Russian River Coho Salmon and Steelhead Monitoring Report: Winter 2019/20

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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: Willow, Dutch Bill, Green Valley, and Mill 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), an effort to improve stream flow and water supply reliability to water-users in flow-impaired Russian River tributaries. In 2013, we partnered with the Sonoma County Water Agency (Sonoma Water) 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.

II. PIT Tag Monitoring

Goals and Objectives

Passive integrated transponder (PIT) tags and PIT tag detection systems (antennas and transceivers) were used to document the status and trends of Russian River coho salmon populations at both stream-specific and basinwide scales. From September 15, 2019, through March 1, 2020, 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). In addition, we were able to estimate these metrics for the Russian River basin overall with the exception of SAR ratios because we do not have the ability to estimate the number of smolts leaving the entire Russian River basin each year.

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). During the winter of 2019/20, we anticipated the return of PIT-tagged adults from cohorts 2017 (age-3 returns) and 2018 (age-2 returns) that had been released as juveniles into multiple streams (Table 2). In addition, approximately half of all natural-origin coho salmon smolts captured in downstream migrant traps during the springs of 2018 and 2019 were PIT tagged in Willow, Green Valley, and Mill creeks (California Sea Grant 2018, California Sea Grant 2019). To increase the sample size for estimating SAR ratios, we also PIT-tagged approximately one quarter of all non-PIT-tagged hatchery smolts captured in the downstream migrant traps during the springs of 2018 and 2019.

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 high water storm events, stream depths may have exceeded maximum read range depths, so if PIT-tagged fish were travelling in the water column above the maximum read depth, they may not have been detected on the antennas. The paired arrays were used to estimate antenna efficiency and account for undetected fish. From September 15, 2019 through March 1, 2020, 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 Sonoma Water, 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%
2017	AUS, DEV, DRY, DUT, FRE, GIL, GRA, GRE, MAI, MIL, PAL, PUR, RCA, SHE, WIL	AUS, DEV, DRY, DUT, FRE, GIL, GRA, GRE, MAI, MIL, PAL, PUR, RCA, SHE, WIL	133,849	31,773	24%
2018	AUS, DEV, DRY, DUT, EAU, FRE, GIL, GRA, GRE, MAR, MAI, MIL, PAL, POR, PUR, RCA, SHE, WIL	AUS, DEV, DRY, DUT, EAU, FRE, GIL, GRA, GRE, MAR, MAI, MIL, PAL, POR, PUR, RCA, SHE, WIL	133,014	27,739	21%

[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, MAI: Russian River Mainstem, MAR: Mark West Creek, MIL: Mill Creek, PAL: Palmer Creek, PEN: Pena Creek, POR: Porter Creek, PUR: Purrington Creek, RCA: Redwood Creek (Atascadero), 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 stream and release group, cohorts 2017 and 2018.

Cohort (Hatch Year)	Tributary	Release Group	Total Coho Salmon Released	PIT-Tagged Coho Salmon Released	Percent PIT-Tagged Coho Salmon Released
2017	Willow Creek	fall	10,075	2,010	20%
2017	Willow Creek	smolt	8,876	1,797	20%
2017	Sheephouse Creek	fall	3,029	608	20%
2017	Freezeout Creek	fall	3,035	610	20%
2017	Russian River	smolt	10,103	2,040	20%
2017	Austin Creek	fall	9,048	1,806	20%
2017	Gilliam Creek	fall	3,042	610	20%
2017	Gray Creek	fall	3,040	608	20%
2017	Devil Creek	fall	3,043	611	20%
2017	Dutch Bill Creek	spring	995	995	100%
2017	Dutch Bill Creek	fall	7,077	1,410	20%
2017	Dutch Bill Creek	smolt	5,258	1,055	20%
2017	Green Valley Creek	spring	454	454	100%
2017	Green Valley Creek	fall	8,069	1,610	20%
2017	Green Valley Creek	smolt	14,066	2,859	20%
2017	Redwood Creek (Atascadero)	fall	3,041	609	20%
2017	Purrington Creek	fall	3,041	610	20%
2017	Porter Creek	fall	6,062	1,728	29%
2017	Dry Creek	fall	2,977	2,977	100%
2017	Dry Creek	smolt	10,105	2,039	20%
2017	Mill Creek	spring	1,006	1,006	100%
2017	Mill Creek	fall	10,063	2,007	20%
2017	Mill Creek	smolt	5,312	1,104	21%
2017	Palmer Creek	fall	3,032	610	20%
2018	Willow Creek	fall	8,194	1620	20%
2018	Willow Creek	presmolt	7,111	1400	20%
2018	Sheephouse Creek	fall	3,038	610	20%
2018	Freezeout Creek	fall	2,043	410	20%
2018	Austin Creek	fall	4,157	810	19%
2018	East Austin Creek	fall	4,152	810	20%
2018	Gilliam Creek	fall	3,039	610	20%
2018	Gray Creek	fall	4,041	810	20%
2018	Devil Creek	fall	3,035	610	20%
2018	Dutch Bill Creek	fall	7,062	1410	20%
2018	Dutch Bill Creek	smolt	5,047	1020	20%
2018	Green Valley Creek	fall	7,063	1410	20%
2018	Green Valley Creek	presmolt	8,054	1600	20%
2018	Green Valley Creek	smolt	5,077	1020	20%
2018	Redwood Creek (Atascadero)	fall	3,005	610	20%
2018	Purrington Creek	fall	3,016	610	20%
2018	Mark West Creek	presmolt	7,135	1599	22%
2018	Porter Creek	fall	5,073	1010	20%
2018	Dry Creek	fall	5,076	1020	20%
2018	Dry Creek	smolt	10,118	2040	20%
2018	Mill Creek	spring	1,010	1010	100%
2018	Mill Creek	fall	8,164	1620	20%
2018	Mill Creek	smolt	5,087	1020	20%
2018	Palmer Creek	fall	5,073	1010	20%
2018	Russian River	smolt	10,144	2040	20%

Figure 1. Passive Integrated Transponder (PIT) antenna locations in the Russian River watershed, winter 2019/20.

Figure 2. Paired flat-plate antenna array on Willow Creek.

Data Analysis

First, all records of two- and three-year-old PIT-tagged coho salmon detected on antenna arrays between September 15, 2019 and March 1, 2020 were examined to determine the migratory disposition of detected fish (i.e., returning adults, age-2 outmigrants, or ghost tags) based on the duration and direction of tag movement. Individuals with a net positive upstream movement during this time frame 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 (ghost tags) and these tags were also 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, 2019 and March 1, 2020 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 released from the hatchery into each respective stream or, in the case of natural-origin fish, the proportion of natural-origin fish PIT-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 avoid the potential for duplication in our expansions of hatchery fish, we did not expand the number of hatchery adults that had been tagged at the smolt traps unless there were no other hatchery adults detected from that cohort and release stream.

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 as the approach used on the Broodstock Program monitoring streams; however, the 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 arrays upstream of Duncans Mills 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, an estimate of adults that entered Willow Creek (but were not detected on or upstream of Duncans Mills) 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 PIT-tagged adults returning to those streams during the winter of 2019/20 so returns to those creeks are not included in the basinwide estimate.

Smolt to Adult Return (SAR) Ratio:

In each of the four Broodstock Program monitoring streams, the sum of the estimated number of two-year old hatchery adults returning during the winter of 2018/19 and three-year old adults returning during the winter of 2019/20 was divided by the estimated number of smolts migrating from each stream between March 1 and June 30 of 2018 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 between September 15, 2019 and March 1, 2020 was just below the 15-year average (Figure 3) and was characterized by a significant storm in early-December, followed by smaller storms in January and February. PIT antenna detections of adults passing over the Duncans Mills antenna array on the mainstem of the Russian River occurred between November 9 and December 7 (Figure 1, Figure 4). It is possible that adults entered the river prior to this time and they were not detected due to malfunctioning equipment at the Duncans Mills antenna array in mid-October through early November (Figure 4). Adult coho salmon detections on the tributary antennas peaked during the early-December storm events, with fewer new detections between mid-December and mid-January (Figure 5). Adult detection timing in the four Broodstock Program streams was similar among streams and peaked in early December (Figure 6 - Figure 9). In Mill Creek, the December peak was less pronounced with more new detections occurring later than in the other streams (Figure 9).

Adult Return Estimates:

The estimated numbers of adult coho salmon returning to Willow, Dutch Bill, Green Valley, and Mill creeks were 17, 42, 94, and 96, respectively (Table 3- Table 6), and the estimated number returning to the Russian River Basin was 547 (Table 7). The composition of release groups returning as adults to each stream was diverse except in Willow Creek where all adult returns originated from releases or tagging events only in Willow Creek. In Dutch Bill adult returns were comprised of fish from five release groups and/or tagging streams, and in Green Valley and Mill creeks, the composition was made up of fish from seven and six streams, respectively. In all but Dutch Bill Creek, over half of the adult returns in 2019/20 were age-2 fish (Table 3- Table 6, Figure 10 - Figure 14). One natural-origin (wild) age-3 adult that was tagged as a smolt in Green Valley Creek in 2018 was detected passing over the Mill Creek antenna array. This was the only natural-origin PIT-tagged fish documented to return during the winter of 2019/20.

Estimated adult returns during the winter of 2019/20 were average in all four monitoring streams as well as in the mainstem Russian River when compared to previous years (Figure 10 - Figure 14). The proportion of age-2 returns appeared higher than average in all but Dutch Bill Creek, and was one of the highest observed in the mainstem of the Russian River at 75% (Figure 15).

Smolt to Adult Return (SAR) Ratio:

Overall, SAR ratios were low for the 2017 cohort, and ranged from 0.2% in Green Valley Creek to 0.8% in Dutch Bill Creek (Figure 16 - Figure 19). In Dutch Bill Creek, the 2019/20 SAR ratio was higher than average whereas in the other three creeks it was below average (Table 8).

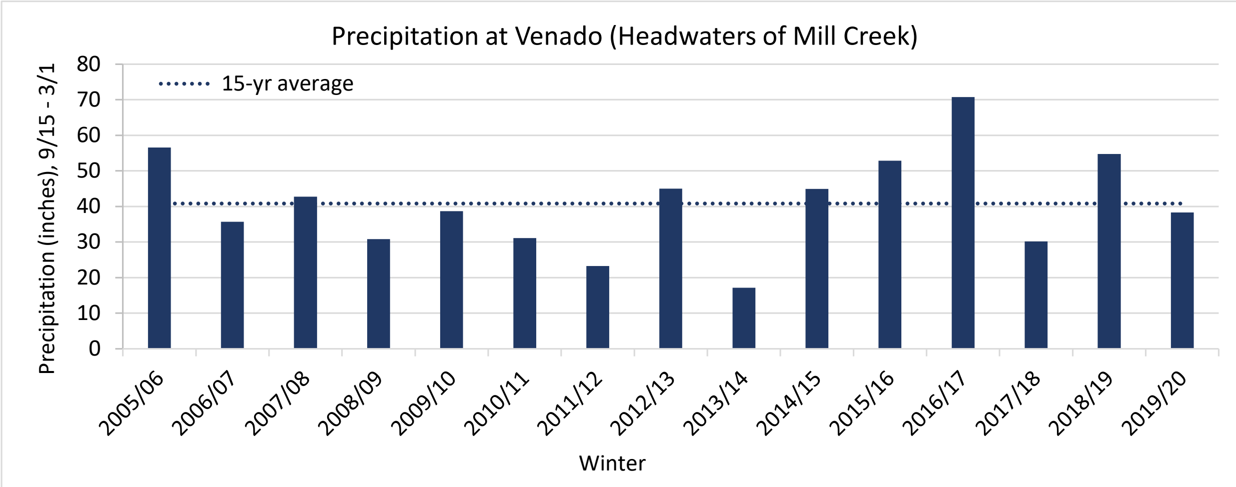


Figure 3. Precipitation at Venado gage near Mill Creek headwaters. Data downloaded from [NOAA website.]

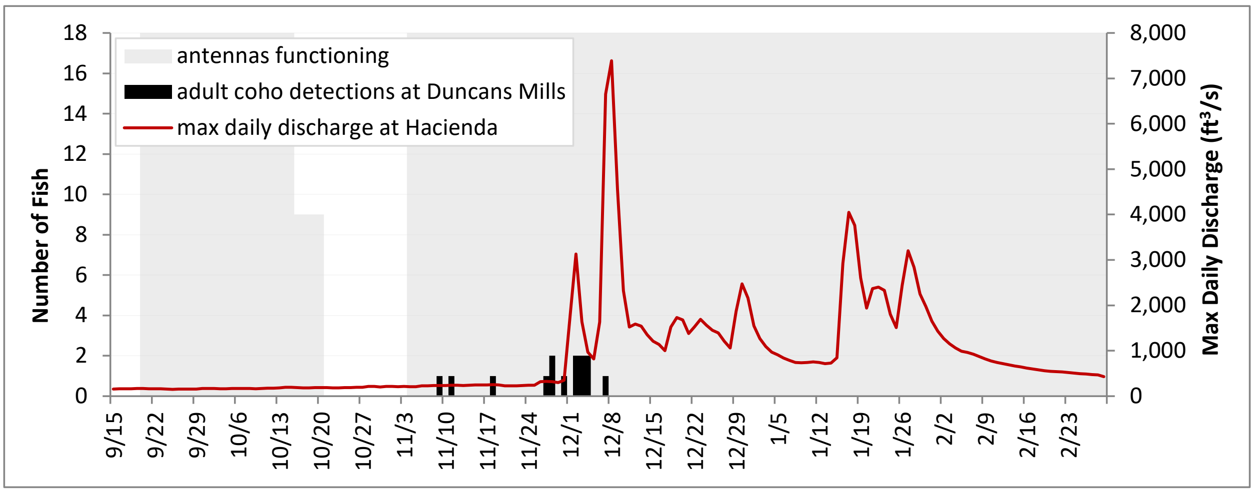


Figure 4. Detections of PIT-tagged coho salmon adults passing upstream of the Duncans Mills antenna array, September 15, 2019 - March 1, 2020. Discharge data was downloaded from USGS website: http://waterdata.usgs.gov.

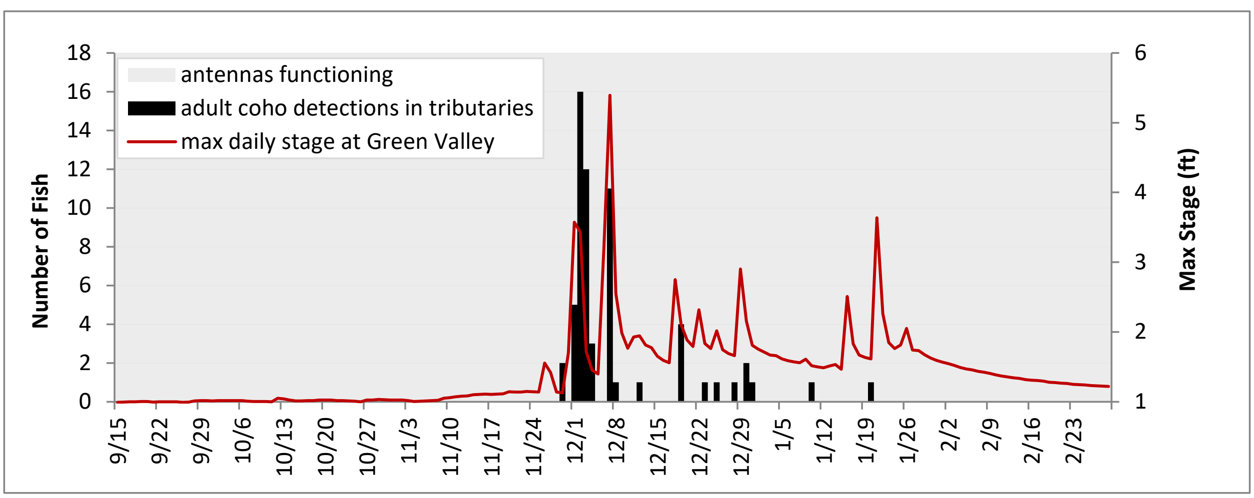


Figure 5. Detections of PIT-tagged coho salmon adults entering tributaries of the Russian River between September 15, 2019 - March 1, 2020. Stage data was provided by Trout Unlimited.

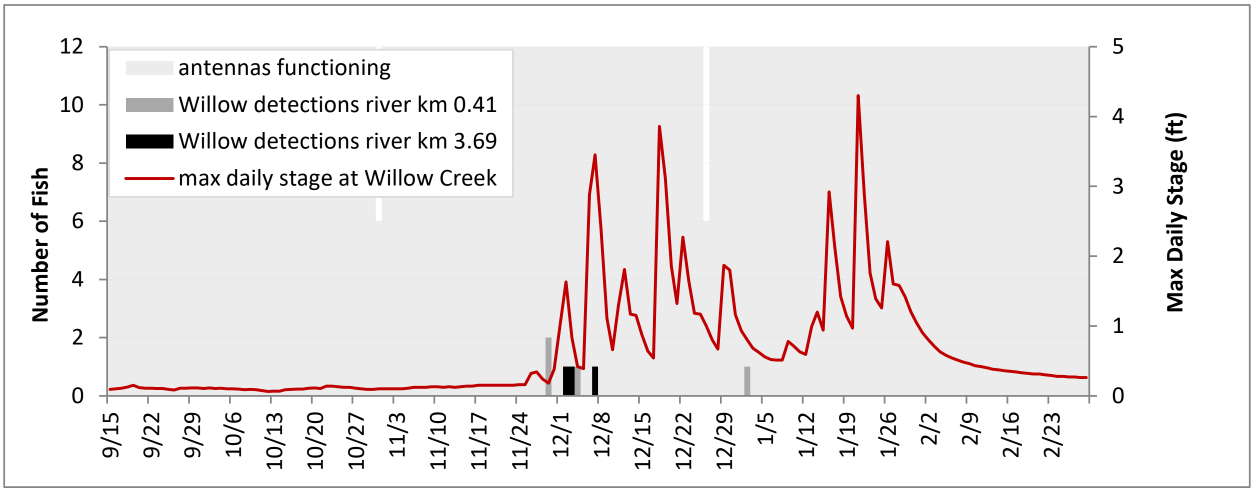


Figure 6. Detections of PIT-tagged coho salmon adults entering Willow Creek between September 15, 2019 - March 1, 2020. Stage data was collected by CSG.

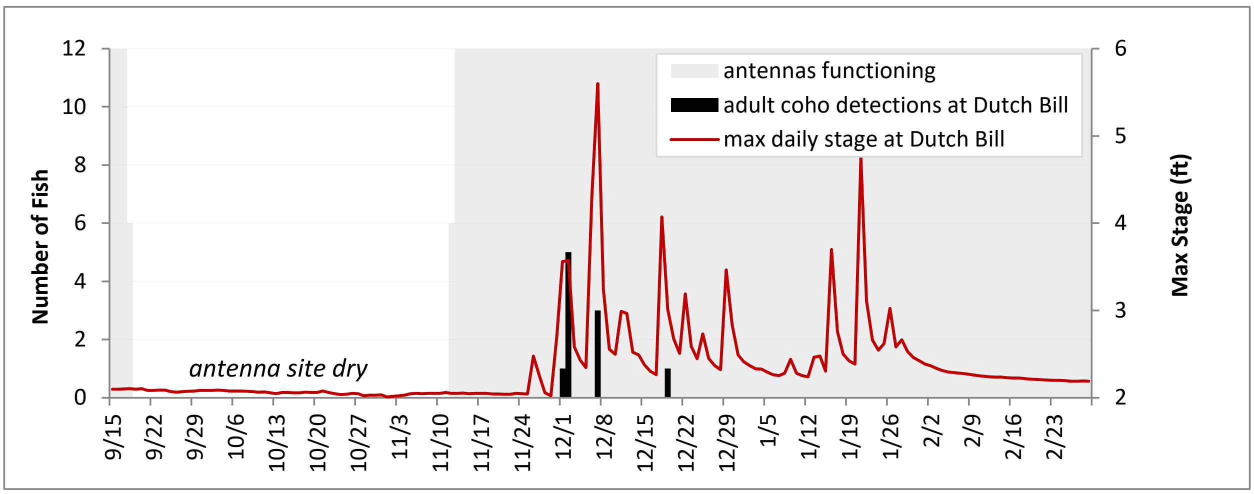


Figure 7. Detections of PIT-tagged coho salmon adults passing upstream of the Dutch Bill Creek antenna array, September 15, 2018 - March 1, 2019. Stage data was provided by Trout Unlimited.

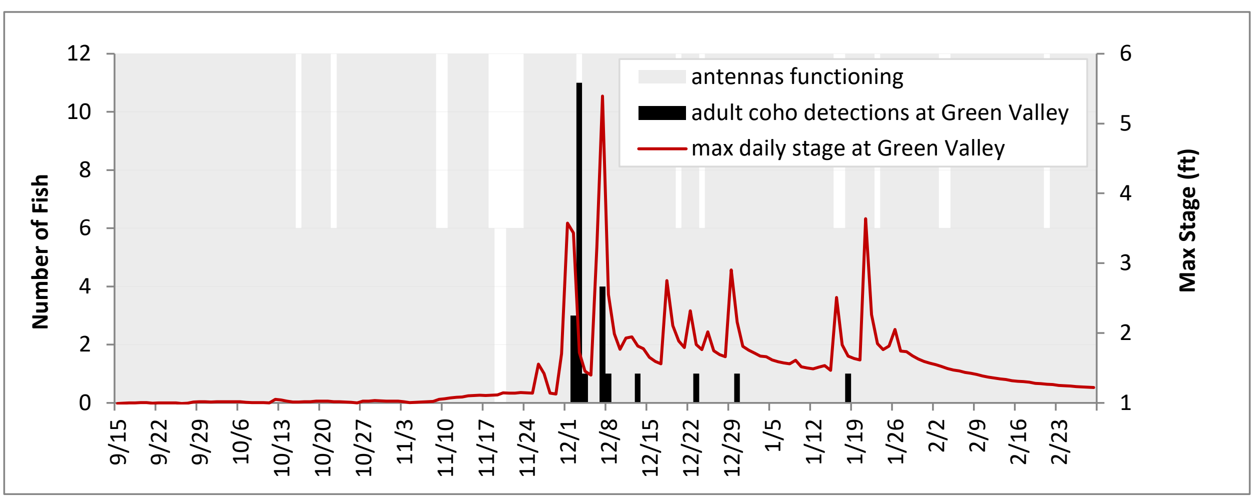


Figure 8. Detections of PIT-tagged coho salmon adults passing upstream of the Green Valley Creek antenna array, September 15, 2018 - March 1, 2019. Stage data was provided by Trout Unlimited.

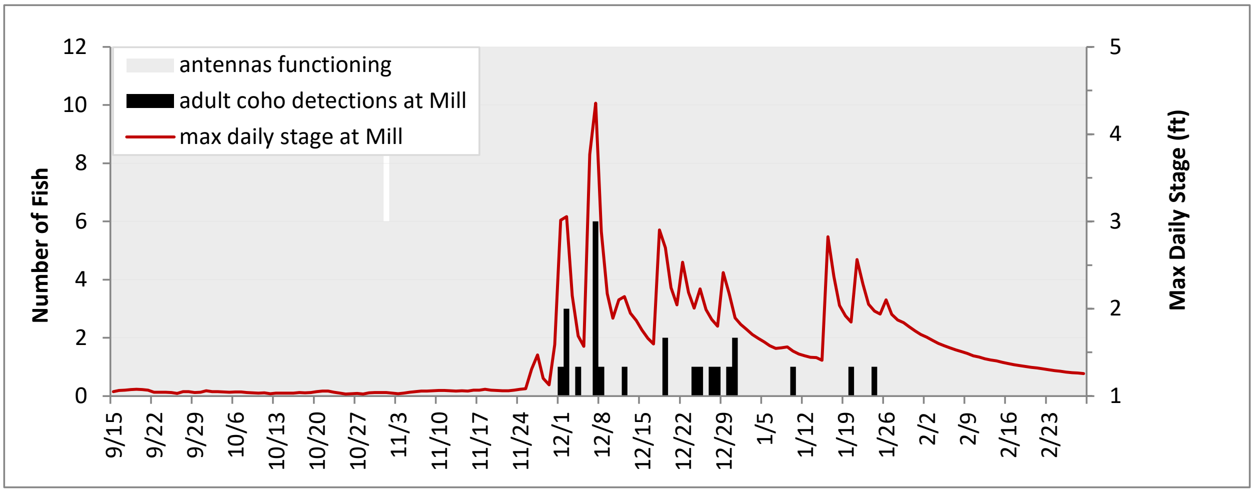


Figure 9. Detections of PIT-tagged coho salmon adults passing upstream of the Mill Creek antenna array, September 15, 2018 - March 1, 2019. Stage data was provided by Trout Unlimited.

Table 3. Minimum, expanded, and estimated counts of adult coho salmon returning to Willow Creek (array upstream of Third Bridge; river km 3.69) between September 15, 2019 and March 1, 2020. 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	Willow Creek	hatchery	tagged at Willow smolt trap	1	15%	6.5	100%	6.5
2	Willow Creek	hatchery	fall	2	20%	10.1	100%	10.1
							Estimated hatchery adult returns (age-3):	10.1
							Estimated hachery adult returns (age-2):	6.5
							Total estimated adult returns:	**17**

Table 4. Minimum, expanded, and estimated counts of adult coho salmon returning to Dutch Bill Creek (river km 0.68) between September 15, 2019 and March 1, 2020. 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	smolt	4	20%	19.9	100%	19.9
	Russian River	hatchery	smolt	1	20%	5.0	100%	5.0
	Willow Creek	hatchery	tagged at Willow smolt trap	1	15%	6.5	100%	6.5
2	Dry Creek	hatchery	smolt	1	20%	5.0	100%	5.0
	Mill Creek	hatchery	spring	1	100%	1.0	100%	1.0
	Russian River	hatchery	smolt	1	20%	5.0	100%	5.0
							Estimated hatchery adult returns (age-3):	31.4
							Estimated hatchery adult returns (age-2):	11.0
							Total estimated adult returns:	**42**

Table 5. Minimum, expanded, and estimated counts of adult coho salmon returning to Green Valley Creek (river km 6.13) between September 15, 2019 and March 1, 2020. 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	Green Valley Creek	hatchery	fall	1	20%	5.0	90%	5.5
	Green Valley Creek	hatchery	smolt	1	20%	4.9	90%	5.4
	Mill Creek	hatchery	fall	1	20%	5.0	90%	5.5
	Freezeout Creek	hatchery	fall	1	20%	5.0	90%	5.5
	Russian River	hatchery	smolt	1	20%	5.0	90%	5.5
	Redwood Creek (Atascadero)	hatchery	fall	1	20%	5.0	90%	5.5
	Green Valley Creek	hatchery	tagged at Green Valley smolt trap	1	NA[1]			
2	Green Valley Creek	hatchery	fall	4	20%	20.2	90%	22.3
	Green Valley Creek	hatchery	presmolt	2	20%	10.1	90%	11.1
	Purrington Creek	hatchery	fall	3	20%	14.9	90%	16.4
	Freezeout Creek	hatchery	fall	1	20%	5.0	90%	5.5
	Russian River	hatchery	smolt	1	20%	5.0	90%	5.5
	Green Valley Creek	hatchery	tagged at Green Valley smolt trap	2	NA[1]			
							Estimated hatchery adult returns (age-3):	33
							Estimated hatchery adult returns (age-2):	61
							Total estimated adult returns:	**94**

[1] Expansions were not made due to potential for duplication (see *Data Analysis* section).

Table 6. Minimum, expanded, and estimated counts of adult coho salmon returning to Mill Creek (river km 2.01) between September 15, 2019 and March 1, 2020. 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	Dry Creek	hatchery	fall	1	100%	1.0	100%	1.0
	Dry Creek	hatchery	smolt	2	20%	9.9	100%	9.9
	Green Valley Creek	hatchery	smolt	1	20%	4.9	100%	4.9
	Mill Creek	hatchery	fall	1	20%	5.0	100%	5.0
	Mill Creek	hatchery	spring	1	100%	1.0	100%	1.0
	Russian River	hatchery	smolt	1	20%	5.0	100%	5.0
	Green Valley Creek	hatchery	tagged at Green Valley smolt trap	1	NA[1]			
	Green Valley Creek	wild	tagged at Green Valley smolt trap	1	37%	2.7	100%	2.7
2	Dry Creek	hatchery	fall	1	20%	5.0	100%	5.0
	Dry Creek	hatchery	smolt	2	20%	10.0	100%	10.0
	Green Valley Creek	hatchery	presmolt	5	20%	25.2	100%	25.2
	Mark West Creek	hatchery	presmolt	1	22%	4.5	100%	4.5
	Mill Creek	hatchery	spring	2	100%	2.0	100%	2.0
	Mill Creek	hatchery	smolt	1	20%	5.0	100%	5.0
	Porter Creek	hatchery	fall	2	20%	10.1	100%	10.1
	Russian River	hatchery	smolt	1	20%	5.0	100%	5.0
	Green Valley Creek	hatchery	tagged at Green Valley smolt trap	1	NA[1]			
							Estimated hatchery adult returns (age-3):	26.8
							Estimated wild adult returns (age-3):	2.7
							Estimated hatchery adult returns (age-2):	66.7
							Total estimated adult returns:	**96**

[1] Expansions were not made due to potential for duplication (see *Data Analysis* section).

Table 7. Minimum, expanded, and estimated counts of hatchery adult coho salmon returning to the Russian River mainstem at Duncans Mills between September 15, 2019 and March 1, 2020. 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	Origin	Release Group	Minimum Count	Percent PIT-tagged	Expanded Count	Estimated Antenna Efficiency	Estimated Count
3	Dry Creek	hatchery	smolt	1	20%	5.0	11%	45.6
	Dutch Bill Creek	hatchery	smolt	1	20%	5.0	11%	45.9
	Sheephouse Creek	hatchery	fall	1	20%	5.0	11%	45.8
2	Dry Creek	hatchery	smolt	1	20%	5.0	11%	45.9
	Green Valley Creek	hatchery	fall	2	20%	10.1	11%	92.8
	Mark West Creek	hatchery	presmolt	3	22%	13.4	11%	123.4
	Mill Creek	hatchery	smolt	1	20%	5.0	11%	46.1
	Russian River	hatchery	smolt	2	20%	10.0	11%	91.9
	Green Valley Creek	hatchery	tagged at Green Valley smolt trap	2	NA[1]			

Estimated adults passing Duncans Mills (age-3):	137.3
Estimated adults passing Duncans Mills (age-2):	400.0
Estimated adults returning to Willow Creek that were not detected at Duncans Mills (age-3):	0.0
Estimated adults returning to Willow Creek that were not detected at Duncans Mills (age-2):	10.0
Total estimated hatchery adult returns:	**547**

[1] Expansions were not made due to potential for duplication (see *Data Analysis* section).

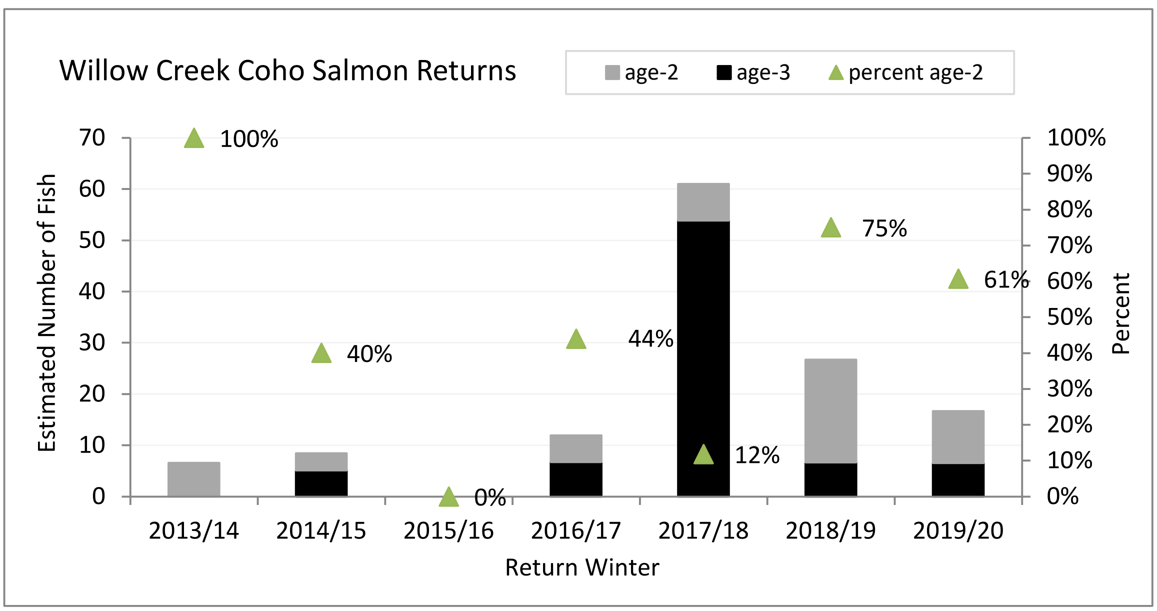


Figure 10. Estimated annual Willow Creek adult hatchery coho salmon returns by age, return seasons 2013/14 – 2019/20. Note that estimates are based on returns to the upper antennas at river km 3.69 whereas in prior to 2018/19, estimates were based on detections at the Willow Creek mouth at river km 0.41.

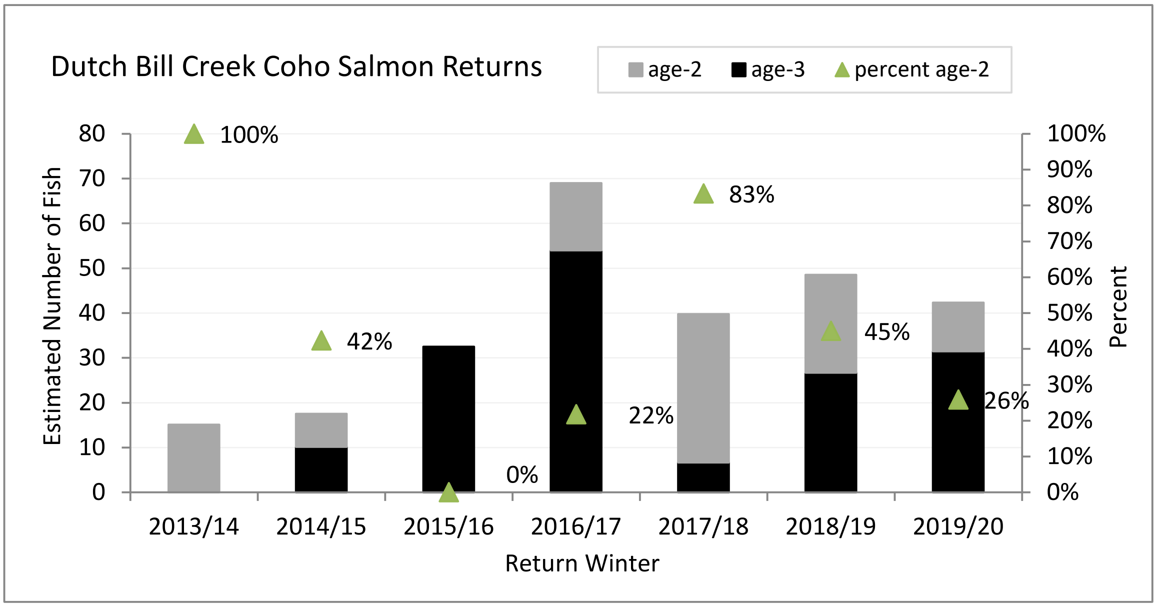


Figure 11. Estimated annual Dutch Bill Creek adult hatchery coho salmon returns by age, return seasons 2013/14 – 2019/20.

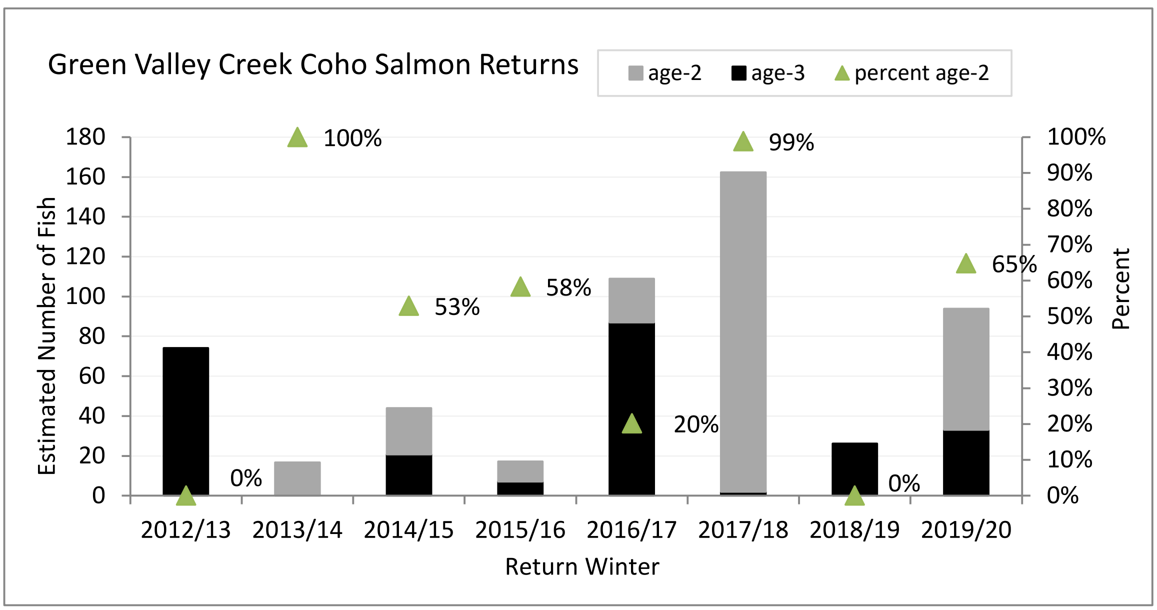


Figure 12. Estimated annual Green Valley Creek adult hatchery coho salmon returns by age, return seasons 2012/13 – 2019/20.

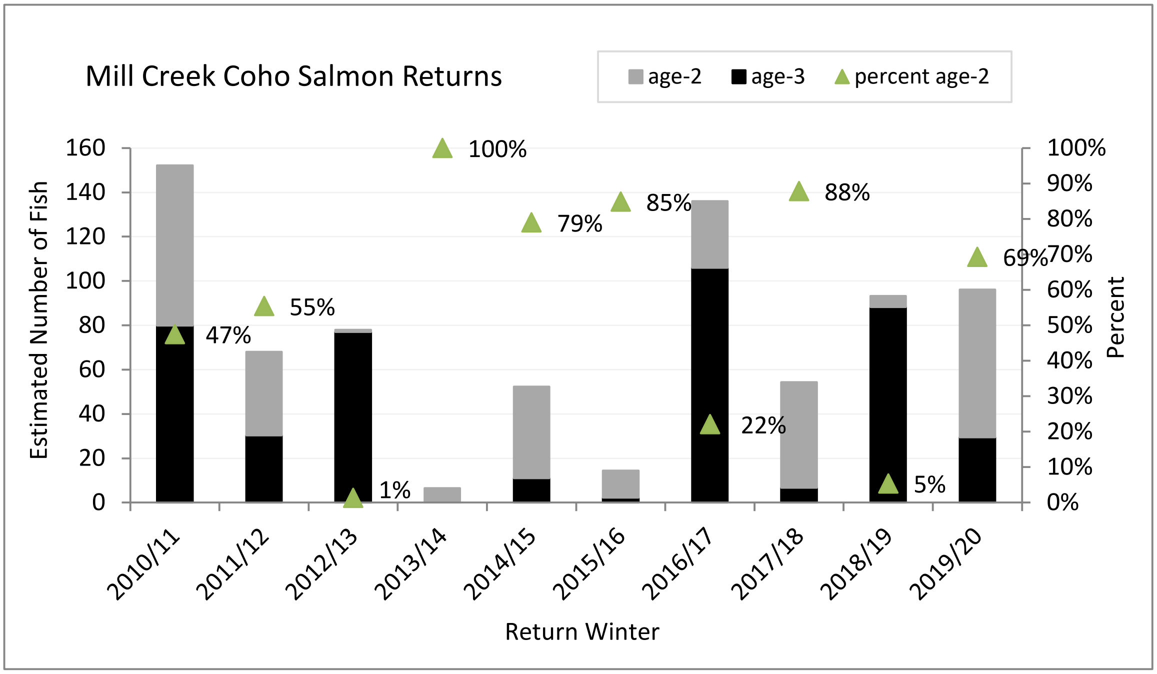


Figure 13. Estimated annual Mill Creek adult hatchery coho salmon returns by age, return seasons 2010/11 – 2019/20.

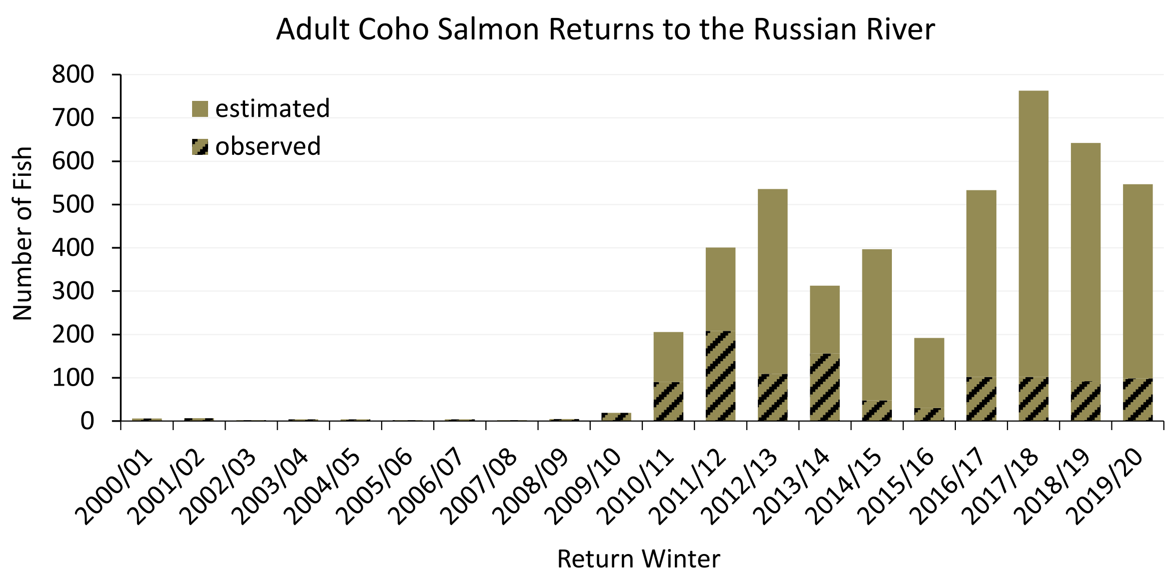


Figure 14. Estimated annual adult hatchery coho salmon returns to the Russian River, return seasons 2000/01-2019/20. Note that methods for counting/estimating the number of returning adult coho salmon were not consistent among years; prior to 2009/10, spawner surveys were the primary method, from 2009/10 – 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.

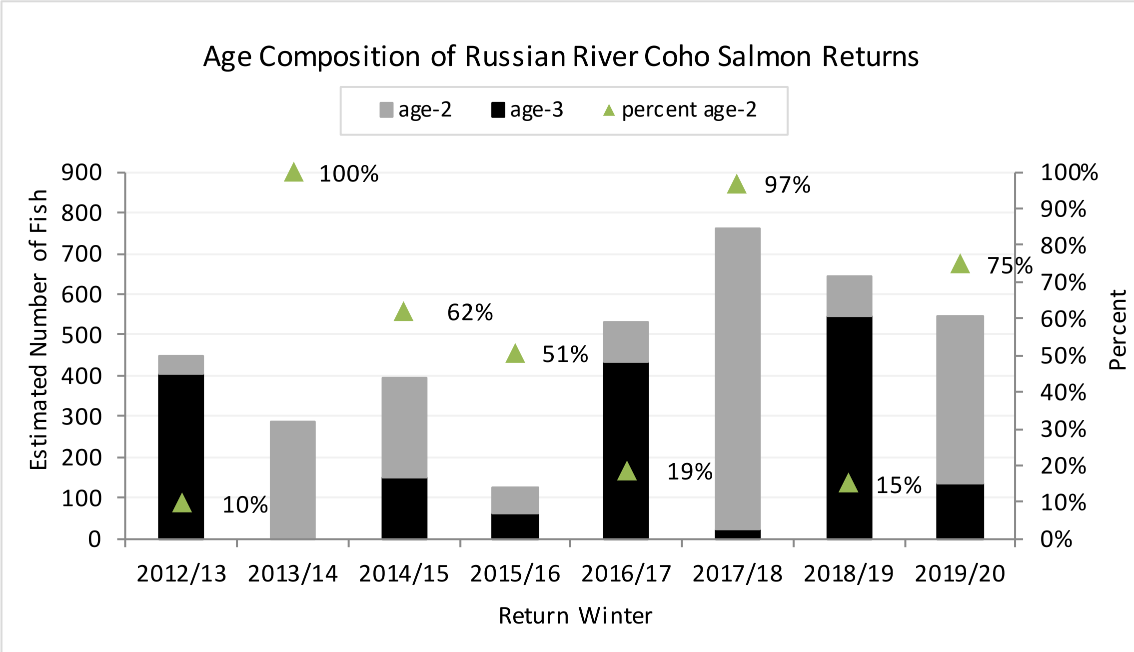


Figure 15. Estimated annual Russian River adult hatchery coho salmon returns by age, return seasons 2012/13-2019/20. Note that this figure includes only fish that we were able to age; therefore, totals will be less than adult return estimates shown in Figure 14.

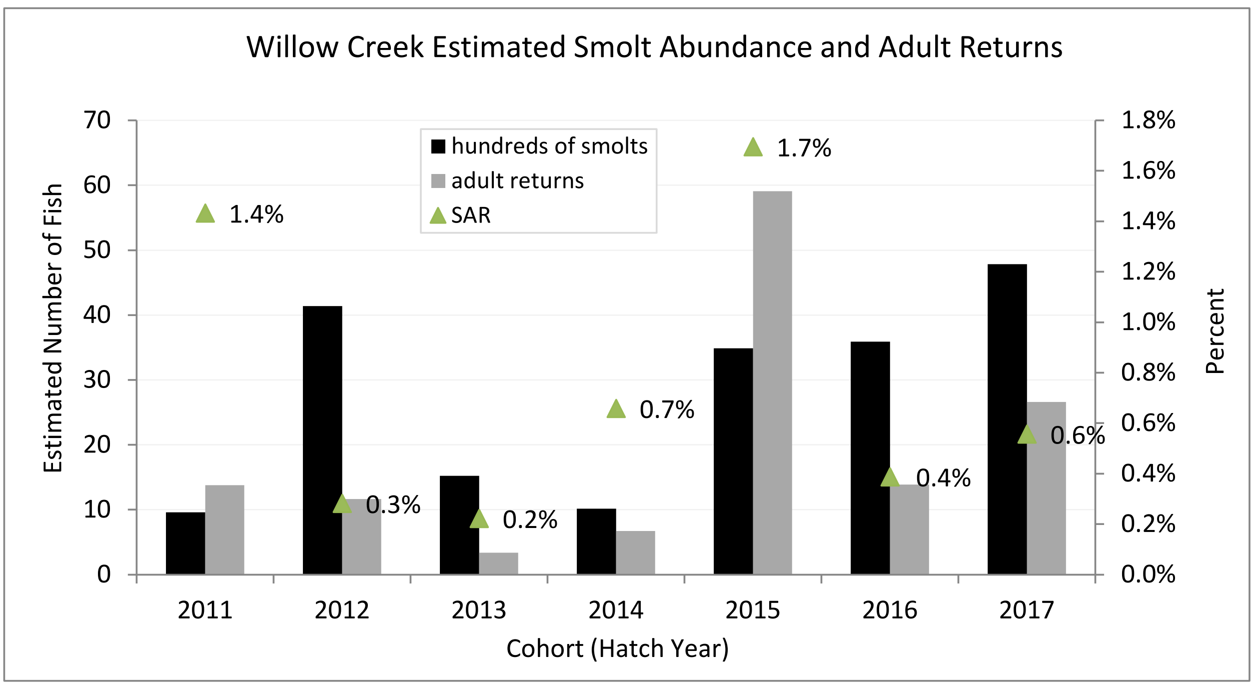


Figure 16. Estimated coho salmon smolt abundance, adult returns and smolt to adult return (SAR) ratios in Willow Creek, cohorts 2011-2017. Note that estimates are based on returns to the upper antennas at river km 3.69 whereas in reports prior to 2018/19, estimates were based on detections at the Willow Creek mouth at river km 0.41.

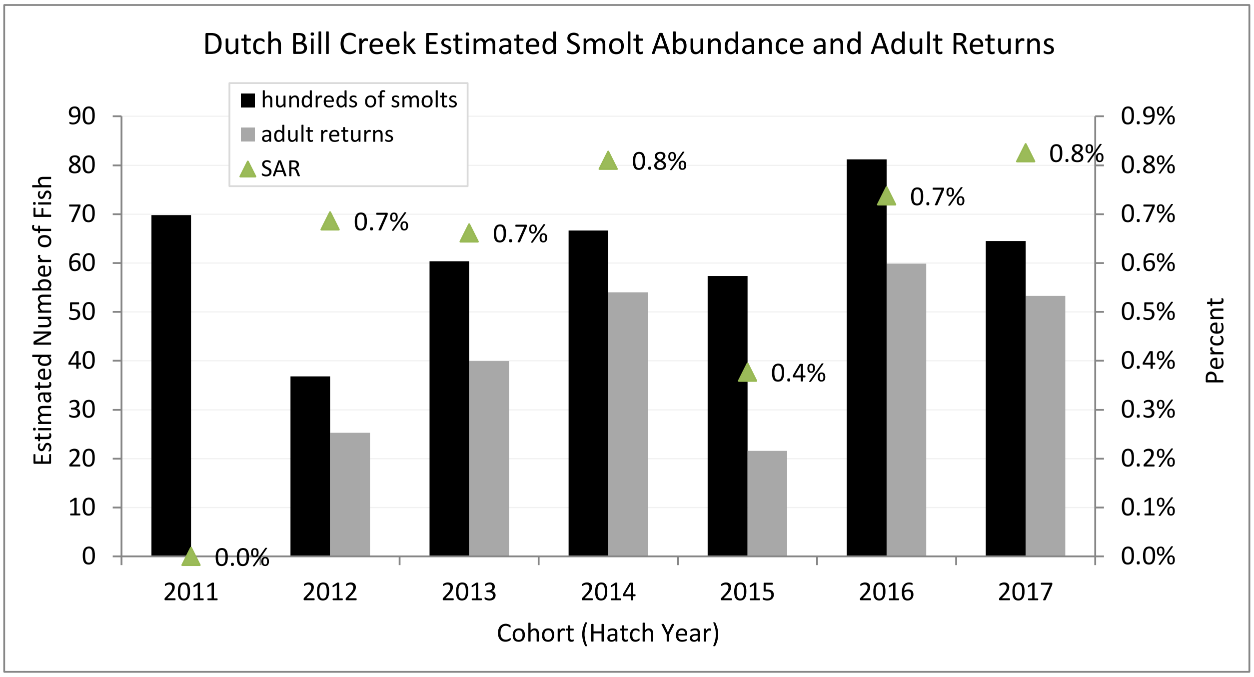


Figure 17. Estimated coho salmon smolt abundance, adult returns and smolt to adult return (SAR) ratios in Dutch Bill Creek, cohorts 2011-2017.

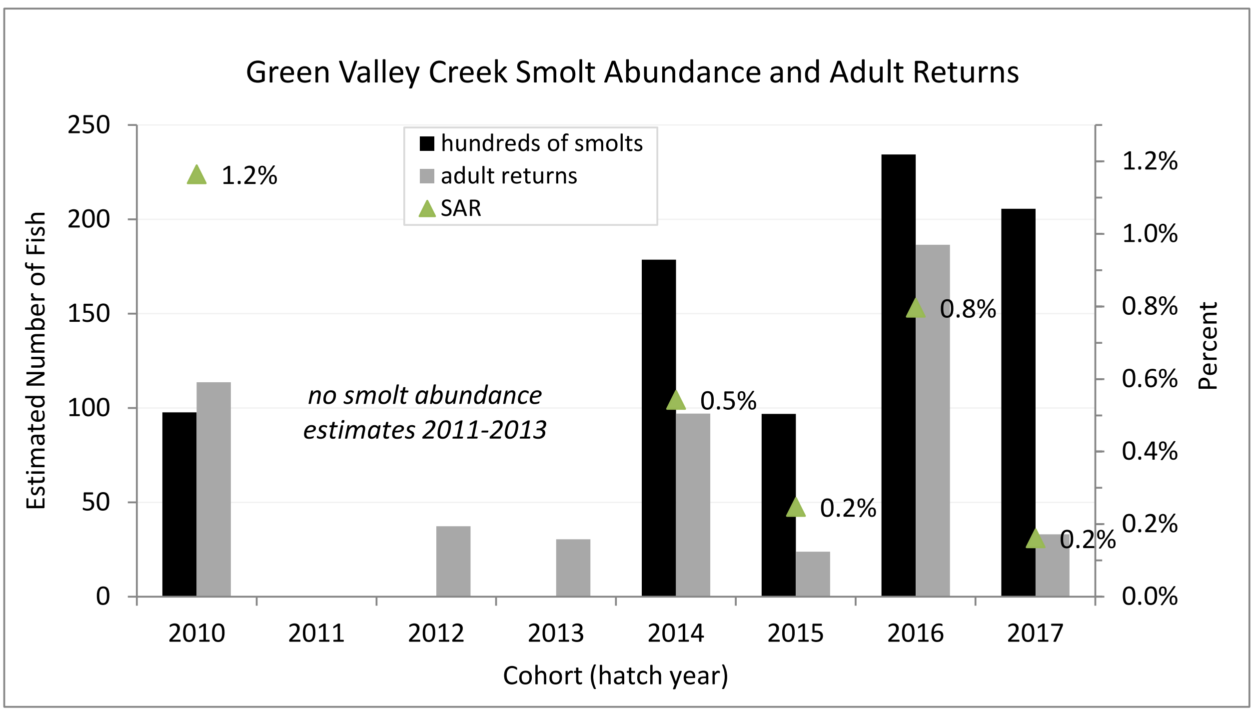


Figure 18. Estimated coho salmon smolt abundance, adult returns and smolt to adult return (SAR) ratios in Green Valley Creek, cohorts 2010-2017.

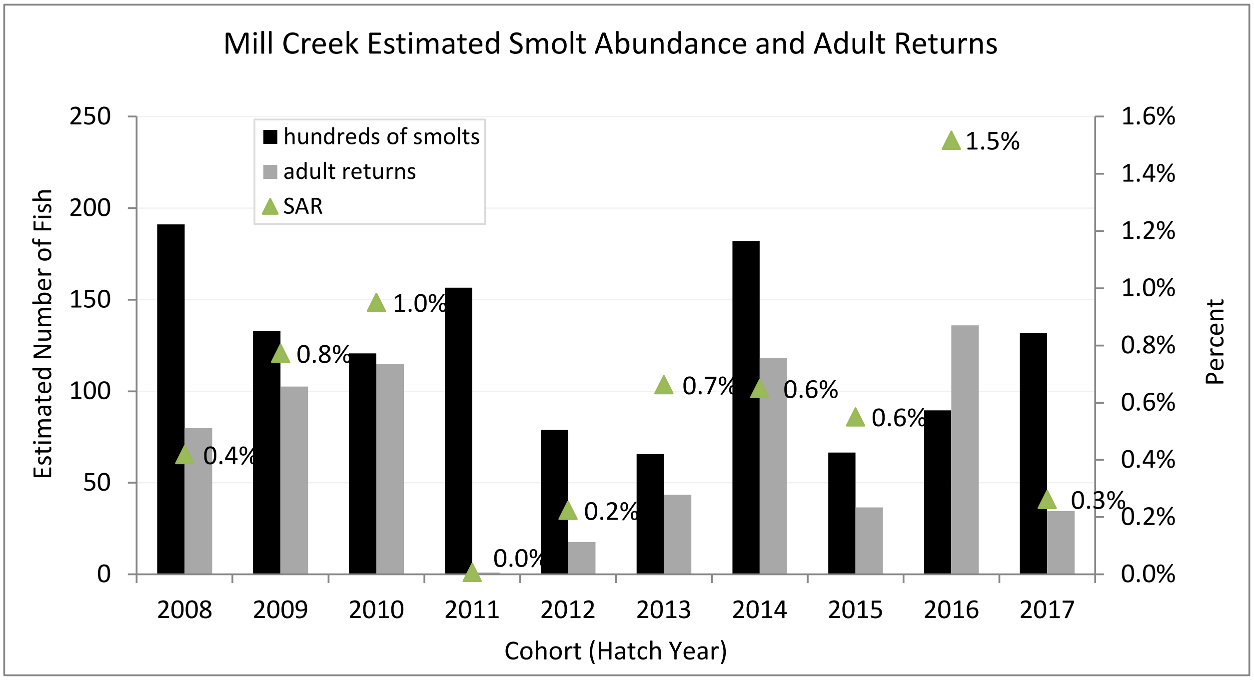


Figure 19. Estimated coho salmon smolt abundance, adult returns and smolt to adult return (SAR) ratios in Mill Creek, cohorts 2008-2017.

Table 8. Smolt to adult return (SAR) ratios estimated for Willow, Dutch Bill, Green Valley, and Mill creeks, cohorts 2008 through 2017.

		Smolt to Adult Return (SAR) Ratio			
Cohort	**Return Winter**	**Willow (River km 3.69)**	**Dutch Bill (River km 0.68)**	**Green Valley (River km 6.13)**	**Mill (River km 2.01)**
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	0.3%	0.7%	*NA*	0.2%
2013	2015/16	0.2%	0.7%	*NA*	0.7%
2014	2016/17	0.7%	0.8%	0.5%	0.6%
2015	2017/18	1.7%	0.4%	0.2%	0.6%
2016	2018/19	0.4%	0.7%	0.8%	1.5%
2017	2019/20	0.6%	0.8%	0.2%	0.3%
	Average	**0.7%**	**0.5%**	**0.6%**	**0.6%**

III. Spawning Surveys

Goals and Objectives

Salmonid spawner surveys were conducted in Russian River tributaries to document spatial distribution and abundance of redds at both individual stream and basinwide scales. The goal for Broodstock Program monitoring was to estimate the spatial distribution and number of redds in Willow, Dutch Bill, Green Valley, and Mill creeks. In 2019, these four streams became the life cycle monitoring streams for the CMP effort, which shared the goal of estimating the number of, redds in each stream. In addition, the CMP effort aimed to generate basinwide estimates of coho salmon and steelhead redds in the entire Russian River watershed. Surveys were conducted in coordination with Sonoma Water using standardized CMP methods (Sonoma Water 2015).

Methods

Sampling framework and survey reaches:

For stream-specific estimates of redd abundance, we surveyed all accessible adult spawning reaches of Willow, Dutch Bill, Green Valley, and Mill creeks. For basinwide estimates, we used a generalized random tessellation stratified (GRTS) approach with soft stratification to survey a random, spatially-balanced selection of coho salmon and steelhead reaches within 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).

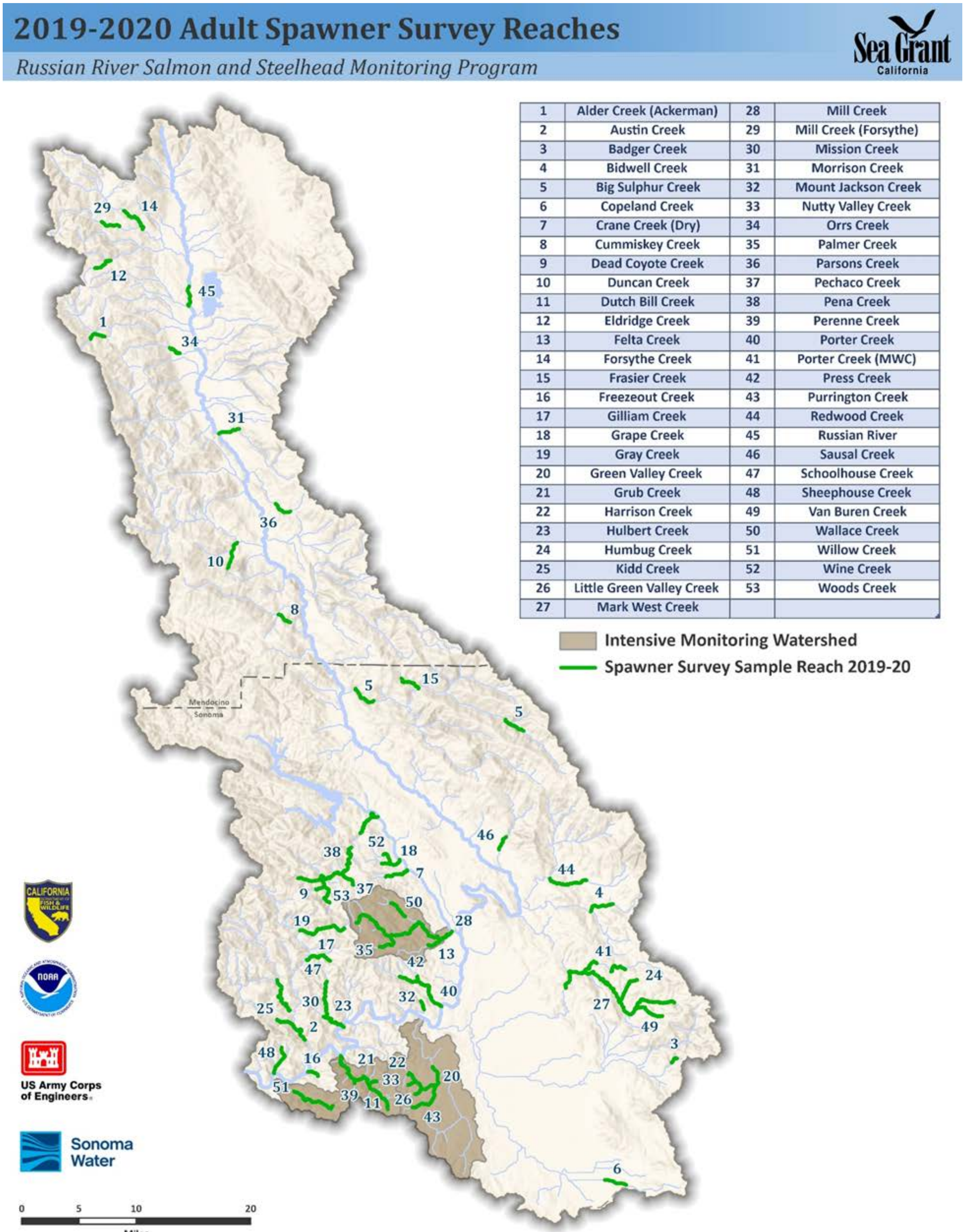
Field methods:

Survey methodology for collecting information on spawning salmonids in the Russian River watershed was adapted from the *Coastal Northern California Salmonid Spawning Survey Protocol* (Gallagher and Knechtle 2005). We attempted to survey each reach at an interval of 10-14 days throughout the spawning season. Two person crews hiked reaches from downstream to upstream looking for adult salmon (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, Chinook salmon (Figure 22), 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 at the reach scale. 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). 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. In the Mill Creek system, the redd estimate was expanded to account for sections of stream that we were unable to sample due to lack of landowner access. This expansion was made by calculating an average redd per stream length in surveyed reaches of Mill Creek and multiplying that ratio by the length of stream that was not surveyed. This total was then added to the sum of redds in the surveyed reaches of Mill Creek. For basinwide estimates, we calculated an average redd density per reach and multiplied that density by the total number of adult coho salmon reaches within the Russian River sample frame.



1	Alder Creek (Ackerman)	28	Mill Creek
2	Austin Creek	29	Mill Creek (Forsythe)
3	Badger Creek	30	Mission Creek
4	Bidwell Creek	31	Morrison Creek
5	Big Sulphur Creek	32	Mount Jackson Creek
6	Copeland Creek	33	Nutty Valley Creek
7	Crane Creek (Dry)	34	Orrs Creek
8	Cummiskey Creek	35	Palmer Creek
9	Dead Coyote Creek	36	Parsons Creek
10	Duncan Creek	37	Pechaco Creek
11	Dutch Bill Creek	38	Pena Creek
12	Eldridge Creek	39	Perenne Creek
13	Felta Creek	40	Porter Creek
14	Forsythe Creek	41	Porter Creek (MWC)
15	Frasier Creek	42	Press Creek
16	Freezeout Creek	43	Purrington Creek
17	Gilliam Creek	44	Redwood Creek
18	Grape Creek	45	Russian River
19	Gray Creek	46	Sausal Creek
20	Green Valley Creek	47	Schoolhouse Creek
21	Grub Creek	48	Sheephouse Creek
22	Harrison Creek	49	Van Buren Creek
23	Hulbert Creek	50	Wallace Creek
24	Humbug Creek	51	Willow Creek
25	Kidd Creek	52	Wine Creek
26	Little Green Valley Creek	53	Woods Creek
27	Mark West Creek		

Figure 20. Broodstock Program watersheds and 2019-2020 spawner survey reaches in the Russian River.

Figure 21. A steelhead redd observed in Woods Creek during 2019/20 spawner surveys.

Figure 22. An adult Chinook salmon carcass observed in Pena Creek during 2019/20 spawner surveys.

Results

Surveys began when streams reconnected to the Russian River mainstem and became accessible to adult salmon in early December, 2019 and continued through mid-March, 2020 when a COVID-19 related shelter in place order was issued for Sonoma County and we were unable to continue surveys through mid-April as we had done in previous years. We were largely able to meet our goal of surveying each reach every 10-14 days, with only small gaps when stream flow was too high for surveys to be completed. Over the winter season, CSG and Sonoma Water biologists completed a total of 718 salmonid spawning surveys on 73 reaches in 53 streams within the Russian River basin. A total of 416 salmonid redds were observed: 66 coho salmon redds, 271 steelhead redds, 17 Chinook salmon redds, and 62 redds of unknown salmonid species origin (Table 9, Figure 23, Figure 24). In addition, one live coho salmon adult was observed in Purrington Creek where no confirmed coho redds were observed (Figure 23). Of the 32 coho salmon streams surveyed during the winter of 2019/20, coho salmon redds and/or adults were observed in 16 (50%) and steelhead redds and/or adults were observed in 30 of the 53 steelhead streams surveyed (57%) (Table 9, Figure 23, Figure 24). Chinook redds were observed in Pena and Forsythe creeks as well as the mainstem Russian River (Table 9).

Over all streams combined, timing of redds varied by species, with Chinook salmon redd observations peaking in mid-December, coho salmon observations beginning in early December and ending in mid-January, and steelhead observations peaking in February (Figure 25). Steelhead redds were observed over the widest timeframe, ranging from early December through the end of the survey season in mid-March (Figure 25). Some steelhead redds were likely missed in late-March and early-April after the shelter-in-place orders were issued.

Coho salmon redd estimates in Broodstock Program monitoring streams ranged from two in Dutch Bill Creek to 40 in Mill Creek, and steelhead redd estimates ranged from two in Willow Creek to 43 in Mill 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 2.4 in Mill Creek to 21.0 in Dutch Bill Creek (Table 10).

When compared with previous years, coho salmon redd estimates were low in Willow and Dutch Bill creeks average in Green Valley Creek, and relatively high in Mill Creek (Figure 26). Steelhead redd estimates were low in Green Valley and Willow creeks, average in Mill Creek, and high in Dutch Bill Creek (Figure 27). At the basinwide scale, redd estimates for coho salmon were approximately average, while estimates for steelhead redds were the second highest observed over the last five winters (Figure 28).

In all of the creeks surveyed, we recovered only 11 intact coho salmon carcasses (Table 11). The average proportion of natural-origin adult coho salmon carcasses across all creeks was 45%, with no natural-origin carcasses recovered in the Willow, Dutch Bill, Green Valley, and Mill creeks and five recovered in other streams throughout the basin. This small sample size makes it difficult to make any inferences about the proportion of natural-origin fish returning to the Russian River watershed during the winter of 2019/20.

Redd distribution varied by stream (Figure 29 - Figure 32). In Willow Creek, one coho salmon redd was located in the lower section of the surveyable reaches with one additional coho redd and four steelhead redds located in the middle (Figure 29). In Dutch Bill Creek, two coho salmon redds were observed one third of the way through the surveyable reaches, and one additional redd was observed approximately halfway up.

One of the three coho redds observed in Dutch Bill Creek had low certainty of species identification and was later estimated to be a steelhead redd based upon Gallagher and Gallagher's redd species determination method (Gallagher and Gallagher 2005), which is why the estimated number of redds is two (Table 10) while the observed count is three (Table 9). Steelhead redds in Dutch Bill Creek were concentrated in the lower part of the creek (Figure 30). In the Green Valley Creek watershed, coho salmon and steelhead redds were observed throughout Green Valley Creek with two unknown salmonid redds and one steelhead redd in Purrington Creek (Figure 31). In the Mill Creek watershed, there was a cluster of coho salmon redds near the confluence with Felta Creek, a redd near the Palmer Creek confluence, and two other redds high up in the system (Figure 32). Steelhead redds were concentrated in the lower portions of the creek, with a few in Felta Creek, two in Wallace Creek, and a cluster of redds near the Palmer Creek confluence (Figure 32).

Table 9. Total salmonid redds observed by species during 2019/20 spawner surveys in Russian River tributaries.

Tributary	Surveyed (km)	Coho Salmon	Steelhead	Chinook Salmon	Salmonid	Total
ALDER CREEK (ACKERMAN)*	2.1	0	0	0	0	0
AUSTIN CREEK	7.6	1	20	0	10	31
BADGER CREEK*	0.9	0	0	0	0	0
BIDWELL CREEK*	3.2	0	0	0	0	0
BIG SULPHUR CREEK*	5.7	0	14	0	2	16
COPELAND CREEK*	2.6	0	0	0	0	0
CRANE CREEK (DRY)	3.2	0	0	0	0	0
CUMMISKEY CREEK*	1.7	0	4	0	1	5
DEAD COYOTE CREEK	1.1	0	0	0	0	0
DUNCAN CREEK*	3.3	0	3	0	0	3
DUTCH BILL CREEK	11.4	3	21	0	4	28
ELDRIDGE CREEK*	2.8	0	0	0	0	0
FELTA CREEK	2	0	4	0	1	5
FORSYTHE CREEK*	3.7	0	0	3	0	3
FRASIER CREEK*	3.6	0	0	0	0	0
FREEZEOUT CREEK	1.5	0	0	0	0	0
GILLIAM CREEK	2.6	4	2	0	0	6
GRAPE CREEK	2.6	1	8	0	2	11
GRAY CREEK	6.3	2	13	0	1	16
GREEN VALLEY CREEK	7	7	5	0	3	15
GRUB CREEK*	1.1	0	0	0	0	0
HARRISON CREEK	0.2	0	0	0	0	0
HULBERT CREEK	8.2	0	17	0	2	19
HUMBUG CREEK*	3.7	0	0	0	0	0
KIDD CREEK	2.5	0	2	0	0	2
LITTLE GREEN VALLEY CREEK	1.2	0	0	0	0	0
MARK WEST CREEK	19.2	1	27	0	5	33
MILL CREEK	16.6	9	23	0	7	39
MILL CREEK (FORSYTHE)*	2.3	0	0	0	1	1
MISSION CREEK	0.4	0	0	0	0	0
MORRISON CREEK*	2.4	0	2	0	0	2
MOUNT JACKSON CREEK*	2.8	0	0	0	0	0
NUTTY VALLEY CREEK	1.2	0	0	0	0	0
ORRS CREEK*	1.7	0	0	0	0	0
PALMER CREEK	2.9	0	1	0	0	1
PARSONS CREEK*	2.2	0	0	0	0	0
PECHACO CREEK	2.3	1	1	0	0	2
PENA CREEK	15.1	17	34	11	10	72
PERENNE CREEK*	0.5	0	0	0	0	0
PORTER CREEK	7.4	8	25	0	1	34
PORTER CREEK (MWC)	5.1	0	3	0	1	4
PRESS CREEK	0.6	0	0	0	0	0
PURRINGTON CREEK	4.8	0	1	0	2	3
REDWOOD CREEK	4.8	0	8	0	2	10
RUSSIAN RIVER*	2.5	0	13	3	1	17
SAUSAL CREEK*	1.8	0	3	0	1	4
SCHOOLHOUSE CREEK	1.1	0	0	0	0	0
SHEEPHOUSE CREEK	3.7	1	1	0	1	3
VAN BUREN CREEK*	4	0	0	0	0	0
WALLACE CREEK	2.5	0	2	0	0	2
WILLOW CREEK	6	2	4	0	0	6
WINE CREEK	1.8	1	5	0	3	9
WOODS CREEK	4.1	8	5	0	1	14
Total	**211.6**	**66**	**271**	**17**	**62**	**416**
*** Steelhead only tributary**						

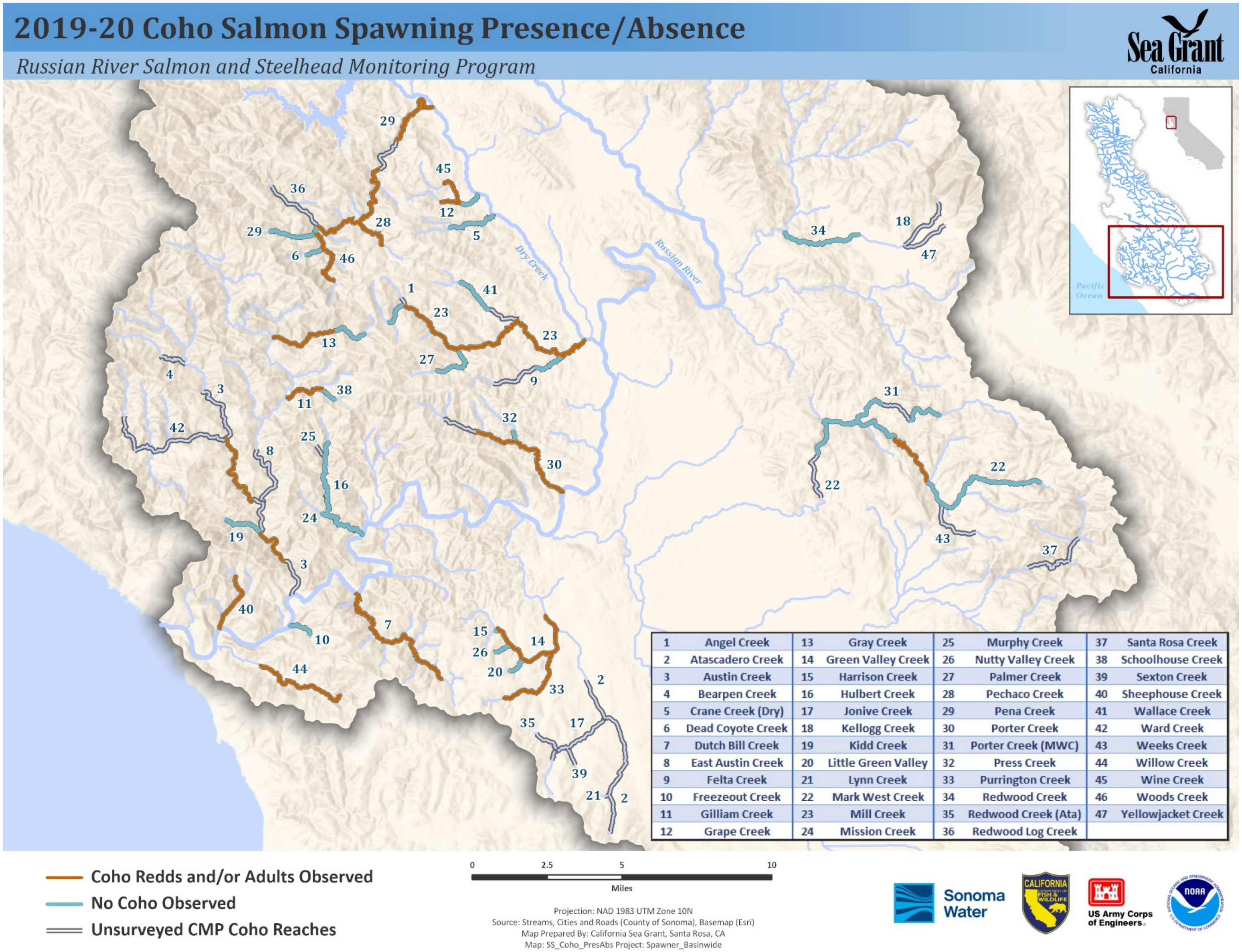
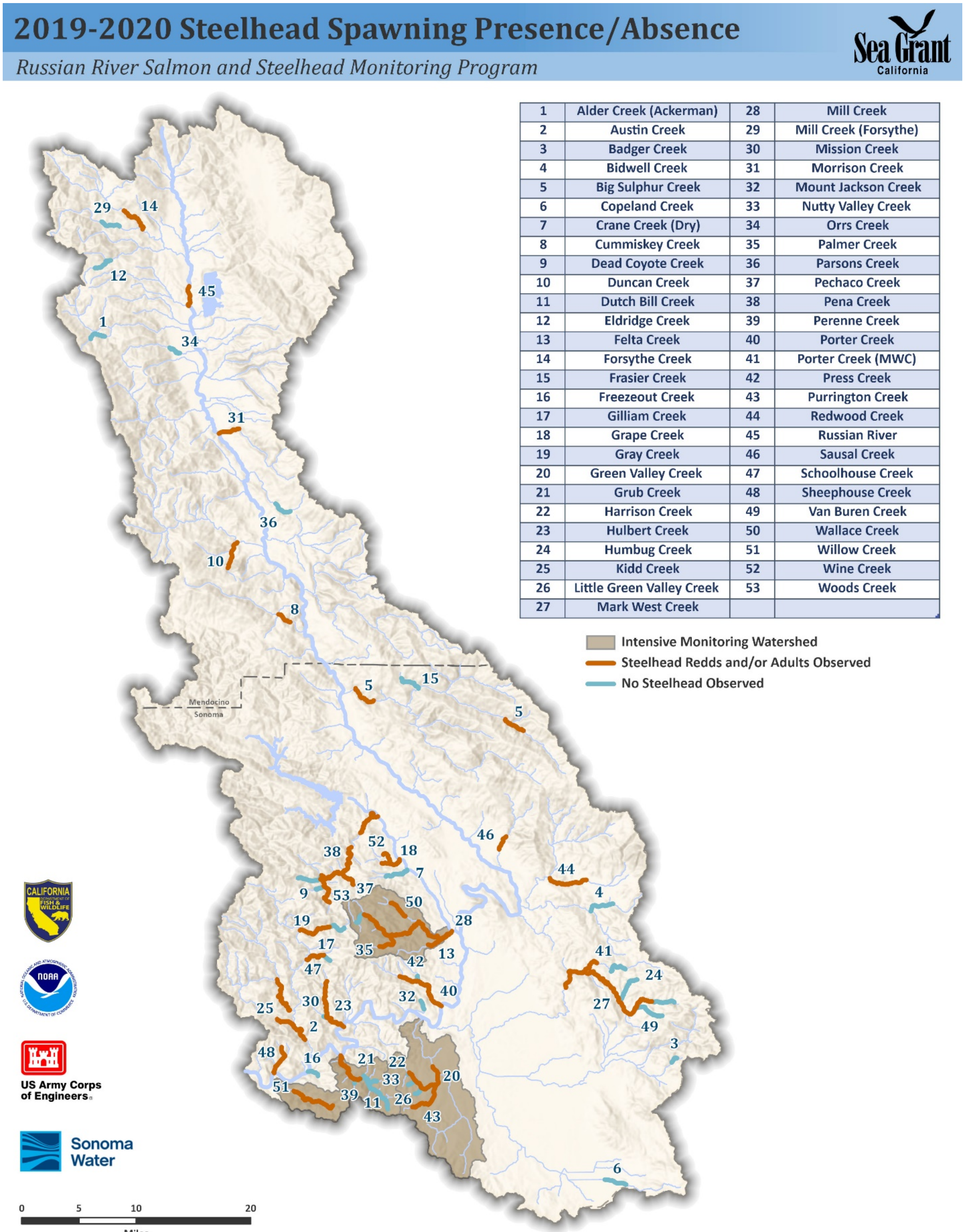


Figure 23. Spawner survey reaches where coho salmon redds and/or coho salmon adults were observed, winter 2019/20.



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16	Freezeout Creek	43	Purrington Creek
17	Gilliam Creek	44	Redwood Creek
18	Grape Creek	45	Russian River
19	Gray Creek	46	Sausal Creek
20	Green Valley Creek	47	Schoolhouse Creek
21	Grub Creek	48	Sheephouse Creek
22	Harrison Creek	49	Van Buren Creek
23	Hulbert Creek	50	Wallace Creek
24	Humbug Creek	51	Willow Creek
25	Kidd Creek	52	Wine Creek
26	Little Green Valley Creek	53	Woods Creek
27	Mark West Creek		

Figure 24. Spawner survey reaches where steelhead redds and/or live steelhead adults were observed, winter 2019/20.

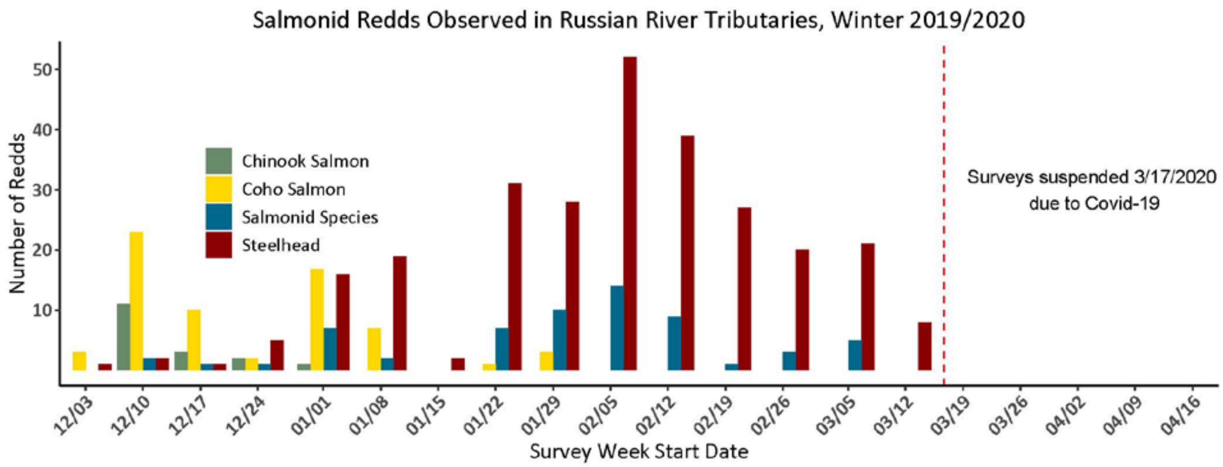

Figure 25. Number of new salmonid redds observed each week in Russian River Coastal Monitoring Program survey streams, winter 2019/20.

Table 10. Estimated coho salmon and steelhead redds and adults in four Russian River tributaries, winter 2019/20. 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	3	17	5.7
Willow Creek	steelhead	2	NA	NA
Dutch Bill Creek	coho salmon	2	42	21.0
Dutch Bill Creek	steelhead	27	NA	NA
Green Valley Creek	coho salmon	9	94	10.4
Green Valley Creek	steelhead	9	NA	NA
Mill Creek	coho salmon	40	96	2.4
Mill Creek	steelhead	43	NA	NA

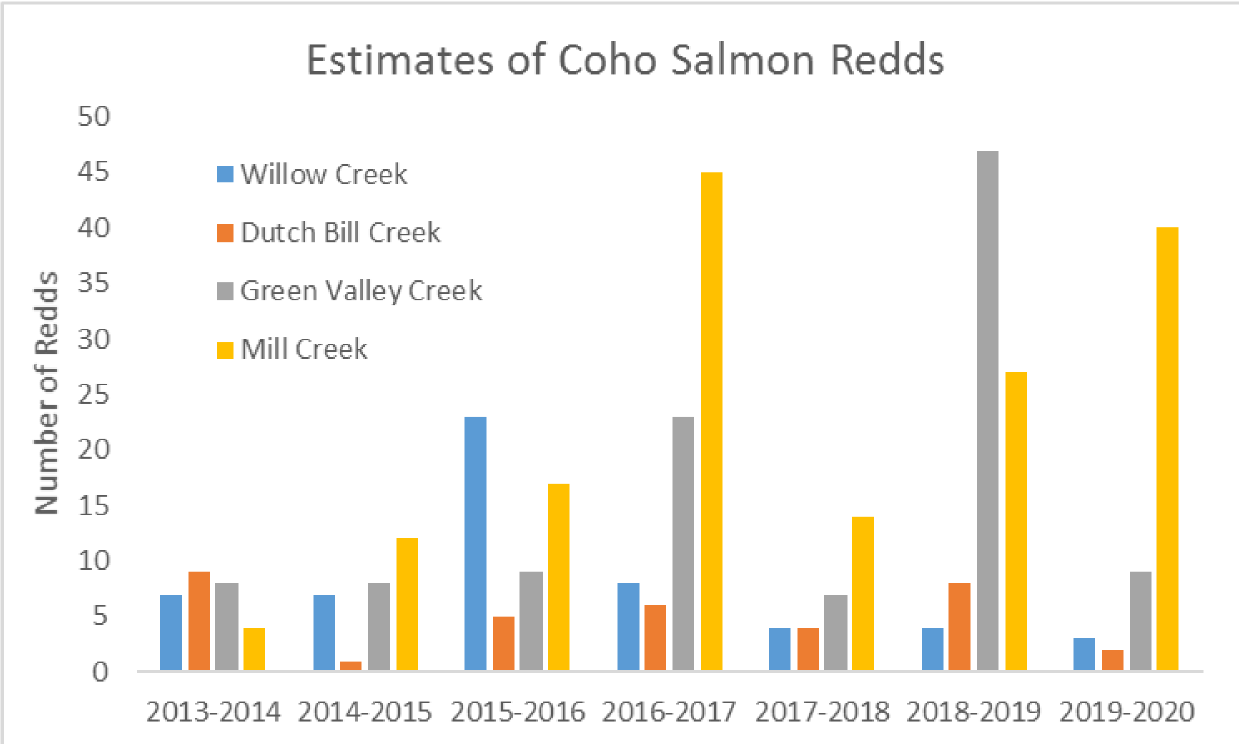

Figure 26. Estimated coho salmon redds in Broodstock Program monitoring tributaries, return winters 2013/14 through 2019/20.

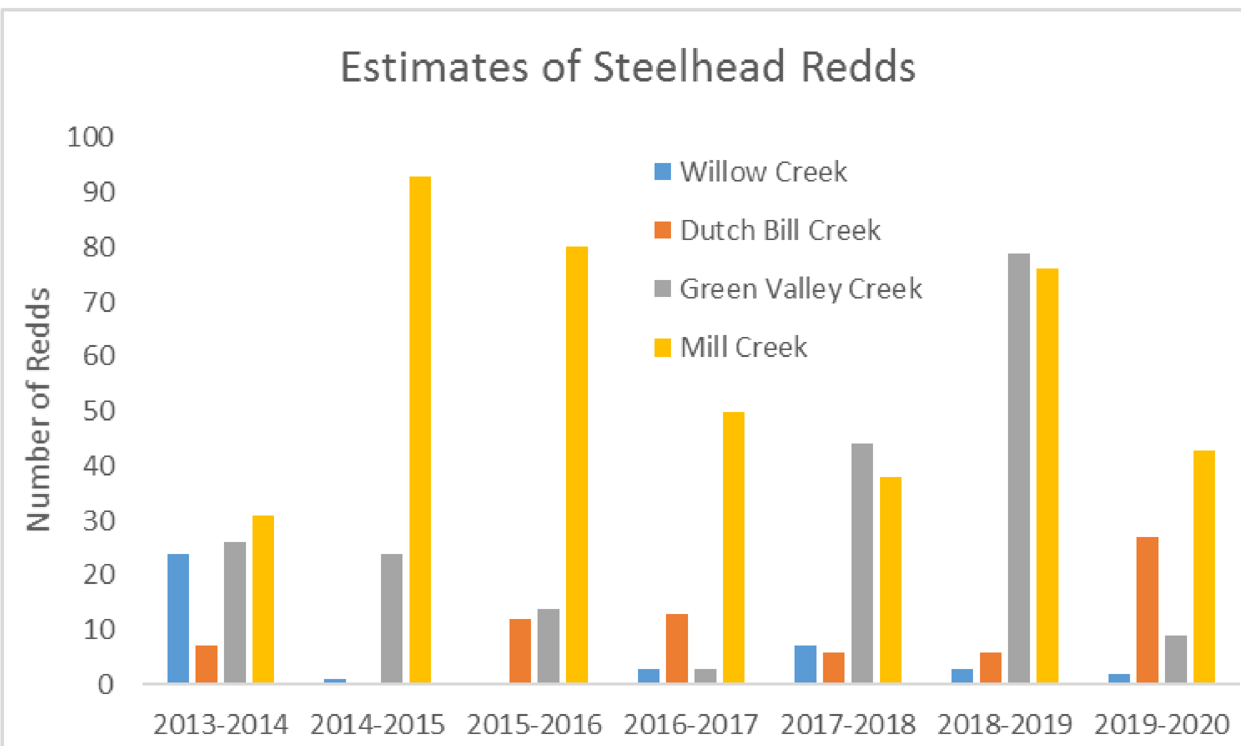

Figure 27. Estimated steelhead redds in Broodstock Program monitoring tributaries, return winters 2013/14 - 2019/20.

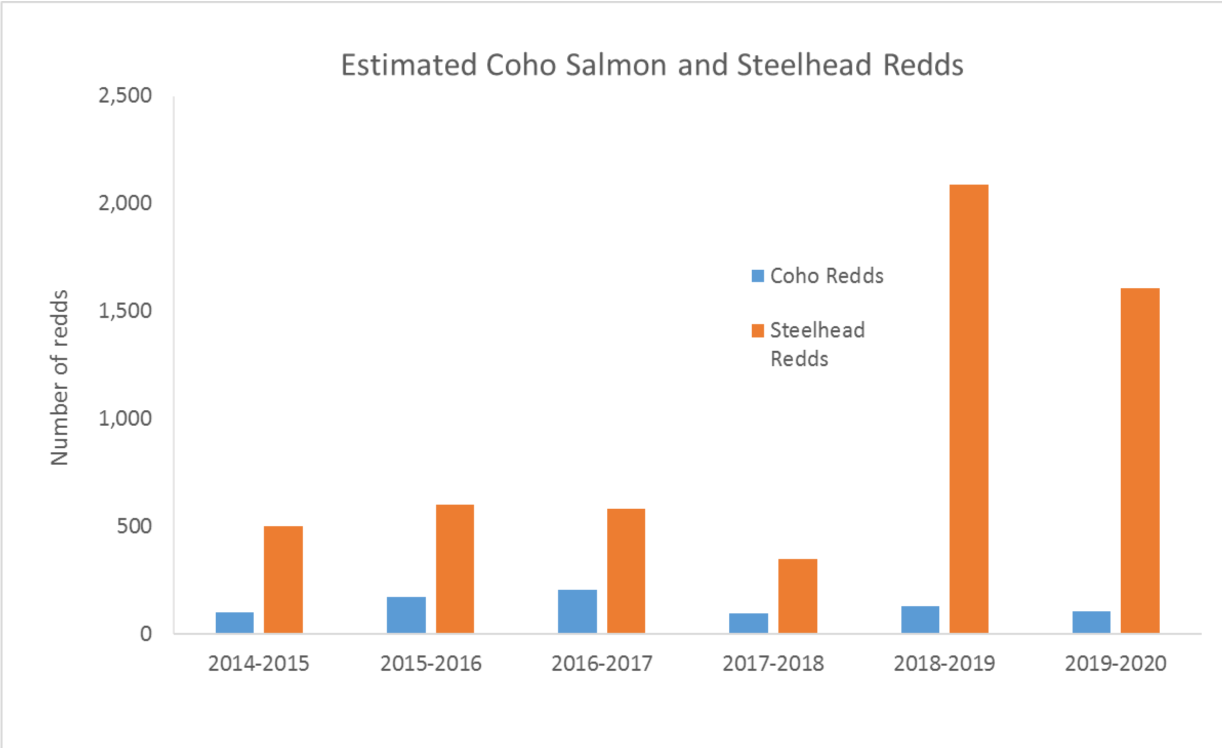

Figure 28. Basinwide estimates of coho salmon and steelhead redds in the Russian River watershed, return winters 2014/15 through 2019/20.

Table 11. Number of coho salmon carcasses observed relative to CWT presence/absence during 2019/20 spawner surveys in Russian River tributaries.

Tributary	CWT Present	CWT Not Present	Proportion Untagged (Natural Origin)
Willow Creek	0	0	NA
Dutch Bill Creek	0	0	NA
Green Valley Creek	2	0	0%
Mill Creek	0	0	NA
Other Streams	4	5	56%
All Streams	**6**	**5**	45%

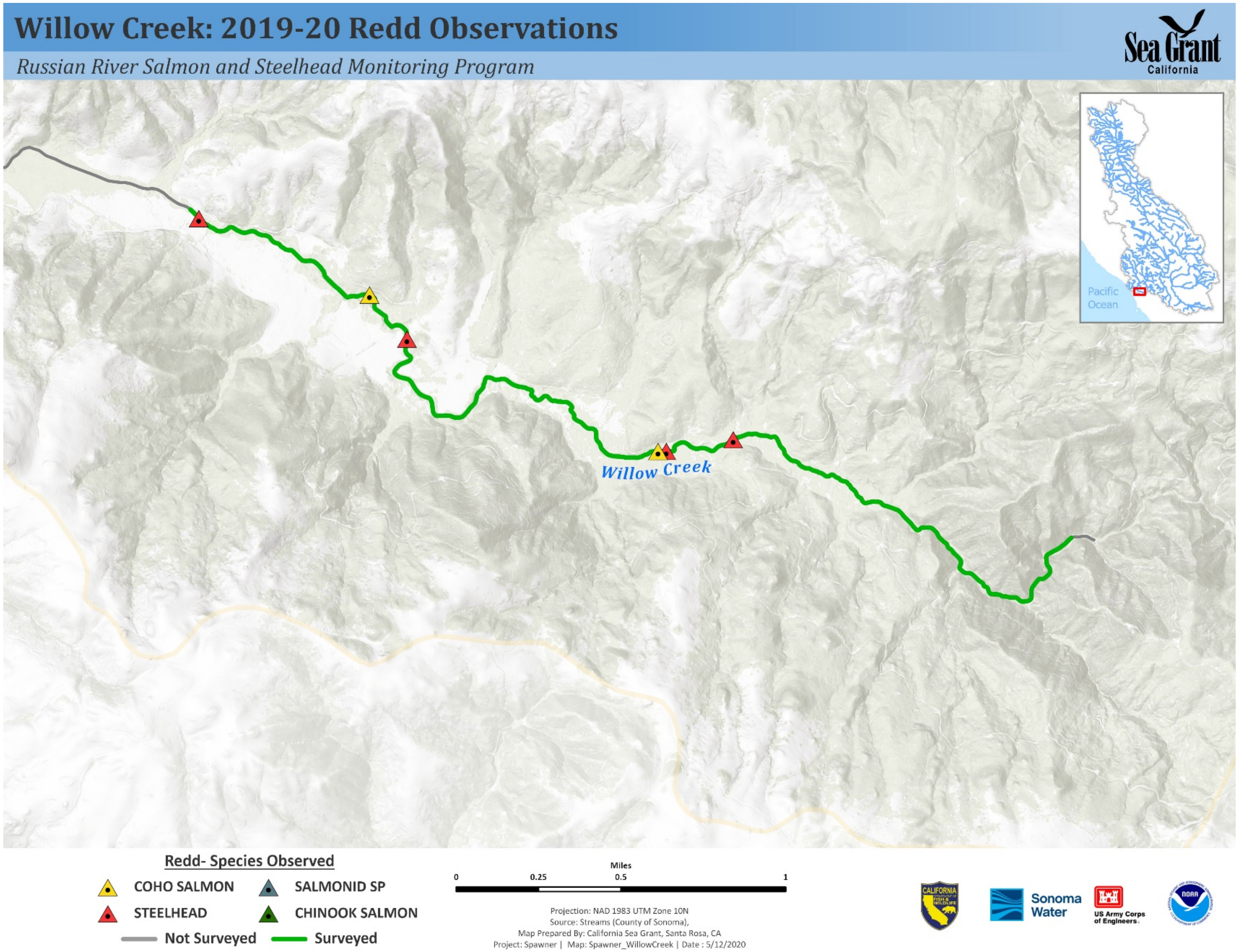

Figure 29. Salmonid redds observed in Willow Creek during winter 2019/20.

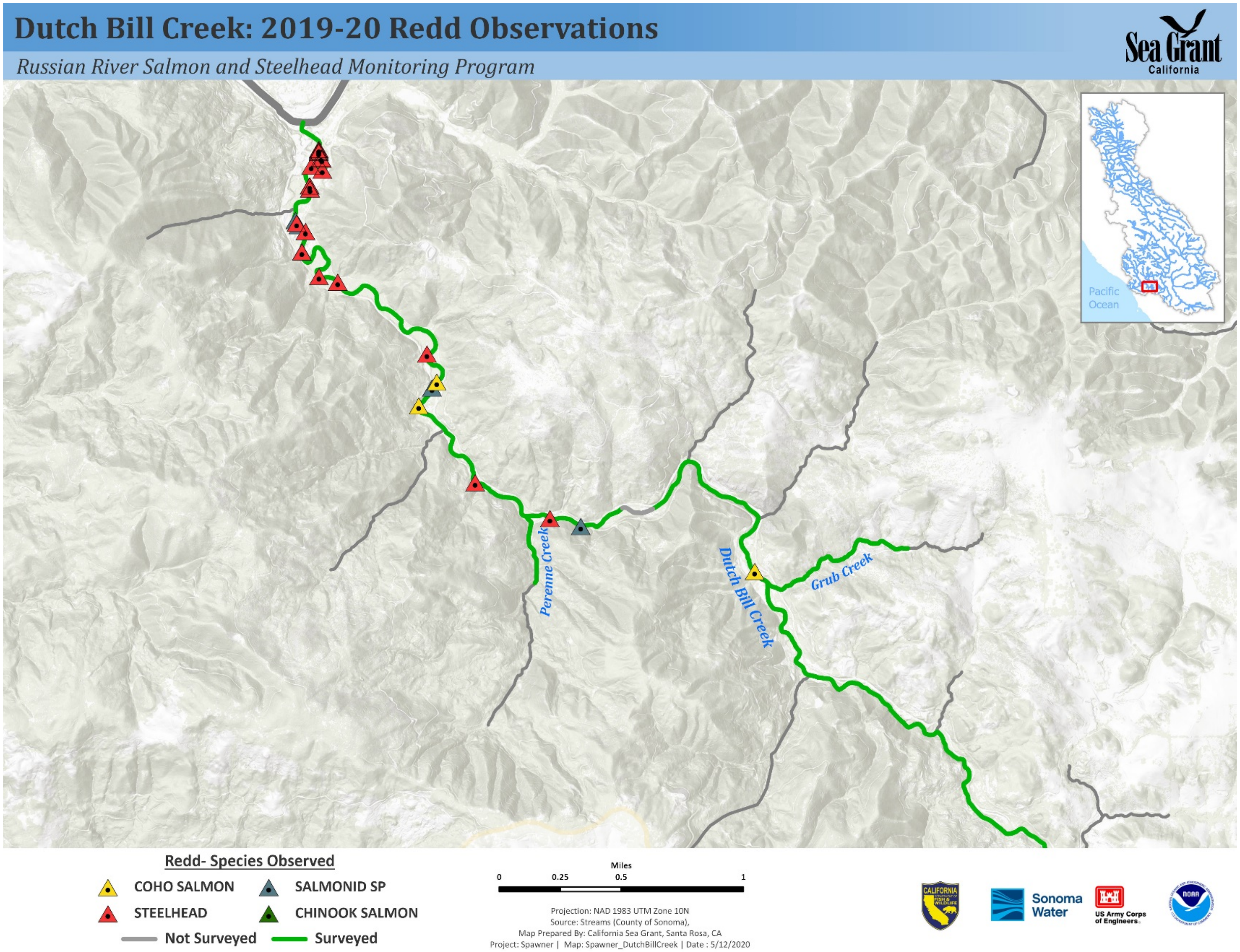

Figure 30. Salmonid redds observed in Dutch Bill Creek during winter 2019/20.

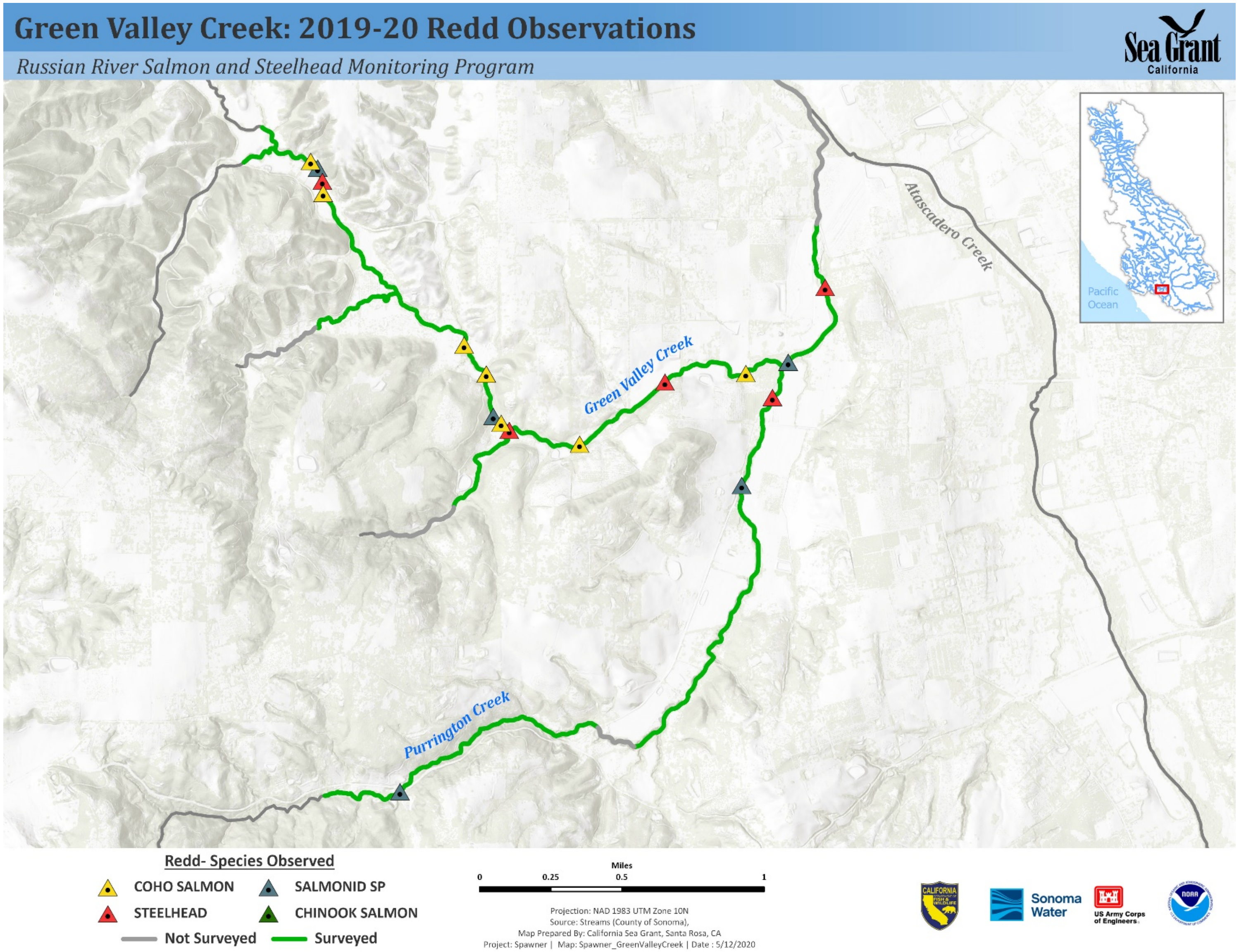

Figure 31. Salmonid redds observed in the Green Valley Creek watershed during winter 2019/20.

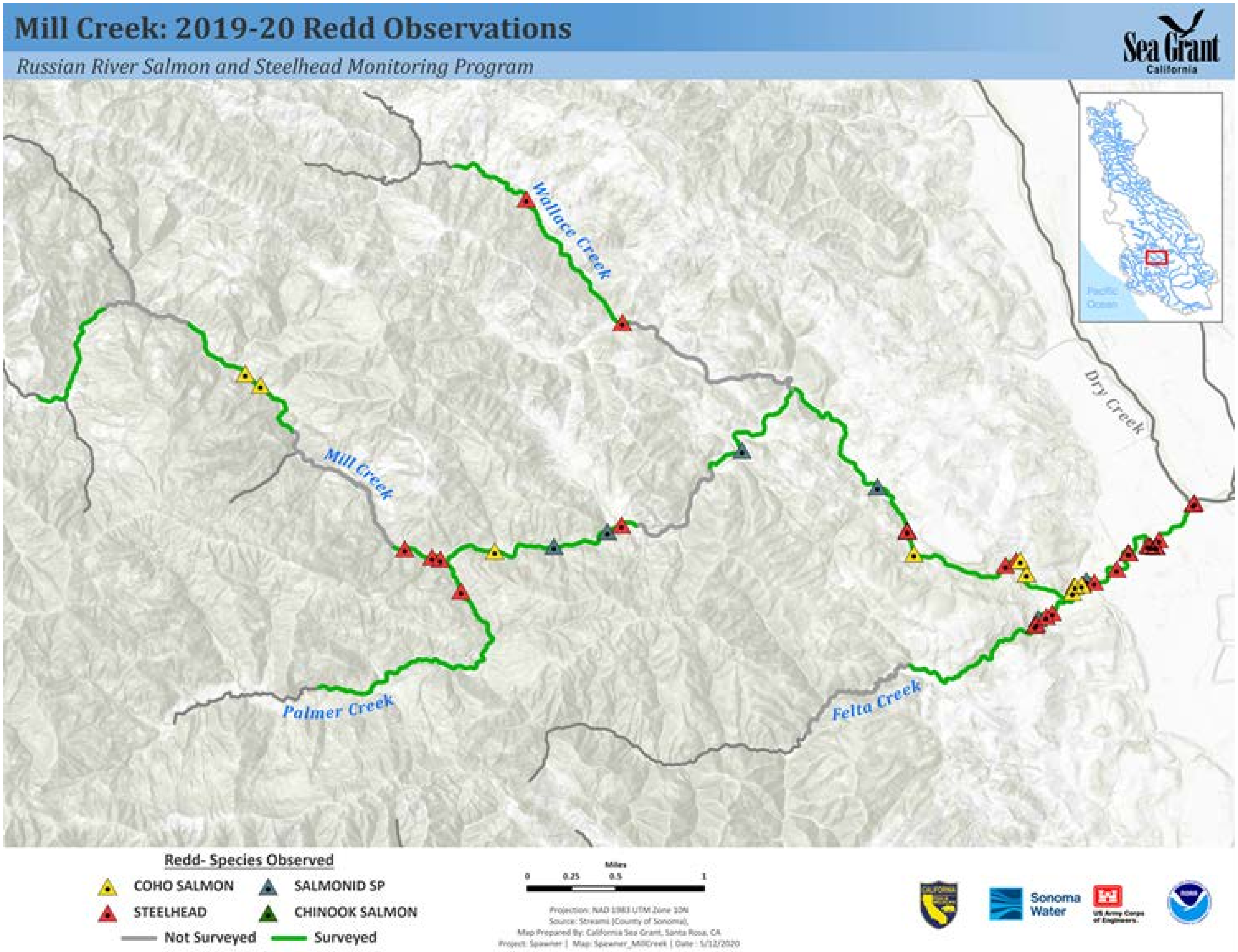

Figure 32. Salmonid redds observed in the Mill Creek watershed during winter 2019/20.

Discussion and Recommendations

The estimated number of coho salmon returning to the Russian River watershed during the winter of 2019/20 was the third highest on record since the beginning of the Broodstock Program (Figure 14). A total of 547 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 32 coho salmon streams surveyed (Figure 23). The 547 fish estimate was comprised of 75% age-2 adults, and there appears to be a pattern of large numbers of age-2 fish returning approximately every other year (Figure 15).

Adult coho salmon were first detected in the lower Russian River at Duncans Mills in November 2019 with the majority of detections occurring during late November and early December (Figure 4). The winter of 2019/20 was a slightly below-average rainfall winter (Figure 3), with the largest storms occurring in early December, which reconnected the tributaries to the mainstem. The December rains enabled adult coho salmon to access the spawning grounds (Figure 5) and the first coho salmon redds were observed in the tributaries in early December (Figure 25). Coho salmon spawning activity continued through the middle of January, lasting approximately six weeks.

Winter 2019/20 storms were moderate compared to previous years, generating streamflow that appeared to provide access to spawning grounds without significantly mobilizing the substrate and causing high levels of redd scour. Large, intense storms can cause extreme flow events, which have been shown to be detrimental for salmon redds (Schuett-Hames et al. 1996), but given the moderate flows of 2019/20, we predicted spawning success to be greater than in years with higher-magnitude storms. Preliminary snorkel results for 2020 indicate that there are high numbers of coho salmon yoy present in many streams, supporting this conclusion.

Two coho salmon redds were observed in the upper reaches of Mill Creek in winter 2019/20. This is noteworthy because coho salmon typically spawn low in the watershed and multiple efforts have been undertaken to improve passage and enable fish to access the high quality spawning and rearing habitat in upper Mill Creek. We are hopeful that fish will continue to utilize more of these headwater areas for spawning as the habitat and water conditions in these areas are more resilient to drought and redd scour.

The winter of 2019/20 was the second year in a row in which we observed high numbers of adult steelhead and steelhead redds. Basinwide steelhead redd estimates were slightly lower than in 2018/19, but still several orders of magnitude larger than in the previous several years (Figure 28). It is possible that our 2019/20 steelhead estimates would have been even higher had surveys not been cut short in mid-March due to the COVID-19 shelter in place order. During the previous two winters, significant numbers of new steelhead redds were observed between mid-March and mid-April so it seems likely that we missed a portion of the 2019/20 run and our estimate was biased low (Figure 25, Figure 33).

In winter 2019/20, we observed uncharacteristically high numbers of steelhead redds in Dutch Bill Creek (Figure 27), and this may have been influenced by adult releases of hatchery steelhead in the mainstem of the Russian River in the vicinity of Dutch Bill Creek. CDFW released ~~FLOY~~Floy-tagged adult steelhead at multiple Russian River sites, including at the Monte Rio boat launch, which is immediately across the river from Dutch Bill Creek. Spawner survey observations of ~~FLOY~~Floy-tagged adult steelhead and steelhead redds in Dutch Bill Creek increased shortly after these releases began. Field crews observed adult ~~FLOY~~Floy-tagged steelhead in other creeks as well, including fish that were actively spawning.

The proportion of age-2 coho salmon that returned to Russian River tributaries and the mainstem at Duncans Mills was high in 2019/20, continuing a pattern of high and variable jack rates (Figure 10 - Figure 13, Figure 15). Broodstock fish from similar genetic stock exhibited a much smaller proportion of fish maturing at age-2 than the fish that were released into the streams (Ben White, personal communication). This leads us to believe that there are environmental (or other non-genetic) factors that are contributing to high proportions of age-2 maturation of fish that are released into the wild. Because there is a correlation between size at ocean entry and the likelihood of returning at age-2, it would be useful to evaluate riverine/estuarine growth of coho smolts prior to ocean entry to see if there are high growth rates that could be influencing the proportions of age-2 spawners. Another potential factor suggested by Broodstock Program TAC members is feeding regime prior to releases, which also warrants investigation.

As in previous years, during the winter of 2019/20, we detected individual coho salmon adults returning to more than one stream and not always to the stream in which the fish was released or tagged (Table 4 - Table 6). To examine fidelity of fish released or tagged in streams with PIT antennas, we estimated the proportion of adults that returned to the stream in which they were either released or tagged. For specific release groups of interest, we divided the number of adults detected returning to the release or tagging stream by the total number of adults from that release/tagging group detected on any antenna within the watershed. It should be noted that antenna efficiency was not accounted for and we do not operate antennas on all streams within the Russian River watershed, which could lead to biased estimates. However, based on this cursory analysis, we observed that fidelity of presmolts and smolts was highest in Dutch Bill and Dry creeks, and decreased in Green Valley, Mill and Mark West creeks, respectively (Figure 34). This variation may be explained by differences in imprinting time; Dry Creek release fish imprint on Dry Creek water their entire lives up until release, Dutch Bill Creek smolts are placed in a streamside imprinting tank with Dutch Bill Creek water for two weeks prior to release, and we have documented that smolts released directly into Green Valley Creek spend a longer period of time before leaving as smolts than fish released into Mill Creek. The antennas at Mark West are relatively newer so we have less information about how quickly fish migrate out of Mark West following release. When grouped over all streams, we found little variation among release groups (spring, fall, presmolt and smolt), but as might be expected, the spring release group had the highest fidelity and the smolt release group had the lowest (Figure 35). Surprisingly, the one wild adult coho detected returning was tagged at the smolt trap in Green Valley but was detected as an adult returning to Mill Creek. Based on these results, if the Broodstock Program desires higher fidelity to streams of release, we recommend employing the imprinting tank approach on streams such as Mill and Mark West creeks, where fidelity appears to be lower than the other streams.

Over the last decade, the Broodstock Program has been releasing coho salmon presmolts and smolts into multiple streams at staggered intervals between February and May as a bet-hedging strategy to safeguard against unpredictable adverse conditions in the stream, riverine, estuarine and/or marine environments. With low overall adult return rates, it has been challenging to evaluate whether earlier or later releases are more or less successful each year. To build our sample size to better examine this question, we combined data across 10 cohorts of smolt releases (hatch years 2008 through 2017), categorized release groups by month (Feb-May), and calculated the proportion of monthly releases that returned as adults (Table 12). Although there was variation among streams, there was a slight overall negative trend in return rate the later the release, with the highest average rate occurring in February, similar rates for March and April and the lowest average rate occurring in May (Table 12, Figure 36). This trend was observed in almost all streams where multiple release timings occurred with the exception of Dry and Willow creeks where no clear patterns were apparent. Only two releases have occurred in the month of February and the one on Green Valley Creek showed the highest rate of return among all releases, while the one in Willow Creek showed a low rate of return. We suggest trying some additional releases in February to further evaluate this earlier release timing. Although the overall negative trend with progressively later releases was not strong, in general, we recommend shifting the smolt releases to a slightly earlier regime, encompassing the months of February through the end of April, to increase freshwater survival of smolts.

Although we have stocked coho salmon at similar levels for many years, over the last decade we have observed variation in the estimated number of adult coho that return to the Russian River each winter (Figure 14). To evaluate whether the source of this variation occurred in the freshwater or marine environments, we first compared freshwater overwinter survival rates with adult abundance, but found no clear pattern, likely because overwinter survival has remained relatively consistent among years. Because only a small number of fish are stocked in the spring, fluctuations in oversummer survival due to drought are unlikely to be a factor either. Other monitoring programs in the Pacific Northwest have observed correlations between ocean conditions and adult coho salmon abundance (Logerwell et al. 2003, Ruzicka et al. 2011), so we compared Russian River adult return estimates with Pacific Decadal Oscillation (PDO). We plotted estimated adult returns with the average PDO conditions experienced by age-3 adult returns. Although we found some evidence of higher returns when PDO was below zero, this pattern was not consistent among years (Figure 37). This suggests that other variables are influencing adult abundance in the Russian River. Likely candidates include environmental factors in the riverine and estuary environments such as temperature, estuary closure and/or predation. We recommend further investigation into these potential relationships to better explain variation in the number of returning adults each year.

In summary, the winter of 2019/20 was a relatively good year for adult coho and steelhead returns. There were some promising observations of coho spawning high up in systems where conditions are typically better for their offspring. Furthermore, the rainfall patterns in December and January were at sufficient levels to provide good access to spawning grounds, without the extreme flow events that are know to cause redd scour. The winter of 2019/20 was the second year in a row in which we observed high numbers of adult steelhead and steelhead redds. Preliminary snorkel survey results have indicated that high numbers of juvenile coho and steelhead are present in many of our streams, suggesting that spawning success was high. We recommend that the Broodstock Program consider adjusting the smolt/pre-smolt release timing earlier to increase survival and use the imprinting tank strategy on Mill and Mark W~~w~~est creeks to increase fidelity to release streams. We also suggest evaluating growth and survival of coho smolts in the mainstem Russian River and estuary to help determine whether survival bottlenecks exist in these environments.

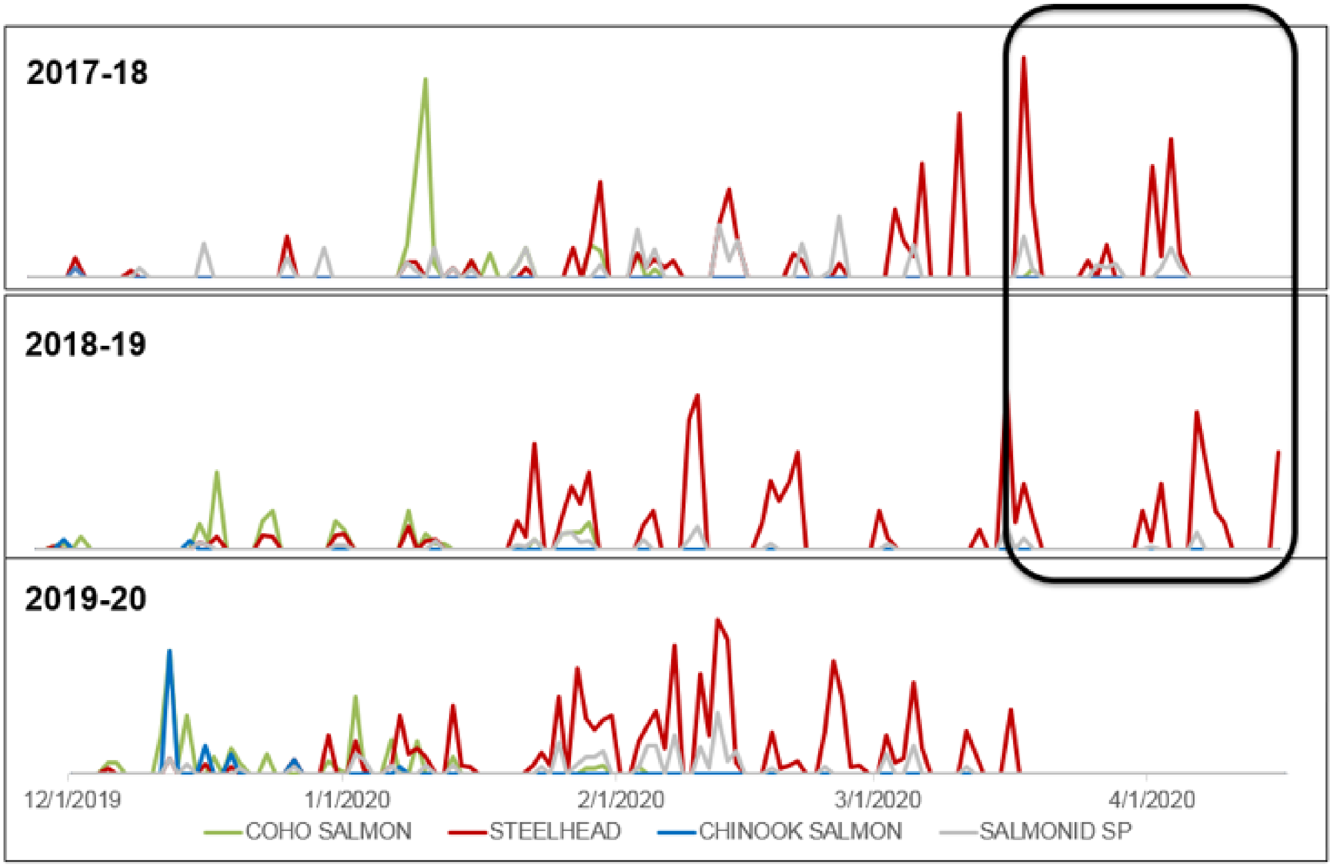

Figure 33. Salmonid redd observations in the Russian River, return winters 2017/18 through 2019/20

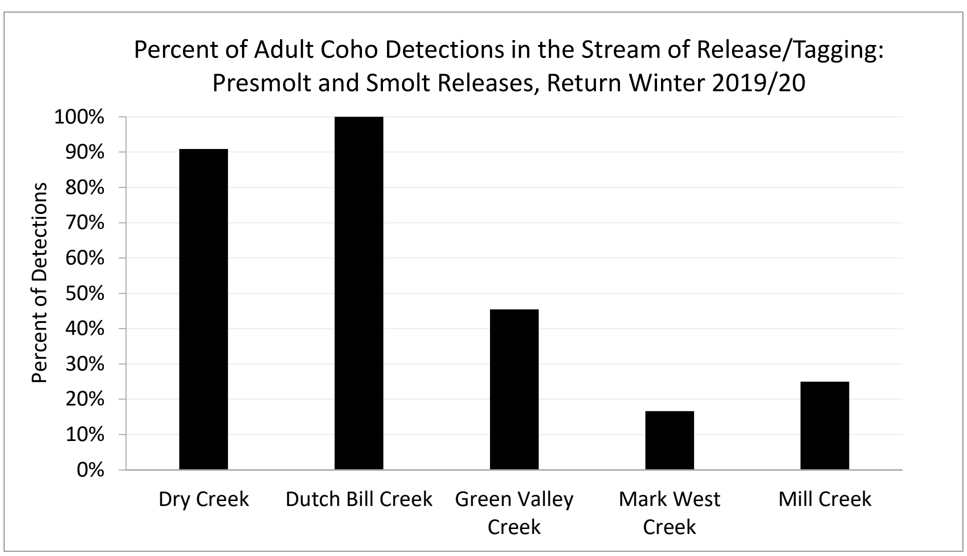

Figure 34. Percent of coho salmon adults detected returning to their stream of release or tagging for presmolt and smolt release groups returning during the winter of 2019/20.

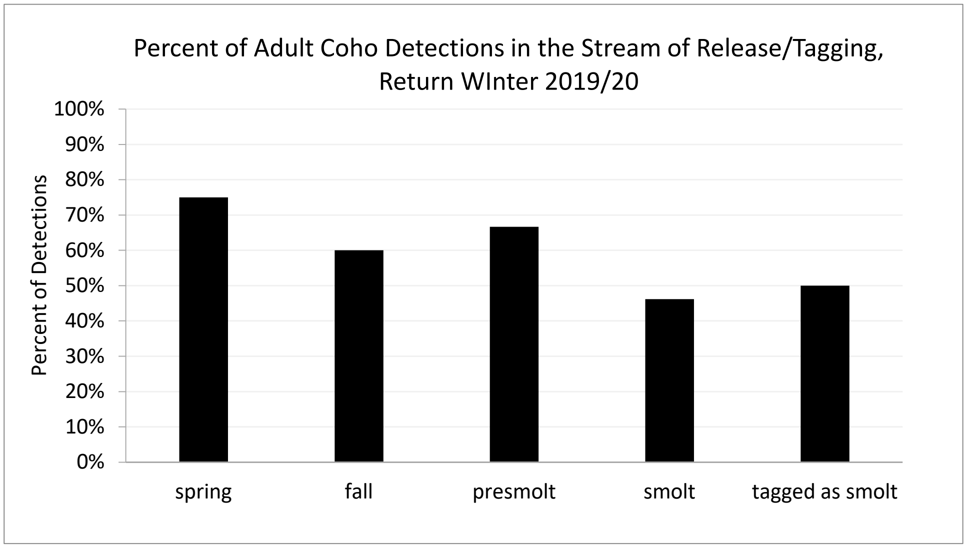

Figure 35. Percent of coho salmon adults detected returning to their stream of release or tagging: all release groups returning during the winter of 2019/20.

Table 12. Proportion of smolts released that returned as adults. Calculations are combined over 10 cohorts (hatch years 2008-2017) and release numbers and streams were not equal among years. The adult return rate was calculated by dividing the number of PIT-tagged adults detected returning by the total number of PIT-tagged fish released as smolts.

	February		March		April		May	
	Number of releases	*Adult return rate*	*Number of releases*	*Adult return rate*	*Number of releases*	*Adult return rate*	*Number of releases*	*Adult return rate*
Austin Creek	0	NA	1	0.20% (3/1,518)	0	NA	0	NA
Dry Creek	0	NA	8	0.27% (28/10,139)	8	0.42%(35/7,913)	7	0.34% (18/6,003)
Dutch Bill Creek	0	NA	0	NA	11	0.16% (7/3,795)	13	0.32% (16/4,492)
Green Valley Creek	1	0.52% (12/2,286)	4	0.41% (19/4,034)	8	0.38% (20/4,120)	13	0.19% (8/3,658)
Mark West Creek	0	NA	1	0.97% (5/514)	1	0.19% (1/515)	1	0.0% (0/513)
Mill Creek	0	NA	3	0.34% (12/4,278)	11	0.20% (18/7,046)	5	0.16% (3/1,752)
Palmer Creek	0	NA	1	0.10% (1/999)	2	0.10% (1/998)	0	NA
Russian River	0	NA	0	NA	1	0.44% (3/680)	2	0.07% (1/1,360)
Willow Creek	1	0.09% (1/1,144)	2	0.30% (7/2,340)	1	0.00% (0/1,797)	0	NA
Combined	***2***	***0.38% (13/3,430)***	***20***	***0.31% (75/23,822)***	***43***	***0.32% (85/26,864)***	***41***	***0.26% (46/17,778)***

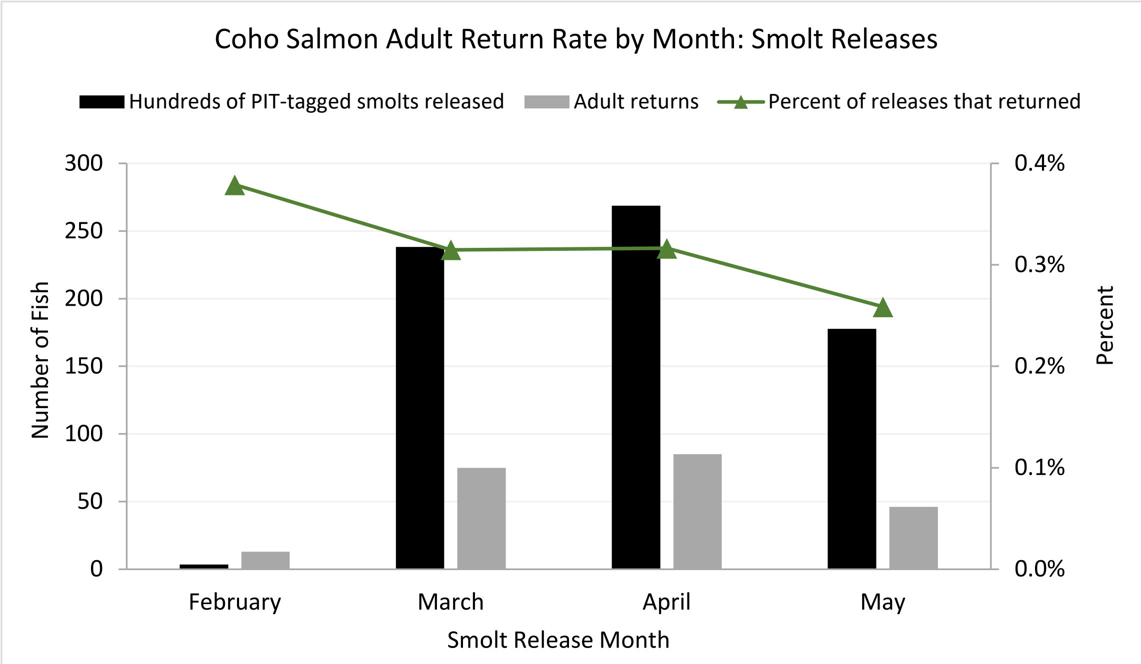

Figure 36. Adult return rates for smolt release groups released each month from February through May. Adult return rates were summed over 10 cohorts (hatch years 2008-2017) and were calculated by dividing the number of PIT-tagged adults detected returning by the total number of PIT-tagged fish released as smolts.

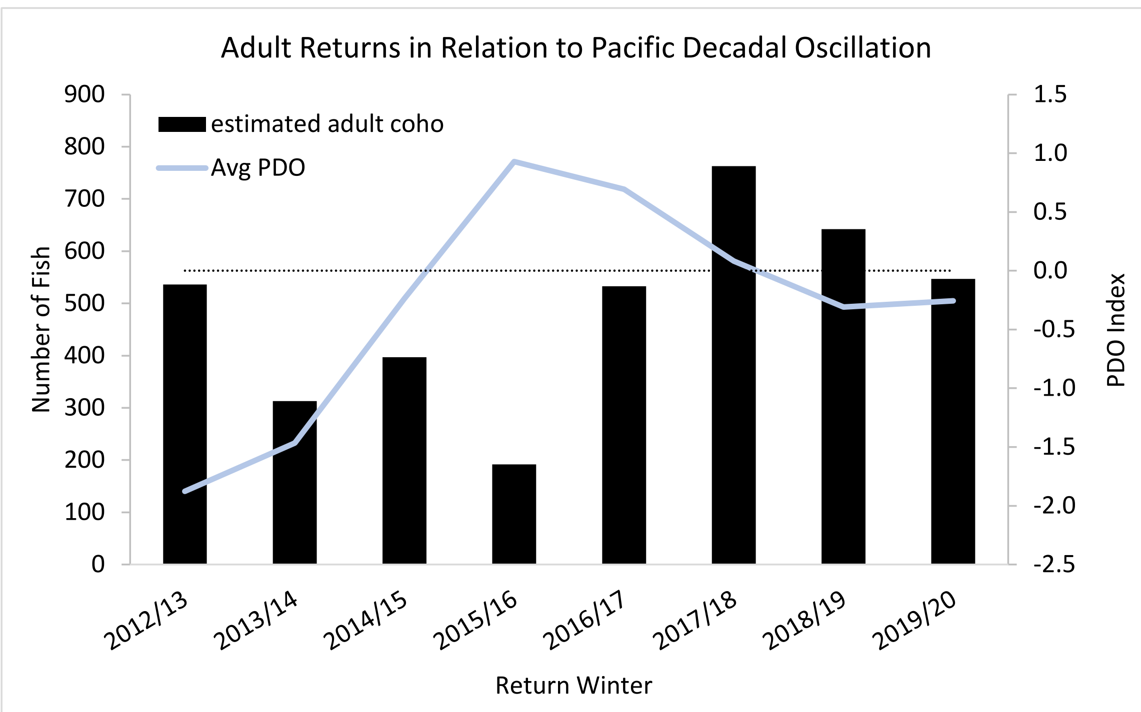

Figure 37. Annual estimated adult coho salmon returns to the Russian River in relation to average Pacific Decadal Oscillation (PDO) experienced by age-3 returns. PDO values below the zero line indicate a cool regime (potentially favorable conditions for salmon). PDO data was downloaded from a NOAA website: https://www.ncdc.noaa.gov/teleconnections/pdo/.

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