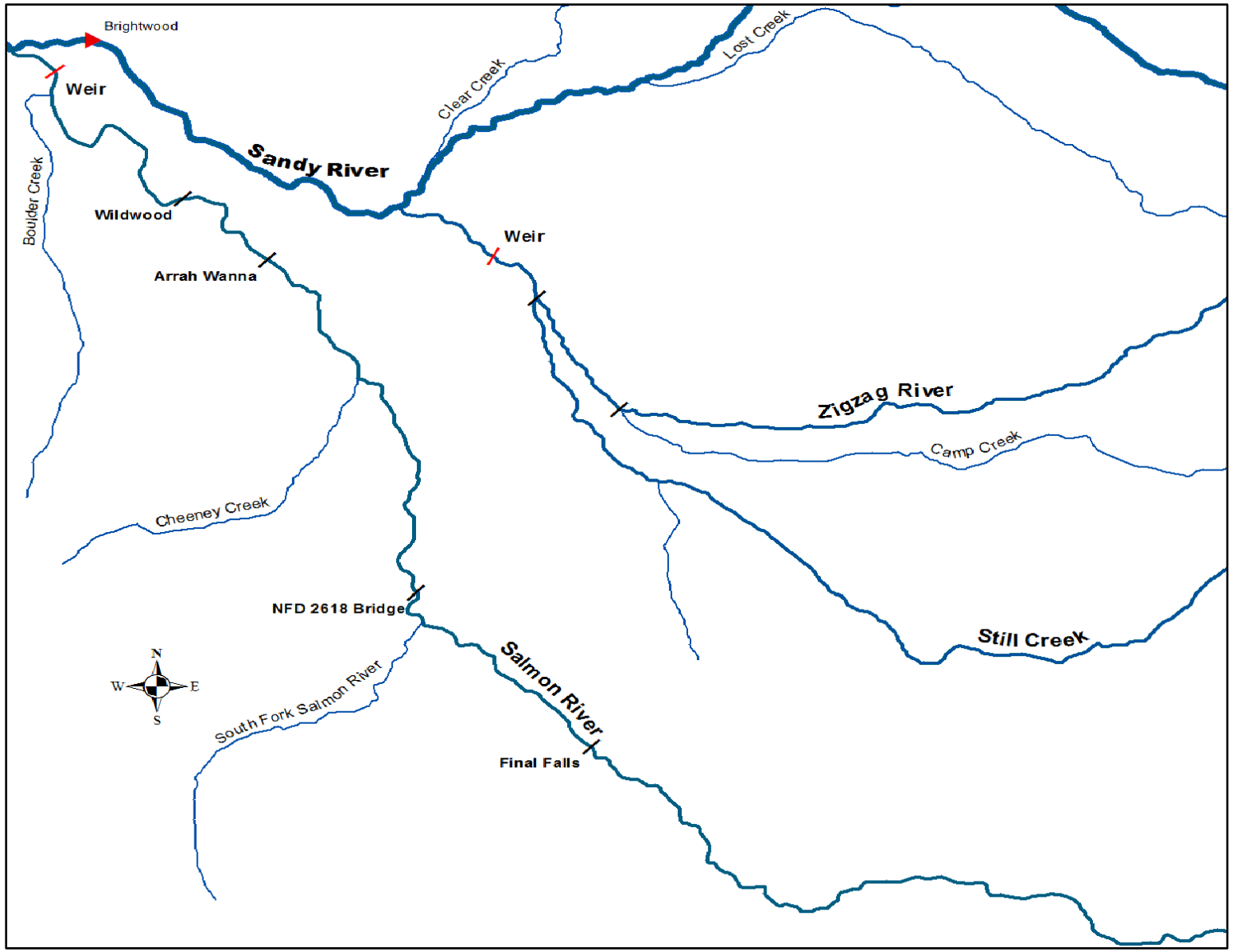

Figure 2. The upper Sandy River Basin with weirs locations and some section breaks on major spawning tributaries.

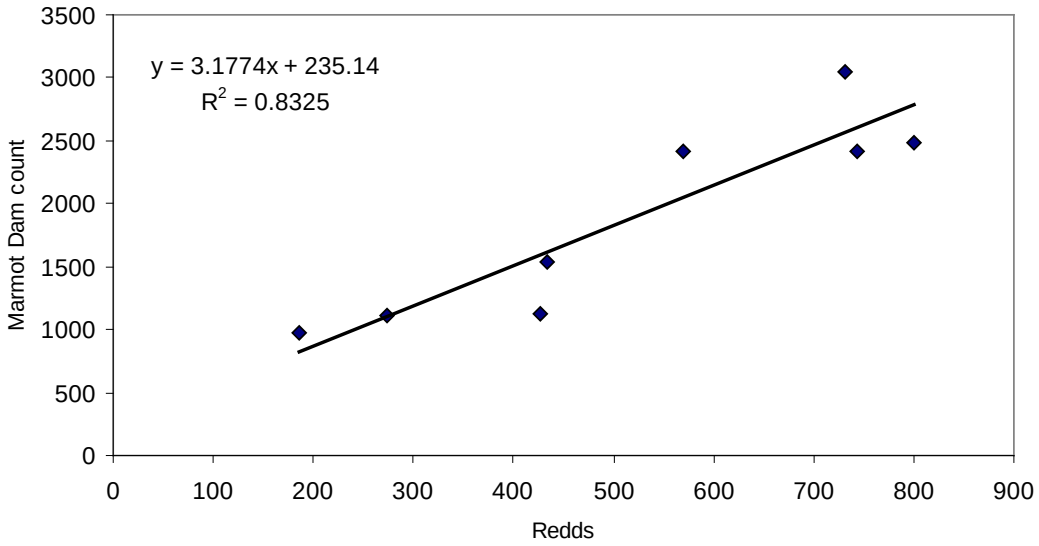

Figure 3. Relationship between count of adult spring Chinook salmon at Marmot Dam and the number of Chinook redds counted upstream of the dam, 1996–1998 and 2002–2006.

Table 1. Percentage of spring Chinook salmon carcasses with fin-clips that were recovered in spawning areas of the Sandy River Basin, 2015.

River/stream	Section	Percent clipped	Sample size
Salmon River	Final Falls - NFD 2618 Br.	1	166
	NFD 2618 Br. - Arrah Wanna	2	95
	Arrah Wanna - Weir	0	159
	Weir - Mouth	20	150
	Cheeney Creek	0	0
Salmon Basin Total		**6**	**570**
Zigzag River	Above Camp Creek	0	3
	Camp Creek - Still Creek	0	7
	Still Creek - weir	0	36
	Weir - mouth	21	239
Zigzag River Total		**17**	**285**
Still Creek	Above Rd 20 Bridge	0	95
	Below Rd 20 Bridge	0	72
Still Creek Total		**0**	**167**
Camp Creek	Campground - mouth	0	1
Zigzag Basin Total		**11**	**453**
Lost Creek	Riley Campground - mouth	0	4
Clear Fork	Mouth area	17	42
Bull Run River	Dam - mouth	38	29
Sandy River	Zigzag River to Marmot Dam	37	38
GRAND TOTAL		**10.1**	**1,136**

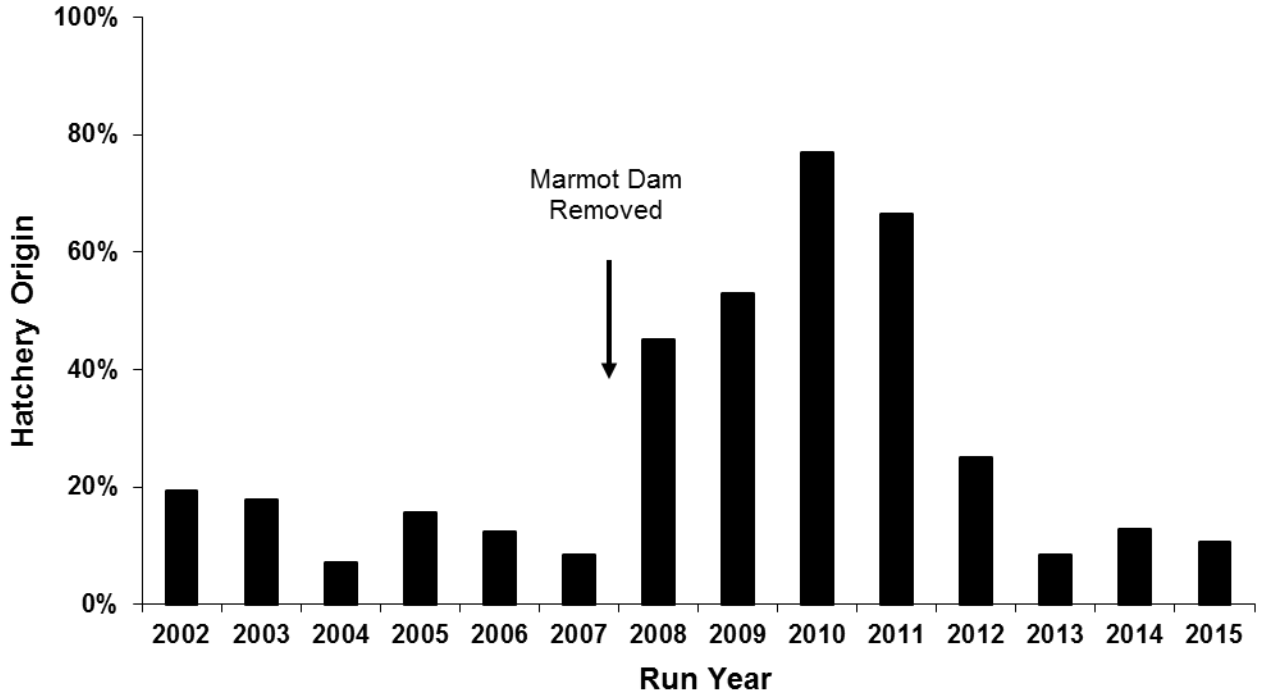

Figure 4. Percentage of hatchery-origin spring Chinook salmon in the spawning population of Sandy River basin upstream of the Marmot Dam site, 2002–2015.

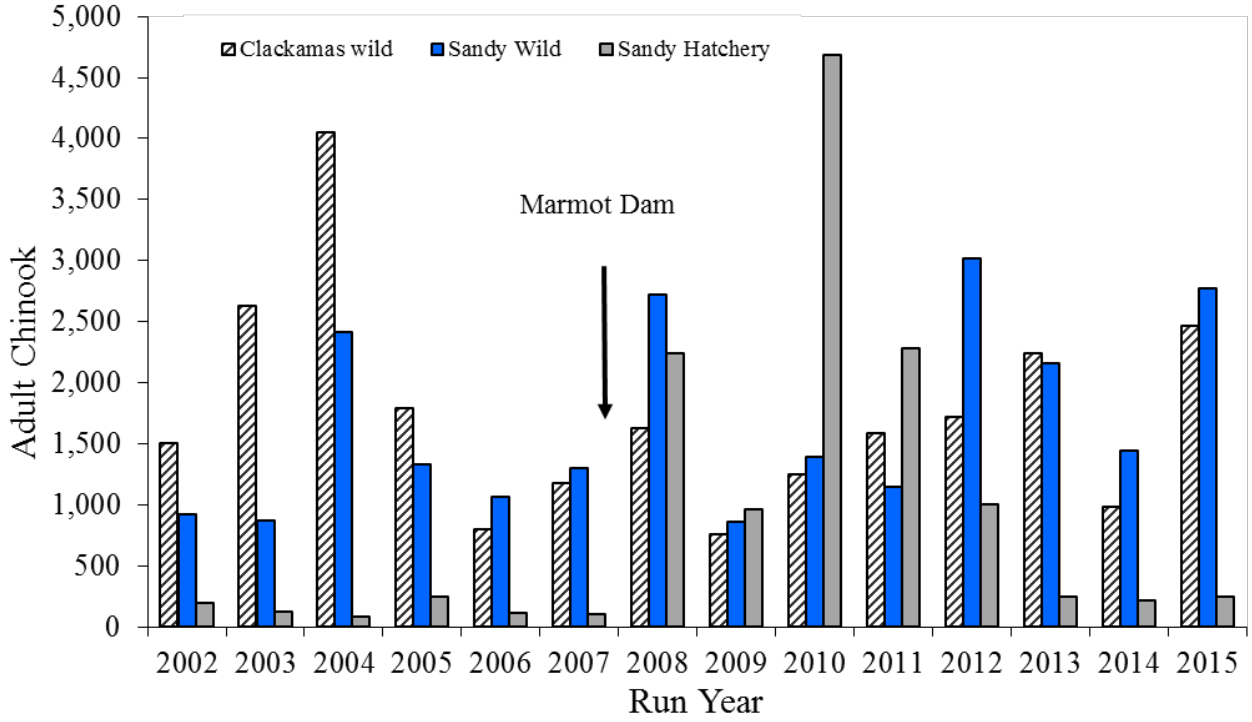

Figure 5. Number of spring Chinook salmon spawning in the Sandy River basin (hatchery and wild), and in the Clackamas Basin upstream of North Fork Dam (wild), 2002–2015. Number of fish in the Sandy River basin in 2008–2015 was estimated from redd counts. For 2002–2006, the number of fish was estimated with the relationship of counts at Marmot Dam to redd counts. The proportion of wild and hatchery fish was estimated from recovery of carcasses.

Table 2. Percentage of spring Chinook salmon carcasses that were hatchery origin in six areas of the Sandy River Basin, 2015.

Basin	Area	Percent hatchery	Sample size
Salmon	Upstream of weir	1.0	420
	Downstream of weir	20.0	150
	Total	**6.0**	**570**
Zigzag	Upstream of weir	0.0	214
	Downstream of weir	20.5	239
	Total	**10.8**	**453**
Sandy R, Lost,& Clear Fork creeks	All surveyed areas	25.0	84
Bull Run River	Dam–mouth	37.9	29

Table 3. Age composition (%) by return year of wild spring Chinook salmon in the Sandy River basin. Origin of fish was determined by presence of the adipose fin and absence of induced thermal marks in otoliths.

Return year (n)	Age 3	Age 4	Age 5	Age 6
2002 (74)	0.0%	45.9%	51.4%	2.7%
2003 (40)	2.5%	25.0%	67.5%	5.0%
2004 (226)	0.4%	73.9%	25.2%	0.4%
2005 (162)	0.0%	23.5%	74.7%	1.9%
2006 (180)	1.1%	41.1%	56.7%	1.1%
2007 (216)	0.9%	23.1%	74.1%	1.9%
2008 (290)	0.3%	42.8%	54.8%	2.1%
2009 (91)	0.0%	41.8%	54.9%	3.3%
2010 (265)	4.9%	43.4%	51.3%	0.4%
2011 (242)	2.9%	58.7%	36.4%	2.1%
2012 (649)	0.3%	55.0%	43.1%	1.5%
2013 (611)	1.6%	32.2%	64.2%	2.0%
2014 (488)	2.5%	51.2%	45.7%	0.6%
2015 (399)	5.8%	67.4%	26.1%	0.8%

Table 4. Age composition (%) by brood year of wild spring Chinook salmon in the Sandy River basin. Origin of fish was determined by presence of the adipose fin and absence of induced thermal marks in otoliths.

Brood year (n)	Age 3	Age 4	Age 5	Age 6
1998 (62)	--	54.8%	43.5%	1.6%
1999 (70)	0.0%	14.3%	81.4%	4.3%
2000 (291)	0.3%	57.4%	41.6%	0.7%
2001 (145)	0.7%	26.2%	70.3%	2.8%
2002 (240)	0.0%	30.8%	66.7%	2.5%
2003 (214)	0.9%	23.4%	74.3%	1.4%
2004 (177)	1.1%	70.1%	28.2%	0.6%
2005 (180)	0.6%	21.1%	75.6%	2.8%
2006 (213)	0.0%	54.0%	41.3%	4.7%
2007 (447)	2.9%	31.8%	62.6%	2.7%
2008 (759)	0.9%	47.0%	51.6%	0.4%
2009 (425)	0.5%	46.4%	52.5%	0.7%
2010 (364)	2.7%	68.7%	28.6%	––

Table 5. Number of spring Chinook salmon counted at traps in the Salmon and Zigzag rivers, 2011-2015. Fin-clipped fish were removed and unclipped fish were passed upstream. Traps were installed by ODFW district biologists to capture and remove fin-clipped salmon.

	Zigzag					Salmon				
	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015
Dates	Aug 19 - Sep 29	Jul 14 - Oct 14	Jul 8 - Sep 27	Jun 20- Oct 10	May 21 - Oct 12	Sep 14 - Oct 4	Jun 18 - Oct 14	Jul 8 - Sep 28	Jul 7- Oct 10	Jun 1 - Oct 21
Fin-clipped	183	188	167	298	36	229[a]	247	98	156	69
Not clipped	91	432	745	567	538	94	1,108	706	566	968

[a] An additional 44 clipped Chinook were netted and removed prior to the trap installation.

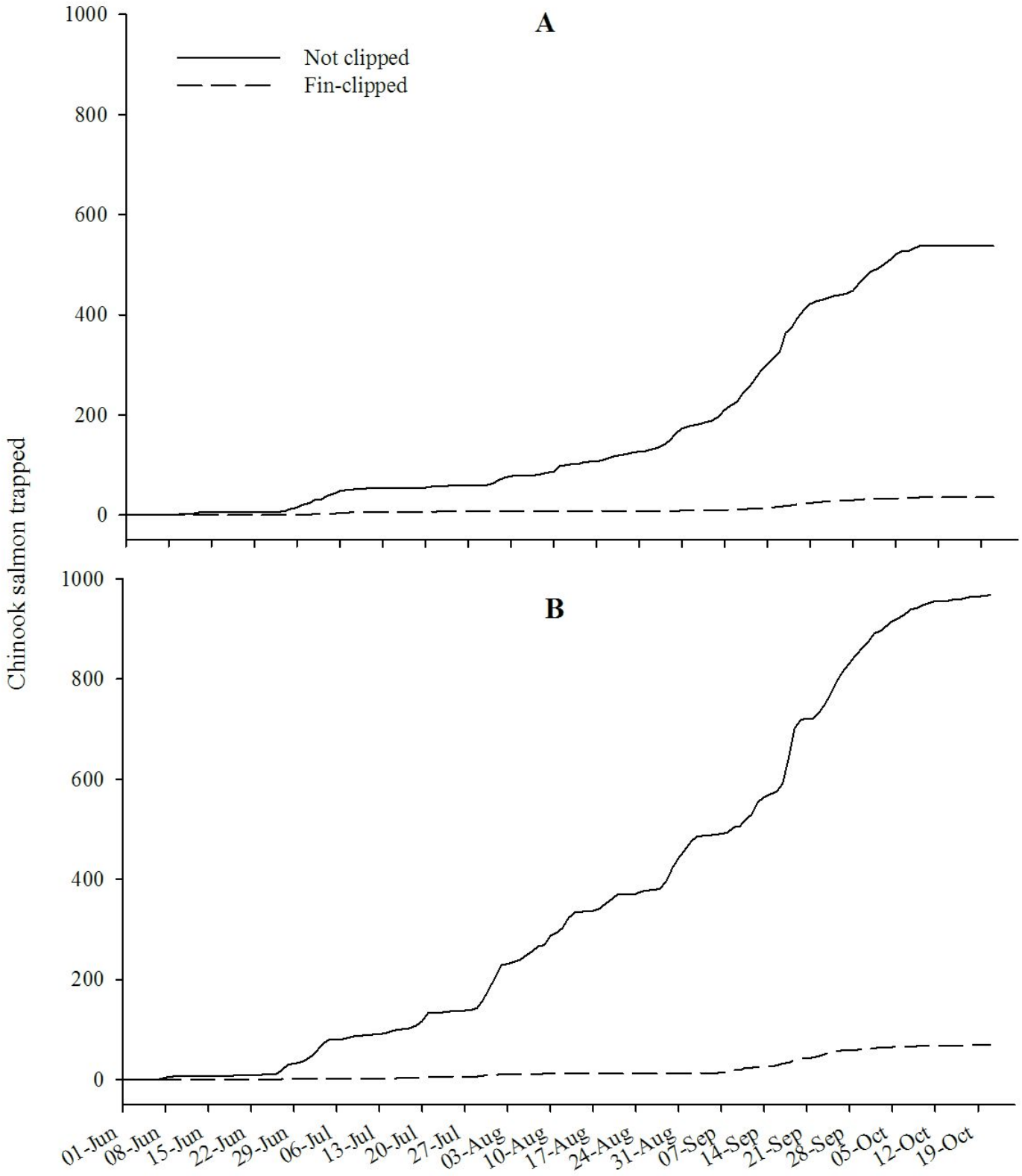

Figure 8. Cumulative number of spring Chinook salmon handled at weirs in the lower Zigzag (A) and Salmon (B) rivers, for fish with an adipose fin clip (dashed line) and without a fin clip (solid line), 2015.

Table 6. Effect of trapping and removing fin-clipped spring Chinook salmon at weirs in the lower Zigzag and Salmon Rivers on the proportion of hatchery spawners in the Zigzag and Salmon rivers and in the upper Sandy River basin, 2015.

		Fin-clipped spawners (%)	
	Number removed	With trapping	Without trapping
Zigzag	36	10.8	17.4
Salmon	69	6.3	16.4
Upper Sandy River basin	105	9.4	17.2

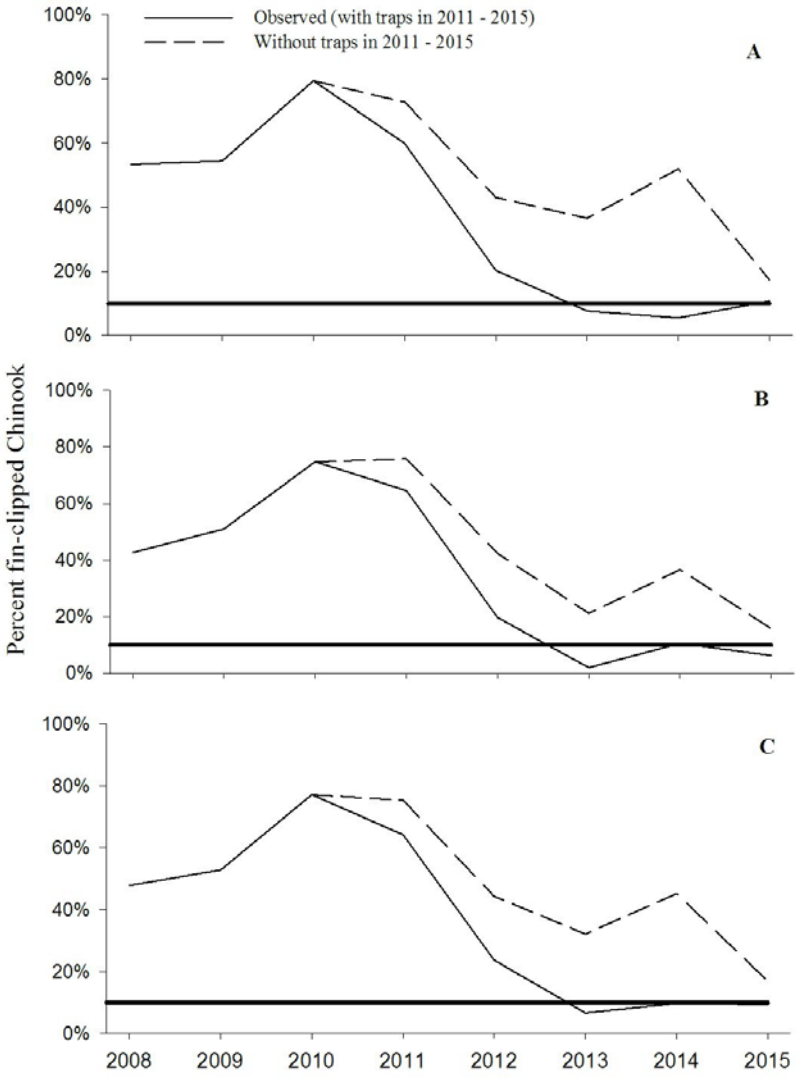

Figure 9. Percentage of fin-clipped spring Chinook salmon in the Zigzag (A) and Salmon (B) rivers, and in the upper Sandy River basin (C). Traps were operated in the lower Salmon and Zigzag rivers in 2011–2015 to remove fin-clipped fish. Estimated percentage of fin-clipped spawners without trapping is shown by dashed line. The 10% line represents the conservation and recovery objectives for proportion of hatchery-origin spawners.

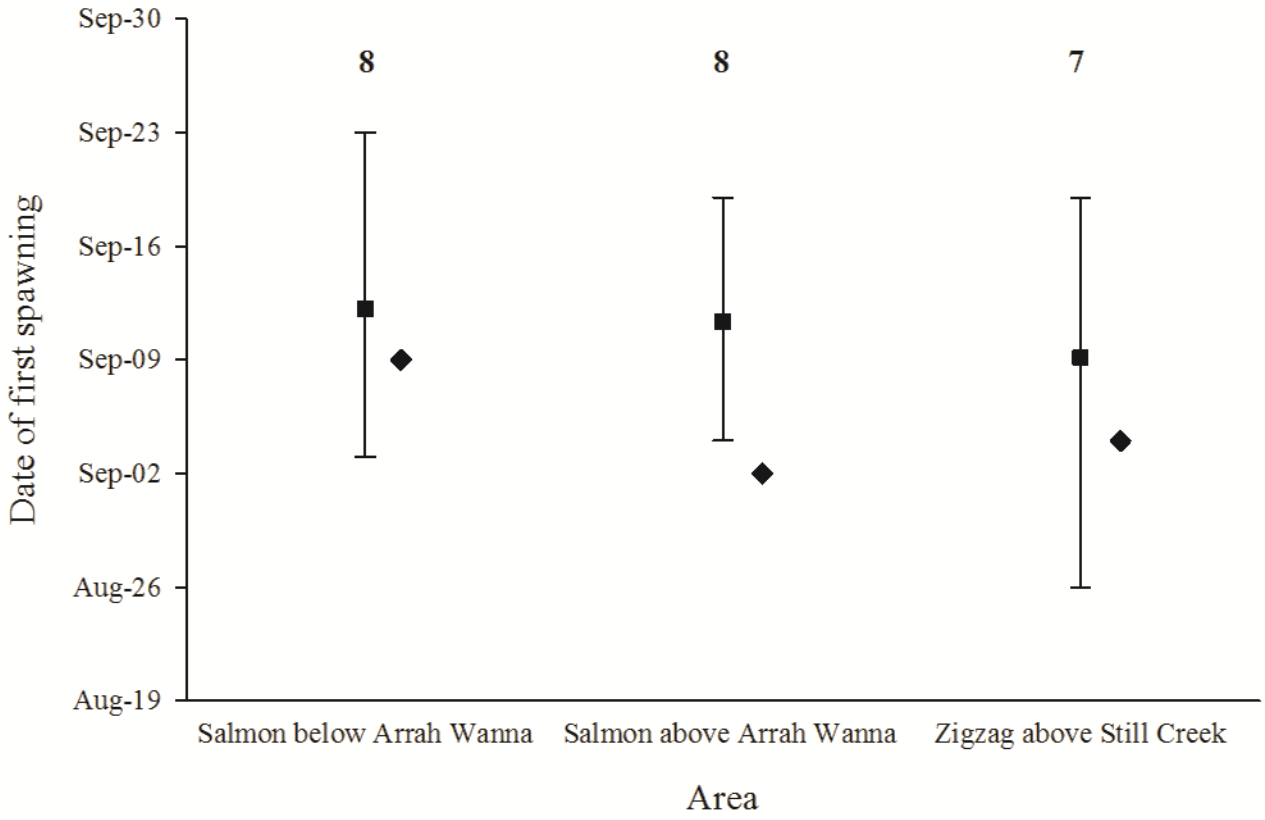

Figure 10. Date of first spawning for spring Chinook salmon in the Salmon and Zigzag River Basins for 2002–2009 (mean, ■), and in 2015 (♦). The capped vertical lines are the range and the numbers above the lines are years in the data set. Data for 2010 were not included because surveys started late. Does not include 2003 for the Zigzag River Basin because surveys were more than two weeks apart between early and late September.

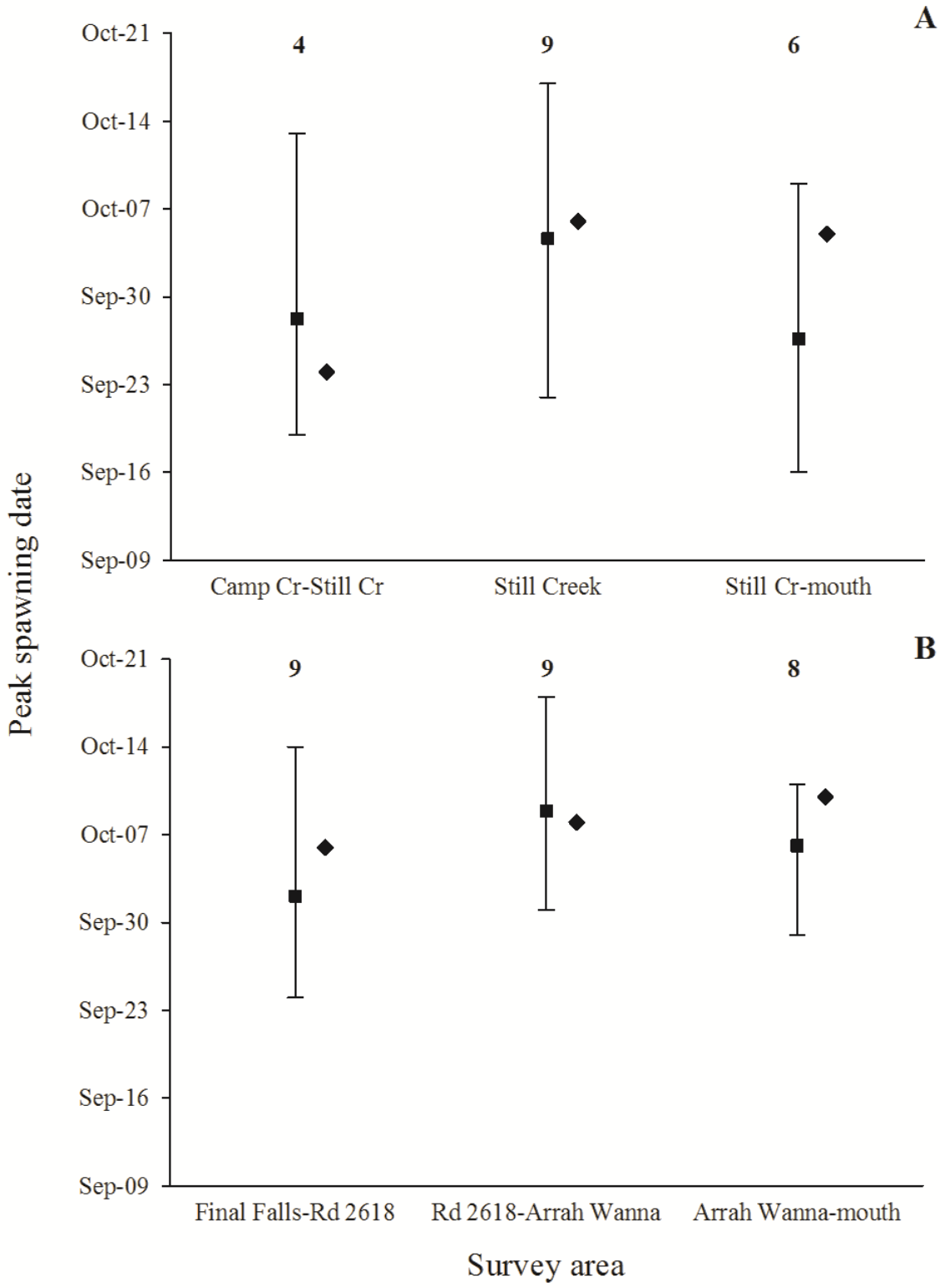

Figure 11. Peak spawning dates of spring Chinook salmon in the Zigzag (A) and Salmon (B) river basins in 2002–2010 (mean, ■) and in 2015 (♦). The capped vertical lines are the range and the numbers above the lines are years in the data set. Years were excluded when only a single survey was conducted (Zigzag River) or when no late surveys were conducted (lower Salmon River).

Table 7. Count of spring Chinook salmon redds and redd density (redds/mi) in standard survey areas of the upper Sandy River basin (upstream of the old Marmot Dam site), 2004-2015. Areas include those that were consistently surveyed in all years, which accounted for 94–100% of all redds in the upper basin.

Basin, section	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Salmon River:						***Redds***						
Final Falls–Forest Rd 2618	233	84	139	79	395	139	382	173	314	179	189	284
Forest Rd 2618–ArrahWanna	188	62	45	54	181	61	251	151	87	79	60	99
ArrahWanna–Wildwood	179	65	67	22	60	14	70	48	32	19	25	41
Wildwood-mouth		81		36	61	25	98	113	135	46	82	191
Salmon R tributaries	3	--	--	--	1	0	53	0	2	34	0	0
Zigzag River:												
Still Creek	108	79	117	28	405	162	550	152	291	291	185	238
Camp Creek	19	8	5	0	--	2	55	19	22	19	9	1
Above Still Creek	6	13	7	13	75	50	80	89	33	77	25	52
Still Creek–mouth	48	31	36	27	109	36	59	122	80	86	48	201
Other streams:												
Lost Creek	20	11	9	9	27	9	5	32	45	15	14	30
Clear Fork Creek	0	--	--	--	1	1	2	10	24	18	9	35
Clear Creek	0	0	2	3	0	0	3	--	--	1	0	1
TOTAL	**801**	**434**	**427**	**271**	**1,314**	**499**	**1,608**	**909**	**1,065**	**864**	**646**	**1,173**
Salmon River:						***Redds/mi***						
Final Falls–Forest Rd 2618	69.1	26.3	43.4	24.7	117.2	43.4	114.8	54.1	98.1	58.2	59.1	88.8
Forest Rd 2618–ArrahWanna	25.4	11.5	8.3	10.0	33.5	8.2	40.4	28.0	16.1	14.6	11.1	18.3
ArrahWanna–Wildwood	111.9	40.6	41.9	13.8	37.5	8.8	43.8	30.0	20.0	11.9	15.6	25.6
Wildwood-mouth		23.8		10.6	17.9	7.4	28.8	33.2	39.7	13.5	24.1	56.2
Salmon R tributaries	1.2	--	--	--	0.4	0.0	21.2	0.0	0.8	13.8	0.0	0.0
Zigzag River:												
Still Creek	32.7	15.8	35.5	8.5	81.0	32.4	109.2	30.4	58.2	58.2	37.0	47.6
Camp Creek	8.3	3.5	2.2	0.0	--	0.9	23.9	8.3	9.6	8.3	3.9	0.4
Above Still Creek	3.2	6.8	3.7	6.8	39.5	13.5	21.6	24.1	8.9	20.8	6.8	14.1
Still Creek–mouth	21.8	14.1	16.4	12.3	49.5	16.4	26.8	55.5	36.4	39.1	21.8	91.4
Other streams:												
Lost Creek	10.0	5.5	4.5	4.5	13.5	4.5	2.5	16.0	22.5	7.5	7.0	15.0
Clear Fork Creek	0.0	--	--	--	1.7	1.7	3.3	16.7	40.0	30.0	15.0	58.3
Clear Creek	0.0	0.0	4.0	6.0	0.0	0.0	6.0	--	--	2.0	0.0	2.0

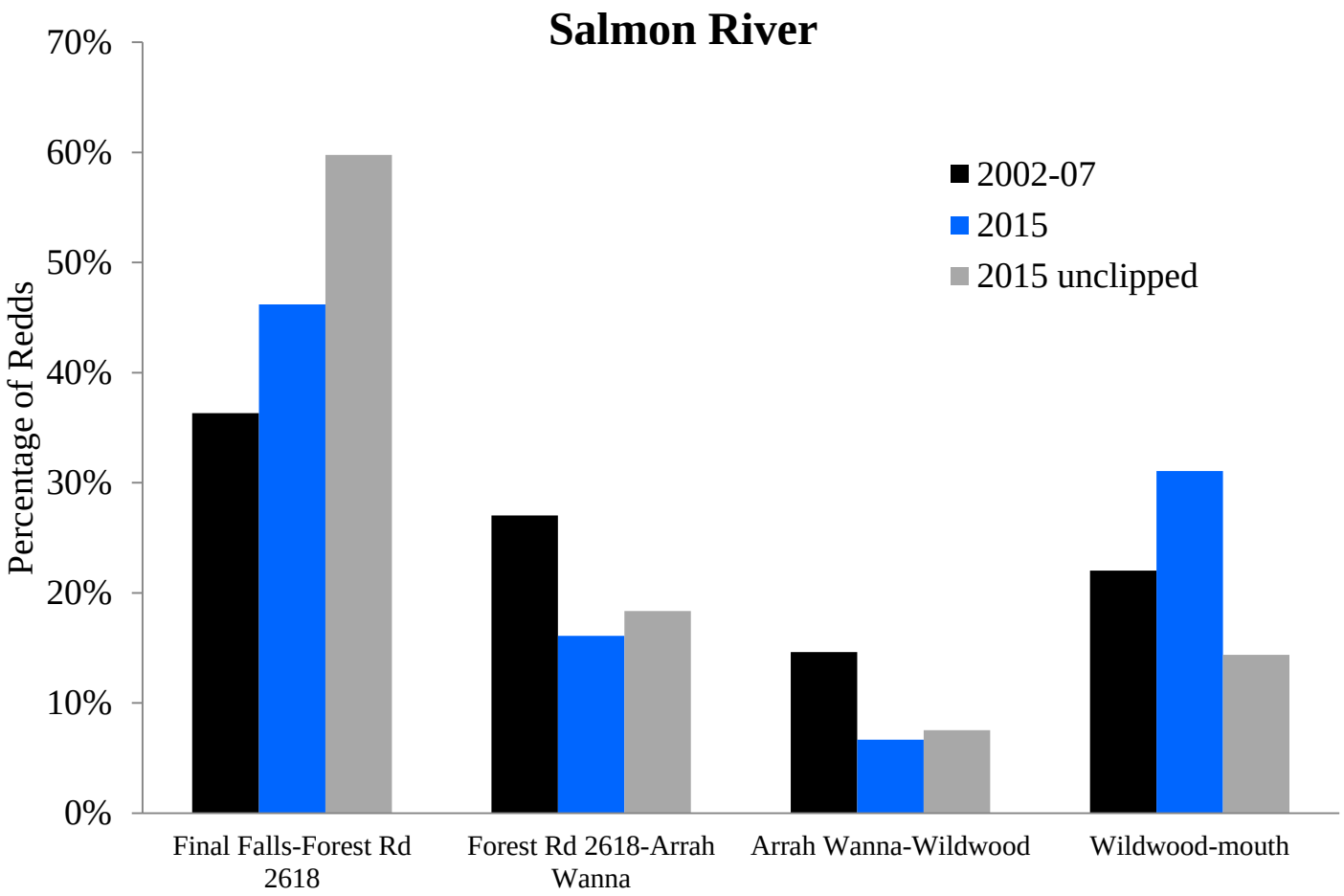

Figure 12. Percentage of spring Chinook salmon redds in four sections of the Salmon River, 2002–2007 and 2015. The 2002–2007 data did not include 2004 and 2006 because redd counts were combined for the lower two sections. The estimated redd distribution of unclipped fish in 2015 was based on the proportion of unclipped carcasses in each section.

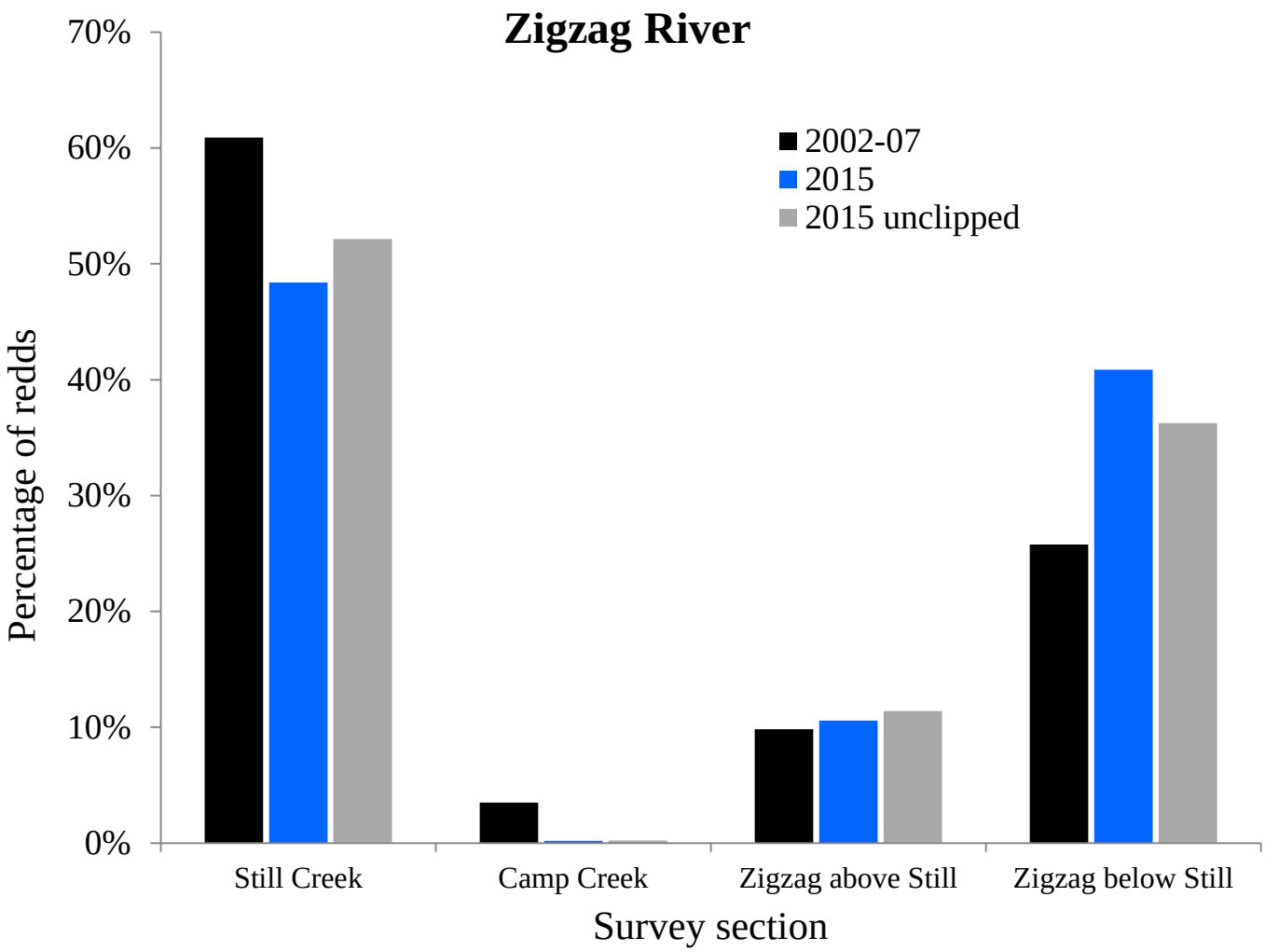

Figure 13. Percentage of spring Chinook salmon redds in four sections of the Zigzag River watershed, 2002–2007 and 2015. The estimated redd distribution of unclipped fish for 2015 is based on the proportion of unclipped carcasses recovered in each section.

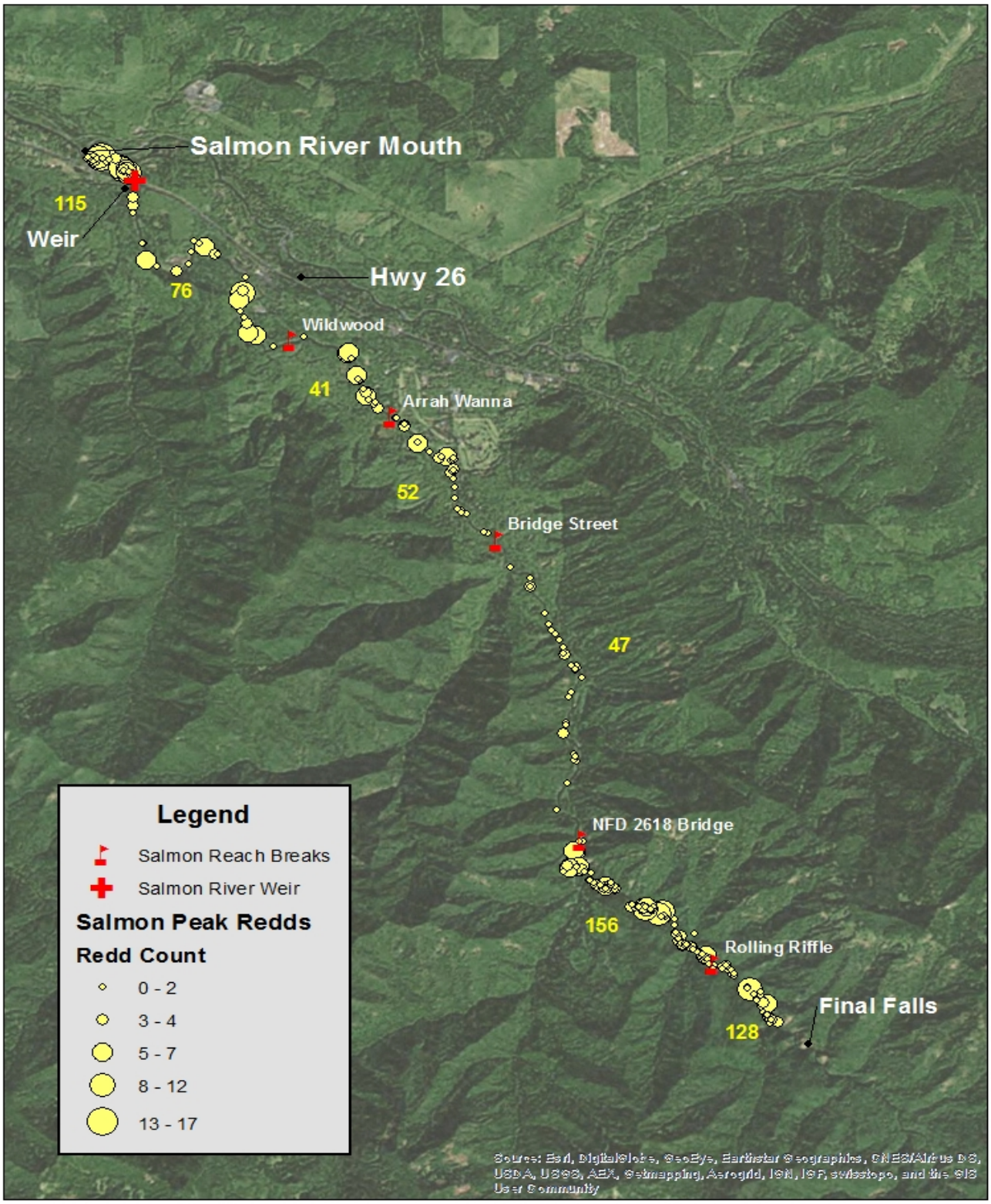

Figure 14. Location of redds in the Salmon River watershed, 2015. Redd locations were marked with GPS receivers synchronized with PDAs. Numbers in yellow are peak counts of redds for survey sections indicated by red markers.

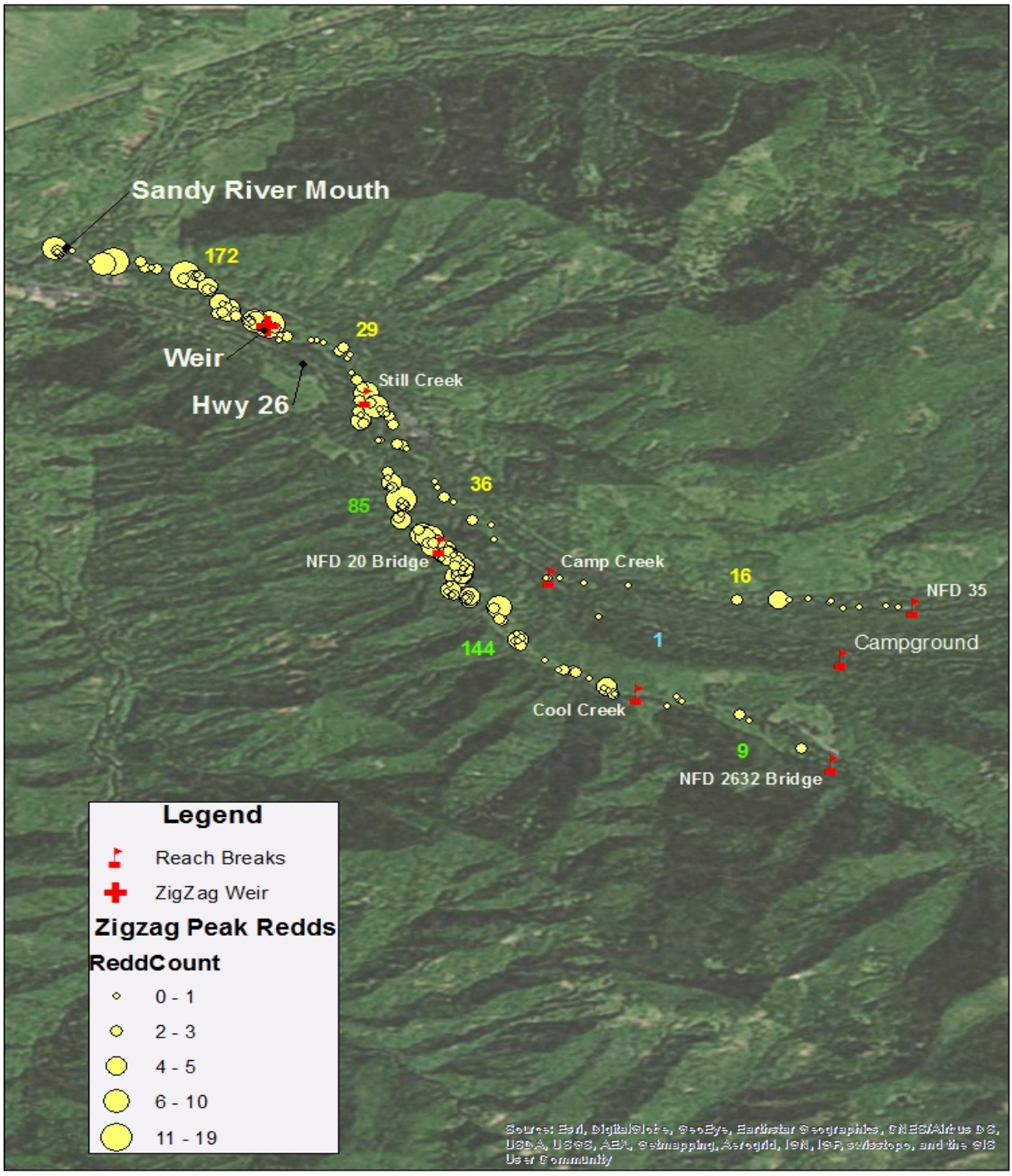

Figure 15. Location of redds in the Zigzag River watershed, 2015. Redd locations were marked with GPS units synchronized with field data collectors PDAs. Numbers in yellow, green, and blue are peak counts of redds for survey sections (indicated by red markers) where redd location data are available.

Table 8. Percentage of spring Chinook salmon females that died prior to spawning as determined by presence of eggs (sample size in parentheses) for the Salmon and Zigzag watersheds, and for the upper Sandy River basin. Fin-clipped fish were removed at Marmot Dam in 2003–2007, no weirs were operated in 2008–2009, and weirs were operated in the lower Salmon and Zigzag rivers in 2011-2015 to trap and remove fin-clipped fish.

Watershed	2003–2007[a]	2008–2009[a]	2011	2012	2013	2014	2015
Salmon	11.1 (75)	8.2 (113)	4.0 (281)	7.4 (285)	5.1 (216)	5.4 (202)	4.7 (254)
Zigzag	1.5 (20)	2.9 (122)	5.5 (91)	5.0 (201)	3.6 (166)	5.8 (138)	5.3 (208)
Upper Sandy	9.2 (97)	5.8 (242)	4.7 (406)	5.6 (550)	4.6 (395)	5.7 (349)	5.2 (501)

[a] 2002 and 2010 were excluded because surveys did not begin until mid-September.