Russian River Coho Salmon and Steelhead Monitoring Report: Winter 2017/18

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Sea Grant California

Russian River Coho Salmon Monitoring Program

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Contents

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I. Background

In 2004, the Russian River Coho Salmon Captive Broodstock Program (Broodstock Program) began releasing juvenile coho salmon into tributaries of the Russian River with the goal of reestablishing populations that were on the brink of extirpation from the watershed. California Sea Grant at University of California (CSG) worked with local, state, and federal biologists to design and implement a coho salmon monitoring program to track the survival and abundance of hatchery-released fish. Since the first Broodstock Program releases, CSG has been closely monitoring smolt abundance, adult returns, survival, and spatial distribution of coho populations in four Broodstock Program release streams: Dutch Bill, Green Valley, Mill, and Willow creeks. Data collected from this effort are provided to the Broodstock Program for use in adaptively managing future releases.

Over the last decade, CSG has developed many partnerships in salmon and steelhead recovery and our program has expanded to include identification of limiting factors to survival, evaluation of habitat enhancement and streamflow improvement projects, and implementation of a statewide salmon and steelhead monitoring program. In 2010, we began documenting relationships between stream flow and juvenile coho survival as part of the Russian River Coho Water Resources Partnership (Coho Partnership) (http://www.cohopartnership.org), an effort to improve stream flow and water supply reliability to water-users in five flow-impaired Russian River tributaries. In 2013, we partnered with the Sonoma County Water Agency (Water Agency) and California Department of Fish and Wildlife (CDFW) to begin implementation of the California Coastal Monitoring Program (CMP), a statewide effort to document status and trends of anadromous salmonid populations using standardized methods and a centralized statewide database. These new projects have led to the expansion of our program, which now includes over 50 Russian River tributaries.

The intention of our monitoring and research is to provide science-based information to all stakeholders involved in salmon and steelhead recovery. Our work would not be possible without the support of our partners, including several public resource agencies and non-profit organizations, along with hundreds of private landowners who have granted us access to the streams that flow through their properties.

In this seasonal monitoring update, we provide results from our fall and winter field season, including results from coho salmon monitoring at PIT tag detection sites located throughout the watershed and from spawning surveys conducted through both Broodstock Program and CMP monitoring efforts. Additional information and previous reports can be found on our website at http://ca-sgep.ucsd.edu/russianrivercoho.

II. PIT Tag Monitoring

Goals and Objectives

Passive integrated transponder (PIT) tags and PIT tag detection systems (antennas and transceivers) have been used increasingly in recent years to document status and trends of Russian River salmonid populations at both stream-specific and basinwide scales. From September 15, 2017, through March 1, 2018, our goal was to collect PIT tag data at multiple sites to document adult hatchery coho salmon return timing, estimate the number of returning hatchery coho salmon adults, and estimate coho salmon smolt to adult return (SAR) ratios in four Broodstock Program monitoring streams (Willow, Dutch Bill, Green Valley, and Mill), and in the Russian River basin overall.

Methods

PIT tagging

Beginning in 2007, a portion of juvenile coho salmon released from Don Clausen Fish Hatchery into the Mill Creek watershed were implanted with 12.5 mm full duplex (FDX) PIT tags. Coho salmon destined for tagging were randomly selected from holding tanks, and for all fish ≥ 56mm and ≥2g, a small incision was made on the ventral side of the fish using a scalpel, and the tag was then inserted into the body cavity. Over the next few years, PIT-tagged coho salmon were released into an increasing number of tributaries and, in 2013, the Broodstock Program began PIT tagging a percentage of all coho salmon released into the Russian River watershed (Table 1). The number and percentage of PIT-tagged coho salmon by stream and release group for cohorts 2015 and 2016 (fish returning during the winter of 2017/18 as age-3 or age-2 adults, respectively) are shown in Table 2. In addition, approximately half of all natural-origin coho salmon smolts captured in downstream migrant traps were PIT tagged in Willow, Green Valley, and Mill creeks (CSG 2016).

Field Methods

As part of the Broodstock Program monitoring effort, CSG operated stationary PIT tag detection systems in stream channels near the mouths of Willow, Dutch Bill, Green Valley and Mill creeks (Figure 1). Multiplexing transceivers, capable of reading FDX tags, were placed in waterproof boxes on the stream bank and powered using AC power with DC conversion systems (Willow, Dutch Bill and Mill creeks) or solar power (Green Valley Creek). Sixteen by two-and-a-half foot antennas, housed in four-inch PVC, were placed flat on top of the streambed and secured with duck bill anchors. The antennas were placed in paired (upstream and downstream), channel-spanning arrays (e.g., Figure 2) so that detection efficiency could be estimated and the movement direction of individuals could be determined. Based on test tag trials at the time of installation, read-range in the water column above the antennas ranged from 10” to 24” during baseflow conditions. During storm events, stream depths exceeded maximum read range depths, so if PIT-tagged fish were travelling in the water column above the maximum read depth, they would not be detected on the antennas. The paired arrays were used to estimate antenna efficiency and account for undetected fish. From September 15, 2017 through March 1, 2018, PIT tag detection systems were visited every other week to download data and check antenna status. More frequent visits (approximately daily) were made during storm events. Additional antenna arrays were operated throughout the watershed by CSG and the Water Agency, including a 10-antenna array located in the mainstem of the Russian River near Duncans Mills (Figure 1).

Table 1.Number and percent of PIT-tagged coho salmon released into Russian River tributaries by cohort.

Cohort (Hatch Year)	Tributaries[1] Stocked with Coho Salmon	Tributaries[1] Stocked with PIT-tagged Coho Salmon	Number Coho Salmon Released into Russian River Tributaries	Number PIT-tagged Coho Salmon Released	Percent of Russian River Releases PIT-tagged
2007	DRY, DUT, GIL, GRA, GRE, MIL, PAL, SHE	MIL, PAL	71,159	7,456	10%
2008	DRY, DUT, GIL, GRA, GRE, MIL, PAL, SHE	MIL, PAL	91,483	11,284	12%
2009	DRY, DUT, GIL, GRA, GRE, MIL, PAL, SHE	MIL, PAL, GRE	81,231	8,819	11%
2010	DEV, DRY, DUT, EAU, FRE, GIL, GRA, GRE, GRP, MIL, PAL, POR, PUR, THO, SHE	DRY, DUT, GRE, GRP, MIL, PAL	155,442	16,767	11%
2011	ANG, BLA, DEV, DRY, DUT, EAU, FRE, GIL, GRA, GRE, GRP, MAR, MIL, PAL, PEN, POR, PUR, THO, SHE, WIL	ANG, BLA, DEV, DRY, DUT, GIL, GRA, GRE, GRP, MIL, PAL, PEN, PUR, THO, WIL	160,397	18,769	12%
2012	BLA, DEV, DRY, DUT, EAU, FRE, GIL, GRA, GRE, GRP, MAR, MIL, PAL, PEN, POR, PUR, THO, SHE, WIL	BLA, DEV, DRY, DUT, GIL, GRA, GRE, GRP, MIL, PAL, PEN, PUR, THO, WIL	182,370	30,934	17%
2013	AUS, BLA, DEV, DRY, DUT, FRE, GIL, GRA, GRE, GRP, MAR, MIL, PAL, PEN, POR, PUR, SHE, THO, WIL	AUS, BLA, DEV, DRY, DUT, FRE, GIL, GRA, GRE, GRP, MAR, MIL, PAL, PEN, POR, PUR, SHE, THO, WIL	171,846	34,536	20%
2014	AUS, BLA, DEV, DRY, DUT, EAU, FRE, GIL, GRA, GRE, GRP, MAR, MIL, PAL, PEN, POR, PUR, SHE, THO, WIL	AUS, BLA, DEV, DRY, DUT, EAU, FRE, GIL, GRA, GRE, GRP, MAR, MIL, PAL, PEN, POR, PUR, SHE, THO, WIL	235,327	39,556	17%
2015	DRY, DUT, GIL, GRA, GRE, MIL, WIL	DRY, DUT, GIL, GRA, GRE, MIL, WIL	70,510	22,620	32%
2016	AUS, DEV, DRY, DUT, FRE, GIL, GRA, GRE, MAR, MIL, PAL, PUR, SHE, THO, WIL	AUS, DEV, DRY, DUT, FRE, GIL, GRA, GRE, MAR, MIL, PAL, PUR, SHE, THO, WIL	158,382	26,546	17%

[1]Stream Codes: ANG: Angel Creek, AUS: Austin Creek, BLA: Black Rock Creek, DEV: Devil Creek, DRY: Dry Creek, DUT: Dutch Bill Creek, EAU: East Austin Creek, FRE: Freezeout Creek, GIL: Gilliam Creek, GRA: Gray Creek, GRE: Green Valley Creek, GRP: Grape Creek, MAR: Mark West Creek, MIL: Mill Creek, PAL: Palmer Creek, PEN: Pena Creek, POR: Porter Creek, PUR: Purrington Creek, SHE: Sheephouse Creek, THO: Thompson Creek, WIL: Willow Creek.

Table 2.Number and percent of PIT-tagged coho salmon released into Russian River tributaries by cohort, stream, and release group.

Cohort (Hatch Year)	Tributary	Release Group	Total Coho Salmon Released	PIT-Tagged Coho Salmon Released	Percent PIT-tagged Coho Salmon Released
2015	Willow Creek	fall	9,032	2,718	30%
2015	Gilliam Creek	fall	4,107	1,211	29%
2015	Gray Creek	fall	4,021	1,208	30%
2015	Dutch Bill Creek	fall	8,989	2,719	30%
2015	Dutch Bill Creek	spring	1,008	1,008	100%
2015	Dutch Bill Creek	smolt	5,018	1,511	30%
2015	Green Valley Creek	fall	8,989	2,715	30%
2015	Green Valley Creek	spring	305	305	100%
2015	Green Valley Creek	smolt	4,864	1,489	31%
2015	Dry Creek	smolt	9,924	3,021	30%
2015	Mill Creek	fall	8,969	2,707	30%
2015	Mill Creek	spring	509	509	100%
2015	Mill Creek	smolt	4,775	1,499	31%
2016	Willow Creek	fall	15,273	2,291	15%
2016	Willow Creek	presmolt	7,961	1,199	15%
2016	Sheephouse Creek	fall	3,084	465	15%
2016	Freezeout Creek	fall	3,083	462	15%
2016	Austin Creek	fall	3,996	604	15%
2016	Gilliam Creek	spring	4,080	604	15%
2016	Thompson Creek	spring	2,073	304	15%
2016	Gray Creek	spring	4,097	608	15%
2016	Devil Creek	spring	4,095	607	15%
2016	Dutch Bill Creek	spring	1,016	1,016	100%
2016	Dutch Bill Creek	fall	9,911	1,494	15%
2016	Dutch Bill Creek	smolt	6,063	914	15%
2016	Green Valley Creek	spring	452	452	100%
2016	Green Valley Creek	fall	6,168	929	15%
2016	Green Valley Creek	presmolt	8,443	1,274	15%
2016	Green Valley Creek	smolt	6,064	913	15%
2016	Purrington Creek	fall	3,090	461	15%
2016	Mark West Creek	fall	15,061	2,291	15%
2016	Mark West Creek	smolt	10,150	1,542	15%
2016	Porter Creek	fall	6,096	913	15%
2016	Dry Creek	fall	1,244	1,244	100%
2016	Dry Creek	smolt	10,152	1,540	15%
2016	Mill Creek	spring	510	510	100%
2016	Mill Creek	fall	16,094	2,384	15%
2016	Mill Creek	smolt	6,079	915	15%
2016	Palmer Creek	spring	4,048	610	15%

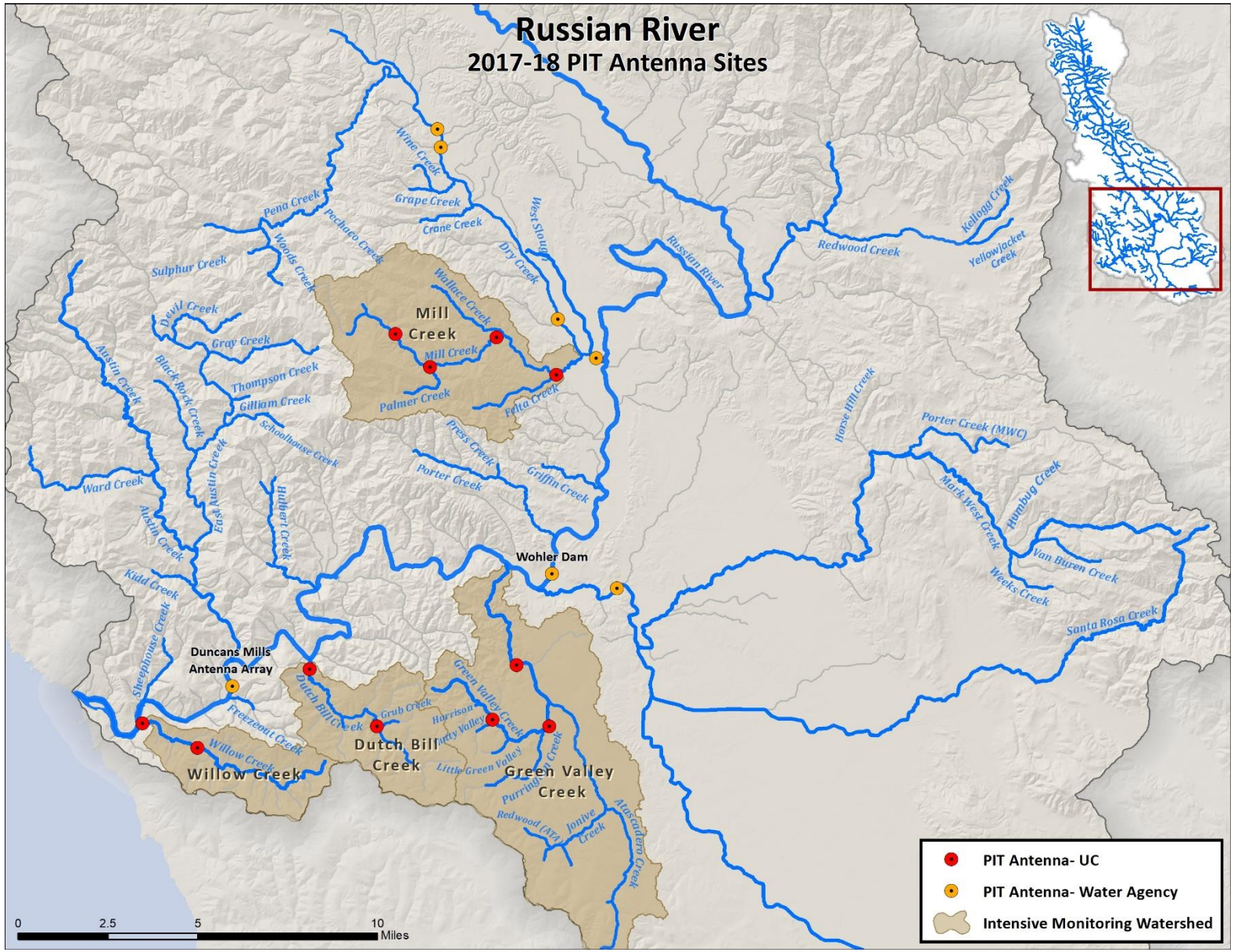

Figure 1. Passive Integrated Transponder (PIT) antenna locations in the Russian River watershed, winter 2017/18.

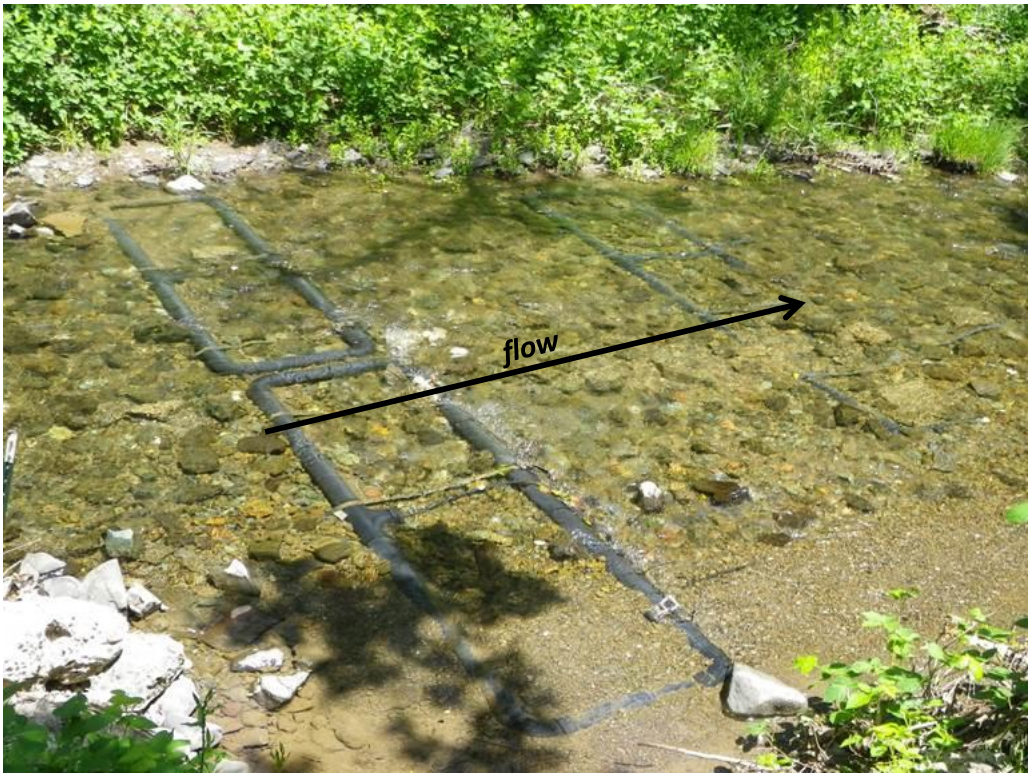

Figure 2. Paired flat-plate antenna array on Mill Creek at spring base flows.

Data Analysis

First, all records of two- and three-year old PIT-tagged coho salmon detected on antenna arrays between September 15, 2017 and March 1, 2018 were examined to determine the migratory disposition of detected fish (i.e., returning adults, age-2 outmigrants, or dead individuals) based on the duration and direction of tag movement. Individuals with a net positive upstream movement were categorized as adult returns, which were further evaluated for their return timing relative to flow conditions, and for minimum and estimated return numbers, as described below. We presumed that two-year olds detected moving in a downstream-only direction were juveniles and they were removed from the adult return dataset. Any tags that were moving very slowly downstream at a given antenna array (approximately greater than one hour between upper and lower arrays) and that were not previously detected leaving as smolts were presumed to be tags from fish that had perished and were removed from the adult return dataset.

Adult Return Timing Relative to Flow Conditions:

The first detection of each returning PIT-tagged hatchery adult coho salmon between September 15, 2017 and March 1, 2018 was plotted with streamflow or stage data from the nearest available streamflow gage at each antenna site.

Adult Return Minimum and Estimated Numbers:

Estimates of the number of adult coho salmon returning to Willow, Dutch Bill, Green Valley and Mill creeks were calculated by 1) counting the number of unique adult PIT tag detections on the lower

antennas of each antenna array (minimum count), 2) dividing the minimum count for each stream by the proportion of PIT-tagged fish either released from the hatchery into each respective stream or tagged at the smolt trap (expanded count per stream), and 3) dividing the expanded count by the estimated efficiency of the lower antennas of each stream array (estimated count per stream). The efficiency of the lower antennas of each paired antenna array was estimated by dividing the number of detections on both upstream and downstream antennas by all detections on the upper antennas. Individual data recorded at the time of tagging was used to estimate the number of returns by release group (age and season of release).

To estimate the total number of hatchery coho salmon adults returning to the Russian River mainstem at Duncans Mills, a similar calculation approach was used; however, efficiency of the Duncans Mills antenna array was estimated by dividing the total number of unique PIT tag detections of adults at both Duncans Mills and at antenna sites upstream by the total number of PIT-tagged adults detected on arrays upstream of Duncans Mills. Once Duncans Mills antenna efficiency was estimated, we then 1) counted the number of unique adult PIT tag detections at Duncans Mills (minimum count), 2) divided the minimum count by the proportion of PIT-tagged fish released from the hatchery (expanded count), and 3) divided the expanded count by the estimated efficiency of the Duncans Mills antenna array (estimated count). Because Willow Creek enters the Russian River downstream of Duncans Mills, the Willow Creek estimate was added to the estimate of adults migrating past Duncans Mills. Freezeout and Sheephouse Creeks also enter the river downstream of Duncans Mills; however, we had no means of estimating adults returning to those streams during the winter of 2017/18 so any returns to those creeks are not included in the basinwide estimate.

Smolt to Adult Return (SAR) Ratio:

In each of the four Broodstock Program streams, the sum of the estimated number of two-year old hatchery adults returning during the winter of 2016/17 and three-year old adults returning during the winter of 2017/18 was divided by the estimated number of smolts migrating from each stream between March 1 and June 30 of 2016 to derive the SAR ratio. The SAR ratio includes the probability of surviving the riverine, estuarine, and ocean environments from when the fish left the tributary as smolts until they returned to the tributary as adults.

Results

Adult Return Timing Relative to Flow Conditions

Total precipitation during the winter of 2017/18 was average (Figure 3) and was characterized by a moderate rain event in November, and a more significant event during the second week of January. The majority of the adults returning to the Russian River passed the Duncans Mills antenna array between the second half of October through early December 2017 with one additional adult in early January 2018 (Figure 4). Detections on the tributary antennas occurred in two main pulses that coincided with storm events; one pulse in mid-November and the second in early January (Figure 5). The proportion of fish detected in the earlier pulse decreased with distance inland (Figure 6 - Figure 9); in Willow Creek (enters the estuary), more fish were detected in November than in January, whereas in Mill Creek (furthest inland) no fish were detected until January.

Adult Return Estimates

The estimated numbers of adult hatchery coho salmon returning to Willow, Dutch Bill, Green Valley, and Mill creeks were 70, 40, 162, and 55, respectively (Table 3 - Table 6), and the estimated number returning to the Russian River Basin was 763 (Table 7). In all four streams, most or all of the adult returns were age-2. Straying was documented in all of the four Broodstock Program monitoring tributaries (Table 3 - Table 6). In Willow, Dutch Bill, and Green Valley creeks, straying occurred primarily from neighboring streams, whereas Mill Creek had strays from Dutch Bill, Dry, Green Valley, and Porter creeks (Figure 1, Table 3 - Table 6). Natural-origin adults were detected only in Willow and Green Valley creeks (Table 3 and Table 5).

Estimated adult returns during the winter of 2017/18 were higher than previously observed in Willow and Green Valley creeks and to the Russian River at Duncans Mills, approximately average in Dutch Bill Creek and lower than average in Mill Creek (Figure 10 - Figure 14). The proportion of age-2 adults returning was higher than in most years of data collection both in the tributaries and at Duncans Mills, ranging from 83% to 100% (Figure 10 - Figure 13, Figure 15).

Smolt to Adult Return (SAR) Ratio

Overall, SAR ratios were generally low, and ranged from 0.1% in Willow Creek to 0.6% in Mill Creek (Figure 16 - Figure 19). With the exception of Mill Creek, SAR ratios were lower in 2017/18 then the average of all years estimated on each creek (Table 8).

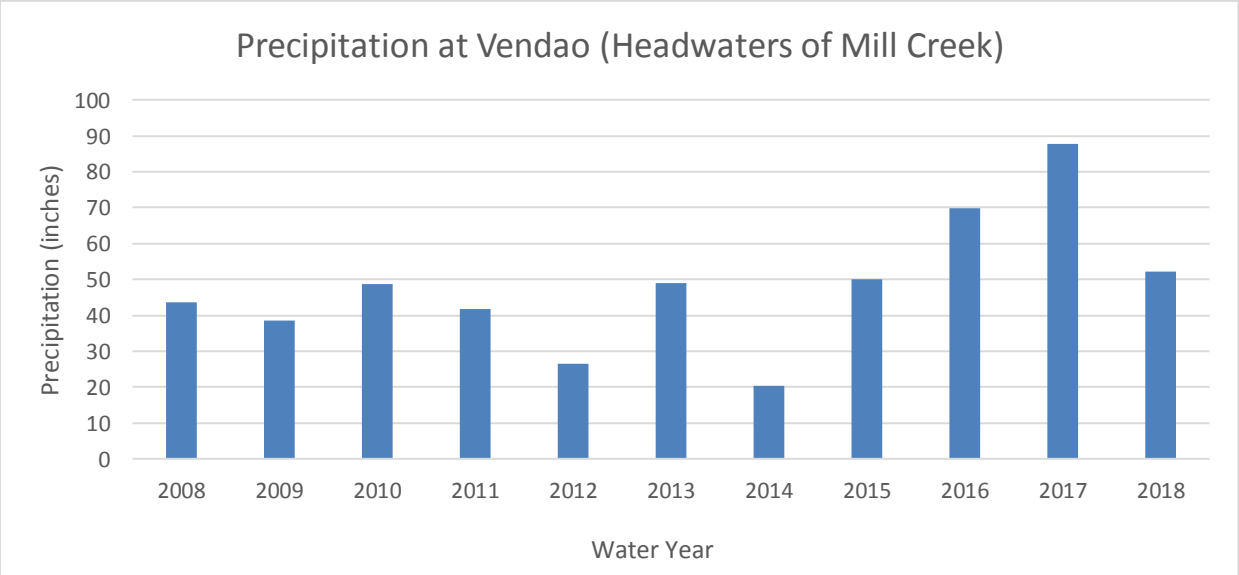

Figure 3. Precipitation at Venado gage near Mill Creek headwaters. data downloaded from NOAA website: www.ncdc.noaa.gov/cdo-web.

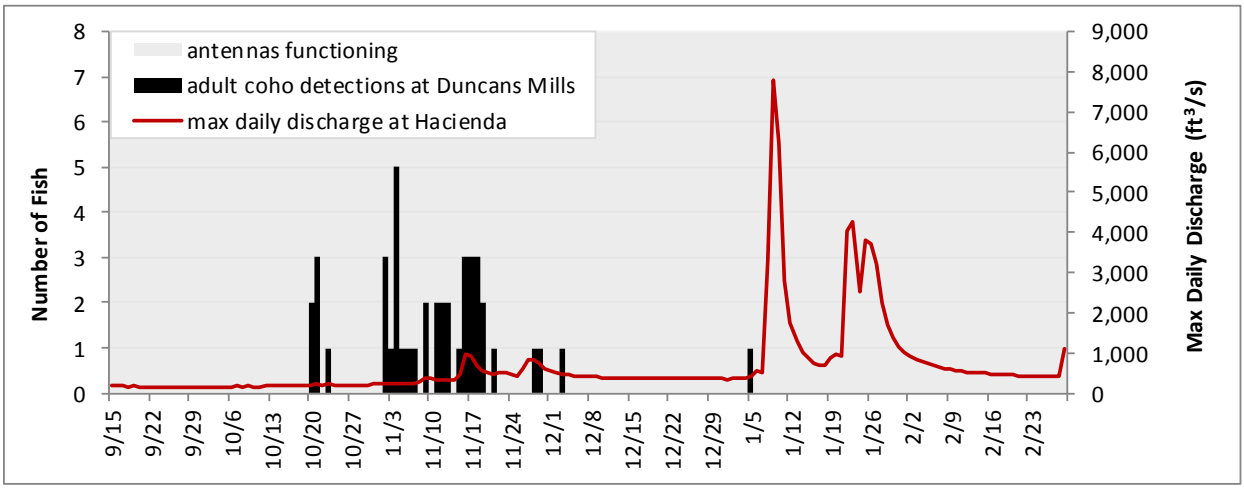

Figure 4. Detections of PIT-tagged coho salmon adults passing upstream of the Duncans Mills antenna array, September 15, 2017 - March 1, 2018. Discharge data was downloaded from USGS website: http://waterdata.usgs.gov.

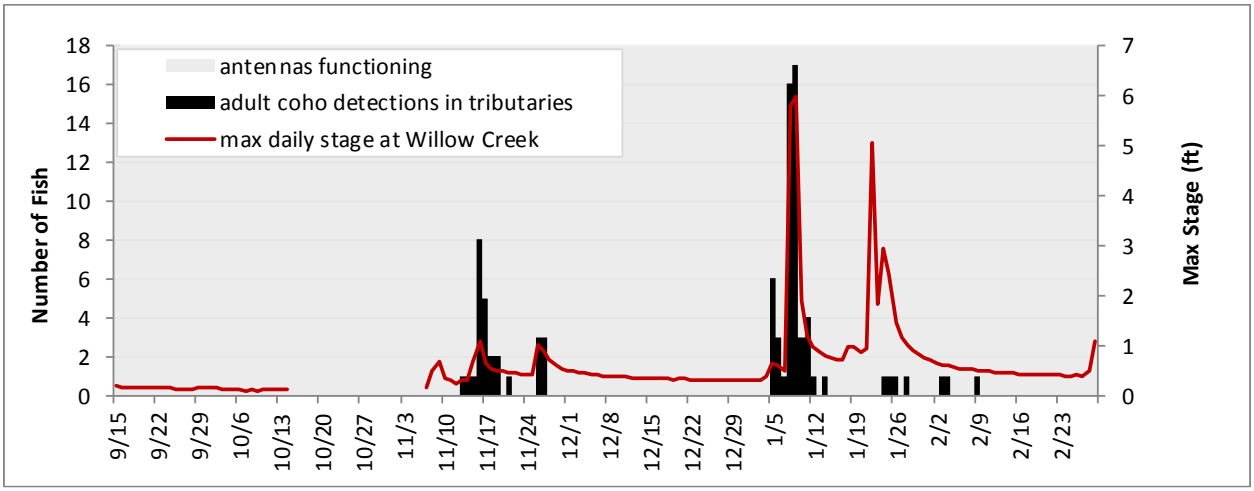

Figure 5. Detections of PIT-tagged coho salmon adults entering tributaries of the Russian River between September 15, 2017 - March 1, 2018. Stage data was collected by CSG.

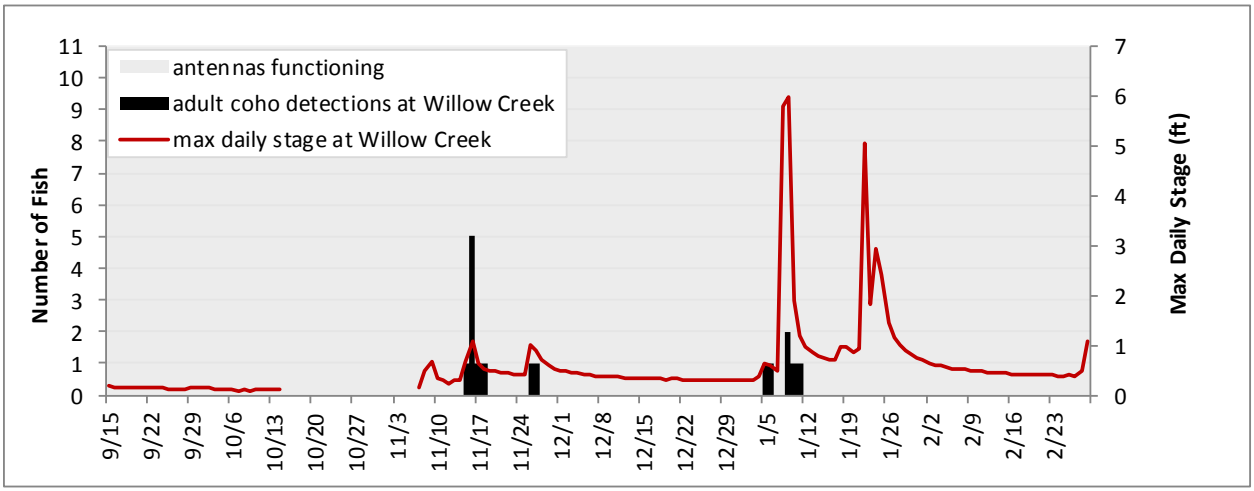

Figure 6. Detections of PIT-tagged coho salmon adults passing upstream of the Willow Creek antenna array, September 15, 2017 - March 1, 2018. Stage data was collected by CSG.

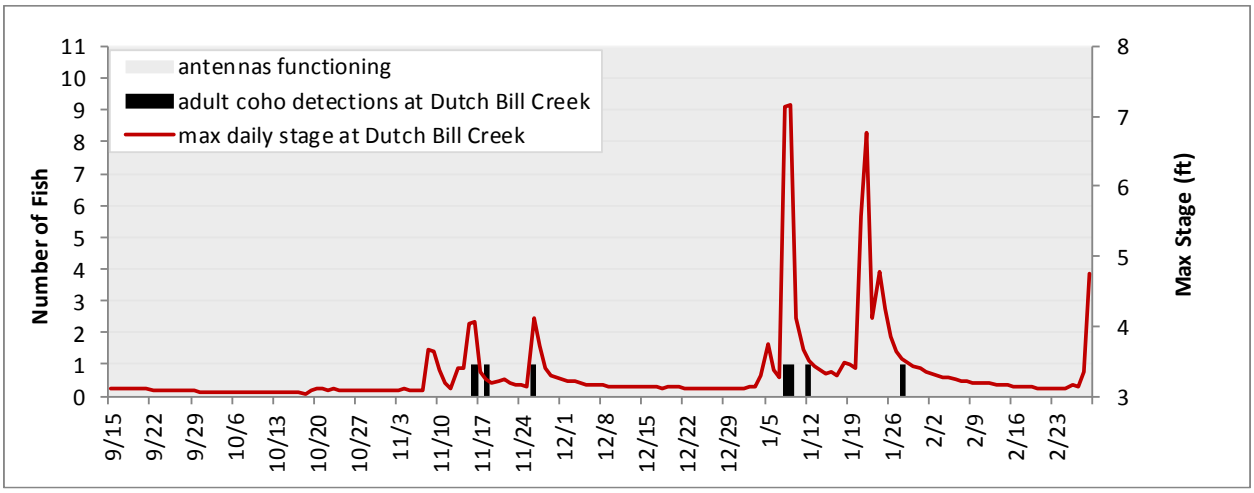

Figure 7. Detections of PIT-tagged coho salmon adults passing upstream of the Dutch Bill Creek antenna array, September 15, 2017 - March 1, 2018. Stage data was provided by Trout Unlimited.

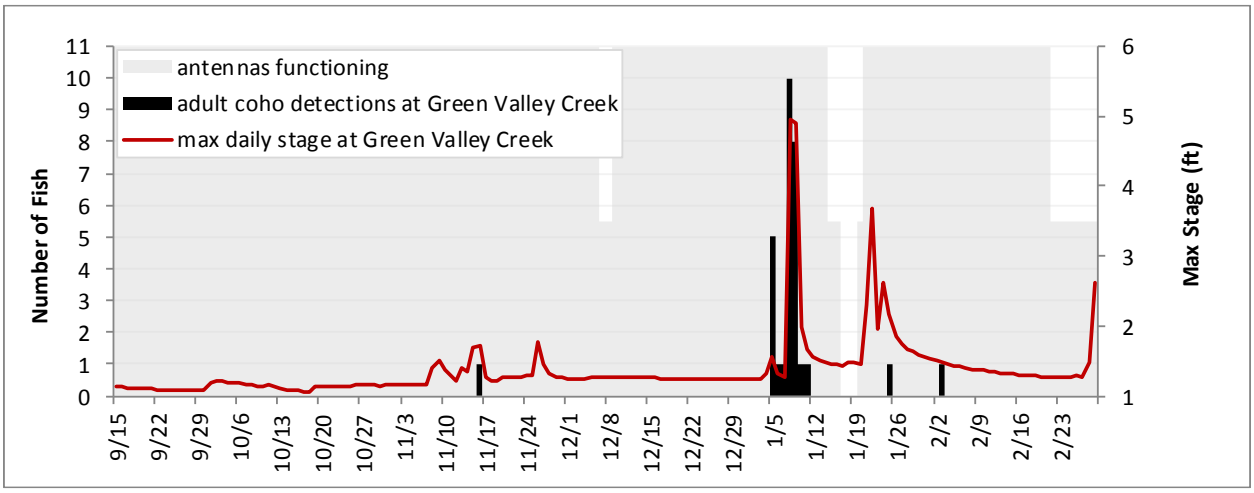

Figure 8. Detections of PIT-tagged coho salmon adults passing upstream of the Green Valley Creek antenna array, September 15, 2017 - March 1, 2018. Stage data was provided by Trout Unlimited.

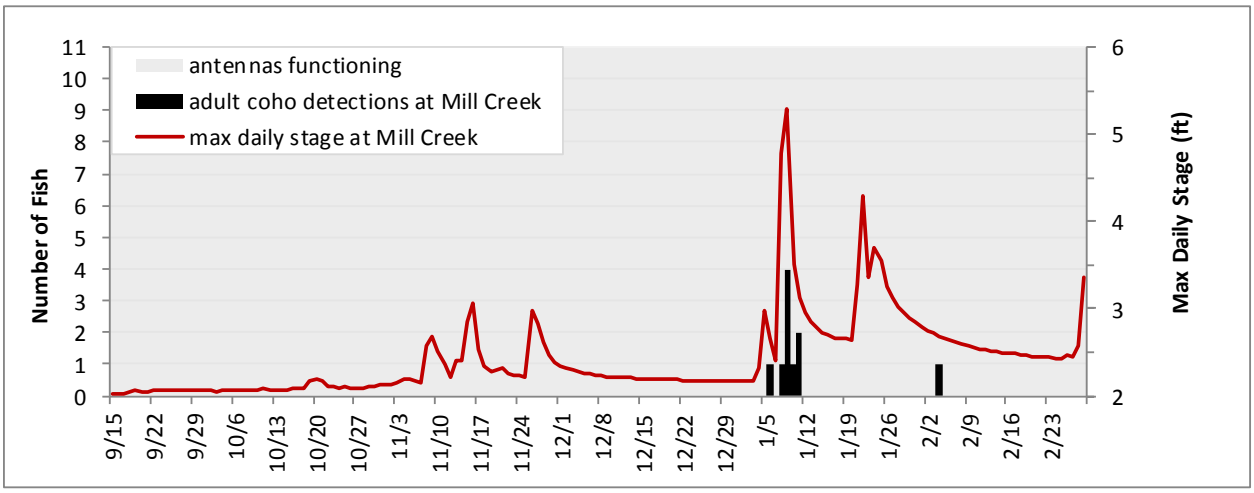

Figure 9. Detections of PIT-tagged coho salmon adults passing upstream of the Mill Creek antenna array, September 15, 2017 - March 1, 2018. Stage data was provided by Trout Unlimited.

Table 3. Minimum, expanded, and estimated counts of adult coho salmon returning to Willow Creek between September 15, 2017 and March 1, 2018. Minimum count= number unique PIT tag detections on lower antenna array; expanded count= minimum count/percent PIT-tagged; estimated count= expanded count/estimated antenna efficiency.

Age	Release Tributary	Origin	Release Group	Minimum Count	Percent PIT-tagged	Expanded Count	Estimated Antenna Efficiency	Estimated Count
2	Sheephouse Creek	fall	fall	1	15%	6.6	100%	6.6
2	Willow Creek	fall	fall	7	15%	46.7	100%	46.7
2	Willow Creek	presmolt	presmolt	2	15%	13.3	100%	13.3
2	Willow Creek	natural	tagged at trap	2	70%	2.9	100%	2.9
							Estimated hatchery adult returns (age-2):	67
							Estimated natural-origin adult returns (age-2):	3
							Total estimated adult returns:	**70**

Table 4. Minimum, expanded, and estimated counts of adult coho salmon returning to Dutch Bill Creek between September 15, 2017 and March 1, 2018. Minimum count= number unique PIT tag detections on lower antenna array; expanded count= minimum count/percent PIT-tagged; estimated count= expanded count/estimated antenna efficiency.

Age	Release Tributary	Origin	Release Group	Minimum Count	Percent PIT-tagged	Expanded Count	Estimated Antenna Efficiency	Estimated Count
3	Dutch Bill Creek	hatchery	fall	1	30%	3.3	100%	3.3
3	Dutch Bill Creek	hatchery	smolt	1	30%	3.3	100%	3.3
2	Dutch Bill Creek	hatchery	fall	3	15%	19.9	100%	19.9
2	Green Valley Creek	hatchery	presmolt	1	15%	6.6	100%	6.6
2	Willow Creek	hatchery	fall	1	15%	6.7	100%	6.7
							Estimated hatchery adult returns (age-3):	7
							Estimated hatchery adult returns (age-2):	33
							Total estimated adult returns:	**40**

Table 5. Minimum, expanded, and estimated counts of adult coho salmon returning to Green Valley Creek between September 15, 2017 and March 1, 2018. Minimum count= number unique PIT tag detections on upper antenna array; expanded count= minimum count/percent PIT-tagged; estimated count= expanded count/estimated antenna efficiency.

Age	Release Tributary	Origin	Release Group	Minimum Count	Percent PIT-tagged	Expanded Count	Estimated Antenna Efficiency	Estimated Count
2	Dutch Bill Creek	hatchery	fall	1	15%	6.6	100%	6.6
2	Green Valley Creek	hatchery	fall	5	15%	33.2	100%	33.2
2	Green Valley Creek	hatchery	presmolt	13	15%	86.2	100%	86.2
2	Green Valley Creek	hatchery	spring	1	100%	1.0	100%	1.0
2	Green Valley Creek	hatchery	smolt	2	15%	13.3	100%	13.3
2	Purrington Creek	hatchery	fall	3	15%	20.1	100%	20.1
2	Green Valley Creek	natural	tagged at trap	1	52%	1.9	100%	1.9
							Estimated hatchery adult returns (age-2):	160
							Estimated natural-origin adult returns (age-2):	2
							Total estimated adult returns:	**162**

Table 6. Minimum, expanded, and estimated counts of adult coho salmon returning to Mill Creek between September 15, 2016 and March 1, 2017. Minimum count= number unique PIT tag detections on upper antenna array; expanded count= minimum count/percent PIT-tagged; estimated count= expanded count/estimated antenna efficiency.

Age	Release Tributary	Origin	Release Group	Minimum Count	Percent PIT-tagged	Expanded Count	Estimated Antenna Efficiency	Estimated Count
3	Dutch Bill Creek	hatchery	smolt	1	30%	3.3	100%	3.3
3	Mill Creek	hatchery	fall	1	30%	3.3	100%	3.3
2	Dry Creek	hatchery	fall	1	100%	1.0	100%	1.0
2	Green Valley Creek	hatchery	fall	1	15%	6.6	100%	6.6
2	Green Valley Creek	hatchery	presmolt	1	15%	6.6	100%	6.6
2	Mill Creek	hatchery	fall	2	15%	13.5	100%	13.5
2	Mill Creek	hatchery	molt	1	15%	6.6	100%	6.6
2	Palmer Creek	hatchery	spring	1	15%	6.6	100%	6.6
2	Porter Creek	hatchery	fall	1	15%	6.7	100%	6.7
							Estimated hatchery adult returns (age-3):	7
							Estimated hatchery adult returns (age-2):	48
							Total estimated adult returns:	**55**

Table 7. Minimum, expanded, and estimated counts of hatchery adult coho salmon returning to the Russian River mainstem at Duncans Mills between September 15, 2017 and March 1, 2018. Minimum count= number unique PIT tag detections at Duncans Mills antenna array; expanded count= minimum count/percent PIT-tagged; estimated count= expanded count/estimated antenna efficiency. Note that Willow Creek fish that were not detected at Duncans Mills were added to the estimated total passing Duncans Mills to estimate the total number of adult hatchery coho salmon returning to the Russian River.

Age	Release Tributary	Release Group	Minimum Count	Percent PIT-tagged	Expanded Count	Estimated Antenna Efficiency	Estimated Count
3	Dutch Bill Creek	spring	1	100%	1.0	30%	1.0
3	Dutch Bill Creek	smolt	2	30%	6.6	30%	22.3
2	Austin Creek	fall	1	15%	6.6	30%	22.2
2	Dry Creek	fall	2	100%	2.0	30%	6.7
2	Dry Creek	smolt	3	15%	19.8	30%	66.4
2	Dutch Bill Creek	fall	2	15%	13.3	30%	44.5
2	Dutch Bill Creek	smolt	1	15%	6.6	30%	22.3
2	Green Valley Creek	fall	3	15%	19.9	30%	66.9
2	Green Valley Creek	presmolt	6	15%	39.8	30%	133.5
2	Mark West Creek	fall	3	15%	19.7	30%	66.2
2	Mark West Creek	smolt	3	15%	19.7	30%	66.3
2	Mill Creek	smolt	1	15%	6.6	30%	22.3
2	Palmer Creek	spring	1	15%	6.6	30%	22.3
2	Porter Creek	fall	1	15%	6.7	30%	22.4
2	Purrington Creek	fall	1	15%	6.7	30%	22.5
2	Sheephouse Creek	fall	1	15%	6.6	30%	22.3
2	Willow Creek	fall	4	15%	26.7	30%	89.5
2	Willow Creek	presmolt	1	15%	6.6	30%	22.3
						Estimated adults passing Duncans Mills (age-3):	23
						Estimated adults passing Duncans Mills (age-2):	719
						Estimated adults returning to Willow Creek that were not detected at Duncans Mills (age-2):	21
						Total estimated hatchery adult returns:	**763**

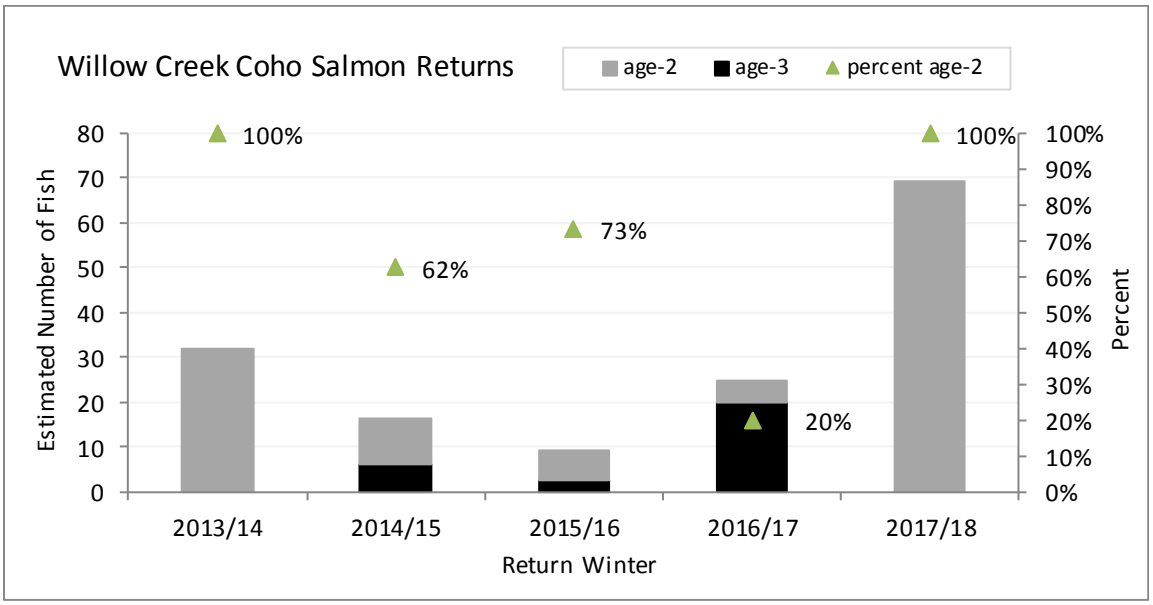

Figure 10. Estimated annual Willow Creek adult hatchery coho salmon returns by age, return seasons 2013/14 – 2017/18.

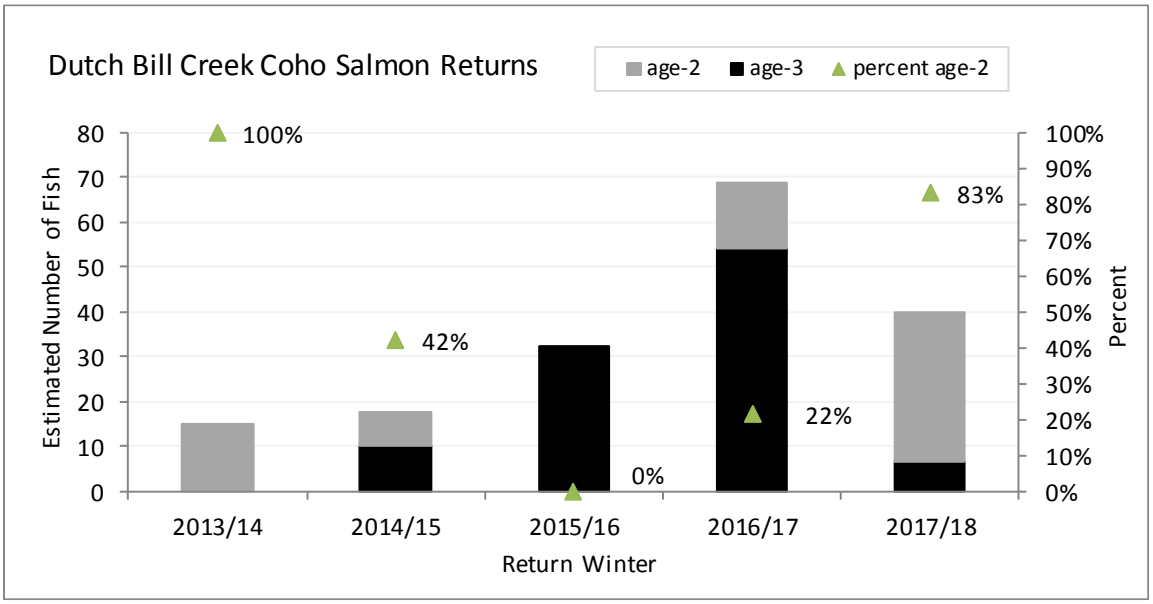

Figure 11. Estimated annual Dutch Bill Creek adult hatchery coho salmon returns by age, return seasons 2013/14 – 2017/18.

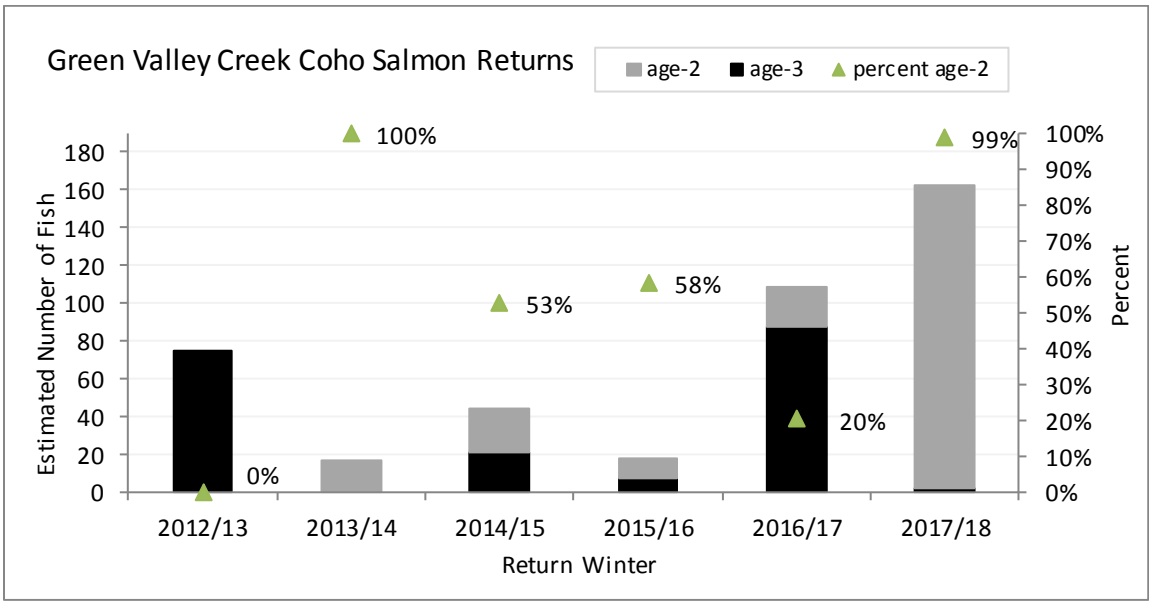

Figure 12. Estimated annual Green Valley Creek adult hatchery coho salmon returns by age, return seasons 2012/13 – 2017/18.

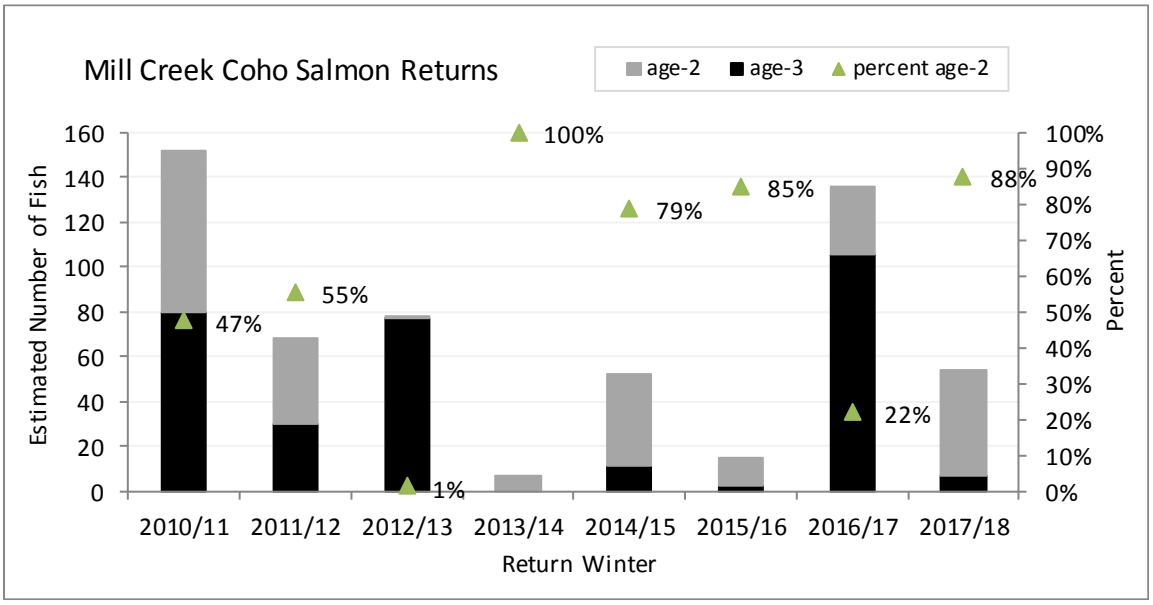

Figure 13. Estimated annual Mill Creek adult hatchery coho salmon returns by age, return seasons 2010/11 – 2017/18.

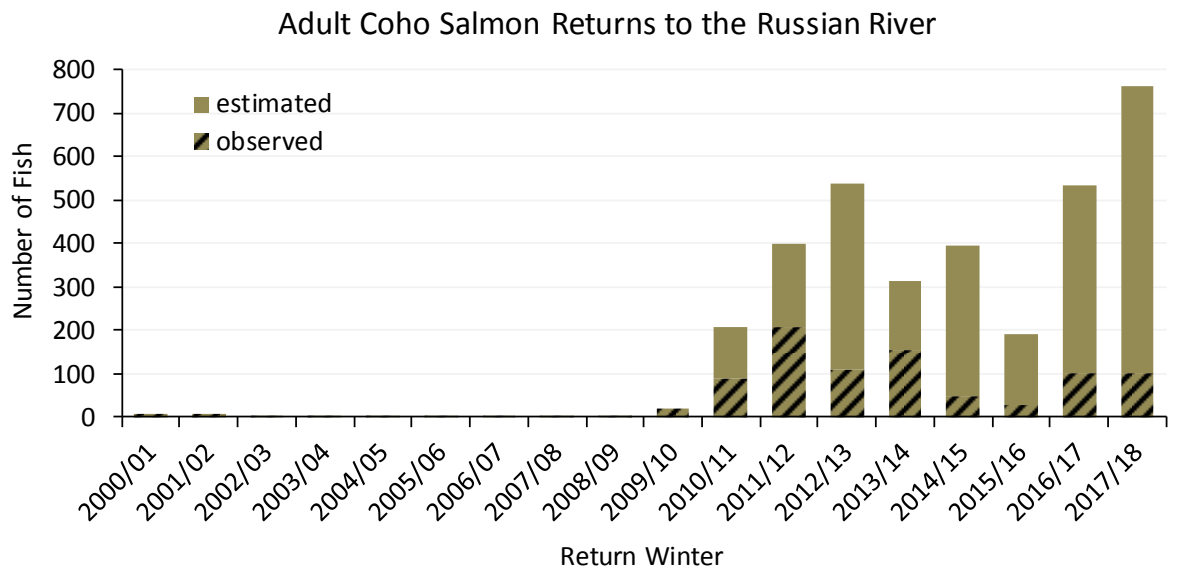

Figure 14. Estimated annual adult hatchery coho salmon returns to the Russian River, return seasons 2000/01-2017/18. Note that methods for counting/estimating the number of returning adult coho salmon were not consistent among years; prior to 2009/10, spawner surveys were the primary method, from 2009/10 – 2011/12 methods included spawner surveys, video monitoring and PIT tag detection systems, and beginning in 2012/13, with the installation of the Duncans Mills antenna array, PIT tag detection systems were the primary method used.

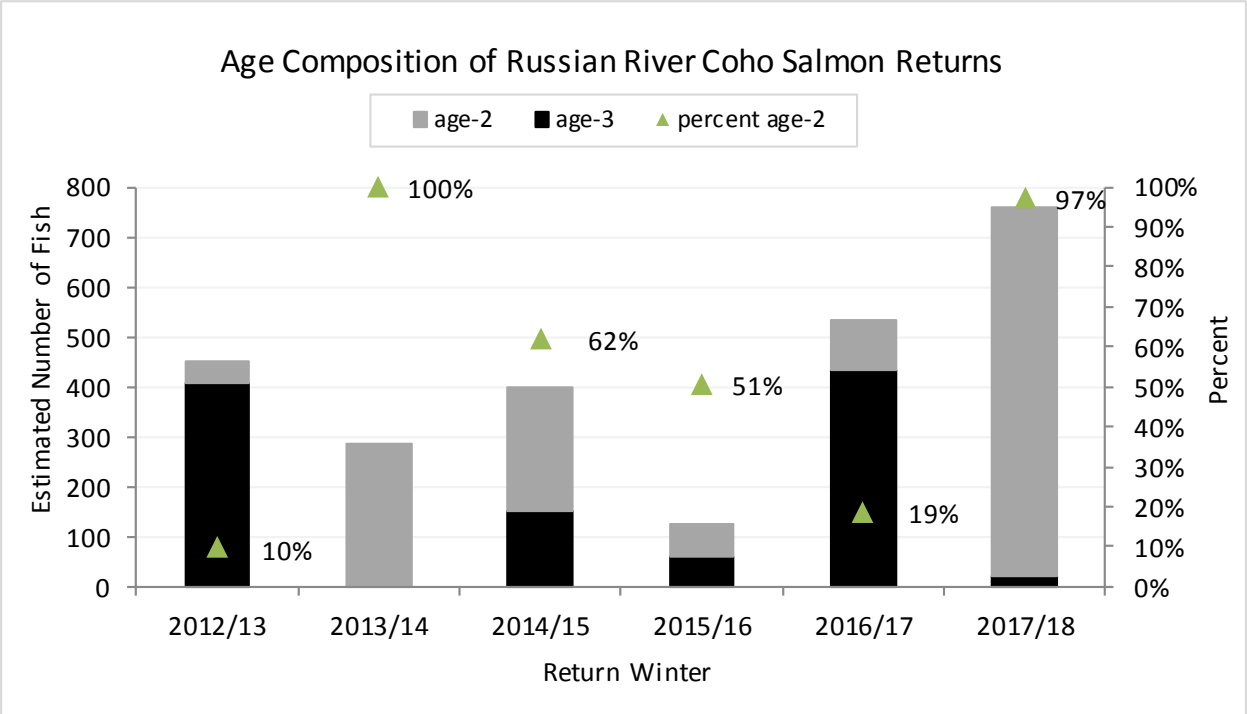

Figure 15. Estimated annual Russian River adult hatchery coho salmon returns by age, return seasons 2012/13-2017/18. Note that this figure includes only fish that we were able to age; therefore, totals will be less than adult return estimates shown in Figure 14.

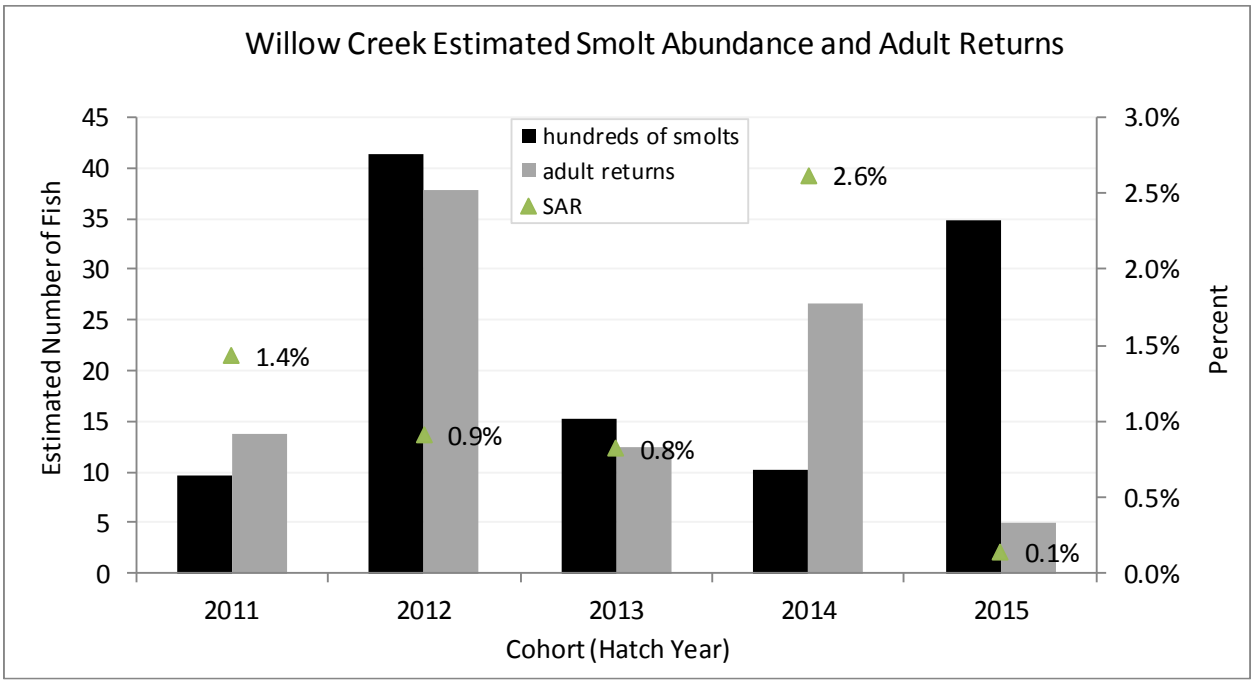

Figure 16. Estimated coho salmon smolt abundance, adult returns and smolt to adult (SAR) survival ratios in Willow Creek, cohorts 2011-2015.

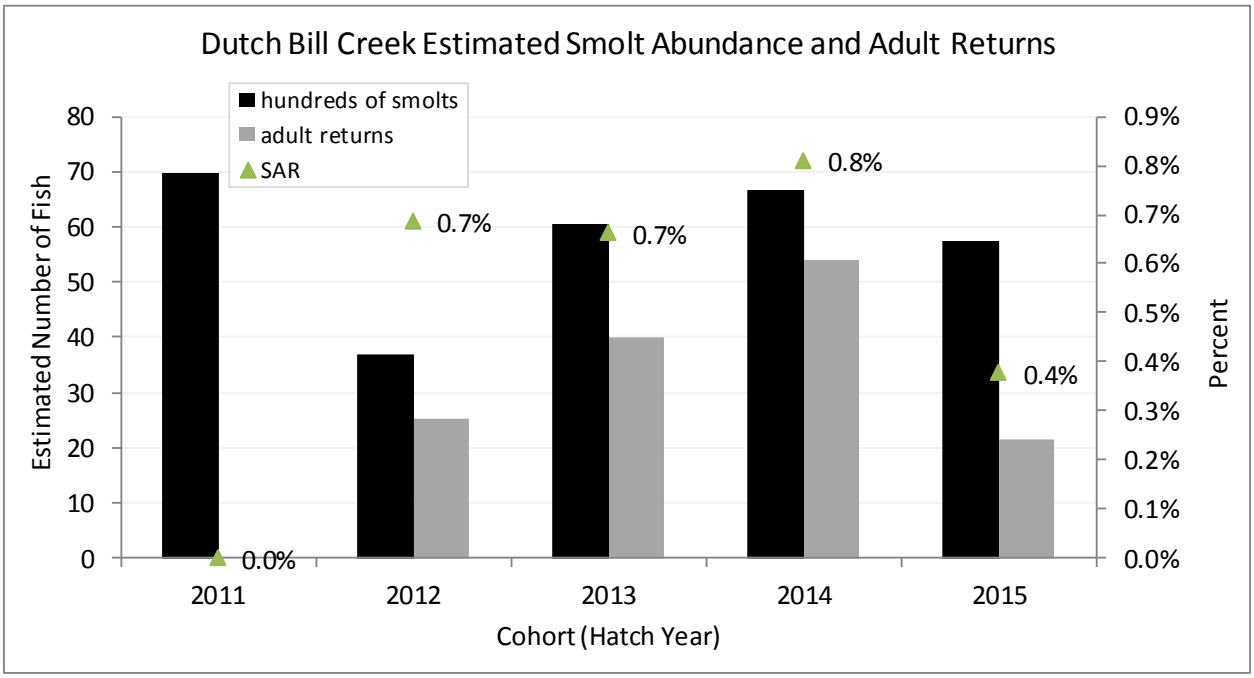

Figure 17. Estimated coho salmon smolt abundance, adult returns and smolt to adult (SAR) survival ratios in Dutch Bill Creek, cohorts 2011-2015.

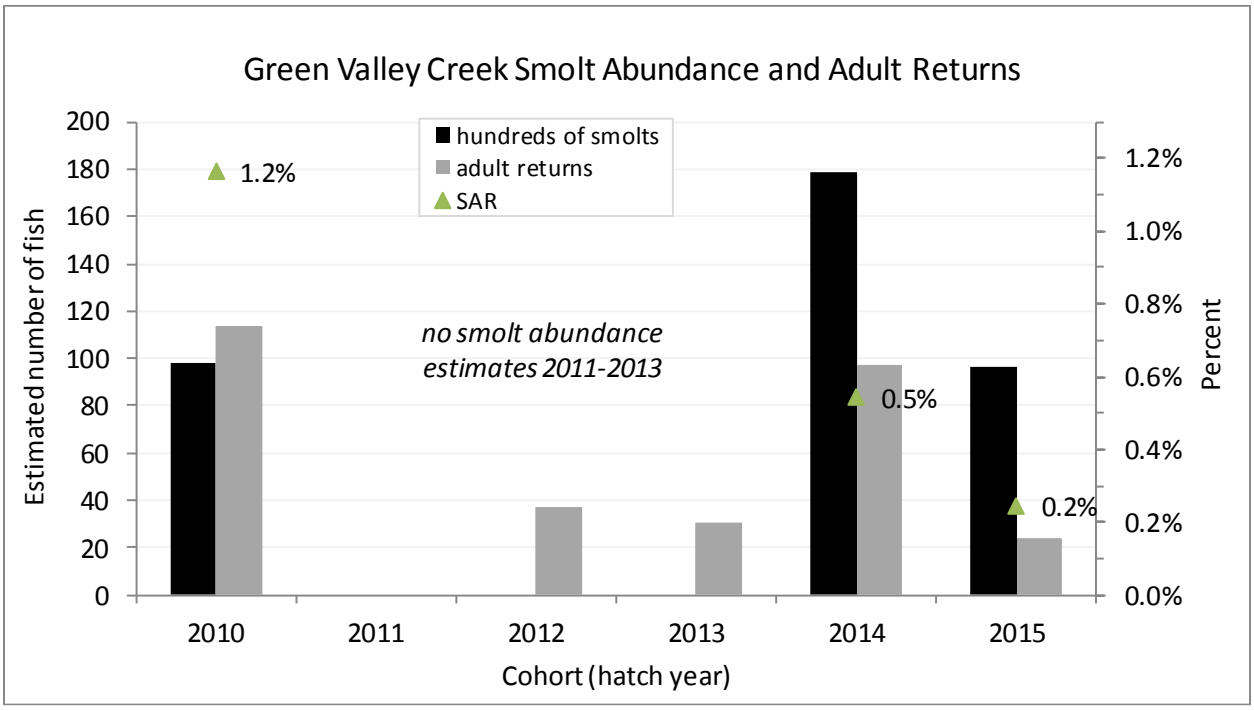

Figure 18. Estimated coho salmon smolt abundance, adult returns and smolt to adult (SAR) survival ratios in Green Valley Creek, cohorts 2010-2015.

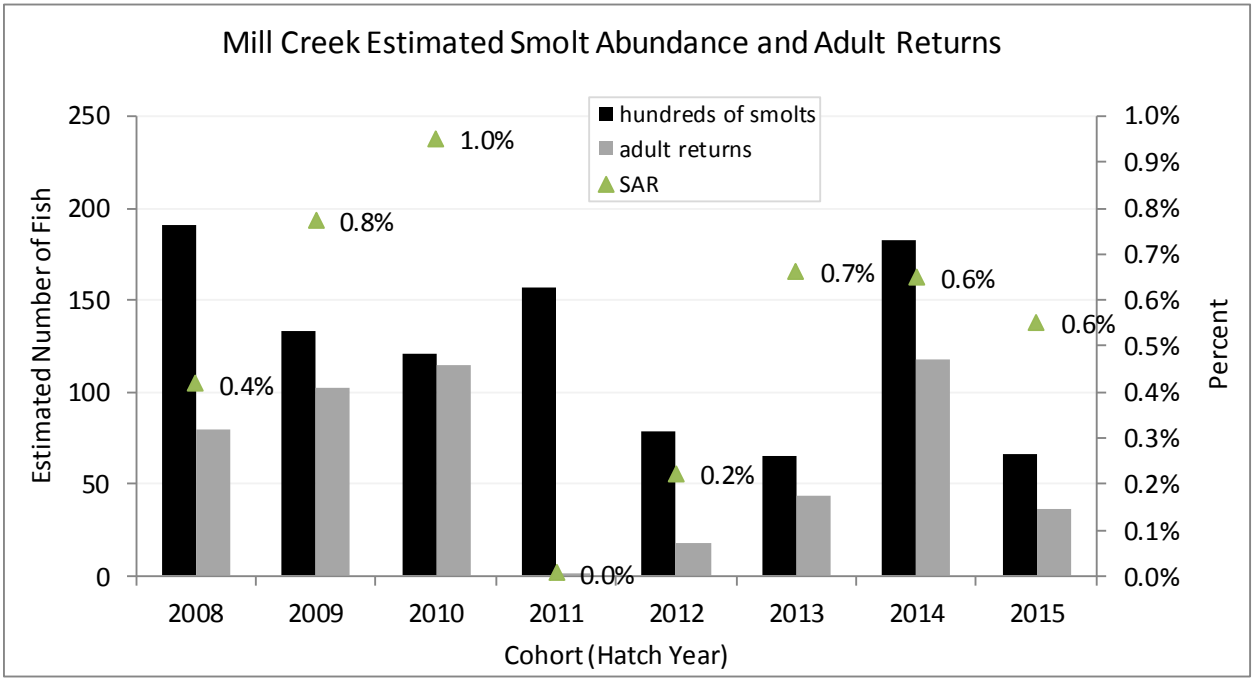

Figure 19. Estimated coho salmon smolt abundance, adult returns and smolt to adult (SAR) survival ratios in Mill Creek, cohorts 2008-2015.

Table 8. Smolt to adult return (SAR) ratios estimated for Willow, Dutch Bill, Green Valley, and Mill creeks, cohorts 2008 through 2015.

		Smolt to Adult Return (SAR) Ratio			
Cohort	Return Winter	Willow	Dutch Bill	Green Valley	Mill
2008	2010/11	*NA*	*NA*	*NA*	0.4%
2009	2011/12	*NA*	*NA*	*NA*	0.8%
2010	2012/13	*NA*	0.2%	1.2%	1.0%
2011	2013/14	1.4%	0.0%	*NA*	0.0%
2012	2014/15	0.9%	0.7%	*NA*	0.2%
2013	2015/16	0.8%	0.7%	*NA*	0.7%
2014	2016/17	2.6%	0.8%	0.5%	0.6%
2015	2017/18	0.1%	0.4%	0.2%	0.6%
	Average	1.2%	0.5%	0.7%	0.5%

III. Spawning Surveys

Objectives

Spawning adult and redd surveys were conducted in Russian River tributaries to document spatial distribution and estimate the number of redds. These data document spawning activity and adult presence in specific streams where juvenile coho salmon are released from Don Clausen Fish Hatchery and throughout other streams in the Russian River basin. For Broodstock Program monitoring, we aimed to survey all spawning reaches of Dutch Bill, Green Valley, Mill, and Willow creeks (Figure 20) in order to estimate the total number of redds in each creek. For CMP monitoring, we aimed to survey a spatially-balanced random sample of adult coho salmon and steelhead reaches in the Russian River sample frame (a sample frame of stream reaches identified by the Russian River CMP Technical Advisory Committee[1] as having coho salmon, steelhead, and/or Chinook salmon habitat) (Figure 20) in order to estimate the total number of coho salmon and steelhead redds in the Russian River watershed. Surveys were conducted in coordination with the Water Agency using standardized CMP methods (Adams et al. 2011; SCWA and UC 2015).

Methods

Sampling framework

For Broodstock Program monitoring, we surveyed all accessible adult spawning reaches of Willow, Dutch Bill, Green Valley, and Mill creeks, for CMP *life cycle* monitoring we surveyed all accessible tributaries of Dry Creek, and for CMP *basinwide* monitoring, we used a soft stratification and generalized random tessellation stratified (GRTS) approach to survey a random, spatially-balanced selection of coho salmon and steelhead reaches within the Russian River watershed (Figure 20).

Field methods

Survey methodology for collecting information on spawning salmonids in the Russian River system was adapted from *Coastal Northern California Salmonid Spawning Survey Protocol* (Gallagher and Knechtle 2005). Each reach was surveyed at an interval of 10-14 days throughout the spawning season. Two person crews hiked reaches from downstream to upstream looking for adult salmon individuals (live or carcasses) and redds (Figure 21). Redds were identified to species based on presence of identifiable adult fish or from observed redd morphology. Measurements were taken on all redds including pot length, width and depth; tailspill length, width and depth; and substrate size. All observed salmonids were identified to species (coho salmon (Figure 22), Chinook salmon, and steelhead), or as unknown salmonids if identification was not possible. Species, certainty of species identification, life stage, sex, certainty of sex, and fork length were recorded for all observed fish. When a carcass was encountered, scans for coded wire tags (CWT) and PIT tags were performed. A genetics sample, scale sample, and the head (for otolith extraction) were also retrieved from all salmonid carcasses. Geospatial coordinates were recorded for all redd and fish observations. Presence of non-salmonid species was also documented. Allegro field computers were used for data entry and, upon returning from the field, data files were downloaded, error checked, and transferred into a SQL database.

[1] A body of fisheries experts, including members of the Statewide CMP Technical Team, tasked with providing guidance and technical advice related to CMP implementation in the Russian River.

Redd and Adult Return Estimates

For redds of unknown species or redds with low certainty of identification, redd measurement data was used to assign redd species following Gallagher and Gallagher's redd species determination method (Gallagher and Gallagher 2005). The total number of unique redds was then summed for each surveyed reach. Within each reach, to account for redds missed by observers, the number of redds observed was expanded based upon the average observational "life span" of redds observed in that same reach (Ricker et al. 2014). For example, in reaches where redds were obscured quickly due to storms or algae (leading to a higher probability of missing redds), expansion rates were higher than in reaches where redds remained visible for longer periods of time. For Broodstock Program monitoring stream estimates, where census surveys were conducted, redd estimates from all tributaries and subreaches within each watershed were summed. For basinwide estimates, we calculated an average redd density per reach and multiplied that density by the total number of coho salmon reaches within the Russian River sample frame. For basinwide adult estimates, redd estimates were multiplied by a literature-based spawner to redd ratio of 2.35 for coho salmon and 1.22 for steelhead (Gallagher et al. 2010) to estimate the total number of adult spawners in the Russian River sample frame.

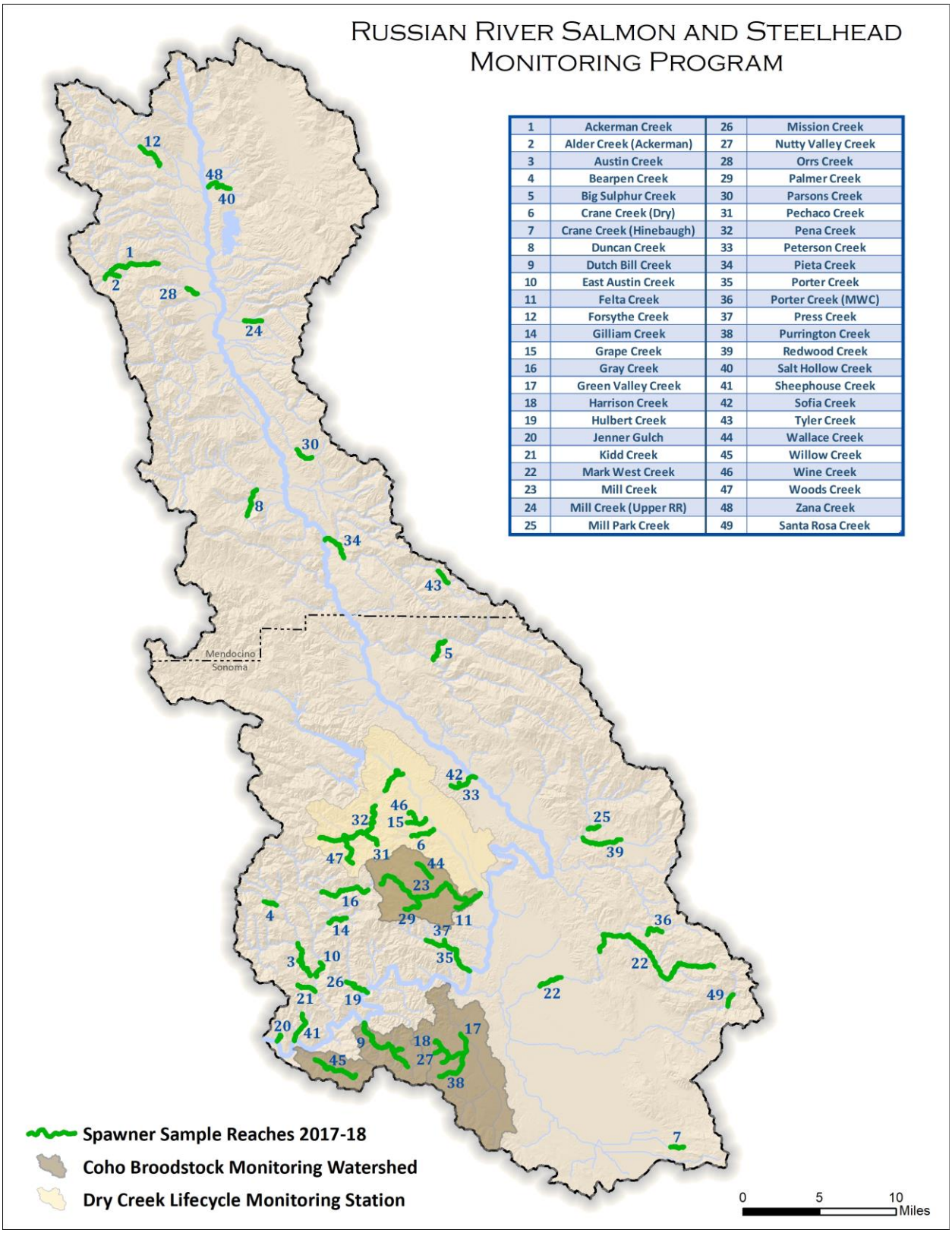

Figure 20. Broodstock Program watersheds and 2017-2018 spawner survey reaches in the Russian River.

Figure 21. A spawner crew member measures a redd in Willow Creek (photo credit: Joshua Asel).

Figure 22. A pair of adult coho salmon observed in Woods Creek during 2017/18 spawner surveys.

Results

Surveys began when streams reconnected to the Russian River mainstem and became accessible to adult salmon in late-November, 2017, and continued through mid-April, 2018. During this time, CSG and Water Agency biologists completed a total of 693 salmonid spawning ground surveys on 75 reaches in 54 streams within the Russian River basin. A total of 228 salmonid redds were observed: 42 coho salmon redds, 127 steelhead redds, 1 Chinook salmon redd, and 58 redds of unknown salmonid species origin (Table 9, Figure 23, Figure 24). Additionally, coho salmon adults were observed in Austin Creek where no confirmed coho redds were observed (Figure 23), and steelhead adults were observed in five streams where no confirmed steelhead redds were observed, including Ackerman, Crane, Grape, Hulbert, Pechaco, and Porter creeks (Figure 24). Of the 30 coho salmon streams surveyed during the winter of 2017/18, coho salmon redds and/or adults were observed in 16 (53%) and steelhead redds and/or adults were observed in 30 of the 54 steelhead streams surveyed (56%) (Table 9, Figure 23, Figure 24).

Over all streams combined, timing of redds varied by species, with the only Chinook salmon redd observation in late-November, coho salmon observations peaking in early January, and steelhead observations peaking in March (Figure 25). Steelhead redds were observed over the widest timeframe, ranging from early December through mid-April (Figure 25).

Coho salmon redd estimates in Broodstock Program monitoring streams ranged from four in Willow and Dutch Bill creeks to 10 in Mill Creek, and steelhead redd estimates ranged from six in Dutch Bill Creek to 44 in Green Valley Creek (Table 10). When coho salmon redd estimates were compared with adult estimates generated using PIT tag detection systems, adult spawner to redd ratios were calculated for each stream, and ranged from 5.50 in Mill Creek to 23.14 in Green Valley Creek (Table 10).

When compared with previous years, coho salmon redd estimates were lower in Willow and Mill creeks, and average for Dutch Bill and Green Valley creeks (Figure 26). Steelhead redd estimates were low in Willow and Dutch Bill creeks and average in Green Valley and Mill creeks (Figure 27). Basinwide, redd estimates were lower than average for both species (Table 11).

In all of the creeks surveyed, we recovered a total of 10 coho salmon carcasses in Dutch Bill, Green Valley, Porter and Pena creeks (Table 12). The proportion of natural-origin adult coho salmon carcasses recovered ranged from 0.4 in Green Valley Creek and 1.0 in Dutch Bill and Pena creeks; however, the sample size was too small to make any inferences about the proportion of natural-origin fish returning to the Russian River watershed.

Redd distribution varied by stream (Figure 28 - Figure 31). In Willow Creek, the coho salmon redds were evenly spaced throughout the surveyed stream reach and only one steelhead redd and two salmonid species redds were observed in the upper extent of the survey reach (Figure 28). In Dutch Bill Creek, a few coho salmon redds were observed in the middle of the survey reach, with one steelhead redd observed further upstream (Figure 29). In Green Valley Creek watershed, coho salmon and steelhead redds were observed throughout the upper half of Green Valley Creek as well as in Purrington Creek (Figure 30). In the Mill Creek watershed, there were two clusters of coho salmon redds; one upstream of the Wallace Creek confluence, and another in Felta Creek near it's confluence with Mill Creek (Figure 31). Spatial distribution of redds for other CMP survey streams can be found on our website: (http://www.cohopartnership.org).

Table 9. Total salmonid redds observed by species during 2017-18 spawner surveys in Russian River tributaries.

Tributary	Coho Salmon	Steelhead	Chinook Salmon	Unknown Salmonid	Total
Ackerman Creek*	0	0	0	1	1
Alder Creek (Ackerman)*	0	0	0	0	0
Austin Creek	0	1	0	2	3
Bearpen Creek*	0	8	0	0	8
Big Sulphur Creek*	0	4	0	0	4
Crane Creek (Dry)	0	0	0	0	0
Crane Creek (Hinebaugh)*	0	0	0	0	0
Duncan Creek*	0	2	0	0	2
Dutch Bill Creek	5	2	0	1	8
East Austin Creek	0	3	0	0	3
Felta Creek	2	2	0	1	5
Forsythe Creek*	0	6	1	3	10
Gilliam Creek	0	1	0	1	2
Grape Creek	3	0	0	0	3
Gray Creek	3	6	0	1	10
Green Valley Creek	8	9	0	10	27
Grub Creek	0	0	0	0	0
Harrison Creek	1	0	0	0	1
Hulbert Creek	0	0	0	0	0
Jenner Gulch*	0	0	0	0	0
Kidd Creek	0	0	0	0	0
Little Green Valley Creek	0	0	0	0	0
Mark West Creek	1	11	0	4	16
Mill Creek	5	12	0	5	22
Mill Creek (Upper Rr)*	0	0	0	0	0
Mill Park Creek*	0	0	0	0	0
Mission Creek	0	0	0	0	0
Nutty Valley Creek	0	1	0	0	1
Orrs Creek*	0	1	0	0	1
Palmer Creek	0	1	0	0	1
Parsons Creek*	0	0	0	1	1
Pechaco Creek*	0	0	0	0	0
Pena Creek	4	36	0	9	49
Perenne Creek*	0	0	0	0	0
Peterson Creek*	0	0	0	0	0
Pieta Creek*	0	5	0	2	7
Porter Creek	1	0	0	1	2
Porter Creek (Mwc)	0	0	0	1	1
Press Creek	0	0	0	0	0
Purrington Creek	2	4	0	3	9
Redwood Creek	1	3	0	6	10
Salt Hollow Creek*	0	0	0	0	0
Santa Rosa Creek	0	2	0	1	3
Schoolhouse Creek	0	0	0	0	0
Sheephouse Creek	0	0	0	0	0
Sofia Creek*	0	0	0	0	0
Tyler Creek*	0	1	0	0	1
Wallace Creek	0	0	0	0	0
Willow Creek	4	1	0	3	8
Wine Creek	1	0	0	0	1
Woods Creek	1	5	0	2	8
Zana Creek*	0	0	0	0	0
Total	42	127	1	58	228
*Steelhead only tributary					

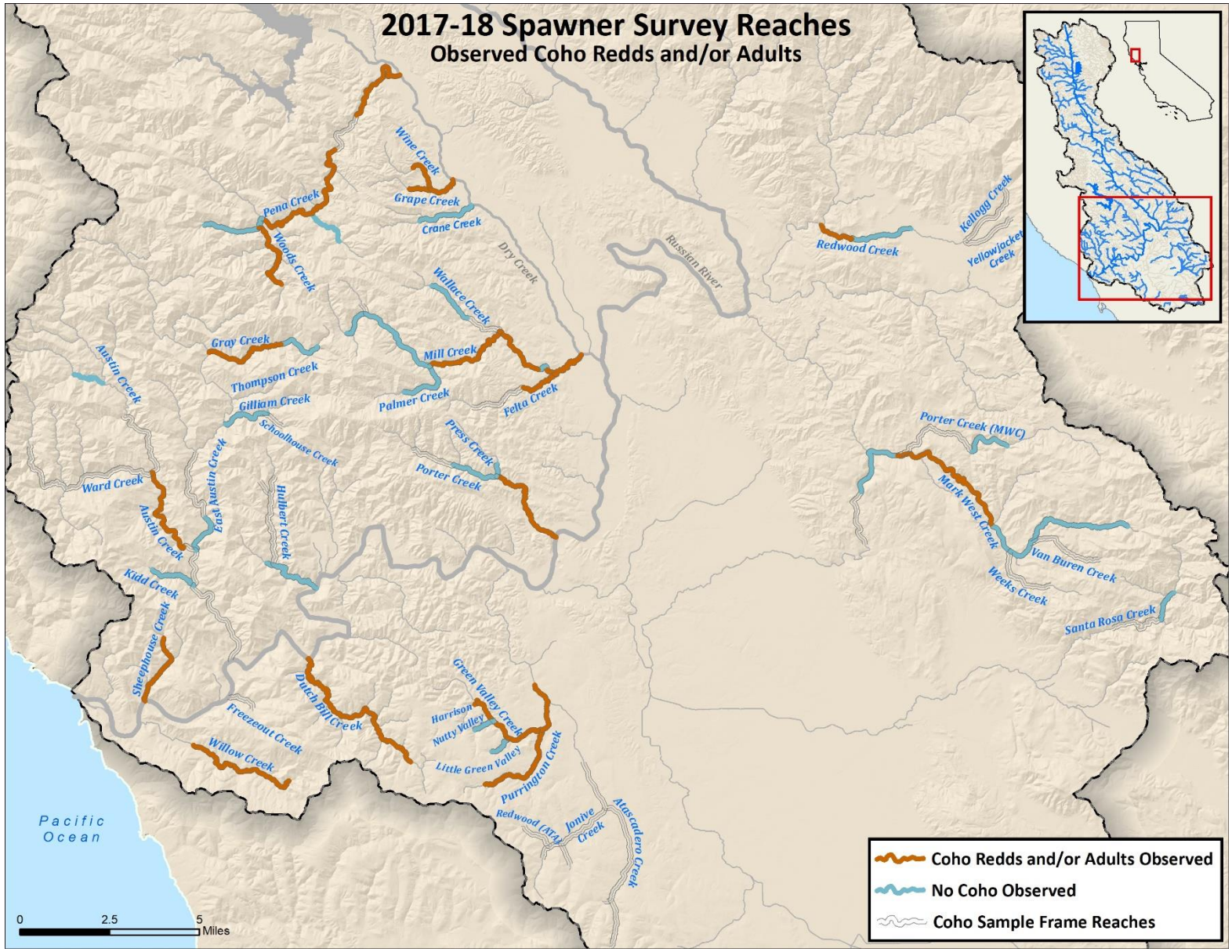

Figure 23. Spawner survey reaches where coho salmon redds and/or coho salmon adults were observed, winter 2017/18.

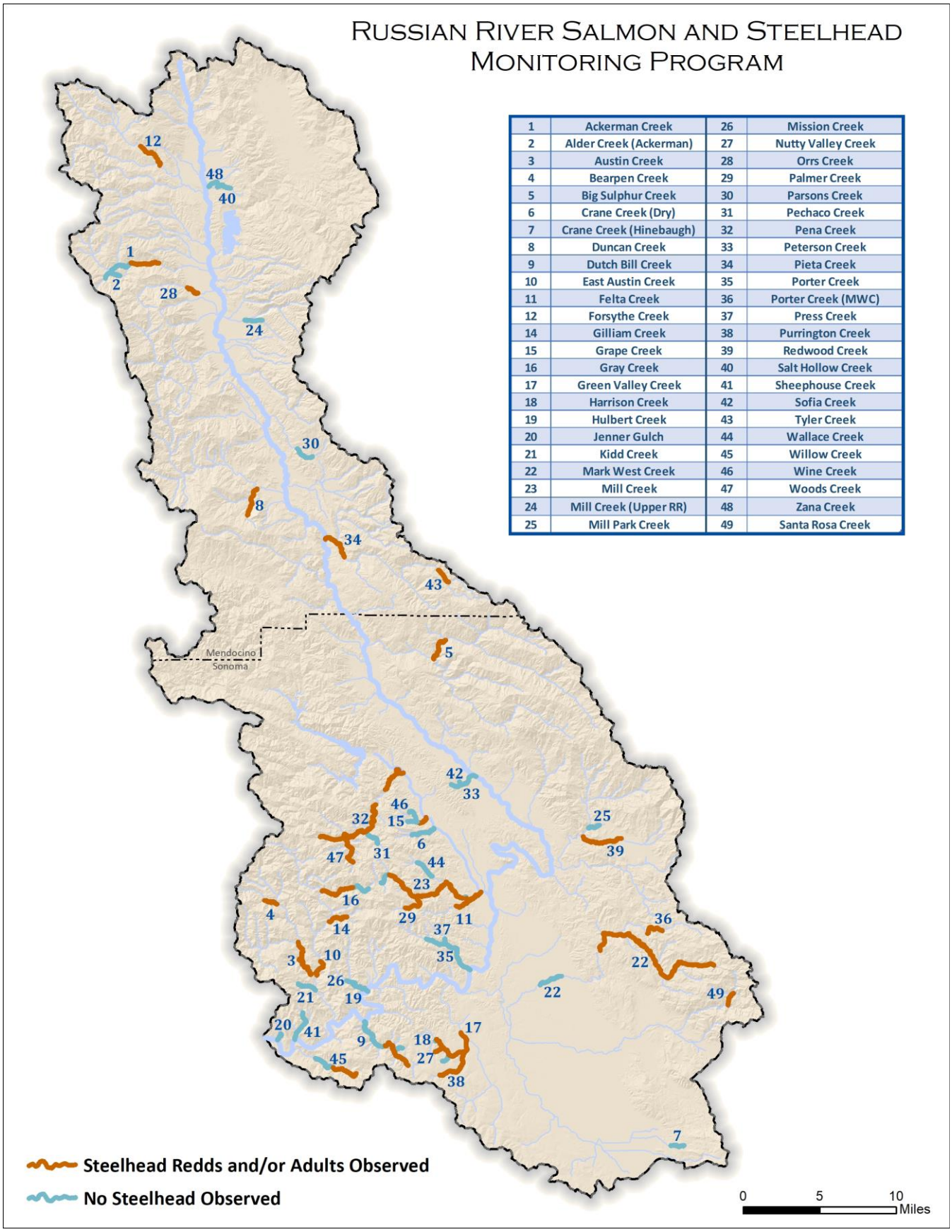

Figure 24. Spawner survey reaches where steelhead redds and/or live steelhead adults were observed, winter 2017/18.

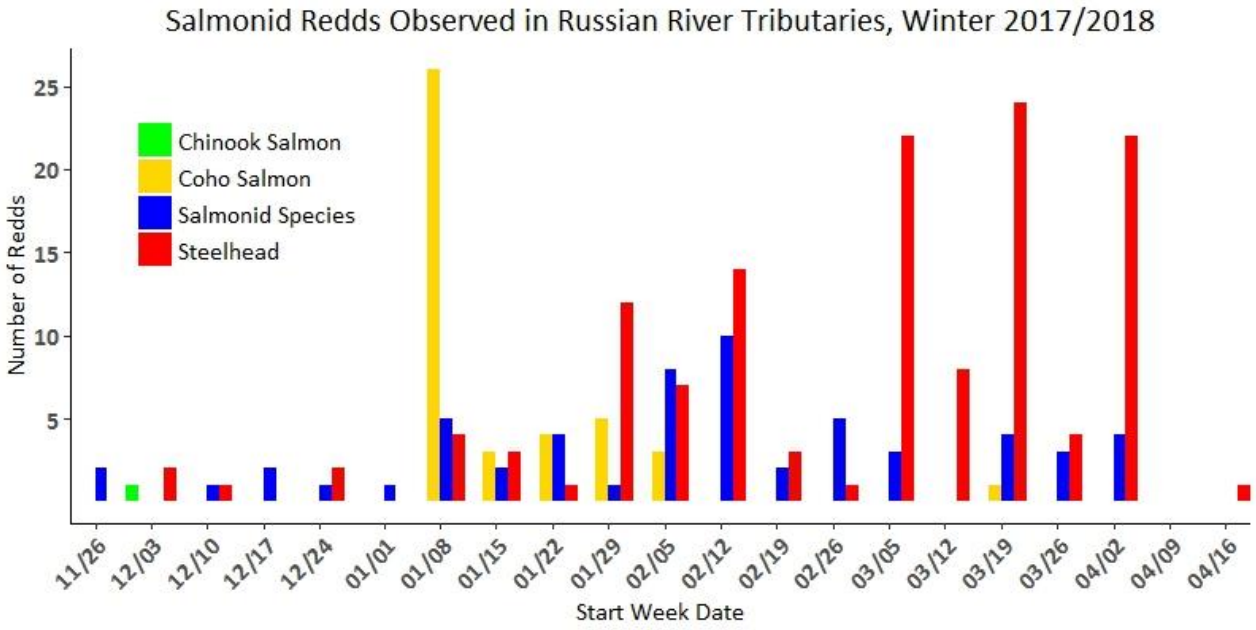

Figure 25. Number of new salmonid redds observed each week in Russian River Coastal Monitoring Program survey streams, winter 2017/18.

Table 10. Estimated coho salmon and steelhead redds and adults in four Russian River tributaries, winter 2017/18. Adult estimates for coho salmon were based on PIT tag data and adult to redd ratios were calculated by dividing the estimated number of adults by the estimated number of redds. Because we do not PIT tag juvenile steelhead in these streams, we were unable to estimate steelhead adult estimates or adult to redd ratios.

Tributary	Species	Estimated Redds	Estimated Adults	Adult:Redd Ratio
Willow Creek	coho salmon	4	70	17.50
Willow Creek	steelhead	7	NA	NA
Dutch Bill Creek	coho salmon	4	40	10.00
Dutch Bill Creek	steelhead	6	NA	NA
Green Valley Creek	coho salmon	7	162	23.14
Green Valley Creek	steelhead	44	NA	NA
Mill Creek	coho salmon	10	55	5.50
Mill Creek	steelhead	25	NA	NA

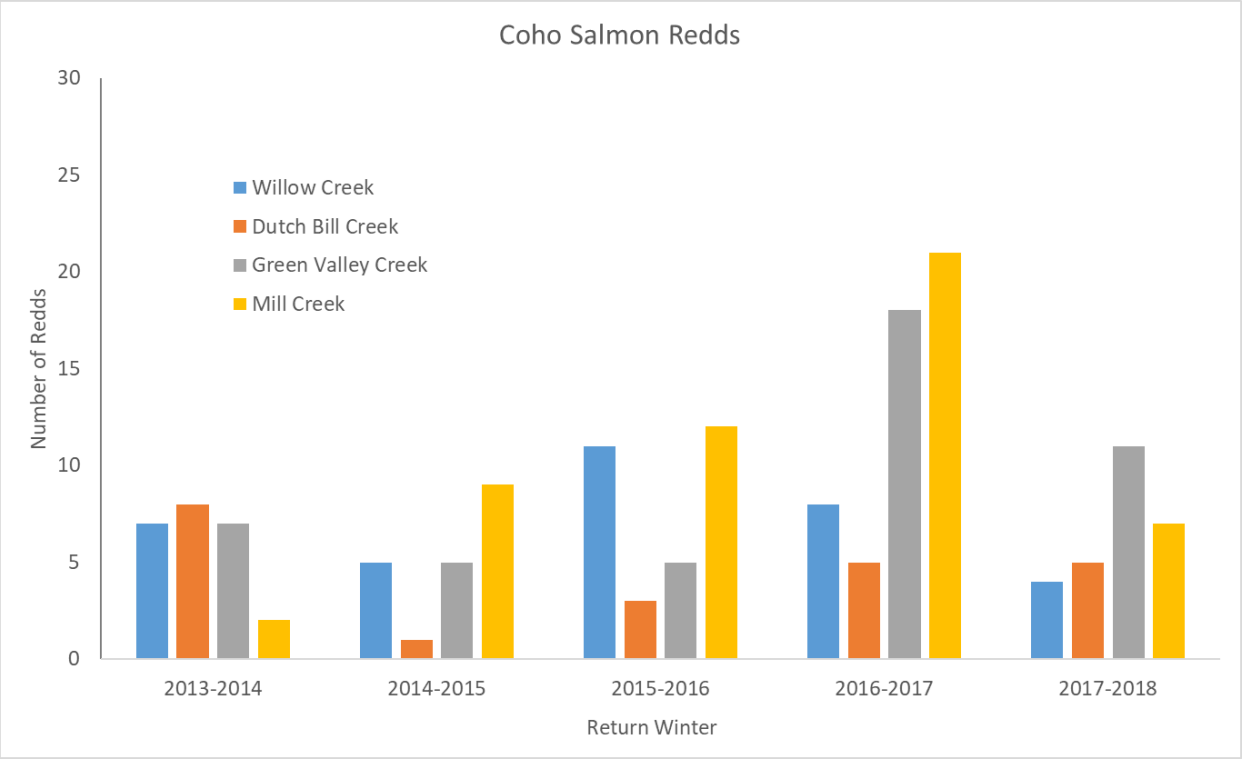

Figure 26. Estimated coho salmon redds in Broodstock Program Monitoring tributaries, return winters 2013/14 – 2017/18.

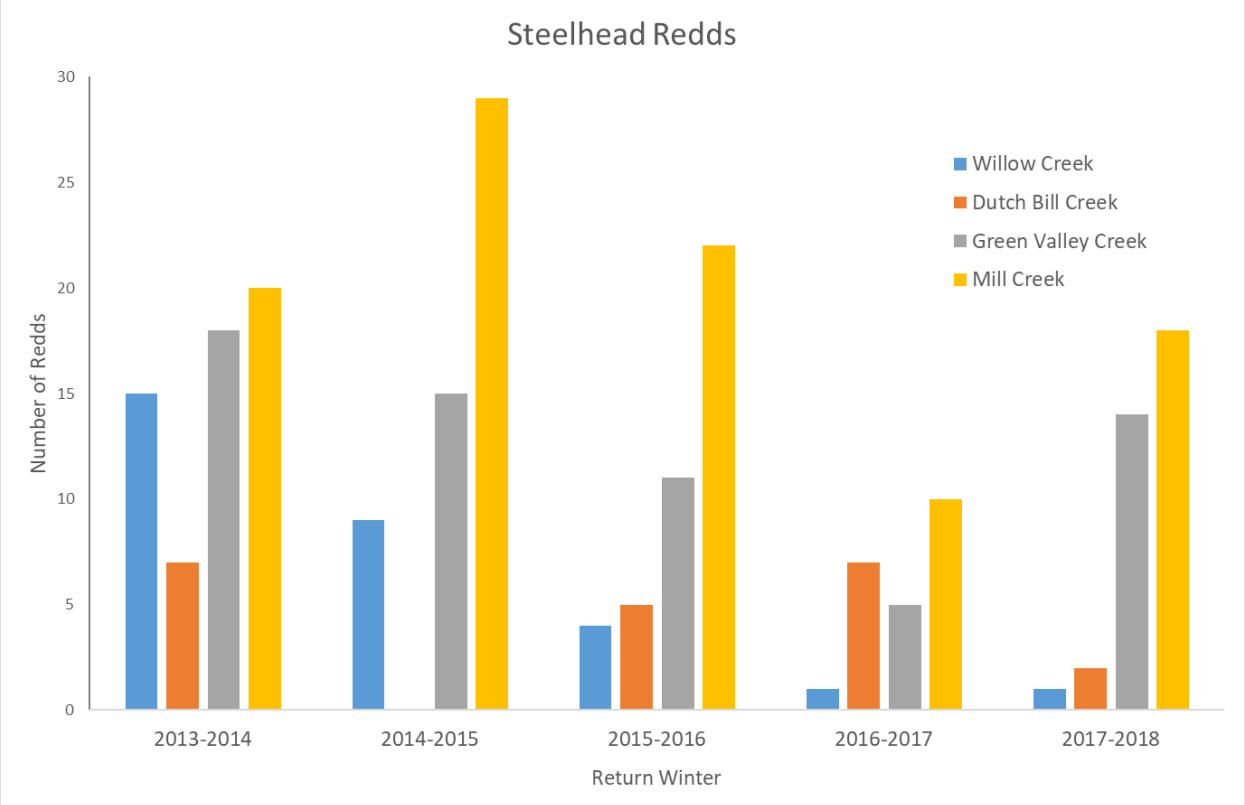

Figure 27. Estimated steelhead redds in Broodstock Program monitoring tributaries, return winters 2013/14 - 2017/18.

Table 11. Estimated coho salmon and steelhead redds and adults in the coho/steelhead stratum of the Russian River watershed, 2014/15-2017/18. Adult estimates were derived by multiplying the number of redds by literature-based spawner to redd ratios of 2.35 for coho salmon and 1.22 for steelhead (Gallagher et al. 2010).

Year	Species	Reaches (%)	95%LCL	Redds	95%UCL	Adults
2014-2015	coho salmon	37 (42)	59	98	137	230
2014-2015	steelhead	37 (42)	298	500	702	610
2015-2016	coho salmon	31 (35)	94	170	246	400
2015-2016	steelhead	31 (35)	272	599	926	731
2016-2017	coho salmon	33 (37)	126	206	286	484
2016-2017	steelhead	33 (37)	200	581	962	709
2017-2018	**coho salmon**	**32 (36)**	**58**	**93**	**128**	**219**
2017-2018	**steelhead**	**32 (36)**	**213**	**348**	**483**	**425**

Table 12. Number of coho salmon carcasses observed relative to CWT presence/absence during 2017/18 spawner surveys in Russian River tributaries.

Tributary	CWT Present	CWT Not Present	Proportion Untagged (Natural-Origin)
Dutch Bill Creek	0	2	1
Green Valley Creek	3	2	0.4
Porter Creek	1	1	0.5
Pena Creek	0	1	1

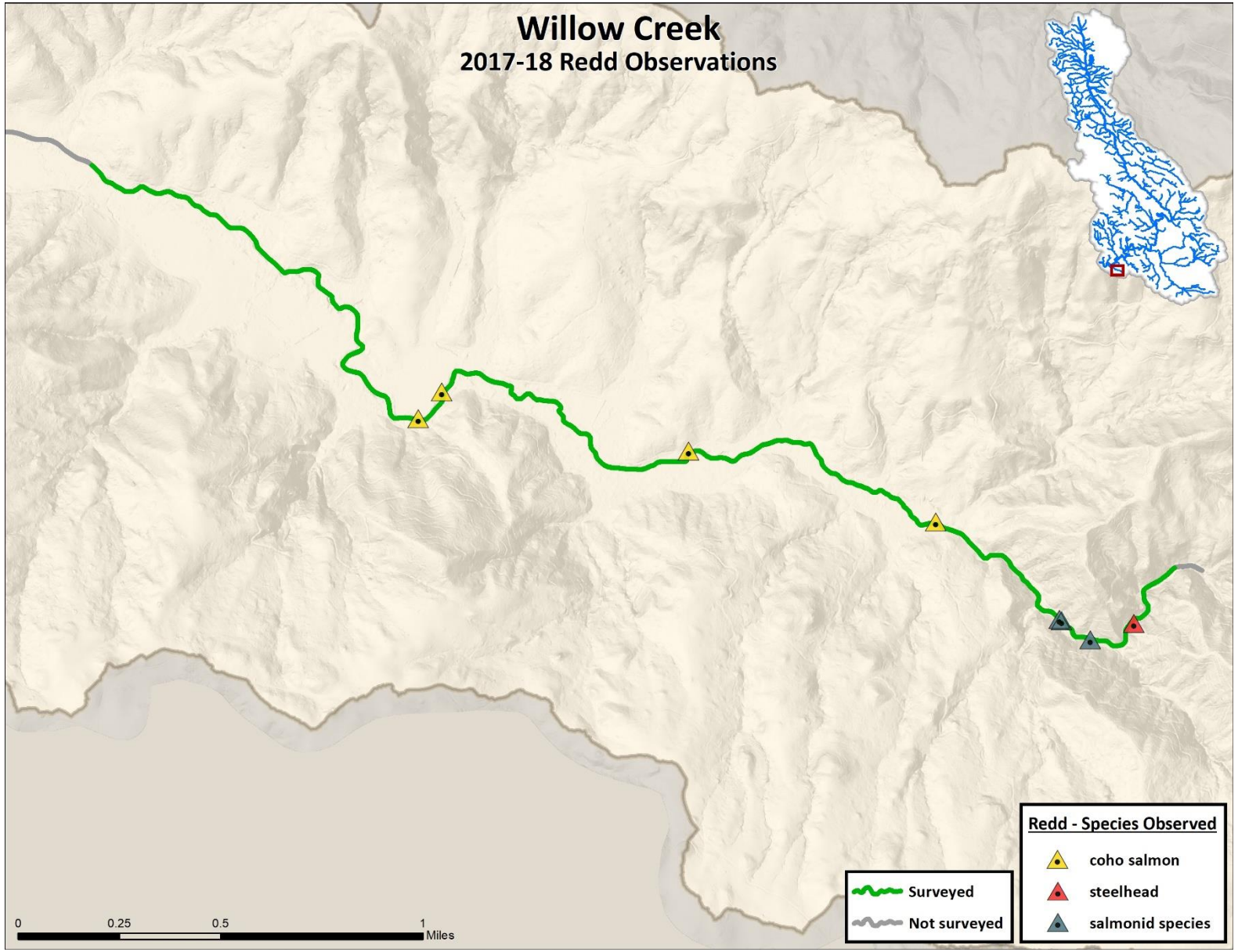

Figure 28. Salmonid redds observed in Willow Creek during winter 2017/18.

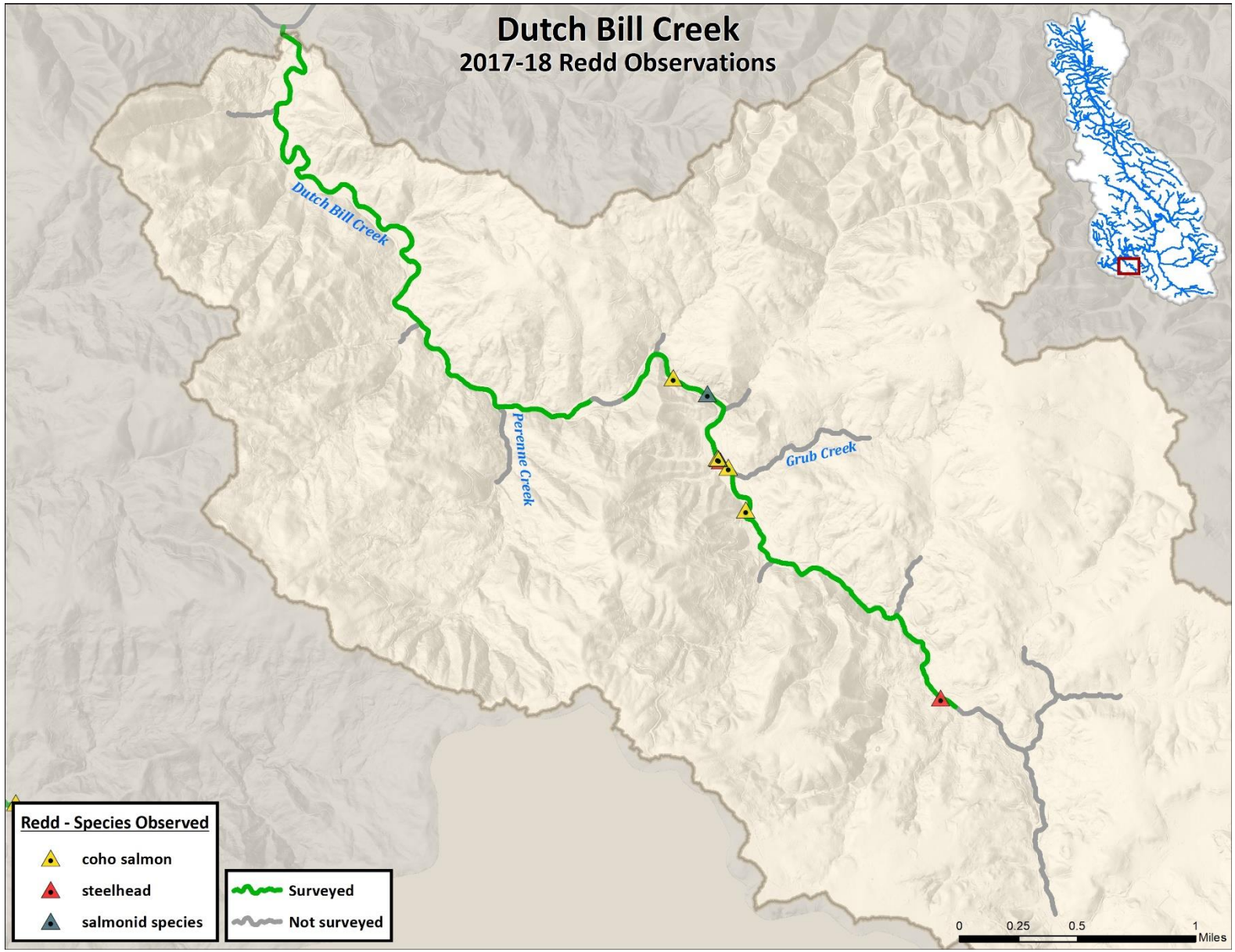

Figure 29. Salmonid redds observed in Dutch Bill Creek during winter 2017/18.

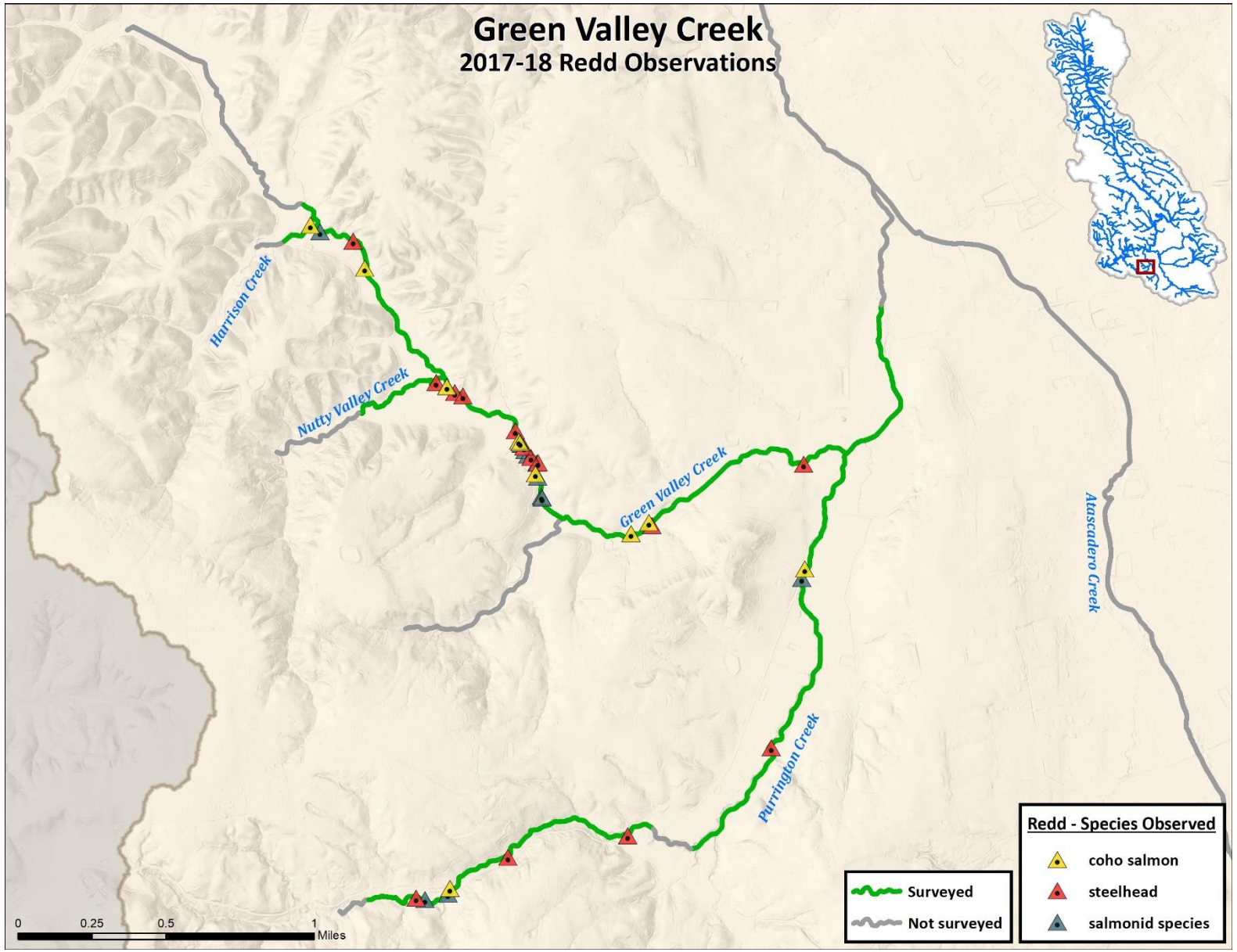

Figure 30. Salmonid redds observed in the Green Valley Creek watershed during winter 2017/18.

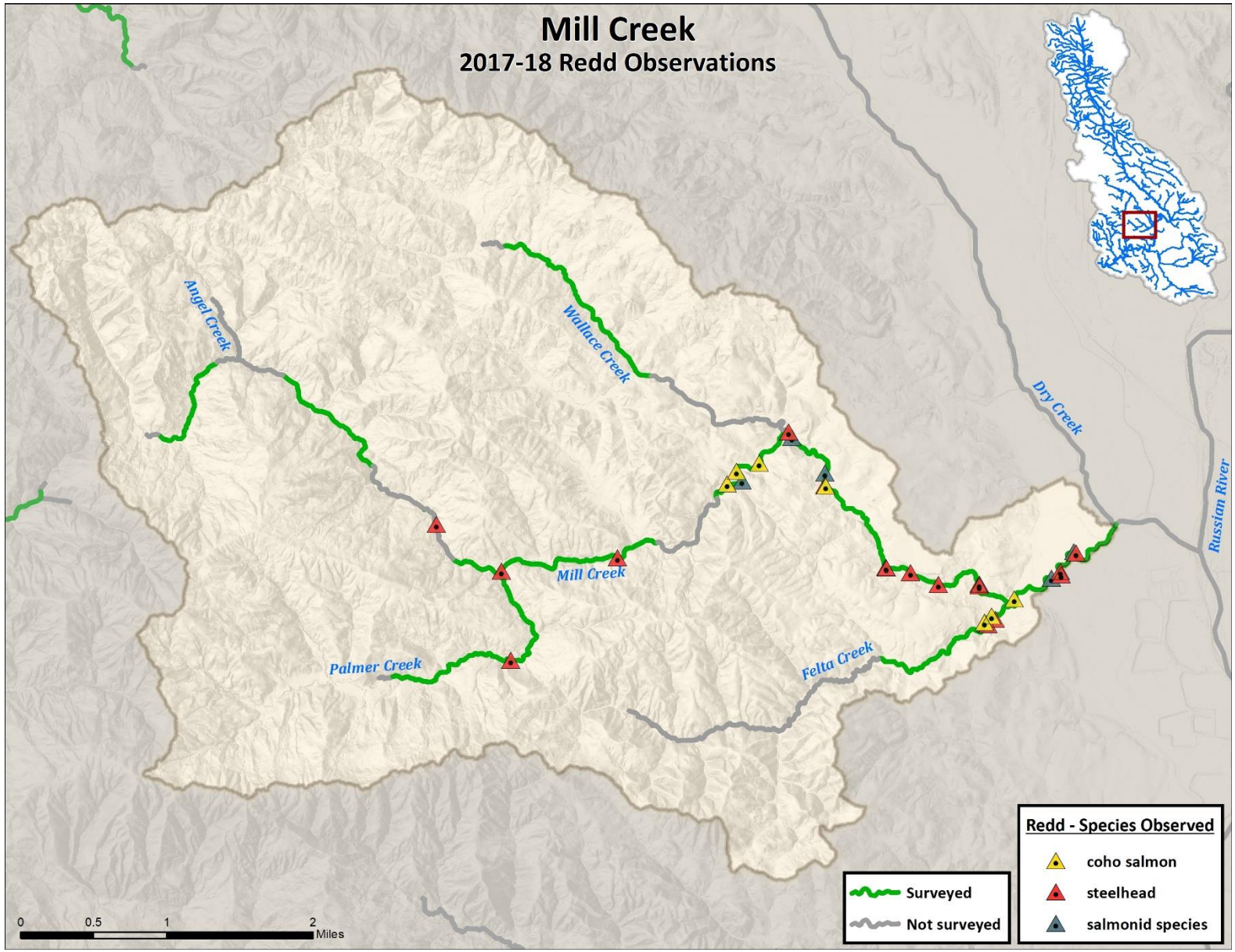

Figure 31. Salmonid redds observed in the Mill Creek watershed during winter 2017/18.

Discussion and Recommendations

The estimated number of coho salmon returning to the Russian River watershed during the winter of 2017/18 was the highest on record since the beginning of the Broodstock Program (Figure 14). A total of 763 hatchery coho salmon adults were estimated to have passed the Duncans Mills or Willow Creek antenna arrays (Table 7), and adult coho salmon redds and/or coho salmon adults were observed in 16 of 30 coho salmon streams surveyed (Table 9). It should be noted, however, that the 763 fish estimate was comprised of 97% age-2 adults, with almost no age-3 hatchery adults returning to the watershed. The minimal returns for the 2015 cohort (fish that returned as age-3 adults in winter 2017/18) may be partially explained by the lower than average number of fish released as compared to previous cohorts (70,510; Table 1). However, nearly 24,000 smolts were estimated to have emigrated from the four Broodstock Program monitoring streams in 2016, so the low number of age-3 adult returns is also likely explained by low survival in the mainstem river, estuarine, and/or marine environments rather than poor overwinter survival in the tributaries.

The high number of age-2 adult returns in 2017/18 could be an indication of good ocean conditions for the 2016 cohort and a promising return of adults in 2018/19. In most years, the trend in age-3 adults has reflected the previous year's return of age-2 adults (Figure 15). The high and variable proportion of age-2 adults each year is not consistent with rates observed in natural populations in coastal California and we recommend investigating potential influences on early maturation. We suggest consulting with other hatchery programs and conducting a literature search to determine if feeding regimes could be modified to influence the proportion of age-2 adults.

Within the four Broodstock Program monitoring streams, estimated adult coho salmon returns during the winter of 2017/18 varied. Willow and Green Valley creeks had higher estimated returns than in the past several years (Figure 10, Figure 12), Dutch Bill Creek had the second highest recorded in the past five years (Figure 11), and the estimate for Mill Creek was average (Figure 13). Smolt to adult return (SAR) ratios were below average in all but Mill Creek and were less than 1% in all four streams (Table 8).

As in previous years, adult coho salmon began entering the lower Russian River at Duncans Mills in October of 2017 (Figure 4). The winter of 2017/18 was an average rainfall winter (Figure 3), with late November rains reconnecting the tributaries to the mainstem. Although these early rains enabled adult coho salmon to access some of the spawning tributaries (Figure 6 - Figure 8), the first coho salmon redds were not observed until the second week of January, which was also when the peak of coho salmon spawning activity occurred (Figure 25). This is two to three weeks later than average and appears correlated with the large storm that occurred during that time period. Similar to previous years, the coho run was largely complete four weeks following our first redd observations.

The estimated number of redds as compared to the estimated number of adult coho salmon returning to each stream was extremely low, resulting in high and variable adult to redd ratios (range 5.5 to 23.1, Table 10). These values are much higher than the average adult to redd ratio of 2.35 observed in Mendocino streams (Gallagher et al. 2010). We attribute the high adult to redd ratios to the extremely high proportion of age-2 adult returns which are typically male "jacks". Although one age-2 female coho carcass was observed, it is likely that very few females returned to the spawning tributaries in 2017/18, which would have consequently resulted in fewer redds than expected.

As in previous years, we detected individual PIT-tagged coho salmon entering multiple streams throughout the 2017/18 spawning season. Of 81 individual adults detected at one or more tributary antennas, 18 (22%) were detected in two different tributaries and two (2.5%) were detected in three or more tributaries. In Willow, Dutch Bill, and Green Valley creeks, where antenna arrays are operated at both downstream and upstream locations (nearer the spawning habitat), we observed detections of individuals on the lower antennas in November with the first smaller storm, but did not detect those same fish at the upper antennas until the larger storm events in January. This is consistent with the observation of no redds until January.

Of the four Broodstock Program streams, Mill Creek had the greatest number of fish from non-Mill Creek release groups (Table 6), and this is similar to previous years (CSG 2017a). In most years, adult coho salmon enter the Russian River prior to the first significant rain event of the winter and the spawning tributaries are usually disconnected from the mainstem and inaccessible to adults. Due to regulated flows, Dry Creek is the exception, with flow levels sufficiently high for adult coho salmon passage in October and November when adults enter the river. For this reason, it is possible that fish from lower river tributaries that are still cut off from the mainstem continue upstream into the Dry Creek watershed to spawn.

After the first large precipitation event in early January of 2018, a period of relatively dry winter conditions persisted through mid-March. During this time period, stream flows receded to the point that they became inaccessible to adult passage and even began to disconnect from the mainstem in multiple streams. In one instance, a relatively fresh adult coho salmon carcass was observed stranded in a pool that completely dried. These conditions adversely affected migration of adult salmonids, and there is also a possibility that low flows may have caused some redds to dry out. We will learn more about the effects of this winter drought when we complete our summer snorkel surveys to evaluate juvenile numbers and distribution. To help address low flow conditions that are now occurring during all seasons of the year, we recommend that resource managers continue to support projects and programs that are designed to improve streamflow conditions in salmonid streams throughout the watershed.

Through our multi-year datasets, we are beginning to identify streams of high use by salmonids. Felta Creek is a tributary to lower Mill Creek and consistently has returning adult coho salmon and steelhead. Lower Felta Creek consistently dries out each summer, which causes mortality among large numbers of juvenile coho salmon and steelhead. A high gradient section of Felta Creek is located just upstream of these drying areas, which may contain barriers to migration. We recommend exploring the possibility of remediating potential barriers in this section of creek so that adult fish could better access the higher quality stream conditions where the creek remains wet year round.

No PIT-tagged adult coho salmon from the East Austin Creek tributaries were detected on the Duncans Mills or other antenna arrays throughout the watershed in 2017/18. Since the Broodstock Program began PIT tagging a portion of all hatchery releases in 2013, no age-3 PIT-tagged adults and only two age-2 PIT-tagged adults from the East Austin Creek tributaries have been detected on the antenna arrays (both from Gray Creek). This is far fewer than the numbers observed from other release streams (Table 7). Releases into the East Austin Creek tributaries have primarily been in the spring, and the additional six months in the stream as compared to the fall release likely influences the lower stock-to-smolt survival rates observed for the spring release groups (CSG 2017b). Because of this there are presumably far fewer smolts from these releases entering the ocean each year. In 2017, the Broodstock Program released fish into the East Austin tributaries in the fall to increase the probability of adult returns to the East Austin sub-watershed and we recommend

continuing this strategy. We also recommend continuation of releases into multiple sub-watersheds of the Russian River watershed to bet-hedge unpredictable environmental conditions that may affect access to habitat and survival of coho salmon in different ways.

IV. References

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