PROGRESS REPORTS

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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 – 2013

Compliance Monitoring for Sandy Hatchery Biological Opinion – June 2014

ANNUAL PROGRESS REPORT

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

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KEY FINDINGS

1. The proportion of hatchery origin spawners (pHOS) for spring Chinook salmon *Oncorhynchus tschwytscha* in the Sandy River Basin was 9.3% in 2013.
2. A total of 265 hatchery fish were removed at the weirs, reducing pHOS from 31% to 9% in the upper Sandy River Basin.
3. An unprecedented rainstorm took place in late September, disrupting our surveys for about a week. However, we still collected accurate redd counts and recovered large numbers of carcasses, before and after the storm.
4. Peak spawn timing occurred the week before the rainstorm. Although early, peak spawning was within the range of dates from 2002-2012.
5. Spawning distribution was similar to 2002-2007, suggesting that weirs did not affect distribution.
6. Pre-spawning mortality of wild fish in the Salmon and Zigzag River basins was lower in 2013 than in 2003–2010 in the absence of weirs. Pre-spawning mortality was lower for wild fish than for hatchery fish.

INTRODUCTION

Spring Chinook salmon 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 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 exclude hatchery adults homing back to this river. Also, ODFW began conducting spawning surveys in the Bull Run River in 2013.

An updated Hatchery Genetics Management Plan (HGMP) for the Sandy River basin that included these new management actions was completed in 2011 and finalized in 2012 (ODFW 2011). A Biological Opinion on the hatchery program in the Sandy River basin was issued by National Marine Fisheries Service (NMFS) in September 2012 (NMFS 2012). These two

documents contain performance standards, monitoring requirements, and terms and conditions for the hatchery program. They require ODFW to make annual reports of progress towards these performance standards.

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 HGMP. Those activities or analyses in bold italics are ongoing and will be reported later as noted.

1. Reduce stray 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 pHOS is 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, 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 pre-spawning mortality in the naturally produced population.
8. Monitor changes in spawning distribution and estimate pre-spawning mortality.

METHODS

Spawning surveys for spring Chinook salmon in the Sandy River basin consist of carcass recovery and redd counts, following the standard methods used in previous years (Crawford et al. 2007; Gallagher et al. 2007; 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 pre-spawning 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 have been used to exclude hatchery spawners from the upper Sandy Basin since 2011.

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 2013, 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 segmented 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 2013 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 pre-spawning 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 was operating the weir on the Bull Run River. We did not conduct these surveys previously because they were being done by PWB and the data was shared for our reports. These surveys documented little spawning activity and limited available spawning habitat (Schroeder et al. 2013).

Carcass Recovery

All recovered carcasses were processed if we could determine whether or not they had an adipose fin. Carcasses were cut open to verify sex, and retention of eggs in females was used to determine spawning success (pre-spawning mortality). We scanned all fin-clipped fish with a hand-held detector to check for coded wire tags (CWT), and we 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. Otoliths were 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. 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).

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 in 2013.

Trapping

District biologists from ODFW installed weirs and fish traps in the lower Salmon and Zigzag rivers to capture and remove hatchery 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 and categorized as either 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, pre-spawning 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. Pre-spawning mortality within watersheds and in the upper Sandy River basin

Data Management and Analysis

All carcass and redd data was 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.

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 and complete counts are no longer available as a result. 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 include 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 2007-2013, 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.

A simple linear regression was used to compare catch at the weir traps with river flow in the mainstem Sandy and tributaries. Water data came from the USGS gauges at the Marmot Dam site and on Blazed Alder Creek. Blazed Alder Creek was chosen because this is the closest catchment to the spawning tributaries with a gage station on it. We can expect water levels in this creek to respond similarly to those in the Salmon and Zigzag rivers as these catchments are close in proximity and receive similar rainfall.

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 2013 from August 19 to October 31. Primary spawning areas in the Salmon and Zigzag watersheds were surveyed 6–9 times through the season, generally on a weekly rotation. These are the sections that have historically accounted for most redds in the upper basin. Secondary spawning areas in the upper Zigzag River, Little Sandy River and, Lost, Clear Fork, Devil's Canyon, Cheeney, and Sixes 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. We also surveyed the Sandy River upstream of the old Marmot Dam site (6 times) and the Bull Run River (8 times).

An unprecedented rainstorm took place on September 27th - 29th. Extremely high water levels following the storm disrupted our spawning surveys during the first week of October. Our surveyors were able to recover some carcasses, but could not count redds during the storm. Anticipating the storm, surveyors worked to verify our redd counts and to recover additional carcasses during the previous week. Peak spawning took place the last week of September, just before the storm. New redds constructed after the storm were verified with GPS coordinates and added to peak redd counts in some sections.

Composition of the Spawning Population

The estimate of pHOS in the Sandy River Basin in 2013, including the Bull Run River and adjusted for bias in recovery of carcasses, was 9.3% (unadjusted 9.4%). 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 Marmot Dam site), the estimated pHOS in 2013 was 8.4% when adjusted for carcass recovery bias and 8.7% without adjustment. 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 5). About 7% of the spring Chinook salmon recovered in the spawning streams of the upper Sandy River Basin in 2013 were fin-clipped (Table 1). Excluding carcasses that died prior to spawning, pHOS would decrease by 2% because pre-spawning mortality was higher in hatchery fish than in wild fish (see Effect on Pre-spawning Mortality).

The percentage of hatchery origin spawners was lowest in the Salmon and Zigzag rivers and highest in the Sandy and Bull Run rivers, Lost and Clear Fork creeks (Table 2). The percentage of hatchery spawners in 2013 was 4.0% and 10.6% upstream of weirs in the Salmon and Zigzag rivers, respectively, whereas just over 33.0% of the spawners downstream of the Zigzag and Salmon weirs were hatchery origin (Table 2).

Estimated abundance of spawning spring Chinook salmon in the Sandy Basin was 2,413 2,395, with 2, 188 2,172 wild spawners and 224 223 hatchery spawners. The number of wild fish returning in 2013 was 7% lower than in 2012, and the number of hatchery fish returning in 2013 was 51% less than in 2012 (Figure 5). By comparison in the Clackamas River basin upstream of North Fork Dam, the number of wild spring Chinook salmon increased 22% from 2012 to 2013 (Figure 5) and the number of hatchery fish counted at the dam decreased 44%. However, the count of hatchery fish at North Fork Dam does not include those that entered Clackamas Hatchery downstream of the dam. 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 2013 were 32.5% age 4 and 63.9% age 5 (Table 3). Each year, a small percentage of spawners will be age 3 and age 6. Wild adults from the 2007 brood year were 31.8% age 4 and 62.6% age 5. Wild adults from the 2008 brood year were 47.2% age 4 and 51.9% age 5, although we expect a small percentage of age 6 adults to return in 2014 (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 2013, the Zigzag River trap was in the same location as in 2012. The Salmon River trap was relocated downstream to an area just below the Highway 26 Bridge, approximately 1 mile downstream from where it was located in 2012.

Trapping began July 8 in the Salmon and Zigzag rivers (Table 3). 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.

Total catch at the weir traps tracked closely with changes in flow in the tributaries to the Sandy River (Figure 6). Total trap catch was positively correlated ($R^2 = 0.96$) with discharge in tributaries (Figure 7). Increases in flow from spawning tributaries likely brought spawners in from the mainstem Sandy River, increasing the catch at the traps as these fish moved upstream to spawning areas.

Weirs were removed just before or during the storm that took place at the end of September to ensure the safety of ODFW staff operating the traps. Adult salmon were trapped at the weirs at the highest rate during the first three weeks of September and trap catches had decreased substantially the week prior to the storm.

A total of 265 hatchery Chinook were removed at the traps, and 1,451 unclipped Chinook were trapped and passed upstream (Table 3, Figure 8). In addition, 45 clipped Chinook were removed and 18 unclipped Chinook were passed upstream at the weir on the Bull Run River.

We estimated that removing fin-clipped fish at the weirs reduced the percentage of hatchery fish in the spawning population from 31% to 9% for the primary spawning areas upstream of the Marmot Dam site (Table 4, Figure 9). The percentage of fin clipped fish upstream of the weirs on the Salmon and Zigzag rivers were low overall (Table 1). These results indicate that trapping in the primary spawning tributaries continues to reduce the number and percentage of hatchery spawners.

Timing of Spawning

The date of first spawning was September 11 in the Salmon River and September 9 in the Zigzag River (Figure 10). Both dates were within the observed range from 2002-2009 (Figure 10). The date of first spawning in 2013 in the lower Salmon River was September 10, similar to the mean from 2002–2009 (Figure 10).

Peak spawning in the Zigzag River Basin occurred September 18-25 within the range from 2002-2010 (Figure 11). In the Salmon River, peak spawning took place on September 27. This date was within the range from 2002-2010 in the most upstream area, although earlier than the range in the sections downstream of Forest Road 2618.

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Hewlett for preparing maps of redd locations. 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. Greg Wanner and his crew at the U.S. Forest Service assisted with surveys in the Salmon River and Still Creek. Burke Strobel and his crew with the City of Portland Water Bureau helped collect biological samples from the Bull Run River.

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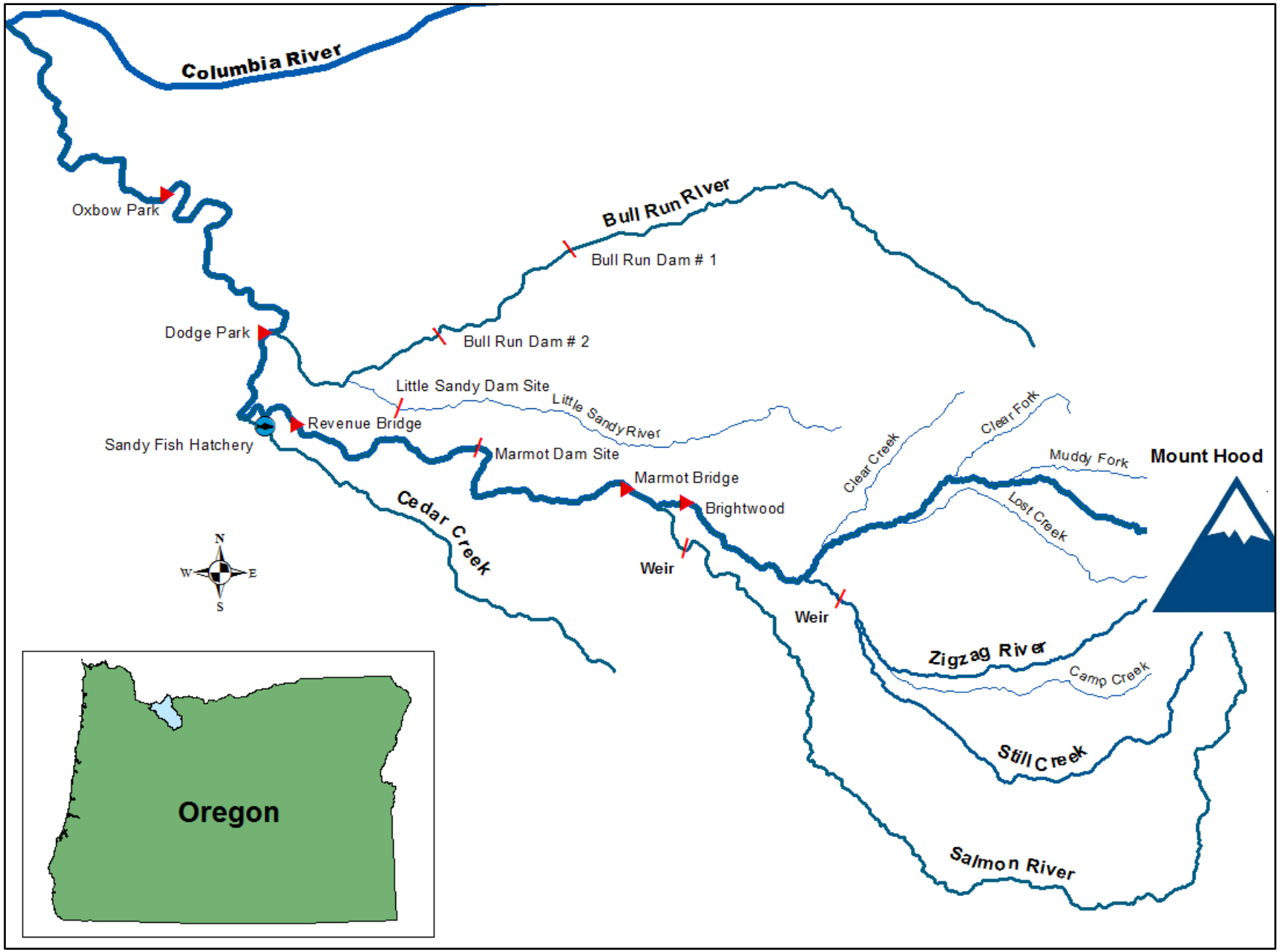

Figure 1. The Sandy River basin, including tributaries with spawning populations of spring Chinook salmon.

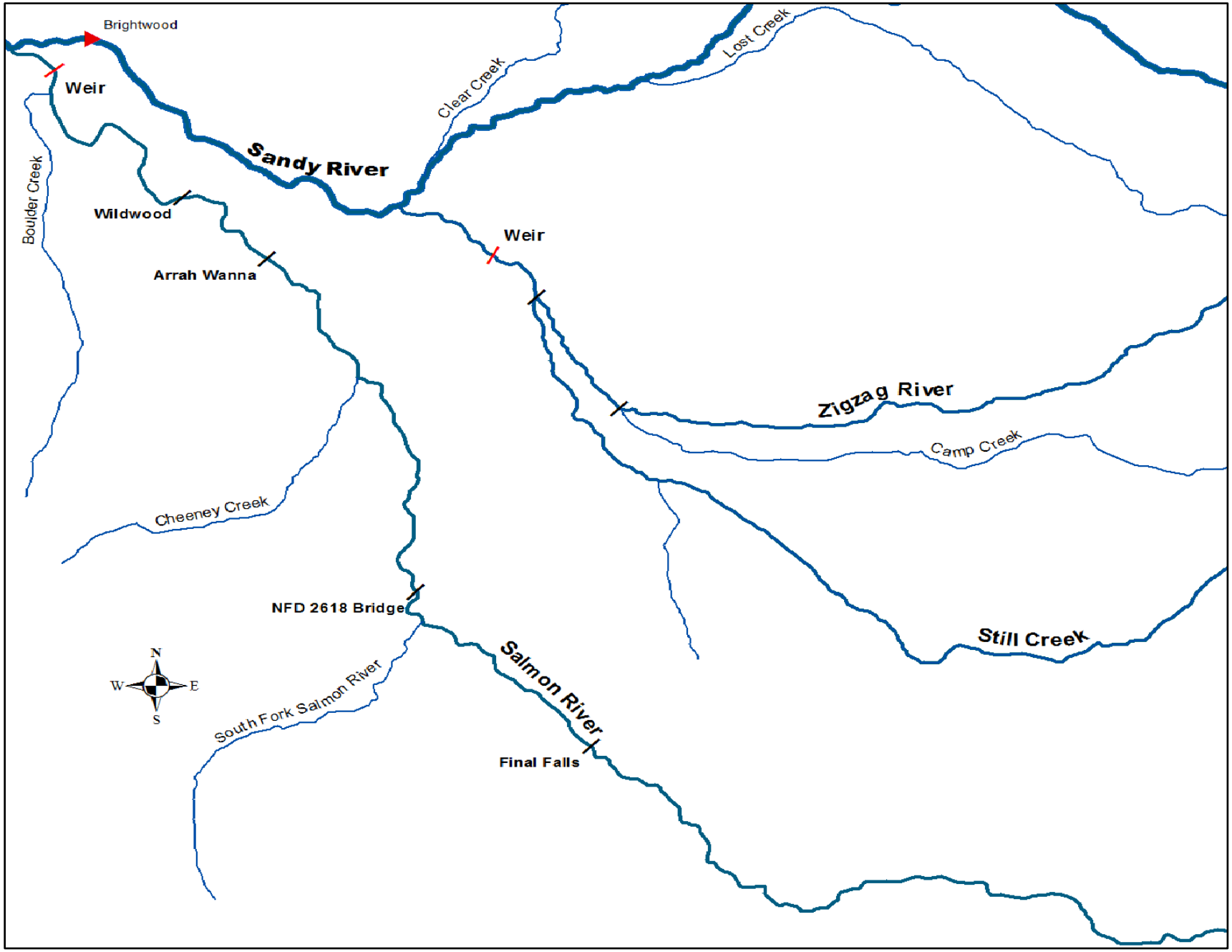

Figure 2. The upper Sandy River basin, with weir locations and some section breaks on major spawning tributaries.

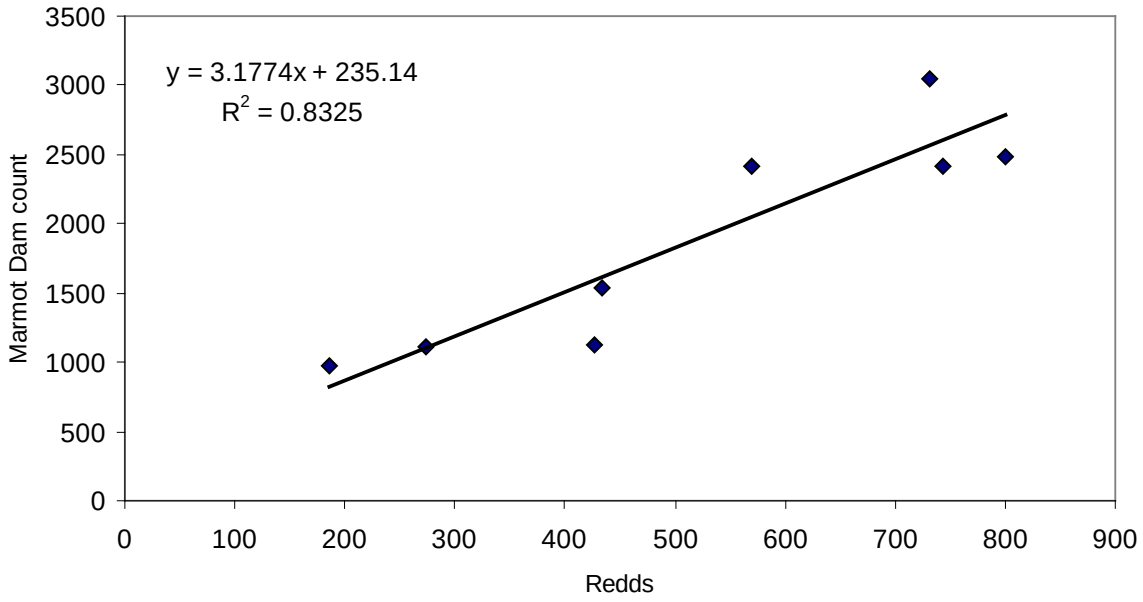

Figure 3. Relationship between count of adult spring Chinook salmon at Marmot Dam and the number of Chinook redds counted upstream of the dam, 1996–1998 and 2002–2006.

Table 1. Percentage of spring Chinook salmon carcasses with fin clips that were recovered in spawning areas of the Sandy River basin, 2013.

River/stream	Section	Percent clipped	Sample size
Salmon River	Final Falls–Forest Rd 2618	1	243
	Forest Rd 2618–Arrah Wanna	4	77
	Arrah Wanna–weir	4	67
	Weir–mouth	0	3
	Cheeney Creek	43	8
	Sixes Creek	14	7
Salmon Basin Total		**2**	**405**
Zigzag River	Above Camp Creek	0	9
	Camp Creek–Still Creek	0	20
	Still Creek–weir	1	73
	Weir–mouth	26	42
Zigzag River Total		8	144
Still Creek	Above Rd 20 Bridge	2	104
	Below Rd 20 Bridge	13	107
Still Total		7	211
Camp Creek	Campground–mouth	0	14
Zigzag Basin Total		**8**	**369**
Lost Creek	Riley Campground–mouth	38	8
Clear Fork	Mouth area	14	14
Bull Run River	Dam–mouth	16	31
Little Sandy	Arrow Creek to mouth	31	13
Sandy River	Zig Zag River to Marmot Dam	33	21
GRAND TOTAL		**6.6**	**861**

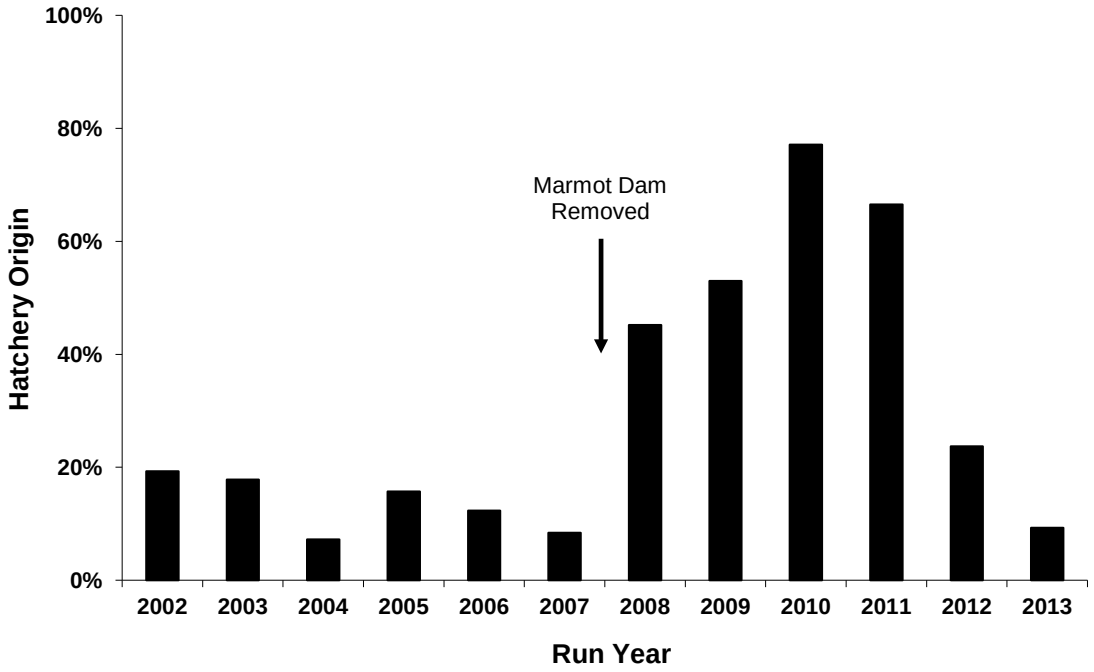

Figure 4. Percentage of hatchery-origin spring Chinook salmon in the spawning population of Sandy River basin upstream of the Marmot Dam site, 2002–2013.

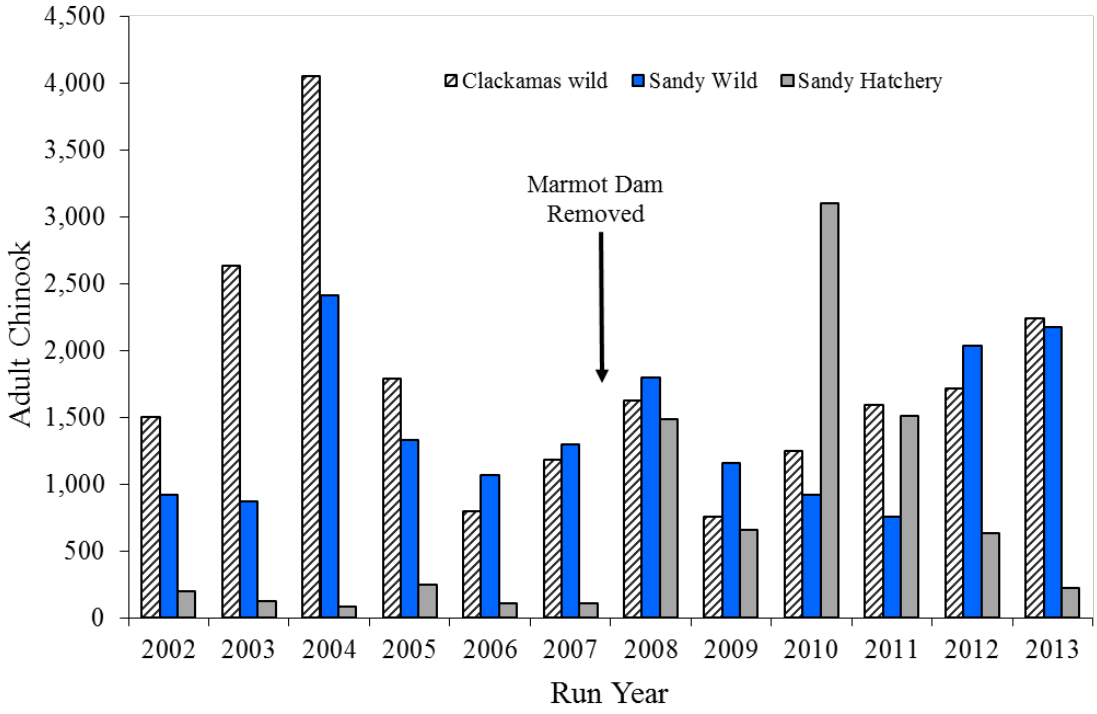

Figure 5. Number of spring Chinook salmon in the Sandy River basin (hatchery and wild), and in the Clackamas Basin upstream of North Fork Dam (wild), 2002–2013. Number of fish in the Sandy River basin in 2008–2013 was estimated from redd counts. For 2002–2006, the number of fish was estimated with the 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, 2013.

Basin	Area	Percent hatchery	Sample size
Salmon	Upstream of weir	4.0	402
	Downstream of weir	33.3	3
	Total	**4.2**	**405**
Zigzag	Upstream of weir	7.8	327
	Downstream of weir	33.1	42
	Total	**10.6**	**369**
Sandy R, Lost,& Clear Fork creeks	All surveyed areas	30.4	43
Bull Run River[a]	Dam–mouth	25.4	44

[a] includes Little Sandy River

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 (613)	1.6%	32.5%	63.9%	2.0%

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 (756)	0.9%	47.2%	51.9%	--

Table 5. Number of spring Chinook salmon counted at traps in the Salmon and Zigzag rivers, 2011- 2013. 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	2011	2012	2013
Dates	Aug 19–Sep 27	Jul 4–Oct 14	Jul 8–Sep 27	Sep 14–Oct 4	Jun 18–Oct 14	Jul 8–Sep 28
Fin-clipped	183	188	167	229[a]	247	98
Not clipped	91	432	745	94	1,108	706

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

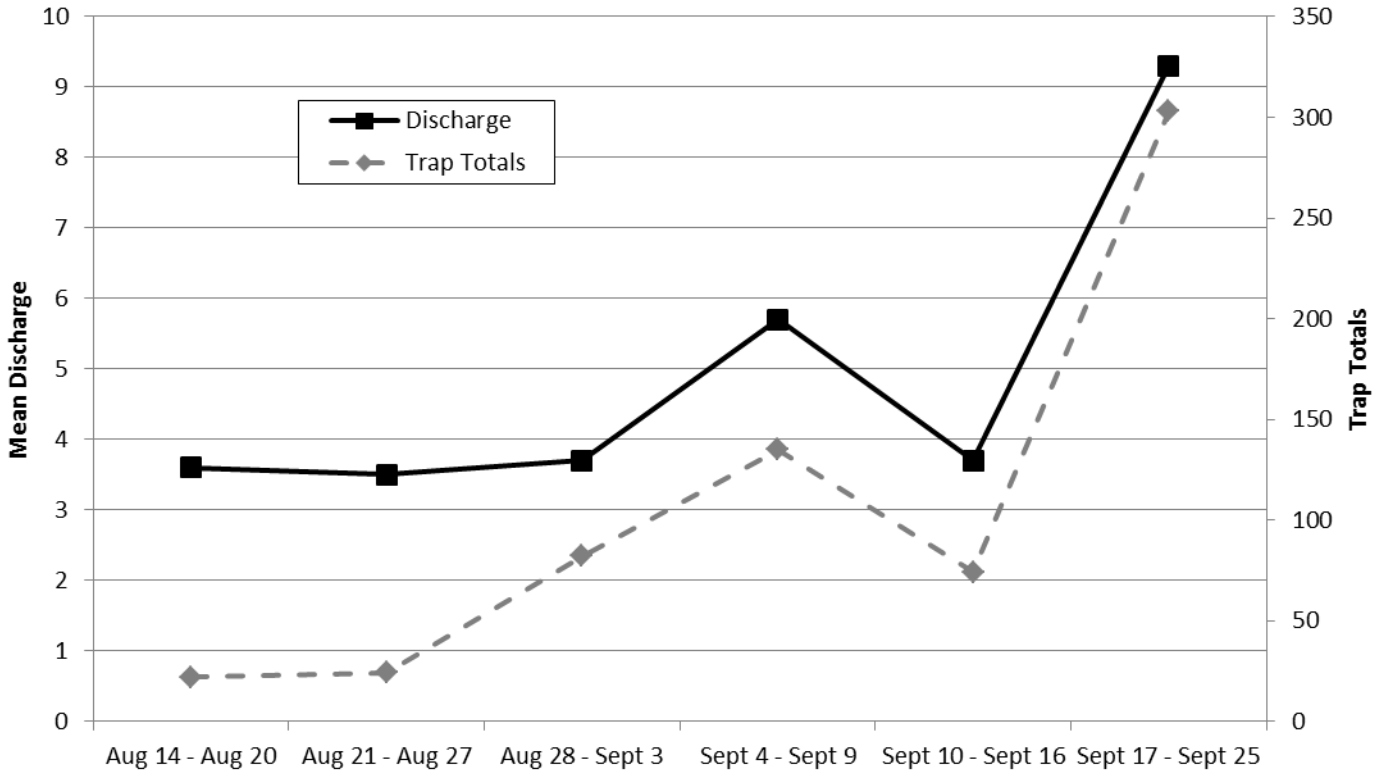

Figure 6. Comparison of weekly trap catch totals with weekly mean discharge from Blazed Alder Creek from August 14 –September 25, 2013.

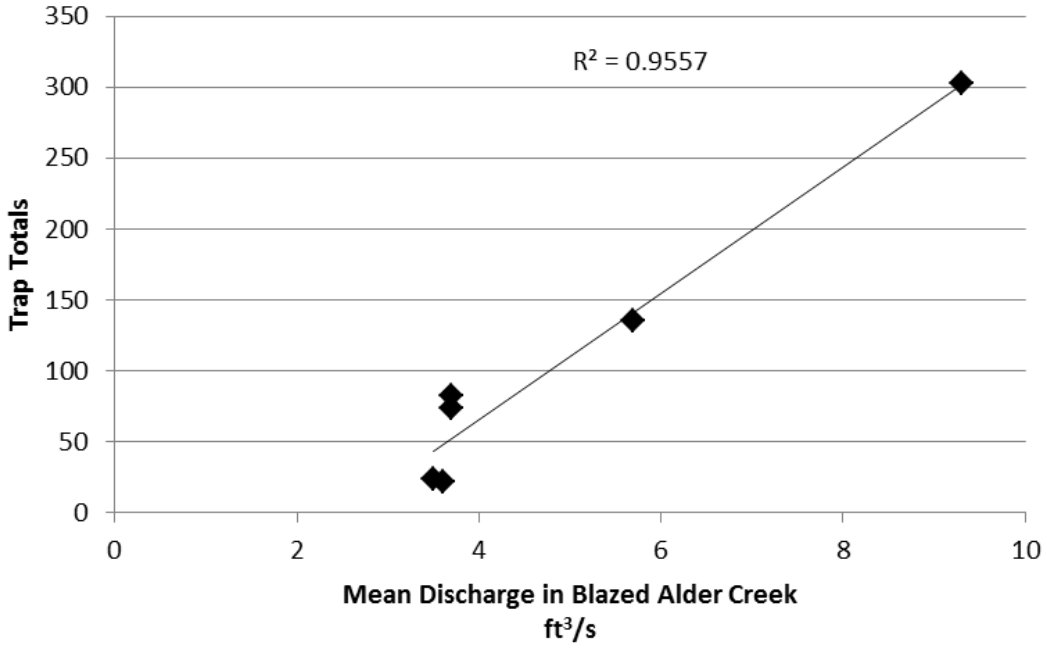

Figure 7. Simple linear regression of weekly trap totals and mean discharge in Blazed Alder Creek.

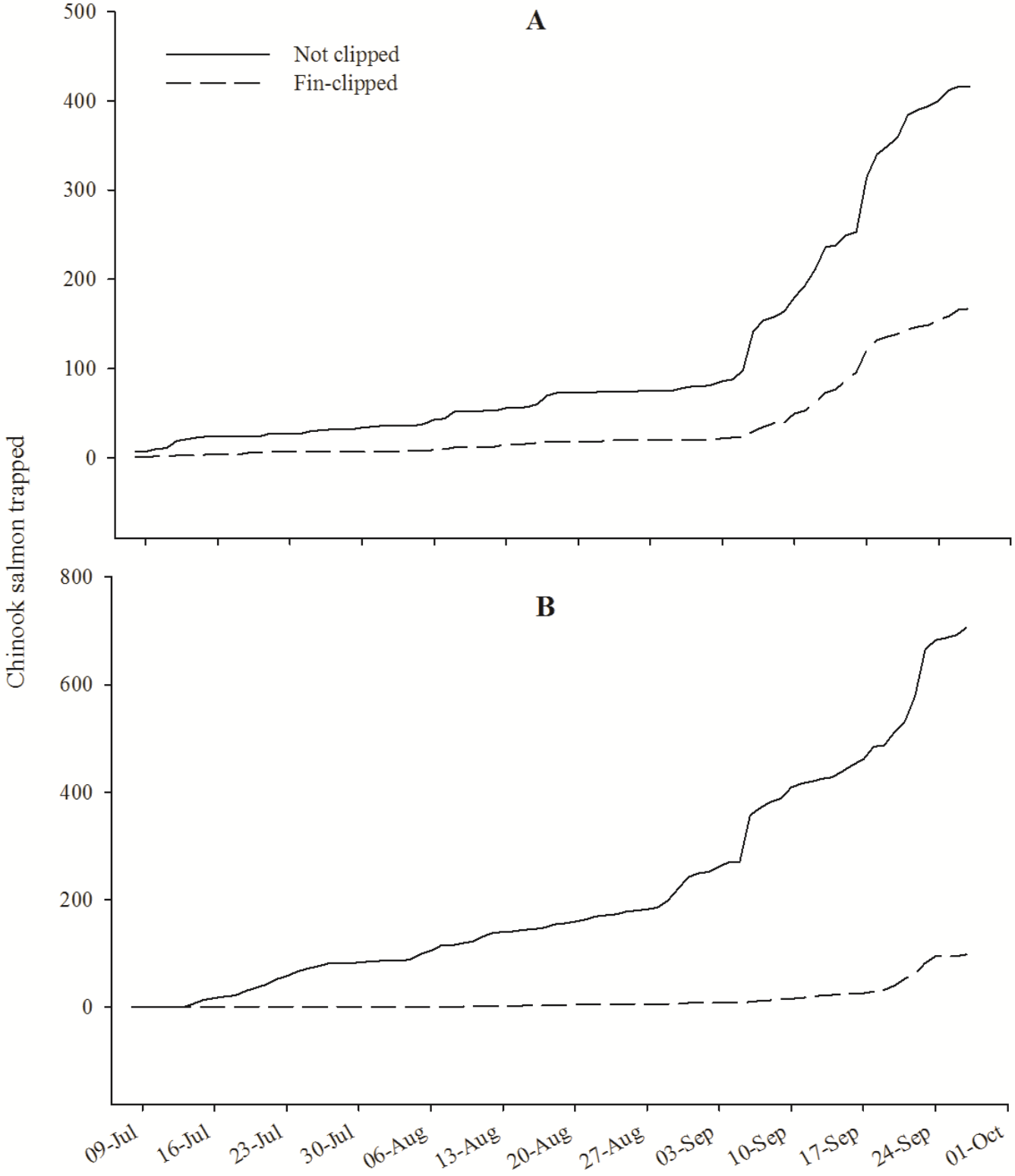

Figure 8. Cumulative number of spring Chinook salmon handled at weirs in the lower Zigzag (A) and Salmon (B) rivers, for fish with an adipose fin clip (dashed line) and without a fin clip (solid line), 2013.

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, 2013.

	Number removed		Fin-clipped spawners (%)	
			With trapping	Without trapping
Zigzag	167		24	38
Salmon	98		5	23
Upper Sandy River basin	265		9	31

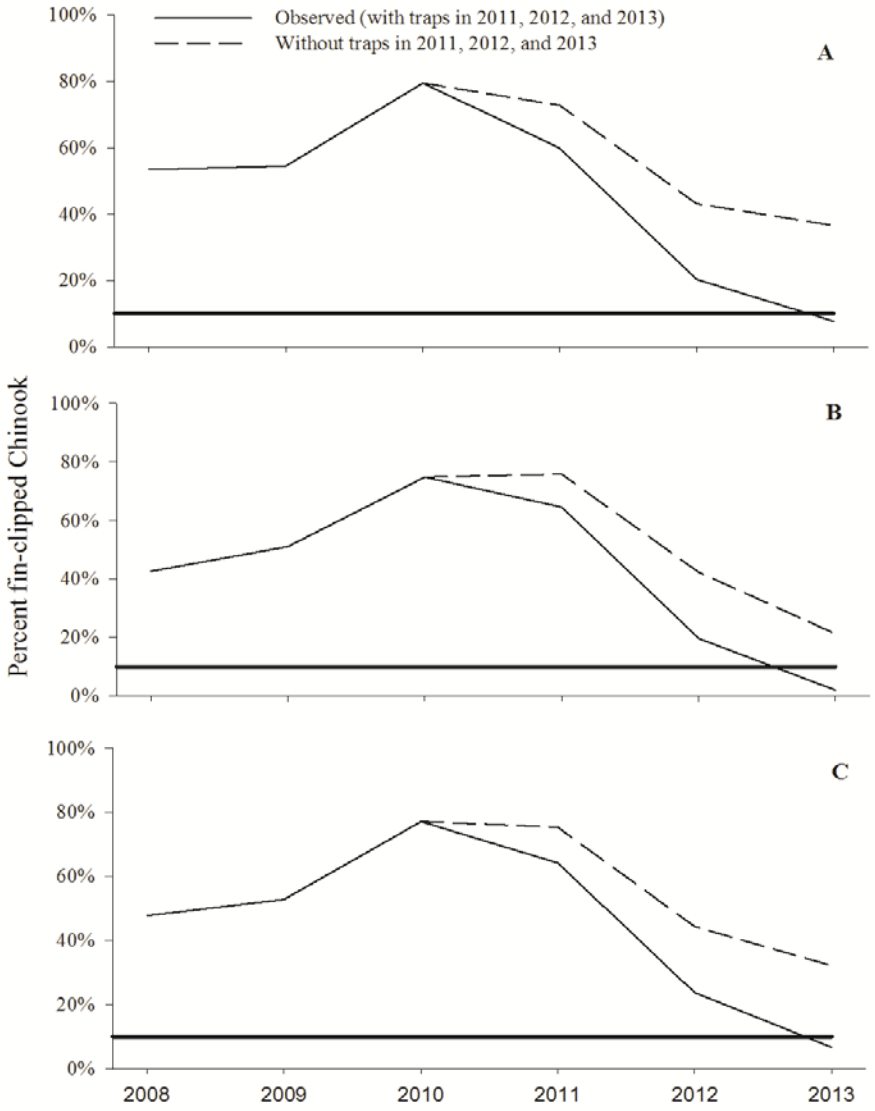

Figure 9. Percentage of fin-clipped spring Chinook salmon in the Zigzag (A) and Salmon (B) rivers, and in the upper Sandy River basin (C). Traps were operated in the lower Salmon and Zigzag rivers in 2011–2013 to remove fin-clipped fish. Estimated percentage of fin-clipped spawners without trapping is shown by dashed line. The 10% line represents the conservation and recovery objectives for proportion of hatchery-origin spawners.

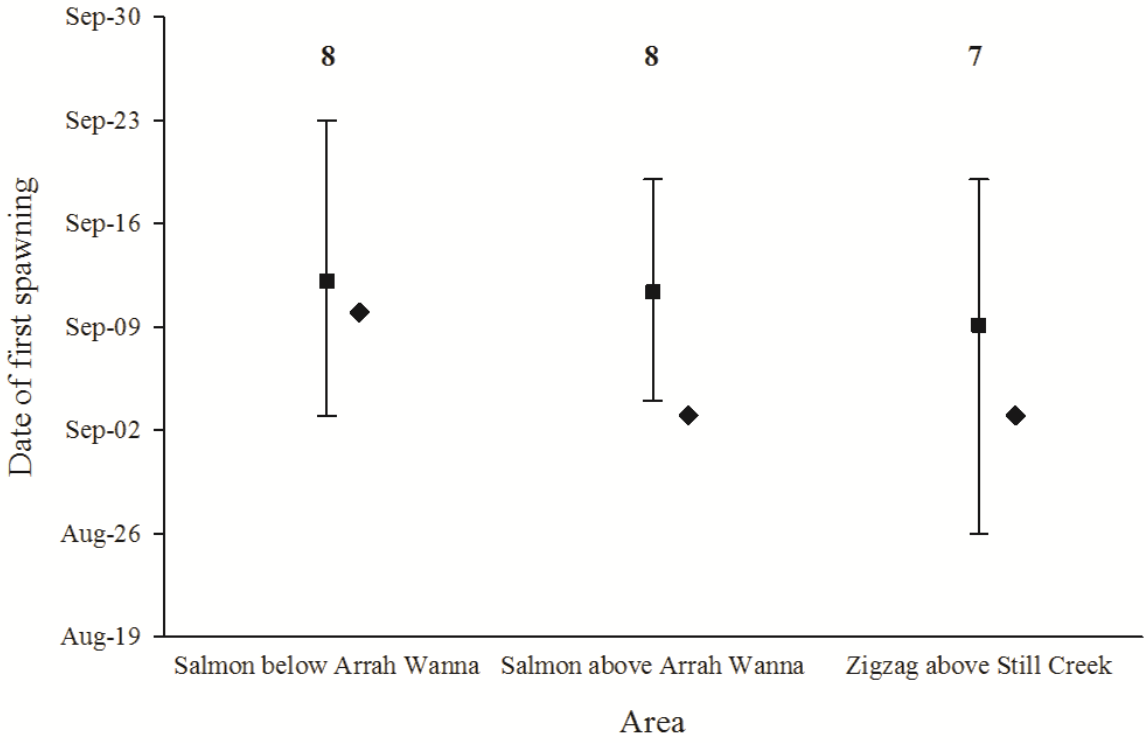

Figure 10. Date of first spawning for spring Chinook salmon in the Salmon and Zigzag river basins for 2002–2009 (mean, ■), and in 2013 (♦). The capped vertical lines are the range and the numbers above the lines are years in the data set. Data for 2010 were not included because surveys started late. Does not include 2003 for the Zigzag River basin because surveys were more than two weeks apart between early and late September.

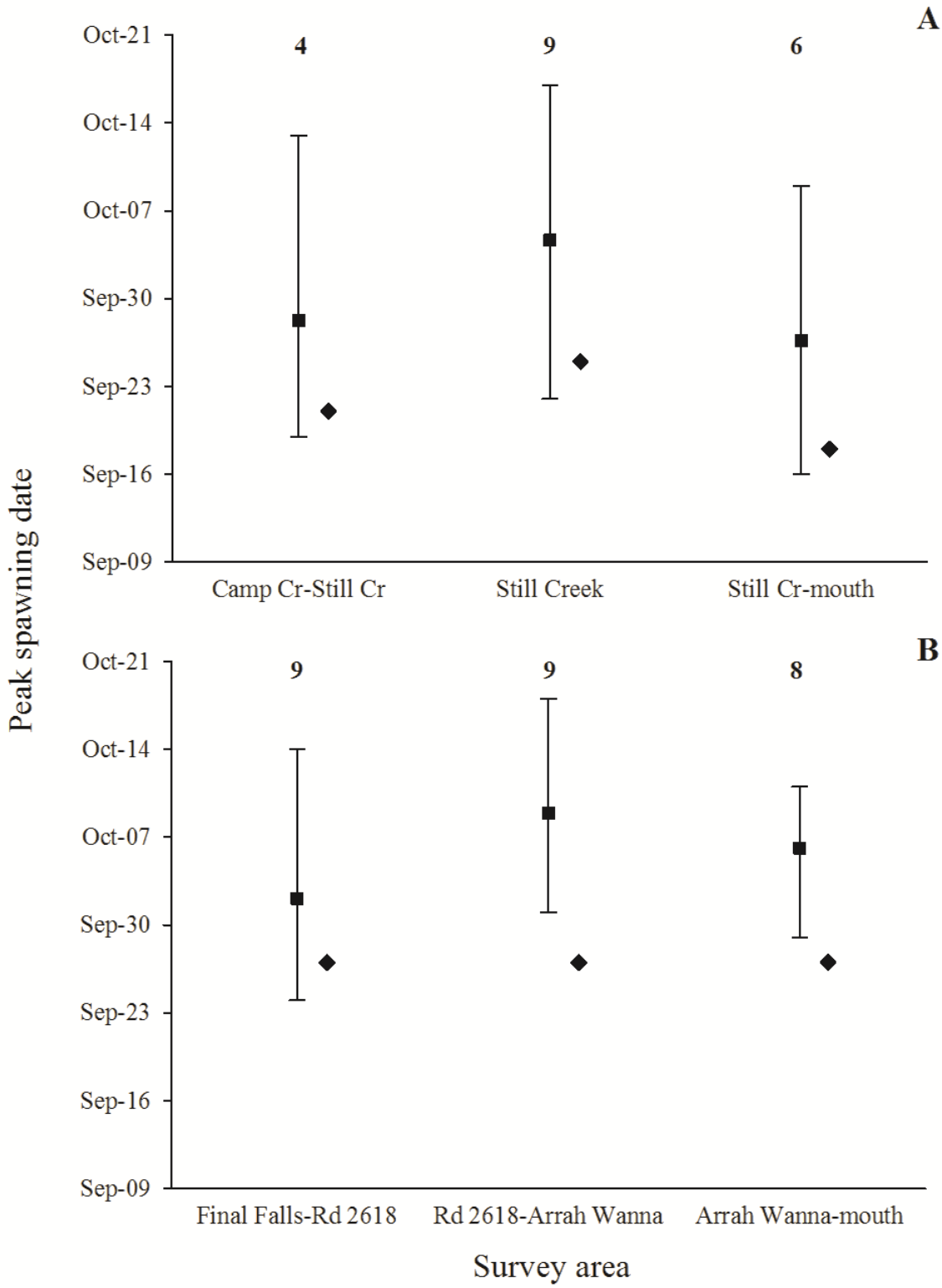

Figure 11. Peak spawning dates of spring Chinook salmon in the Zigzag (A) and Salmon (B) river basins in 2002–2010 (mean, ■) and in 2013 (♦). The capped vertical lines are the range and the numbers above the lines are years in the data set. Years were excluded when only a single survey was conducted (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), 2002-2013. Areas include those that were consistently surveyed in all years, which accounted for 94–100% of all redds in the upper basin.

Basin, section	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
						Redds						
Salmon River:												
Final Falls–Forest Rd 2618	53	60	233	84	139	79	395	139	387	173	314	179
Forest Rd 2618–ArrahWanna	68	29	188	62	45	54	181	61	299	151	89	79
ArrahWanna–mouth	69	38	179	146	67	58	121	39	168	161	167	65
Salmon R tributaries	--	0	3	--	--	--	1	0	53	0	2	34
Zigzag River:												
Still Creek	62	28	108	79	117	28	405	162	550	152	291	291
Above Still Creek & Camp Cr	11	5	25	21	12	13	75	52	135	108	55	96
Still Creek–mouth	5	19	48	31	36	27	109	36	59	122	80	86
Other streams:												
Lost Creek	6	7	20	11	9	9	27	9	5	32	45	15
Clear Fork Creek	0	--	0	--	--	--	1	1	2	10	24	18
Clear Creek	0	0	0	0	2	3	0	0	3	--	--	1
TOTAL	**274**	**186**	**801**	**434**	**427**	**271**	**1,314**	**499**	**1,608**	**909**	**1,065**	**864**
						Redds/mi						
Salmon River:												
Final Falls–Forest Rd 2618	16.6	17.8	69.1	26.3	43.4	24.7	117.2	43.4	114.8	54.1	98.1	55.9
Forest Rd 2618–ArrahWanna	12.6	3.9	25.4	11.5	8.3	10.0	33.5	8.2	40.4	28.0	16.1	14.6
ArrahWanna–mouth	13.8	7.6	35.8	29.2	13.4	11.6	24.2	7.8	33.6	32.2	33.4	13.0
Salmon R tributaries	--	0.0	1.2	--	--	--	0.4	0.0	21.2	0.0	0.8	13.8
Zigzag River:												
Still Creek	18.8	5.6	32.7	15.8	35.5	8.5	81.0	32.4	109.2	30.4	58.2	58.2
Above Still Creek & Camp Cr	2.8	1.3	6.3	5.3	3.0	3.3	41.7	8.8	22.9	18.0	9.2	16.0
Still Creek–mouth	2.3	8.6	21.8	14.1	16.4	12.3	49.5	16.4	26.8	55.5	36.4	39.1
Other streams:												
Lost Creek	3.0	3.5	10.0	5.5	4.5	4.5	13.5	4.5	2.5	16.0	22.5	7.5
Clear Fork Creek	0.0	--	0.0	--	--	--	1.7	1.7	3.3	16.7	40.0	30.0
Clear Creek	0.0	0.0	0.0	0.0	4.0	6.0	0.0	0.0	6.0	--	--	2.0

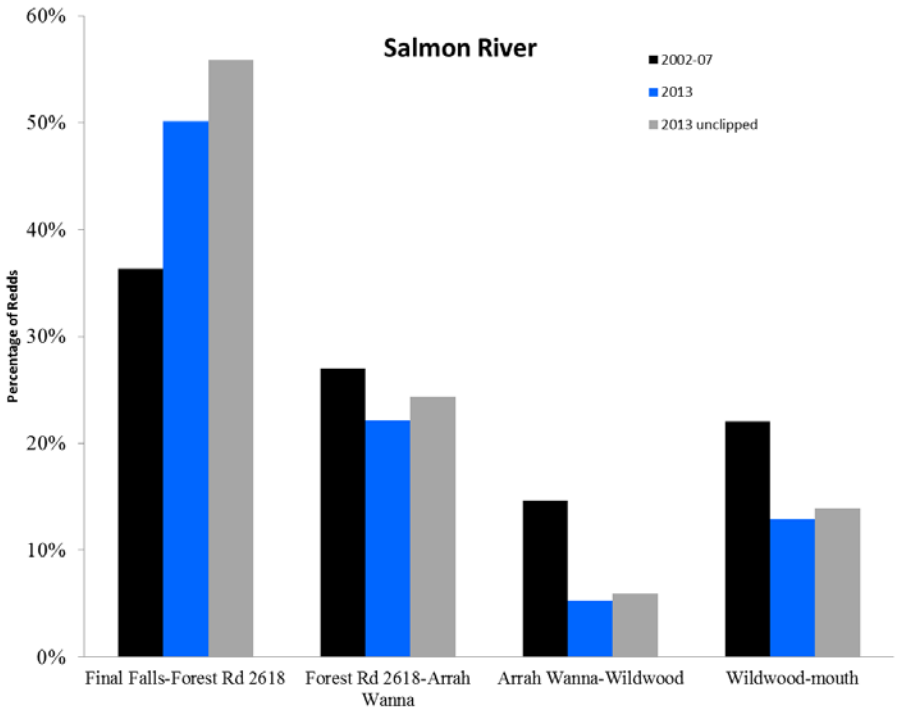

Figure 12. Percentage of spring Chinook salmon redds in four sections of the Salmon River, 2002–2007 and 2013. The 2002–2007 data did not include 2004 and 2006 because redd counts were combined for the lower two sections. The estimated redd distribution of unclipped fish in 2013 was based on the proportion of unclipped carcasses in each section.

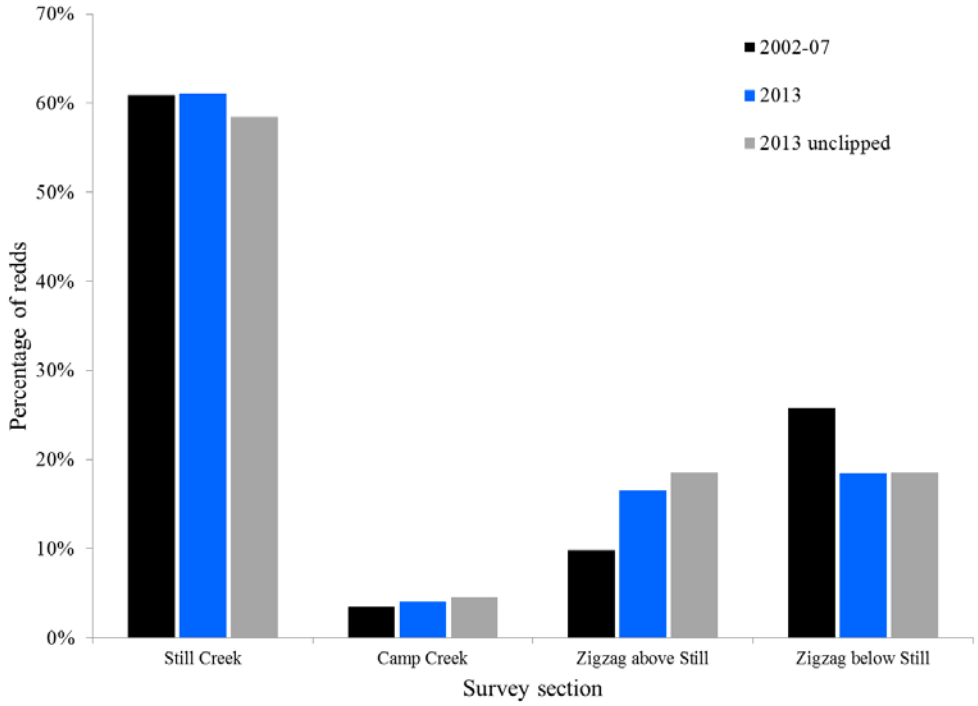

Figure 13. Percentage of spring Chinook salmon redds in four sections of the Zigzag River basin, 2002–2007 and 2013. The estimated redd distribution of unclipped fish for 2013 is based on the proportion of unclipped carcasses recovered in each section.

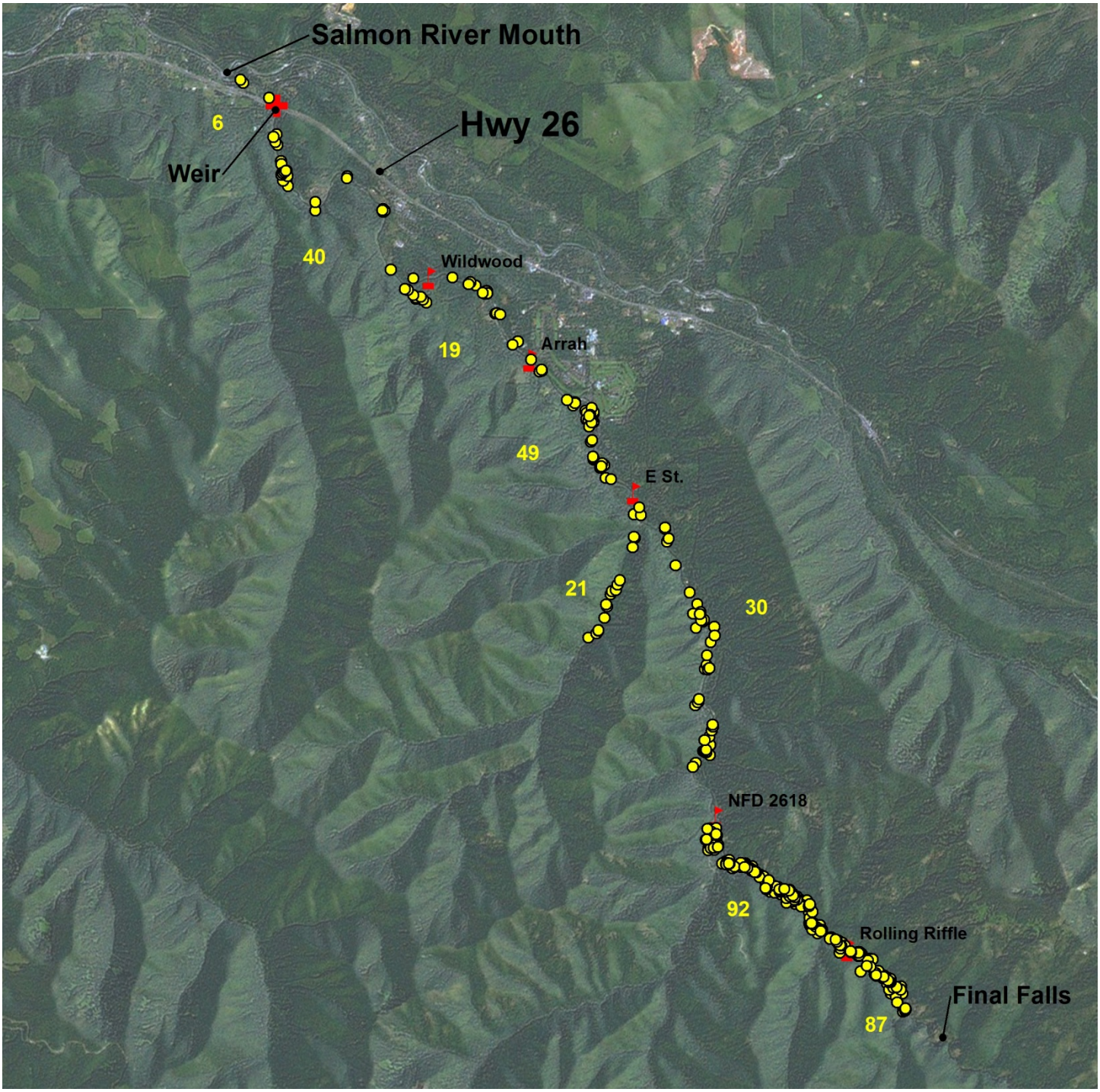

Figure 14. Location of redds in the Salmon River basin, 2013. Redd locations were marked with GPS receivers synchronized with PDAs. Numbers in yellow are peak counts of redds for survey sections indicated by red markers.

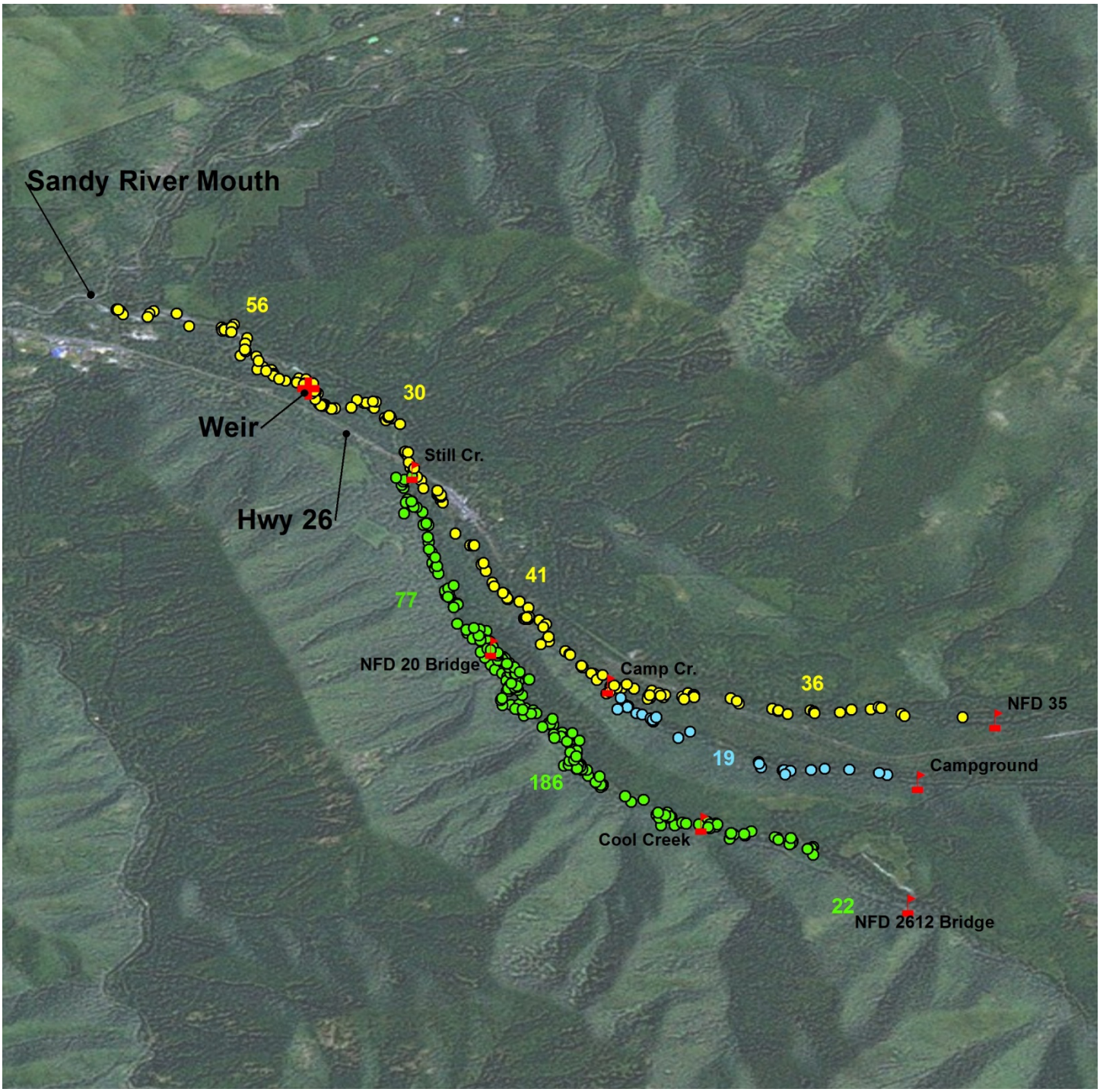

Figure 15. Location of redds in the Zigzag River basin, 2013. Redd locations were marked with GPS units synchronized with field data collectors PDAs. Numbers in yellow, green, and blue are peak counts of redds for survey sections (indicated by red markers) where redd location data are available.

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 basins, 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 2011-2013 to trap and remove fin-clipped fish.

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

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

Table 9. Percentage of wild and hatchery spring Chinook salmon females that died prior to spawning as determined by presence of eggs (sample size in parentheses) for the Salmon and Zigzag basins upstream and downstream of weirs, and for the upper Sandy River basin, 2013.

Watershed	Wild			Hatchery		
	Above weir	Below weir	Total	Above weir	Below weir	Total
Salmon	4.0 (174)	0.0 (0)	4.0	10.0 (10)	0.0 (0)	10.0
Zigzag	2.9 (102)	0.0 (15)	2.6	17.6 (17)	0.0 (10)	11.1
Upper Sandy			3.4 (291)			10.8 (37)