UC Coho Salmon and Steelhead Monitoring Report: Winter 2016/17

Steelhead adults in Pena Creek.

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Sea Grant California

Russian River Coho Salmon Monitoring Program

University of California

Contents

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 (UC) 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, UC 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, UC 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 40 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, 2016, through March 1, 2017, 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 2014 and 2015 (fish returning during the winter of 2016/17 as age-3 or age-2 adults, respectively) are shown in Table 2.

Field Methods

As part of the Broodstock Program monitoring effort, UC 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, 2016 through March 1, 2017, 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 UC and the Water Agency, including a 12-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%

[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, 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
2014	Willow Creek	spring	15,393	2,255	15%
2014	Willow Creek	presmolt	15,300	2,285	15%
2014	Sheephouse Creek	fall	3,066	455	15%
2014	Freezeout Creek	fall	3,051	456	15%
2014	Austin Creek	fall	10,102	1,547	15%
2014	East Austin Creek	fall	10,067	1,505	15%
2014	Black Rock Creek	spring	4,102	610	15%
2014	Gilliam Creek	spring	5,148	758	15%
2014	Thompson Creek	spring	2,102	309	15%
2014	Gray Creek	spring	6,080	906	15%
2014	Devil Creek	spring	4,053	606	15%
2014	Dutch Bill Creek	spring	1,009	1,009	100%
2014	Dutch Bill Creek	fall	12,164	1,821	15%
2014	Dutch Bill Creek	smolt	6,152	947	15%
2014	Green Valley Creek	spring	505	505	100%
2014	Green Valley Creek	fall	10,088	1,514	15%
2014	Green Valley Creek	presmolt	15,248	2,286	15%
2014	Green Valley Creek	smolt	6,154	927	15%
2014	Purrington Creek	fall	5,012	759	15%
2014	Mark West Creek	fall	15,127	2,273	15%
2014	Porter Creek	fall	8,084	1,212	15%
2014	Dry Creek	fall	5,110	2,769	54%
2014	Dry Creek	smolt	22,205	3,321	15%
2014	Mill Creek	spring	1,009	1,006	100%
2014	Mill Creek	fall	18,173	2,720	15%
2014	Mill Creek	smolt	10,512	1,567	15%
2014	Palmer Creek	spring	7,204	1,262	18%
2014	Grape Creek	fall	3,012	455	15%
2014	Pena Creek	fall	10,095	1,511	15%
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%

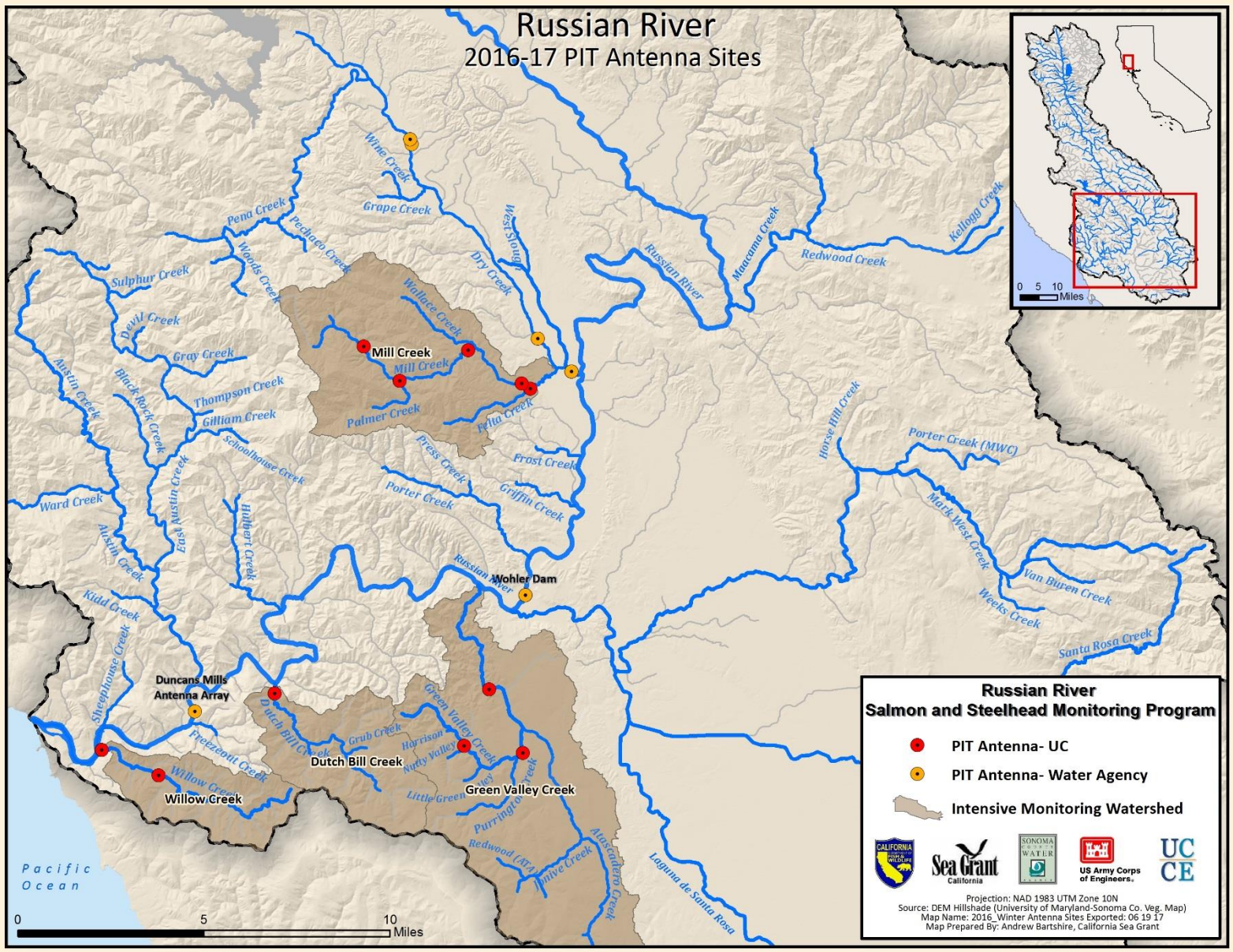

Figure 1. Passive Integrated Transponder detection system antenna locations in the Russian River watershed, winter 2016/17.

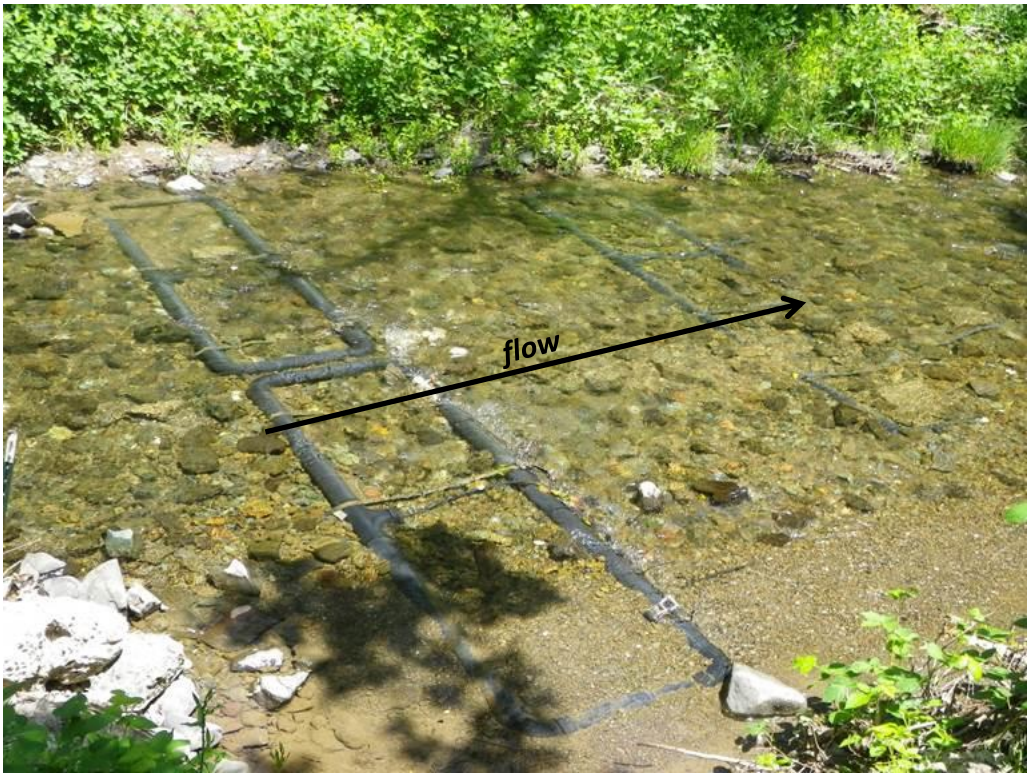

Figure 2. Paired flat-plate antenna array on Mill Creek at spring base flows.

Data Analysis

First, all records of two- and three-year old PIT-tagged coho salmon detected on antenna arrays between September 15, 2016 and March 1, 2017 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 between September 15, 2016 and March 1, 2017 of each returning PIT-tagged hatchery adult coho salmon was plotted with streamflow or stage data from the nearest available streamflow gauge 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 2015/16 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 2015/16 and three-year old hatchery adults returning during the winter of 2016/17 was divided by the estimated number of hatchery smolts migrating from each stream between March 1 and June 30 of 2015 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

With precipitation beginning in October 2016 and continuing throughout the spawning season, the winter of 2016/17 was one the wettest winters in recent years (Figure 3). The majority of the adults returning to the Russian River passed the Duncans Mills antenna array in October and November of 2016 with an additional pulse in early January (Figure 4). Severe January storms caused damage to the Duncans Mills array and it ceased to operate after January 10, 2017. Entry of adults into the tributaries was slightly later, ranging from late-October through late-January or mid-February, depending on the tributary (Figure 5 - Figure 8). Although adults were detected throughout these timeframes, an early-December peak was apparent in some streams (Figure 5 - Figure 8).

Adult Return Estimates

The estimated numbers of adult hatchery coho salmon returning to Willow, Dutch Bill, Green Valley, and Mill creeks were 25, 70, 110, and 136, respectively (Table 3 - Table 6), and the estimated number returning to the Russian River Basin was 533 (Table 7). Age-3 and age-2 adults were detected in all four tributaries and at Duncans Mills, and a single age-4 adult was detected at Duncans Mills (Table 3 - Table 7). With the exception of Willow Creek, straying was documented in each tributary (Table 3 - Table 6). Dutch Bill Creek had strays from the greatest number of release streams, including Willow, Freezeout, Green Valley, Dry, Mill, and Pena creeks (Table 4).

Estimated adult returns during the winter of 2016/17 were higher than the previous two years in the four Broodstock Program monitoring tributaries and to the Russian River at Duncans Mills (Figure 9 - Figure 13). In Dutch Bill and Green Valley creeks, 2016/17 returns were the highest observed since PIT tag monitoring began in 2013/14 and 2012/13, respectively (Figure 10, Figure 11). In Willow and Mill creeks, 2016/17 returns were similar to the highest recorded return years in 2013/14 and 2010/11, respectively (Figure 9, Figure 12).

The proportion of age-2 adults (jacks) returning was lower than in most years of data collection both in the tributaries and at Duncans Mills, ranging from 19% to 22% (Figure 9 -Figure 12, Figure 14).

Smolt to Adult Return (SAR) Ratio

Overall, SAR ratios were generally low, and ranged from zero to 2.7 percent over all of the streams and years we have sampled (Figure 15 - Figure 17). For the 2014 cohort that returned as three-year olds during the winter of 2016/17, SAR estimates were similar in Dutch Bill and Mill creeks (0.8% and 0.6%, respectively) and higher in Willow Creek at 2.7% (Figure 15 - Figure 17). The SAR ratio for the 2014 cohort in Green Valley Creek was 0.5%. Because traps were not operated between 2011 and 2014 on Green Valley Creek, SAR ratios could not be estimated for previous years in that creek.

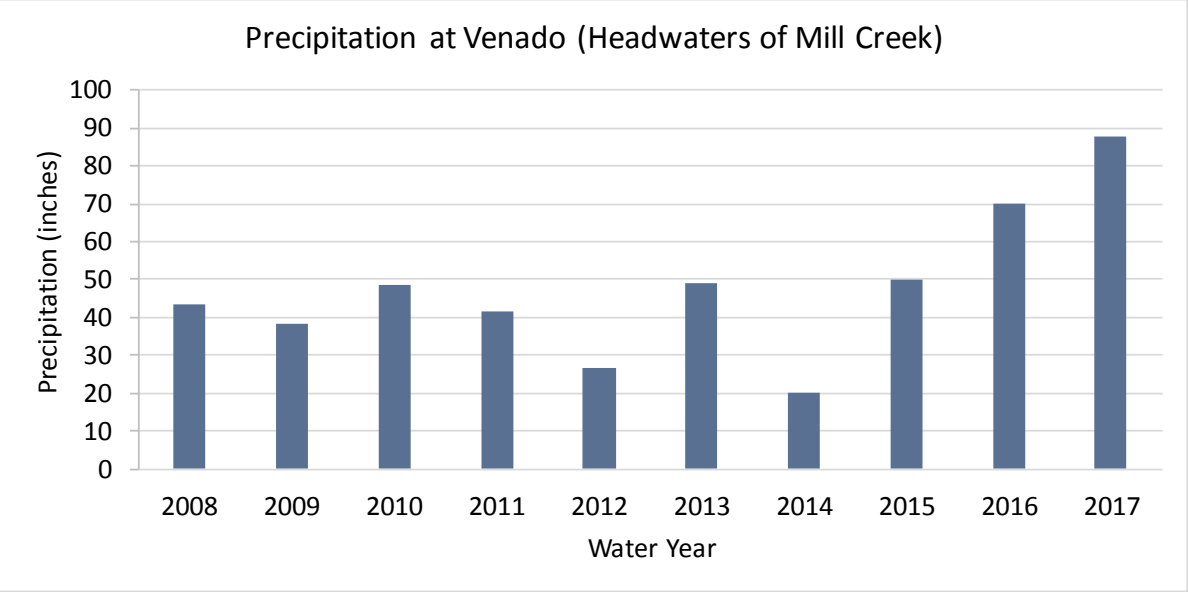

Figure 3. Precipitation at Venado gauge near Mill Creek headwaters. data downloaded from NOAA website: www.ncdc.noaa.gov/cdo-web.

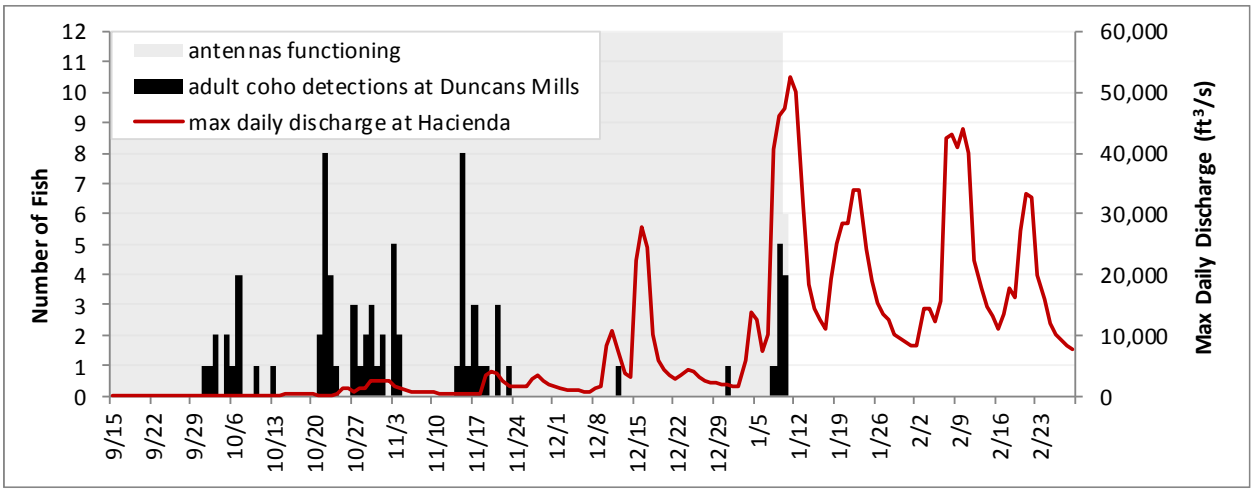

Figure 4. Detections of PIT-tagged coho salmon adults passing upstream of the Duncans Mills antenna array, September 15, 2016 - March 1, 2017. Discharge data downloaded from USGS website: http://waterdata.usgs.gov.

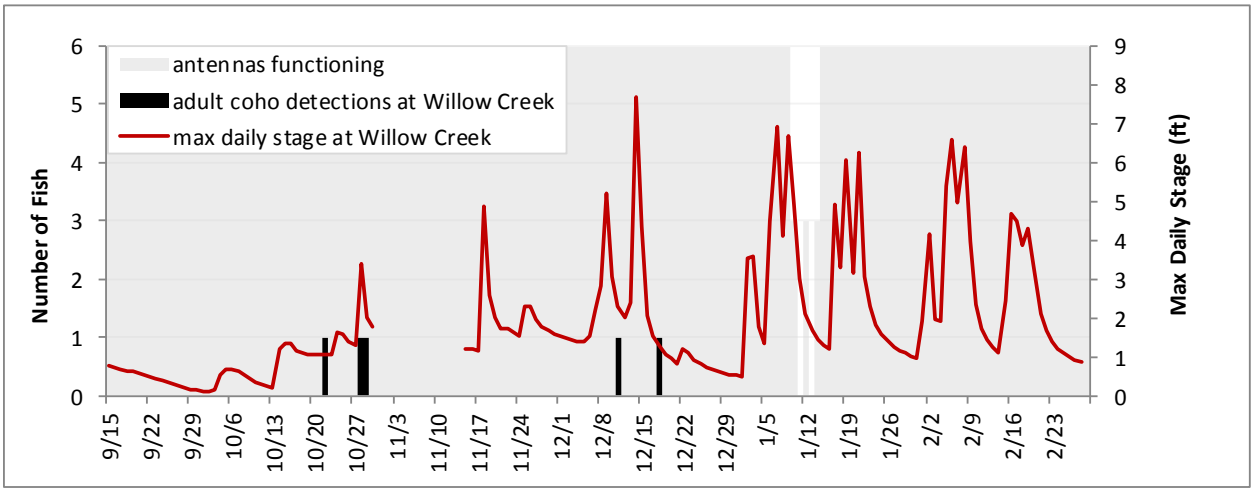

Figure 5. Detections of PIT-tagged coho salmon adults passing upstream of the Willow Creek antenna array, September 15, 2016 - March 1, 2017. Stage data provided by NOAA.

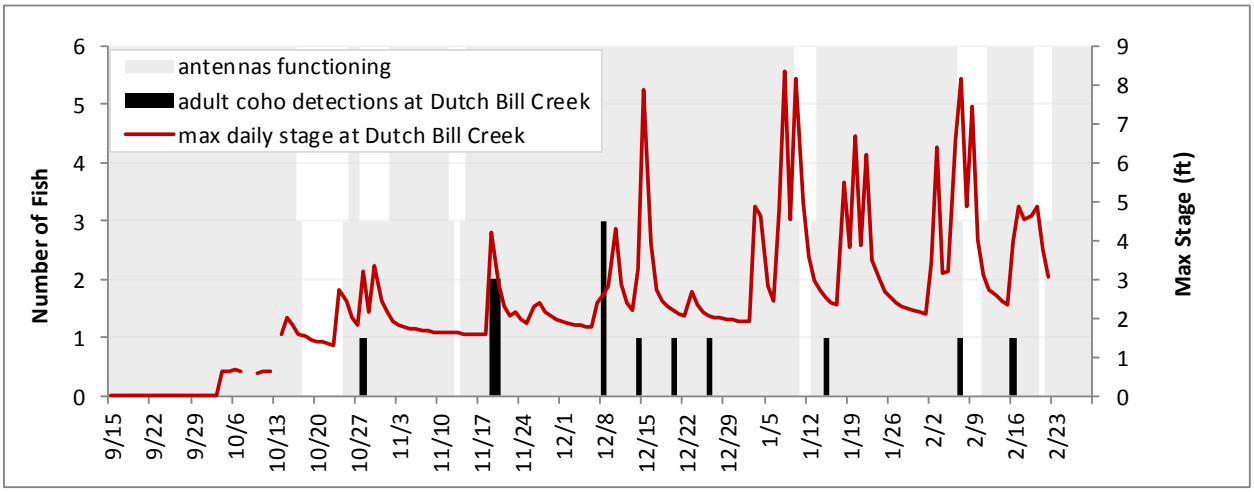

Figure 6. Detections of PIT-tagged coho salmon adults passing upstream of the Dutch Bill Creek antenna array, September 15, 2016 - March 1, 2017. Stage data provided by NOAA.

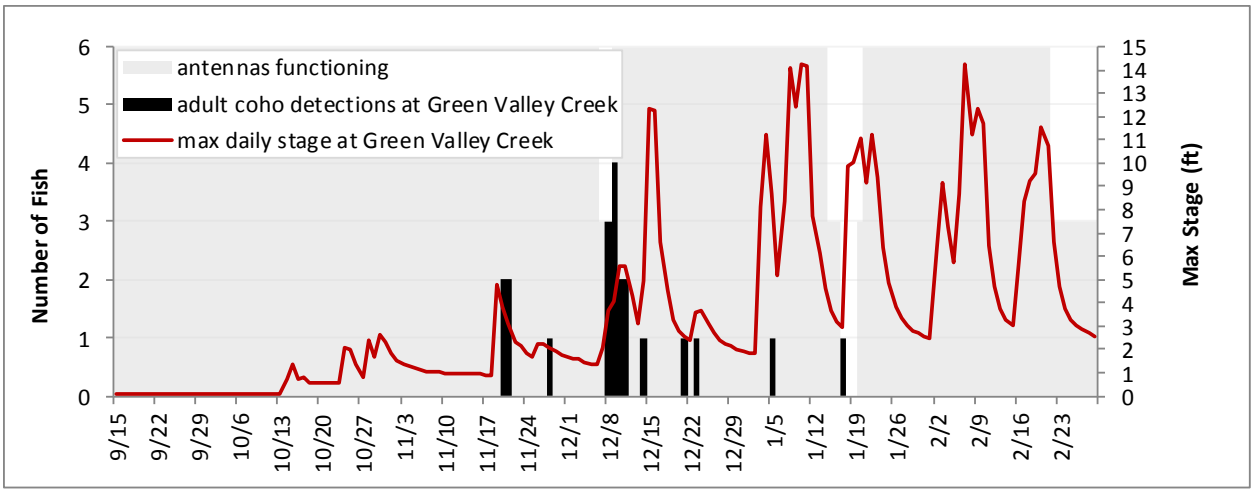

Figure 7. Detections of PIT-tagged coho salmon adults passing upstream of the Green Valley Creek antenna array, September 15, 2016 - March 1, 2017. Stage data collected by CA Sea Grant.

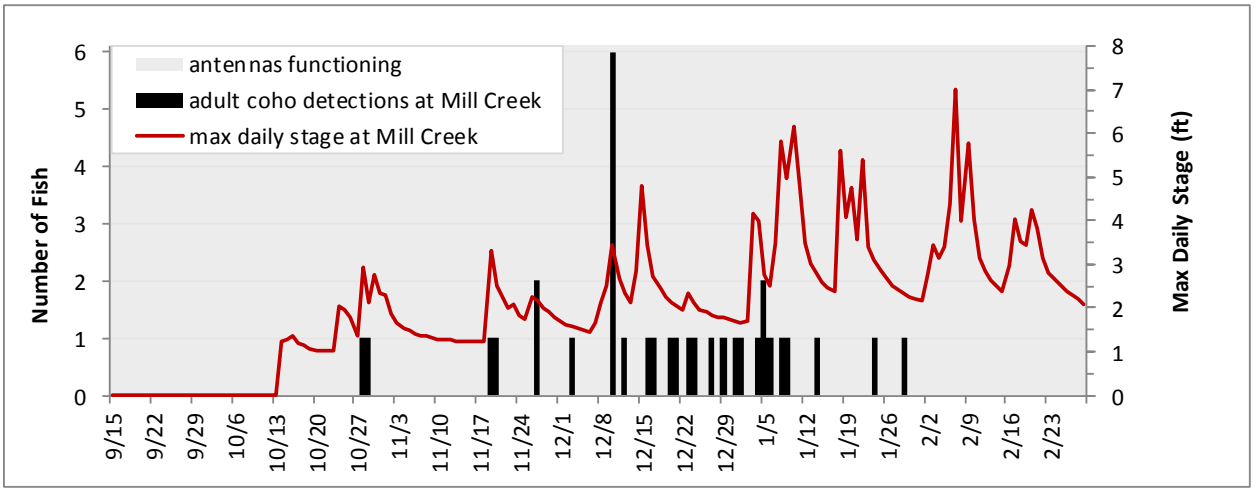

Figure 8. Detections of PIT-tagged coho salmon adults passing upstream of the Mill Creek antenna array, September 15, 2016 - March 1, 2017. Stage data was provided by Trout Unlimited.

Table 3. Minimum, expanded, and estimated counts of adult coho salmon returning to Willow Creek between September 15, 2016 and March 1, 2017. 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	presmolt	2	15%	13.4	100%	13.4
3	Willow Creek	hatchery	spring	1	15%	6.8	100%	6.8
2	Willow Creek	hatchery	fall	1	30%	3.3	100%	3.3
2	Willow Creek	natural	tagged at smolt trap	1	52%	1.9	100%	1.9
							Estimated hatchery adult returns (age-3):	20
							Estimated hatchery adult returns (age-2):	3
							Estimated natural-origin adult returns (age-3):	0
							Estimated natural-origin adult returns (age-2):	2
							Total estimated adult returns:	**25**

Table 4. Minimum, expanded, and estimated counts of adult coho salmon returning to Dutch Bill Creek between September 15, 2016 and March 1, 2017. 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	Dry Creek	hatchery	smolt	1	15%	6.7	100%	6.7
3	Dutch Bill Creek	hatchery	fall	1	15%	6.7	100%	6.7
3	Dutch Bill Creek	hatchery	spring	1	100%	1.0	100%	1.0
3	Dutch Bill Creek	hatchery	smolt	1	15%	6.5	100%	6.5
3	Freezeout Creek	hatchery	fall	1	15%	6.7	100%	6.7
3	Mill Creek	hatchery	smolt	1	15%	6.7	100%	6.7
3	Pena Creek	hatchery	fall	1	15%	6.7	100%	6.7
3	Willow Creek	hatchery	presmolt	2	15%	13.4	100%	13.4
2	Dry Creek	hatchery	smolt	1	30%	3.3	100%	3.3
2	Dutch Bill Creek	hatchery	smolt	2	30%	6.6	100%	6.6
2	Green Valley Creek	hatchery	fall	1	30%	3.3	100%	3.3
2	Willow Creek	natural	tagged at smolt trap	1	52%	1.9	100%	1.9
							Estimated hatchery adult returns (age-3):	54
							Estimated hatchery adult returns (age-2):	13
							Estimated natural-origin adult returns (age-3):	0
							Estimated natural-origin adult returns (age-2):	2
							Total estimated adult returns:	**70**

Table 5. Minimum, expanded, and estimated counts of adult coho salmon returning to Green Valley 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	Dry Creek	hatchery	fall	1	54%	1.8	88%	2.1
3	Dry Creek	hatchery	smolt	2	15%	13.4	88%	15.2
3	Green Valley Creek	hatchery	presmolt	6	15%	40.0	88%	45.4
3	Green Valley Creek	hatchery	smolt	2	15%	13.3	88%	15.0
3	Willow Creek	hatchery	presmolt	1	15%	6.7	88%	7.6
2	Green Valley Creek	hatchery	fall	4	30%	13.2	88%	15.0
2	Green Valley Creek	hatchery	smolt	2	31%	6.5	88%	7.4
3	Green Valley Creek	natural	tagged at smolt trap	1	52%	1.9	88%	2.2
							Estimated hatchery adult returns (age-3):	85
							Estimated hatchery adult returns (age-2):	22
							Estimated natural-origin adult returns (age-3):	2.2
							Estimated natural-origin adult returns (age-2):	0
							Total estimated adult returns:	**110**

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	Dry Creek	hatchery	fall	1	54%	1.8	100%	1.8
3	Dry Creek	hatchery	smolt	8	15%	53.5	100%	53.5
3	Green Valley Creek	hatchery	presmolt	2	15%	13.3	100%	13.3
3	Green Valley Creek	hatchery	smolt	1	15%	6.6	100%	6.6
3	Mill Creek	hatchery	fall	3	15%	20.0	100%	20.0
3	Mill Creek	hatchery	smolt	1	15%	6.7	100%	6.7
2	Dry Creek	hatchery	smolt	2	30%	6.6	100%	6.6
2	Green Valley Creek	hatchery	fall	1	30%	3.3	100%	3.3
2	Green Valley Creek	hatchery	smolt	1	31%	3.3	100%	3.3
2	Mill Creek	hatchery	fall	5	30%	16.6	100%	16.6
2	Green Valley Creek	natural	tagged at smolt trap	2	52%	3.8	100%	3.8
							Estimated hatchery adult returns (age-3):	102
							Estimated hatchery adult returns (age-2):	30
							Estimated natural-origin adult returns (age-3):	0
							Estimated natural-origin adult returns (age-2):	4
							Total estimated adult returns:	**136**

Table 7. Minimum, expanded, and estimated counts of adult coho salmon returning to the Russian River mainstem at Duncans Mills between September 15, 2016 and March 1, 2017. Minimum count= number unique PIT tag detectios on lower antenna array; expanded count= minimum count/percent PIT-tagged; estimated count= expanded count/estimated antenna efficiency. Note that the Willow Creek and Duncans Mills estimates were summed 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
4	Austin Creek	smolt	1	15%	1.0	69%	1.0
3	Austin Creek	fall	1	15%	6.5	69%	9.4
3	Dry Creek	fall	4	54%	7.4	69%	10.6
3	Dry Creek	smolt	13	15%	86.9	69%	125.4
3	Dutch Bill Creek	spring	1	100%	1.0	69%	1.4
3	Dutch Bill Creek	smolt	4	15%	26.0	69%	37.5
3	East Austin Creek	fall	1	15%	6.7	69%	9.6
3	Grape Creek	fall	1	15%	6.6	69%	9.5
3	Green Valley Creek	presmolt	5	15%	33.4	69%	48.1
3	Green Valley Creek	smolt	1	15%	6.6	69%	9.6
3	Mark West Creek	fall	1	15%	6.7	69%	9.6
3	Mill Creek	fall	3	15%	20.0	69%	28.9
3	Mill Creek	smolt	4	15%	26.8	69%	38.7
3	Pena Creek	fall	4	15%	26.7	69%	38.5
3	Willow Creek	presmolt	5	15%	33.5	69%	48.3
2	Dry Creek	smolt	4	30%	13.1	69%	19.0
2	Dutch Bill Creek	smolt	2	30%	6.6	69%	9.6
2	Gray Creek	fall	1	30%	3.3	69%	4.8
2	Green Valley Creek	fall	4	30%	13.2	69%	19.1
2	Green Valley Creek	smolt	3	31%	9.8	69%	14.1
2	Mill Creek	fall	4	30%	13.3	69%	19.1
2	Mill Creek	smolt	2	31%	6.4	69%	9.2
2	Willow Creek	fall	1	30%	3.3	69%	4.8

Estimated adults passing Duncans Mills (age-4) [1]*:*	1
Estimated adults passing Duncans Mills (age-3):	425
Estimated adults passing Duncans Mills (age-2):	100
Estimated adults returning to Willow Creek that were not detected at Duncans Mills (age-3):	7
Total estimated hatchery adult returns:	**533**

[1] *Because age-4 returns are an anomaly, we did not expand to the proportion PIT-tagged for this fish.*

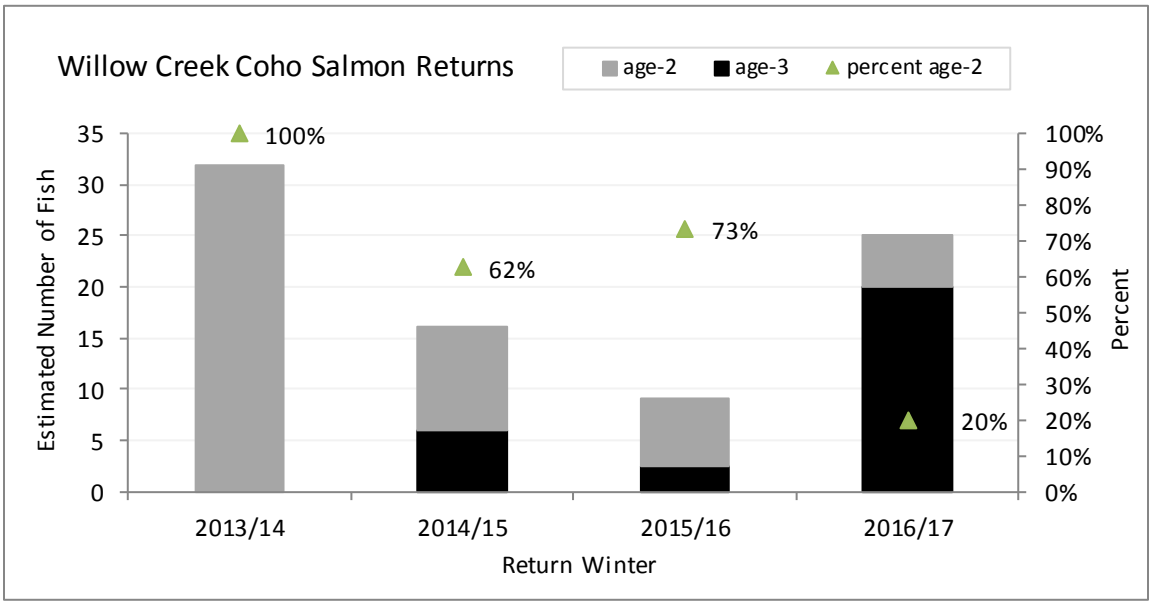

Figure 9. Estimated annual Willow Creek adult hatchery coho salmon returns by age, return seasons 2013-14 – 2016/17.

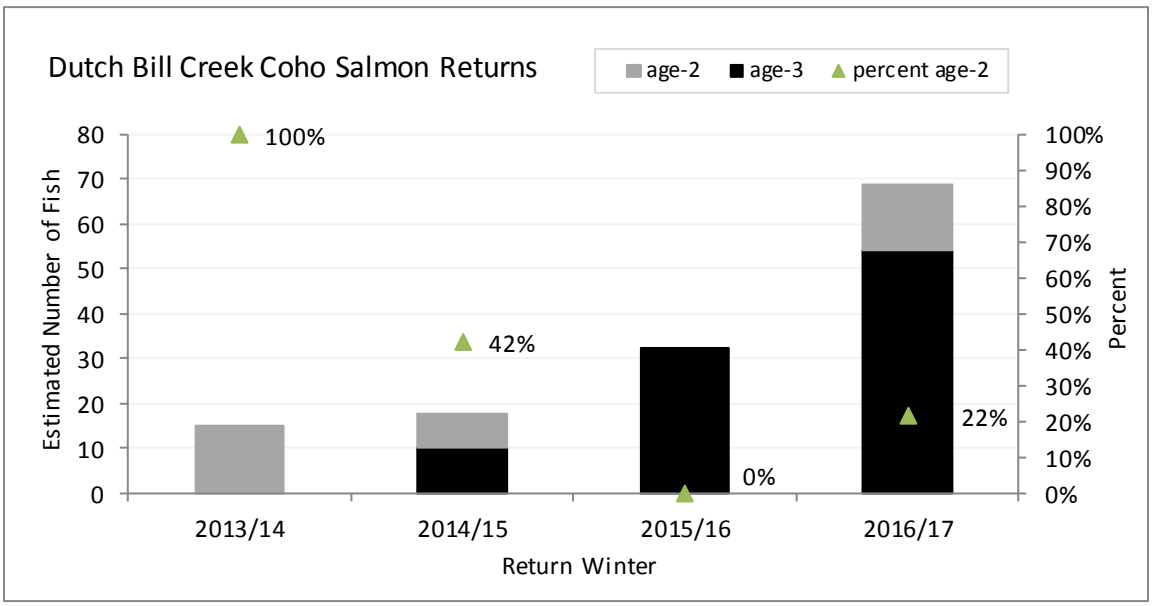

Figure 10. Estimated annual Dutch Bill Creek adult hatchery coho salmon returns by age, return seasons 2013/14 – 2016/17.

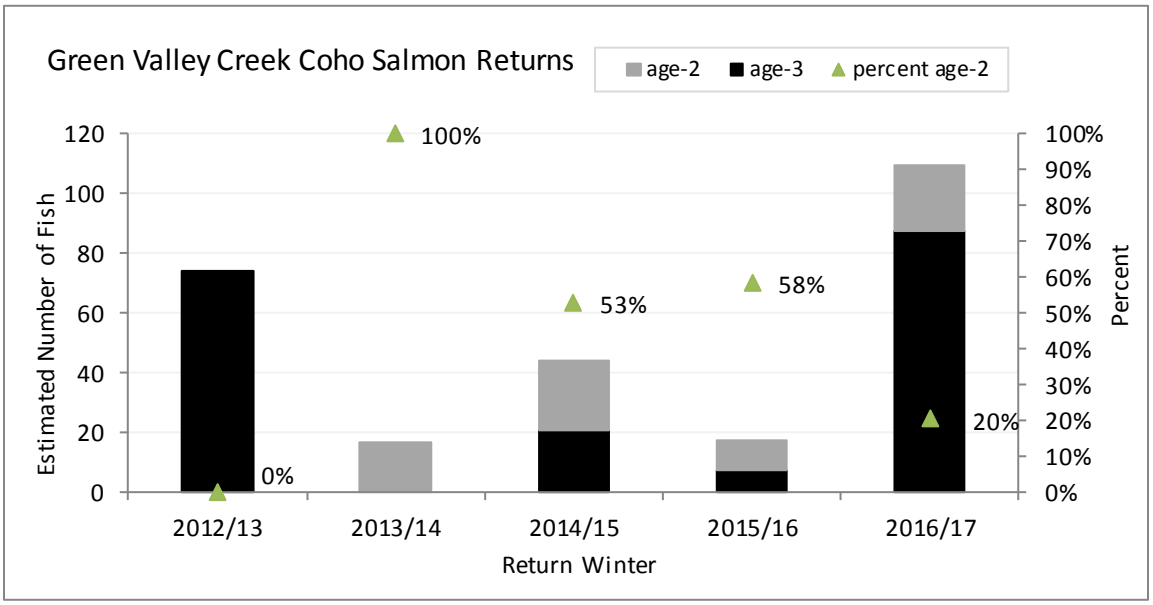

Figure 11. Estimated annual Green Valley Creek adult hatchery coho salmon returns by age, return seasons 2012/13 – 2016/17.

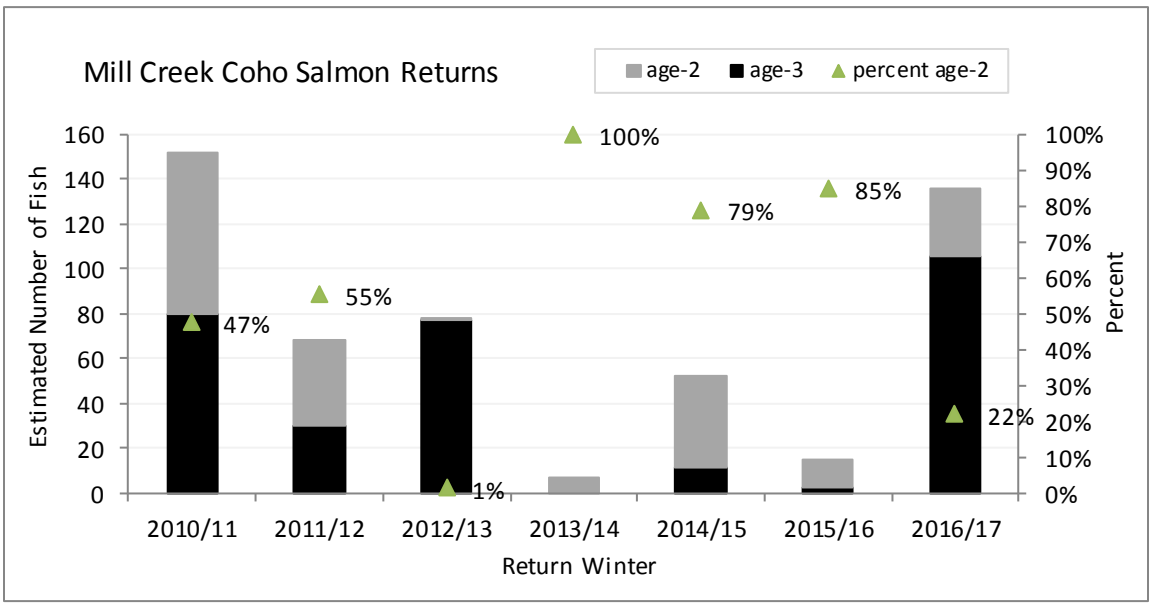

Figure 12. Estimated annual Mill Creek adult hatchery coho salmon returns by age, return seasons 2010/11 – 2016/17.

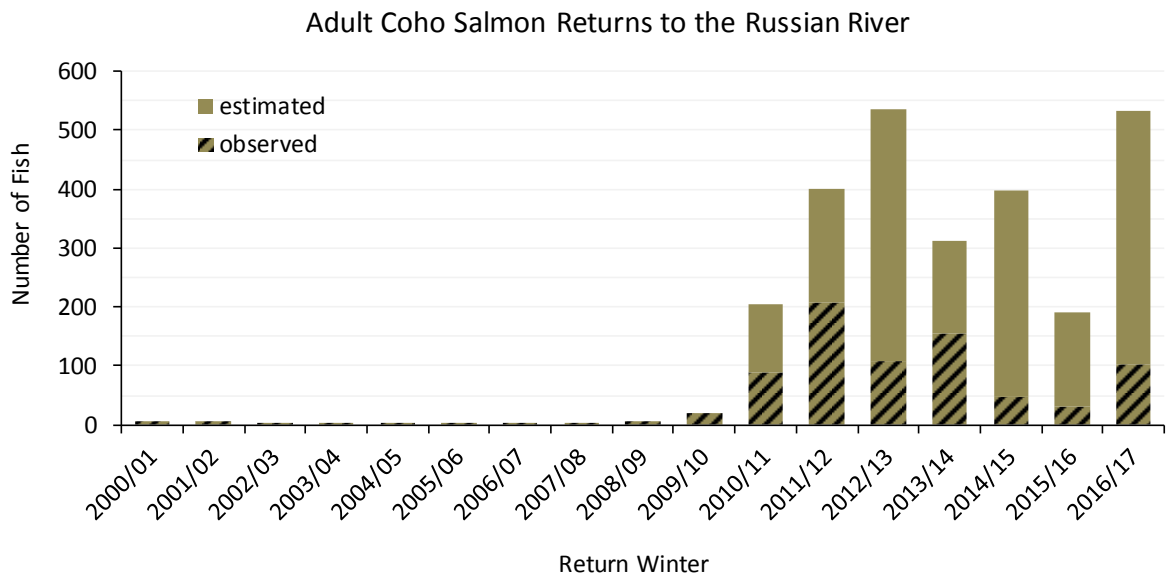

Figure 13. Estimated annual adult hatchery coho salmon returns to the Russian River, return seasons 2000/01-2016/17. Note that methods for counting/estimating the number of returning adult coho salmon were not consistent among years; prior to 2009/10, spawner surveys were the primary method, from 2009/10 – 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.

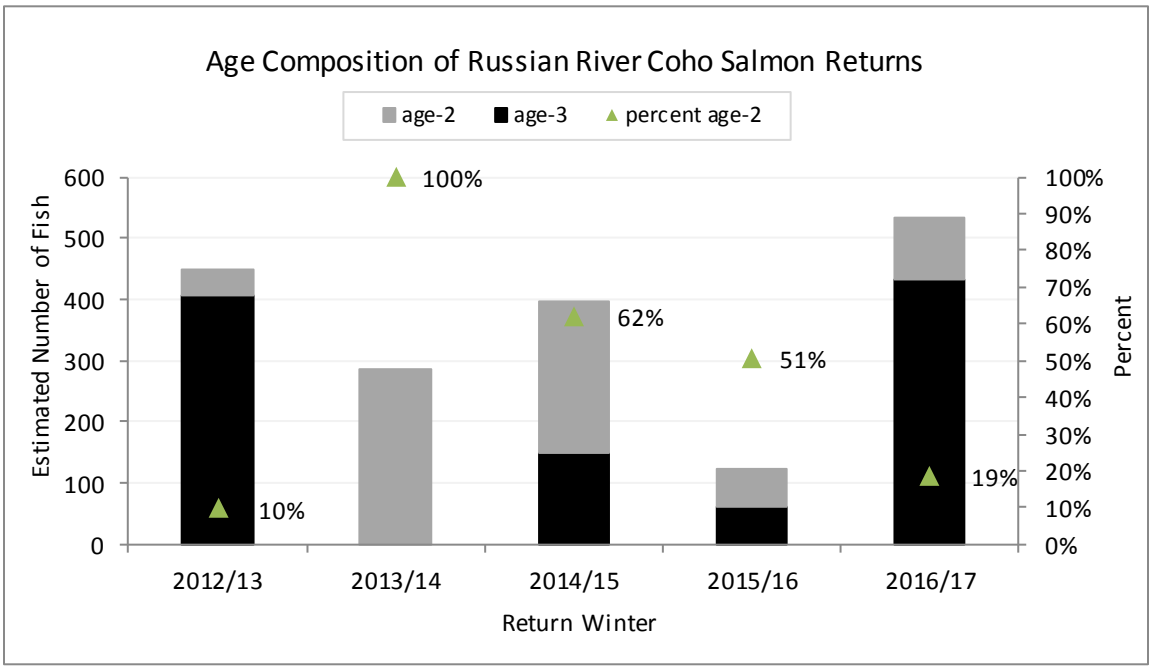

Figure 14. Estimated annual Russian River adult hatchery coho salmon returns by age, return seasons 2012/13-2016/17. Note that this figure includes only fish that we were able to age; therefore, totals will be less than adult return estimates shown in Figure 13.

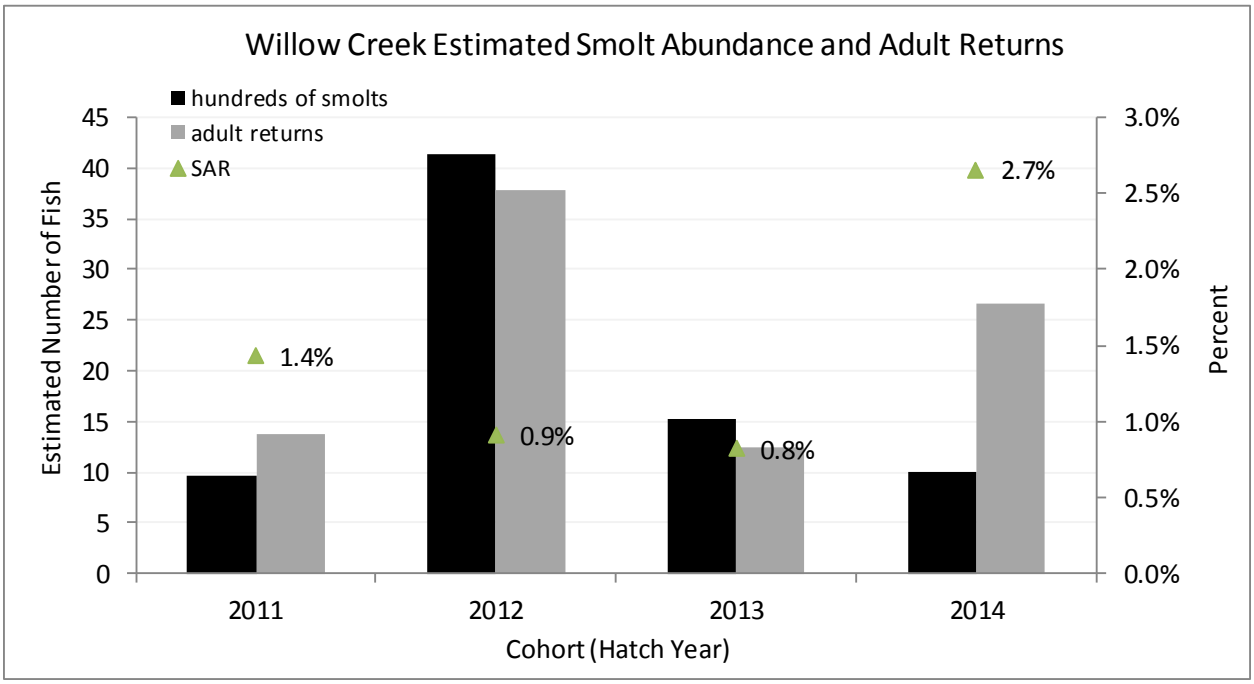

Figure 15. Estimated coho salmon smolt abundance, adult returns and smolt to adult (SAR) survival ratios in Willow Creek, cohorts 2011-2014.

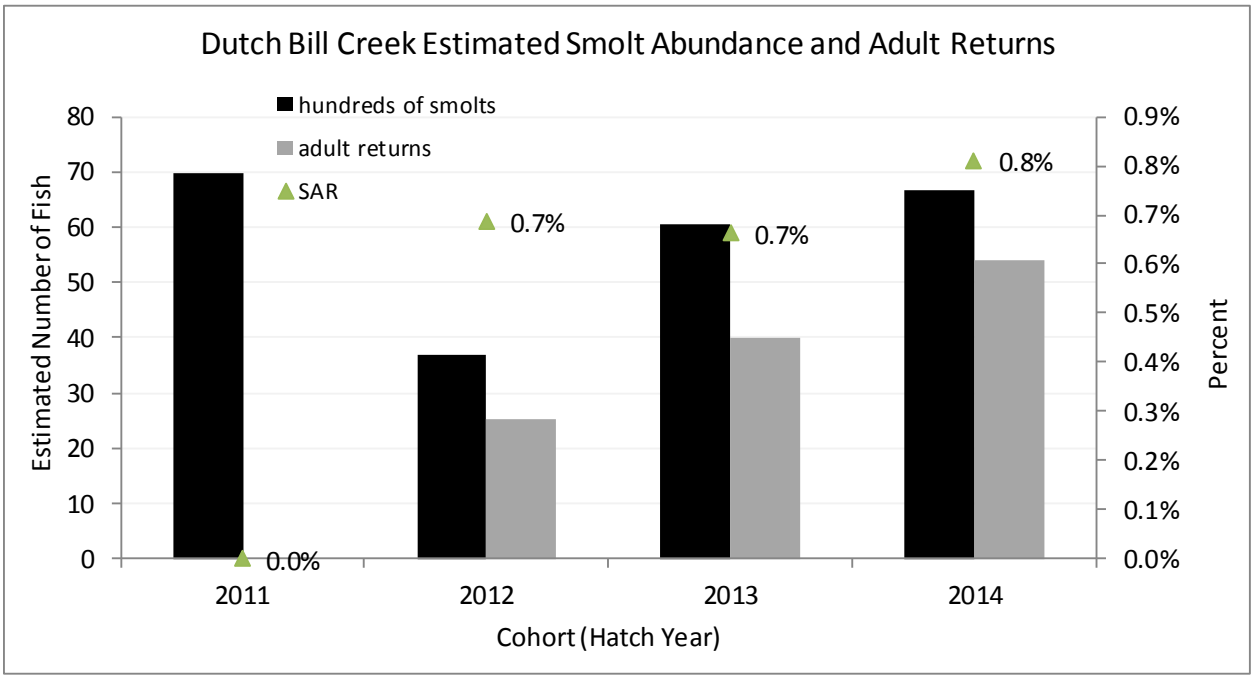

Figure 16. Estimated coho salmon smolt abundance, adult returns and smolt to adult (SAR) survival ratios in Dutch Bill Creek, cohorts 2011-2013.

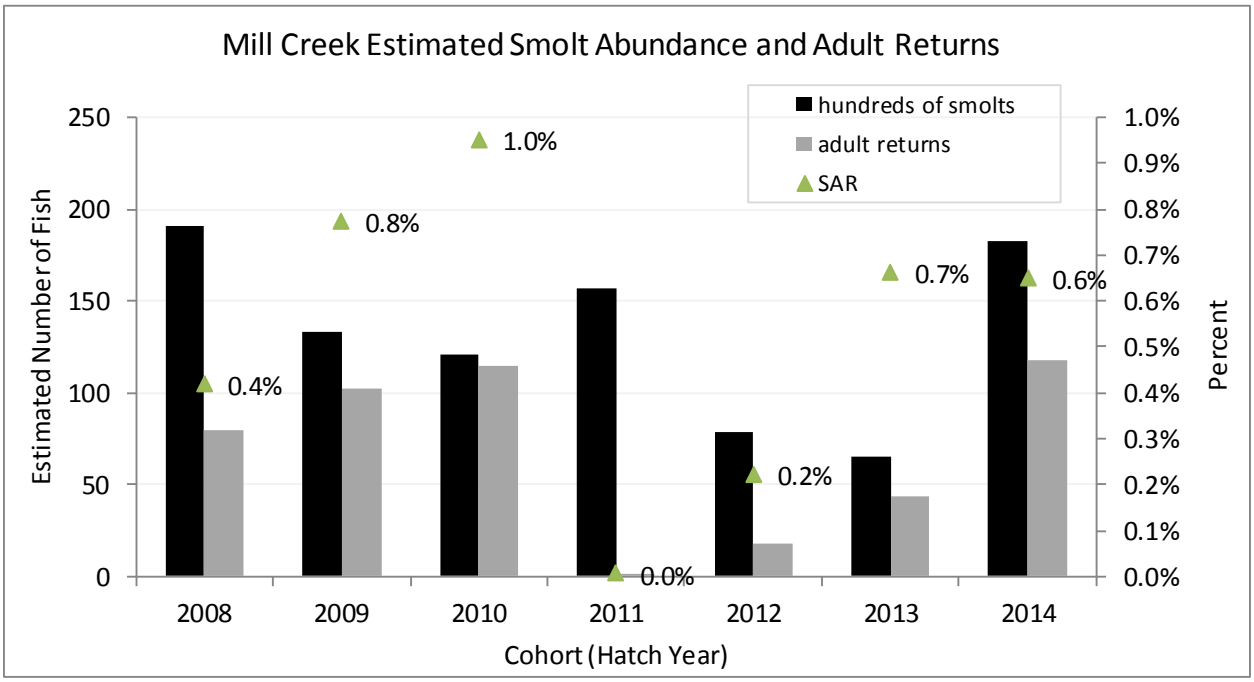

Figure 17. Estimated coho salmon smolt abundance, adult returns and smolt to adult (SAR) survival ratios in Mill Creek, cohorts 2008-2013.

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 the hatchery and throughout other streams in the Russian River basin. Surveys were conducted in four release streams for the Broodstock Program monitoring effort. For CMP monitoring, surveys were completed in a subsample of stream reaches in the Russian River adult coho sample frame (a sample frame of stream reaches identified by the Russian River CMP Technical Advisory Committee[1] as having adult coho habitat). Surveys were conducted in coordination with the Water Agency using standardized methods (SCWA and UC 2015).

Methods

Sampling framework

For Broodstock Program monitoring, we surveyed adult spawning reaches of Willow, Dutch Bill, Green Valley, and Mill creeks, and CMP *life cycle* monitoring was conducted in tributaries of Dry Creek. For CMP *basinwide* monitoring, we soft-stratified the basin-wide sample frame to include only those reaches containing coho salmon habitat and then used generalized random tessellation stratified (GRTS) sampling as outlined in Fish Bulletin 180 (Adams et al. 2011) to obtain a spatially-balanced random sample from 86 reaches comprising the Russian River adult coho salmon sample frame (Figure 18). Our target sampling effort was 25% (22) of the reaches in the coho salmon sample frame (SCWA and UC 2014).

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 19). 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 20), 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.

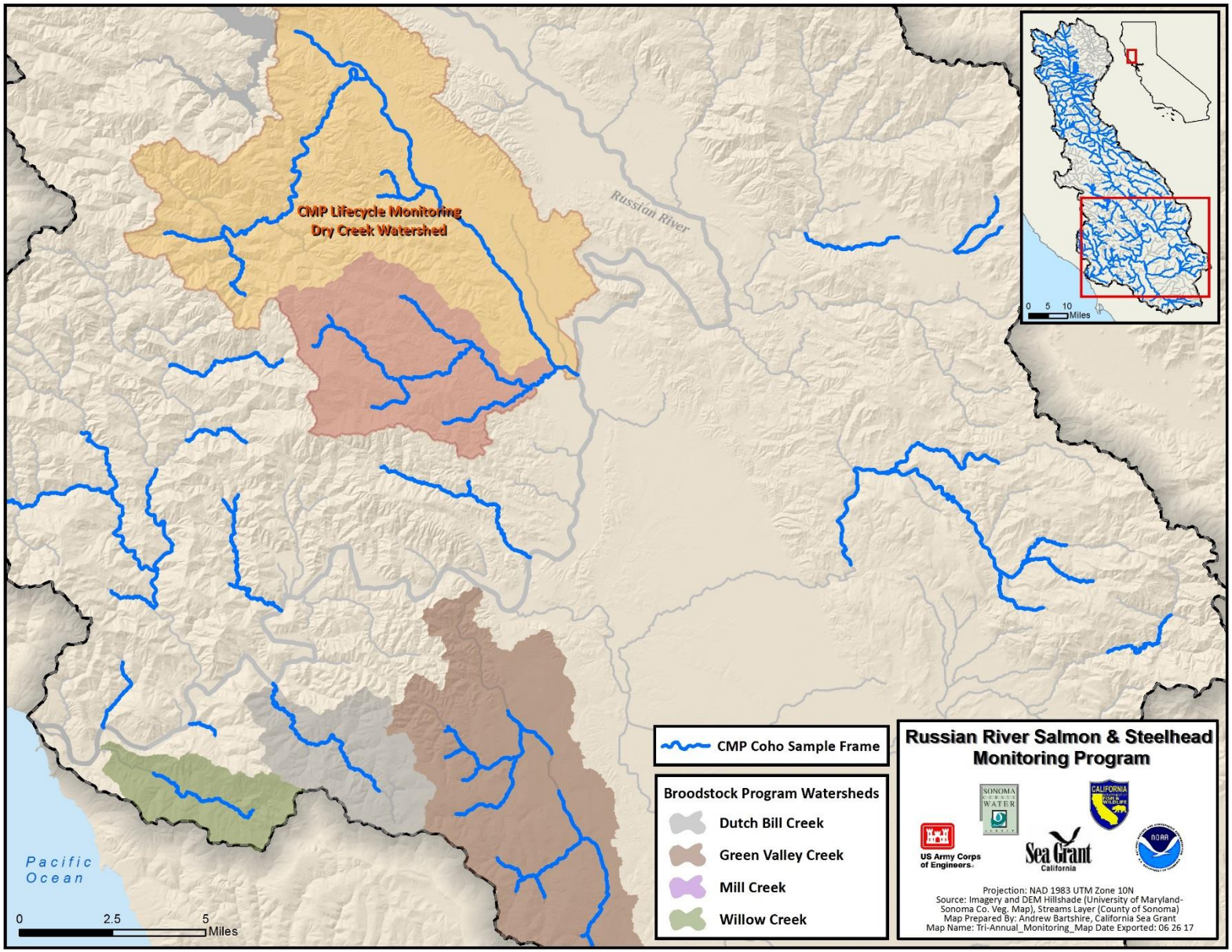

Figure 18. Broodstock Program watersheds and CMP sample frame for 2016-2017 spawner survey in the Russian River.

Figure 19. A spawner crew member measures a redd in Willow Creek (photo credit: Joshua Asel).

Figure 20. A pair of adult coho salmon observed in Mill Creek during 2016/17 spawner surveys.

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 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 reaches within the adult coho sample frame. For Broodstock Program stream and basinwide estimates, redd estimates were then multiplied by a literature-based spawner to redd ratio of 2.33 for coho salmon and 1.22 for steelhead (Gallagher et al. 2010) to estimate the total number of adult spawners.

Results

Surveys began when streams became reconnected to the Russian River mainstem and accessible to adult salmon in mid-October, 2016, and continued through mid-April, 2017. During this time, UC and Water Agency biologists completed a total of 664 salmonid spawning ground surveys on 47 reaches (55% of coho sample frame) in 34 streams within the Russian River basin. A total of 404 salmonid redds were observed: 75 coho salmon redds, 197 steelhead redds, 68 Chinook salmon redds, and 64 redds of unknown salmonid species origin (Table 8). Additionally, coho salmon adults were observed in six streams where no confirmed coho redds were observed, including Austin, Freezeout, Nutty Valley, Palmer, Redwood, and Sheephouse creeks (Figure 21), and steelhead adults were observed in Palmer Creek where no confirmed steelhead redds were observed (Figure 22). Of the 34 streams surveyed during the winter of 2016/17, coho salmon redds and/or adults were observed in 23 streams (68%), steelhead redds and/or adults were observed in 22 streams (65%), and Chinook salmon redds and/or adults were observed in three streams (9%) (Table 8, Figure 21, Figure 22).

Over all streams combined, timing of redds varied by species, with Chinook salmon redd observations peaking in late-November, coho salmon observations peaking in mid-December, and steelhead observations peaking in March and April (Figure 23). Steelhead redds were observed over the widest timeframe, ranging from early November through mid-April (Figure 23). Although surveys ended in mid-April, steelhead were observed spawning into early May in streams where other monitoring activities occurred (UC unpublished data).

Coho salmon redd estimates in Broodstock Program monitoring streams ranged from seven in Dutch Bill Creek to 23 in Green Valley Creek, and steelhead redd estimates ranged from three in Willow and Green Valley creeks to 37 in Mill Creek (Table 9). 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 3.13 in Willow Creek to 10.0 in Dutch Bill Creek (Table 9).

Basinwide, we estimated a total of 211 coho salmon redds and 600 steelheads redds in the coho sample frame (Figure 18, Table 10). Basinwide adult spawner estimates were 492 coho salmon and 732 steelhead (Table 10).

When compared with previous years, coho salmon redd estimates were higher than in previous years in Green Valley and Mill creeks, and average for Willow and Dutch Bill creeks (Figure 24, Table 11). Steelhead redd estimates were lower than in previous years in all but Dutch Bill Creek (Figure 25, Table 11); however, the spawner survey season for 2016/17 ended prior to completion of the steelhead spawning season and is likely biased low (UC unpublished data).

The proportion of natural to hatchery origin adult coho returns was zero in Green Valley Creek and 0.33 in Mill Creek; however, only four coho salmon carcasses were recovered in Broodstock Program monitoring streams during the 2016/17 spawner survey season (Table 12). NO carcasses were recovered in Willow or Dutch Bill creeks (Table 12).

Redd distribution varied by stream (Figure 26 - Figure 29). In Willow Creek, there was a cluster of coho salmon redds in the middle of the reach and only one steelhead redd observed in the upper section of the survey reach (Figure 26). In Dutch Bill Creek, nearly all coho salmon and steelhead redds were observed in the upstream half of the survey reach (Figure 27). In Green Valley Creek watershed, coho salmon redds were observed throughout the mainstem of Green Valley Creek upstream of Purrington Creek and in Little Green Valley Creek, while most of the steelhead redds were observed higher up in Green Valley Creek, as well as in Purrington and Nutty Valley creeks (Figure 28). In the Mill Creek watershed, there were two clusters of coho salmon redds; one downstream of the Palmer Creek confluence, and another in the vicinity of the confluence with Felta Creek (Figure 26). Spatial distribution of redds for other CMP survey streams can be found on our website: (http://www.cohopartnership.org).

Table 8. Total salmonid redds observed per species during 2016/17 spawner surveys in Russian River tributaries.

Tributary	Coho Salmon	Steelhead	Chinook Salmon	Unknown Salmonid	Total
Austin Creek	0	2	0	2	4
Crane Creek	1	6	0	0	7
Dutch Bill Creek	5	7	0	2	14
East Austin Creek	0	0	0	0	0
Felta Creek	4	1	0	2	7
Freezeout Creek	0	0	0	0	0
Gilliam Creek	1	1	0	2	4
Grape Creek	4	22	0	4	30
Gray Creek	2	3	0	2	7
Green Valley Creek	13	2	0	4	19
Grub Creek	0	0	0	0	0
Harrison Creek	1	0	0	0	1
Hulbert Creek	1	2	0	1	4
Kidd Creek	0	0	0	1	1
Little Green Valley Creek	2	0	0	0	2
Mark West Creek	0	1	0	2	3
Mill Creek	17	9	0	5	31
Mission Creek	0	0	0	0	0
Nutty Valley Creek	0	1	0	0	1
Palmer Creek	0	0	0	0	0
Pechaco Creek	0	3	0	0	3
Pena Creek	3	85	58	17	163
Perenne Creek	0	0	0	0	0
Porter Creek	4	12	0	0	16
Press Creek	0	0	0	0	0
Purrington Creek	2	2	0	0	4
Redwood Creek	0	3	2	4	9
Santa Rosa Creek	0	3	0	1	4
Schoolhouse Creek	0	0	0	0	0
Sheephouse Creek	0	0	0	0	0
Wallace Creek	0	0	0	0	0
Willow Creek	8	1	0	2	11
Wine Creek	3	19	0	6	28
Woods Creek	4	12	8	7	31
TOTAL	75	197	68	64	404

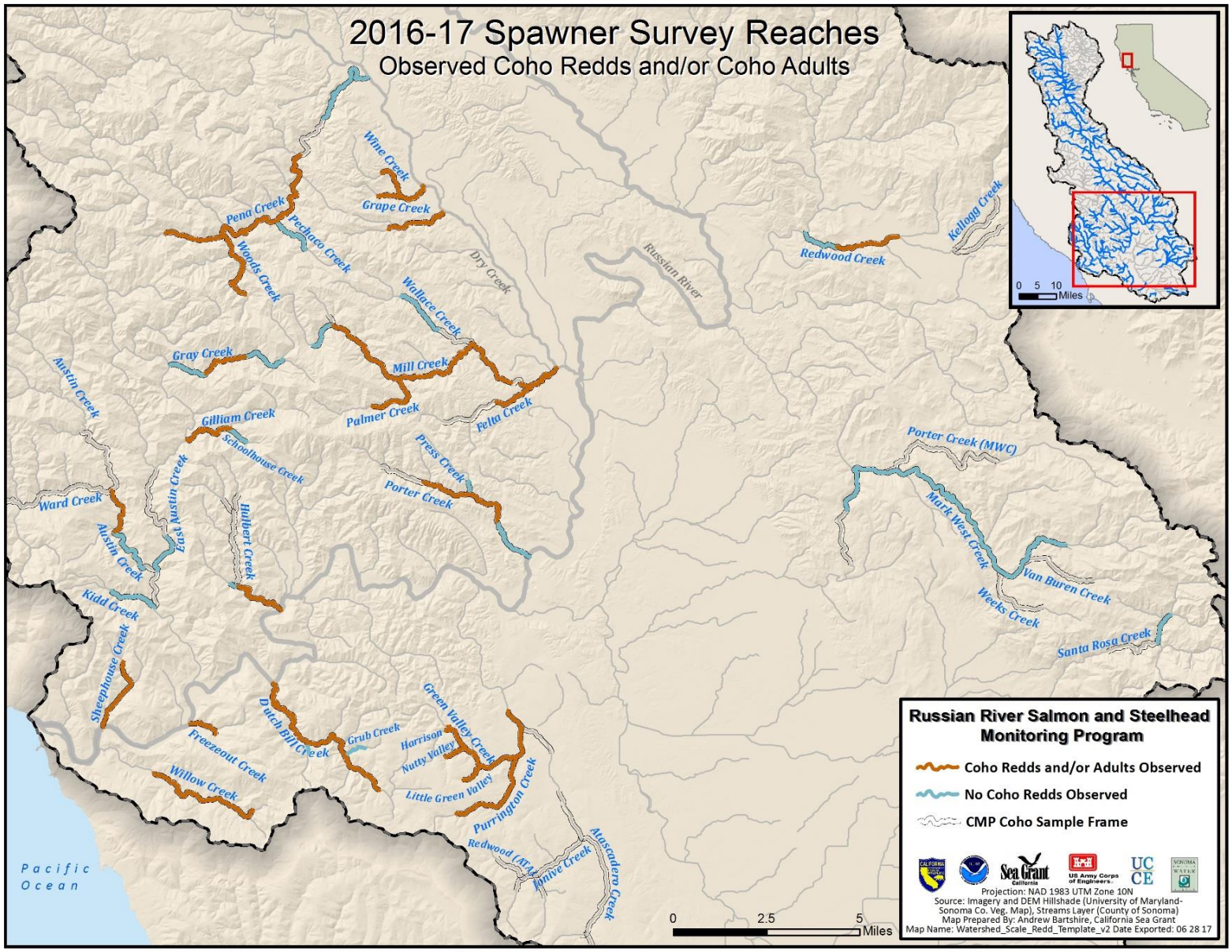

Figure 21. Spawner survey reaches where coho salmon redds and/or coho salmon adults were observed, winter 2016/17.

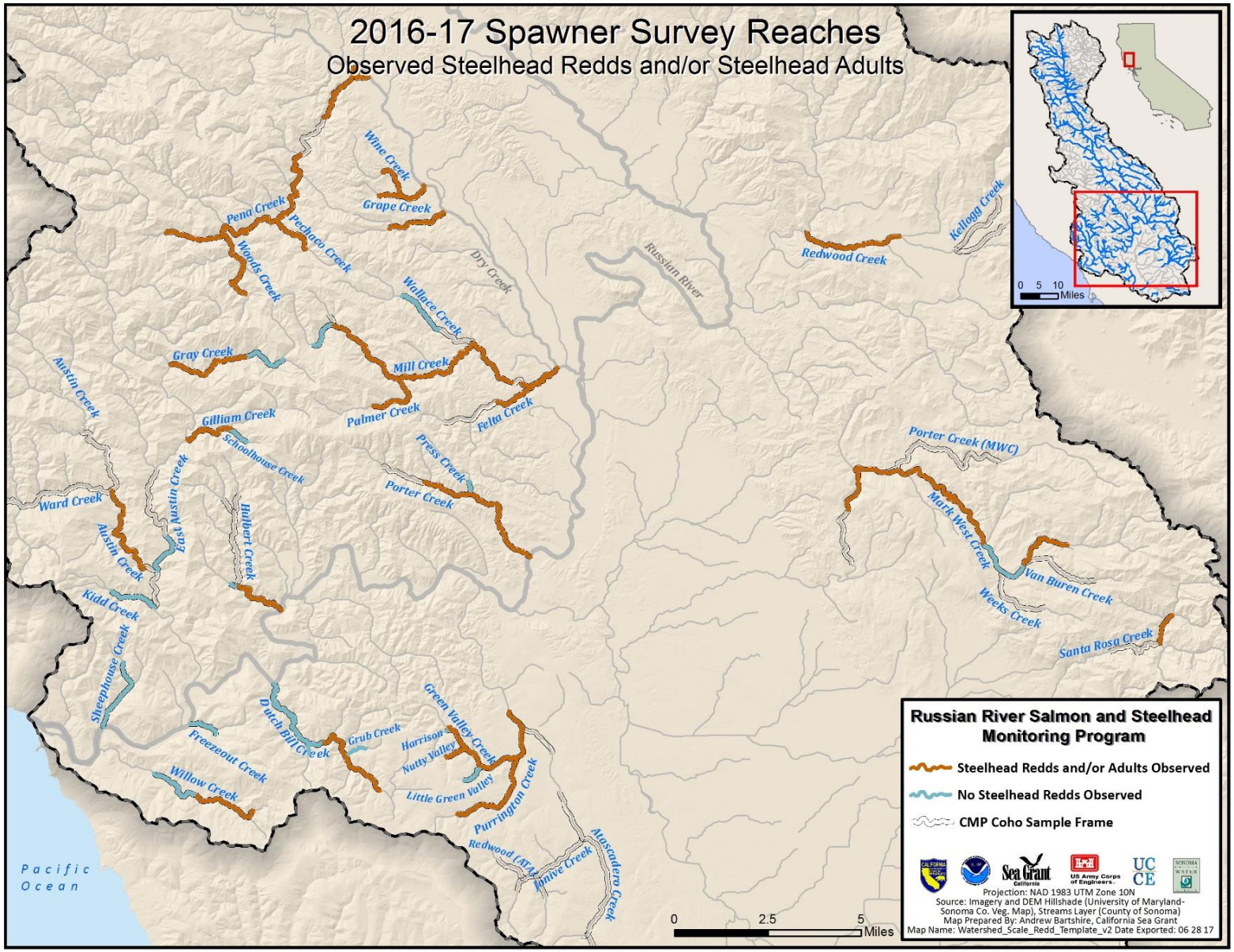

Figure 22. Spawner survey reaches where steelhead redds and or live steelhead adults were observed, winter 2016/17.

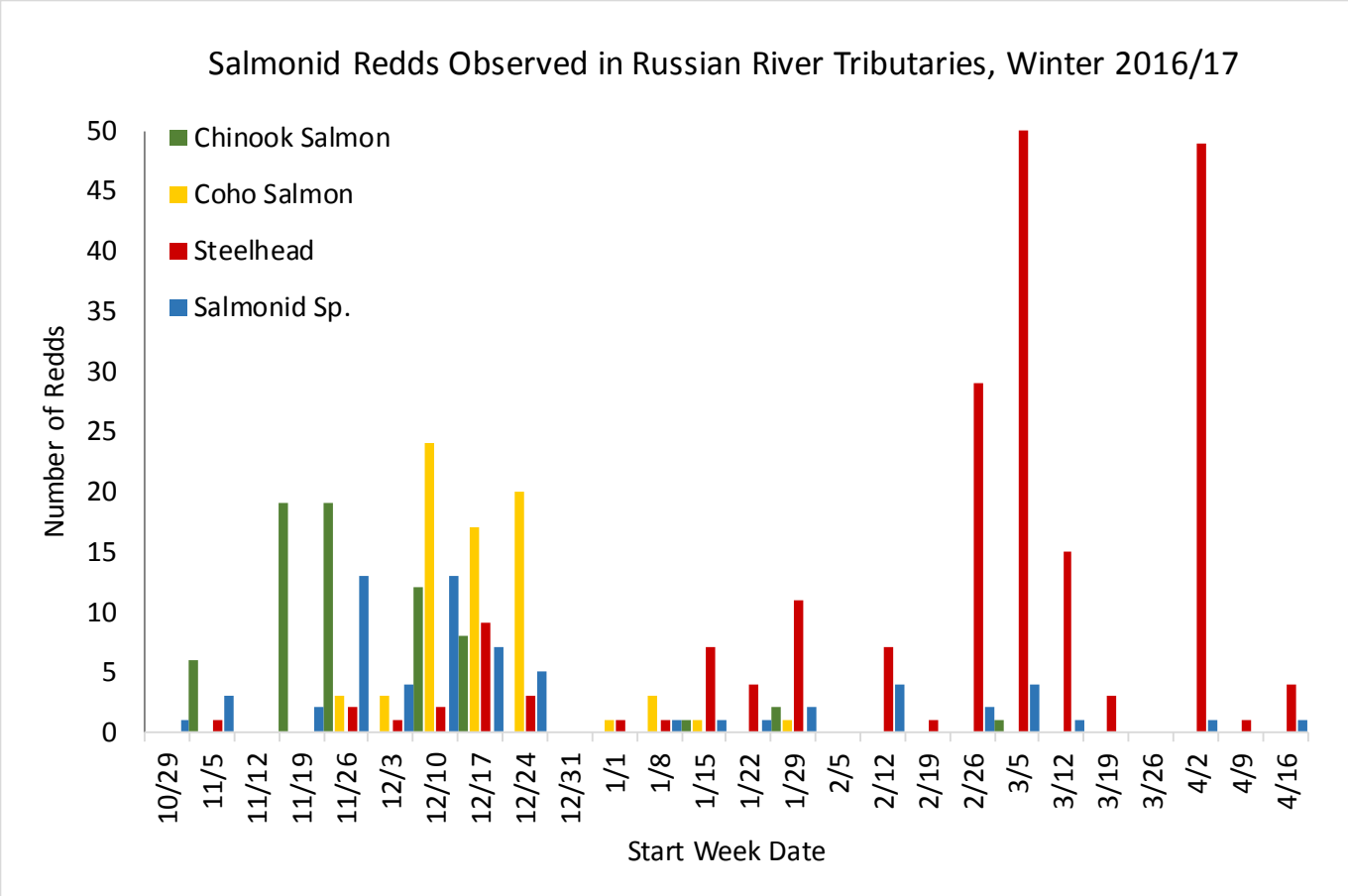

Figure 23. Number of new salmonid redds observed each week in Russian River Coastal Monitoring Program survey streams, winter 2016/17.

Table 9. Estimated coho salmon and steelhead redds and adults in four Russian River tributaries, winter 2016/17. Adult estimates for coho salmon were based on PIT tag data (Table 3- Table 6) and adult to redd ratios were calculated by dividing the estimated number of adults by the estimated number 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	8	25	3.13
Willow Creek	steelhead	3	NA	NA
Dutch Bill Creek	coho salmon	7	70	10.00
Dutch Bill Creek	steelhead	13	NA	NA
Green Valley Creek	coho salmon	23	110	4.78
Green Valley Creek	steelhead	3	NA	NA
Mill Creek	coho salmon	18	136	7.56
Mill Creek	steelhead	37	NA	NA

Table 10. Estimated coho salmon and steelhead redds and adults in the Russian River watershed, winter 2016/17.

Species	Estimated Redds (95 % CI)	Estimated Adults (95% CI)
coho salmon	211 (127 - 295)	492 (296 - 687)
steelhead	600 (220 - 980)	732 (268 - 1,196)

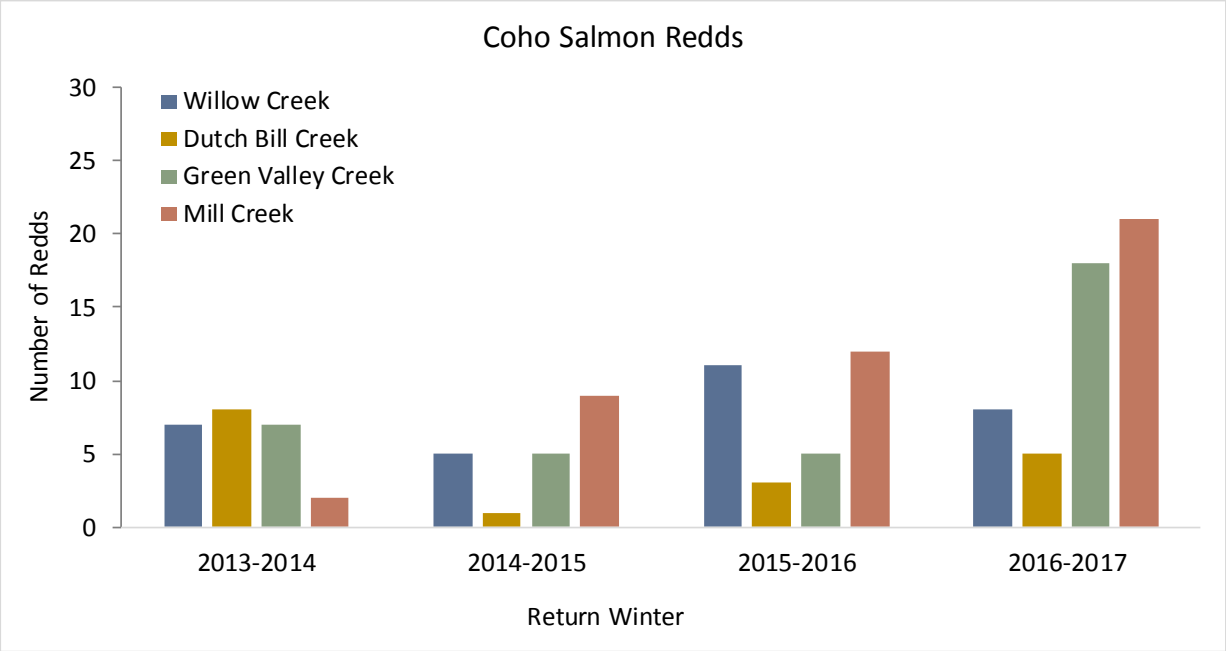

Figure 24. Estimated coho salmon redds in Broodstock Program Monitoring tributaries, return winters 2013/14 - 2016/17.

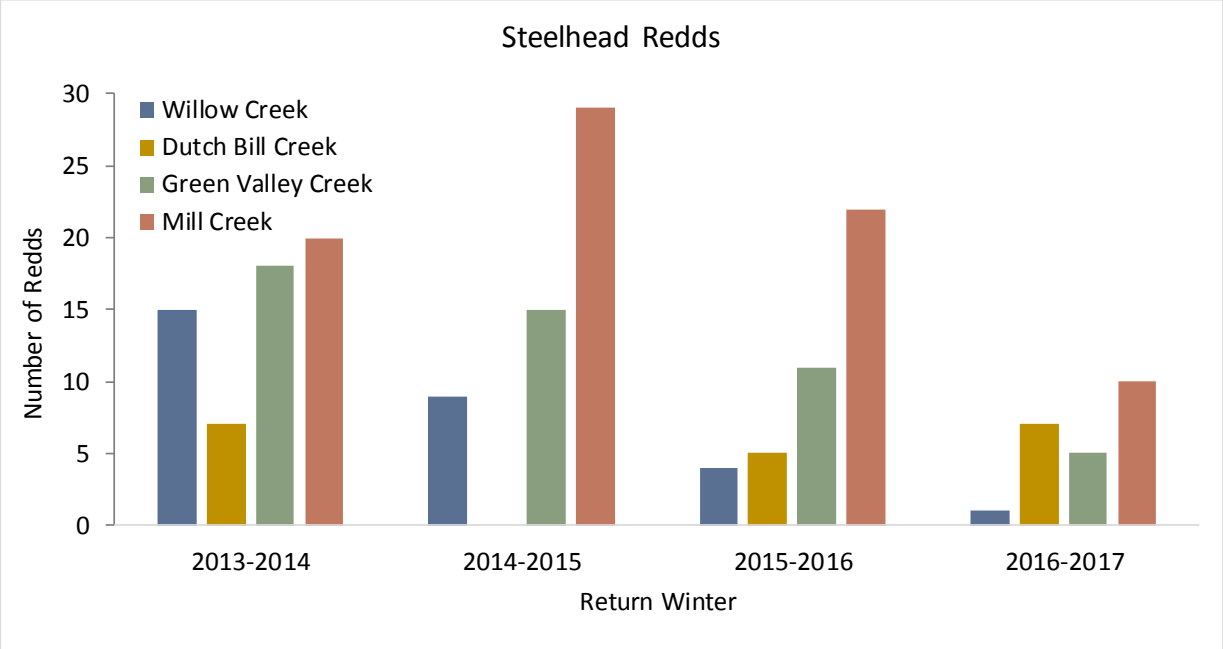

Figure 25. Estimated steelhead redds in Broodstock Program monitoring tributaries, return winters 2013/14 - 2016/17.

Table 11. Estimated coho salmon, steelhead and unknown salmonid redds in four Russian River tributaries, return winters 2011/12 through 2016/17.

Return Winter	Tributary	Coho Salmon	Steelhead	Unknown Salmonid
2011/2012	Willow Creek	0	0	0
	Dutch Bill Creek	4	16	0
	Green Valley Creek	6	29	3
	Mill Creek	15	27	0
2012/2013	Willow Creek	0	0	1
	Dutch Bill Creek	6	6	0
	Green Valley Creek	19	28	3
	Mill Creek	27	17	2
2013/2014	Willow Creek	7	15	0
	Dutch Bill Creek	8	7	1
	Green Valley Creek	7	18	1
	Mill Creek	2	20	2
2014/2015	Willow Creek	5	9	2
	Dutch Bill Creek	1	0	0
	Green Valley Creek	5	15	9
	Mill Creek	9	29	11
2015/2016	Willow Creek	11	4	8
	Dutch Bill Creek	3	5	5
	Green Valley Creek	5	11	5
	Mill Creek	12	22	13
2016/2017	Willow Creek	8	1	2
	Dutch Bill Creek	5	7	2
	Green Valley Creek	18	5	4
	Mill Creek	21	10	7

Table 12. Number of coho salmon carcasses observed relative to CWT presence/absence during 2016/17 spawner surveys in Russian River tributaries.

Tributary	CWT Present	CWT Not Present	Proportion Untagged
Willow Creek	0	0	NA
Dutch Bill Creek	0	0	NA
Green Valley Creek	1	0	0
Mill Creek	2	1	0.33

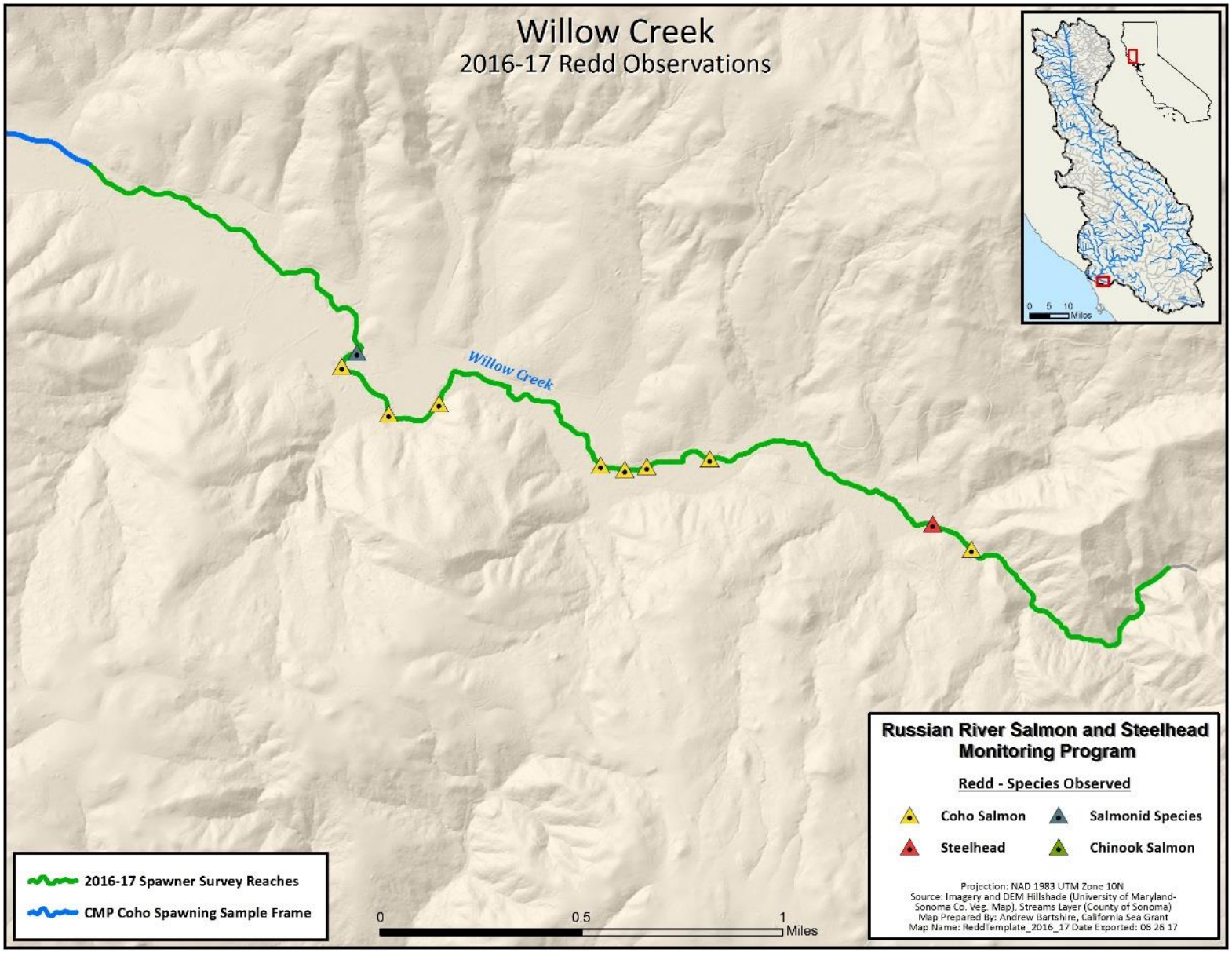

Figure 26. Salmonid redds observed in the Willow Creek during the 2016/17 spawner season.

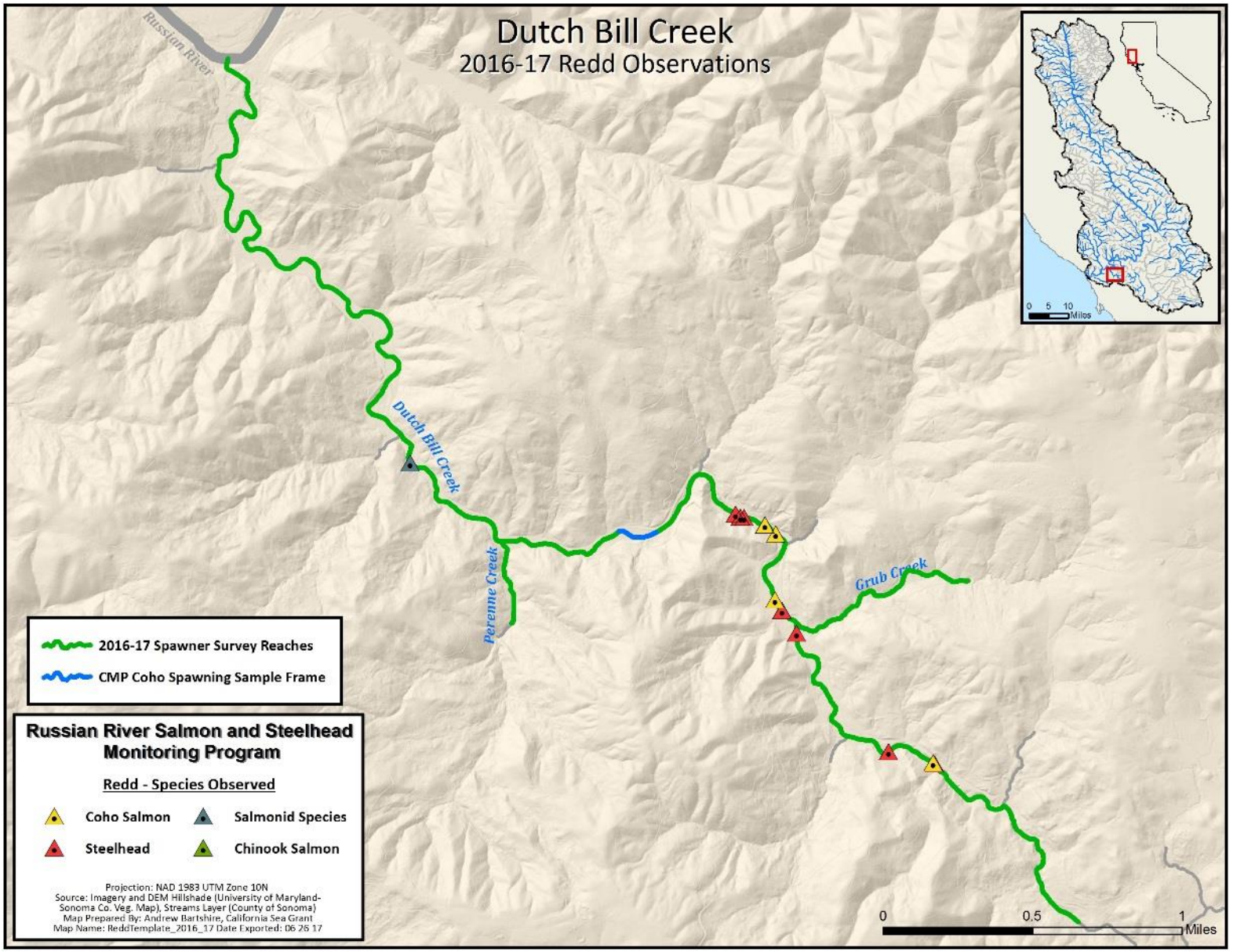

Figure 27. Salmonid redds observed in the Dutch Bill Creek system during the 2016/17 spawner season.

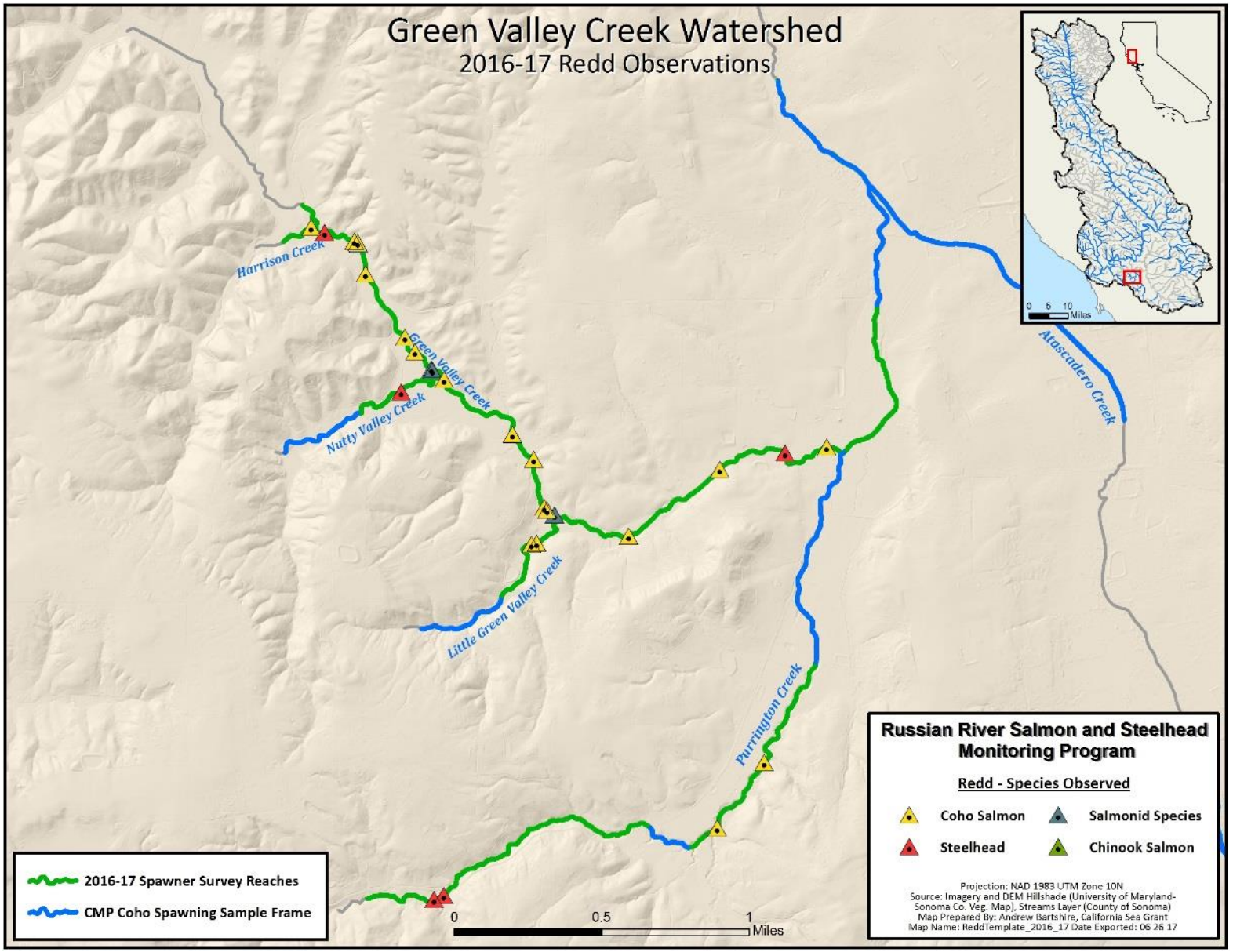

Figure 28. Salmonid redds observed in the Green Valley Creek system during the 2016/17 spawner season.

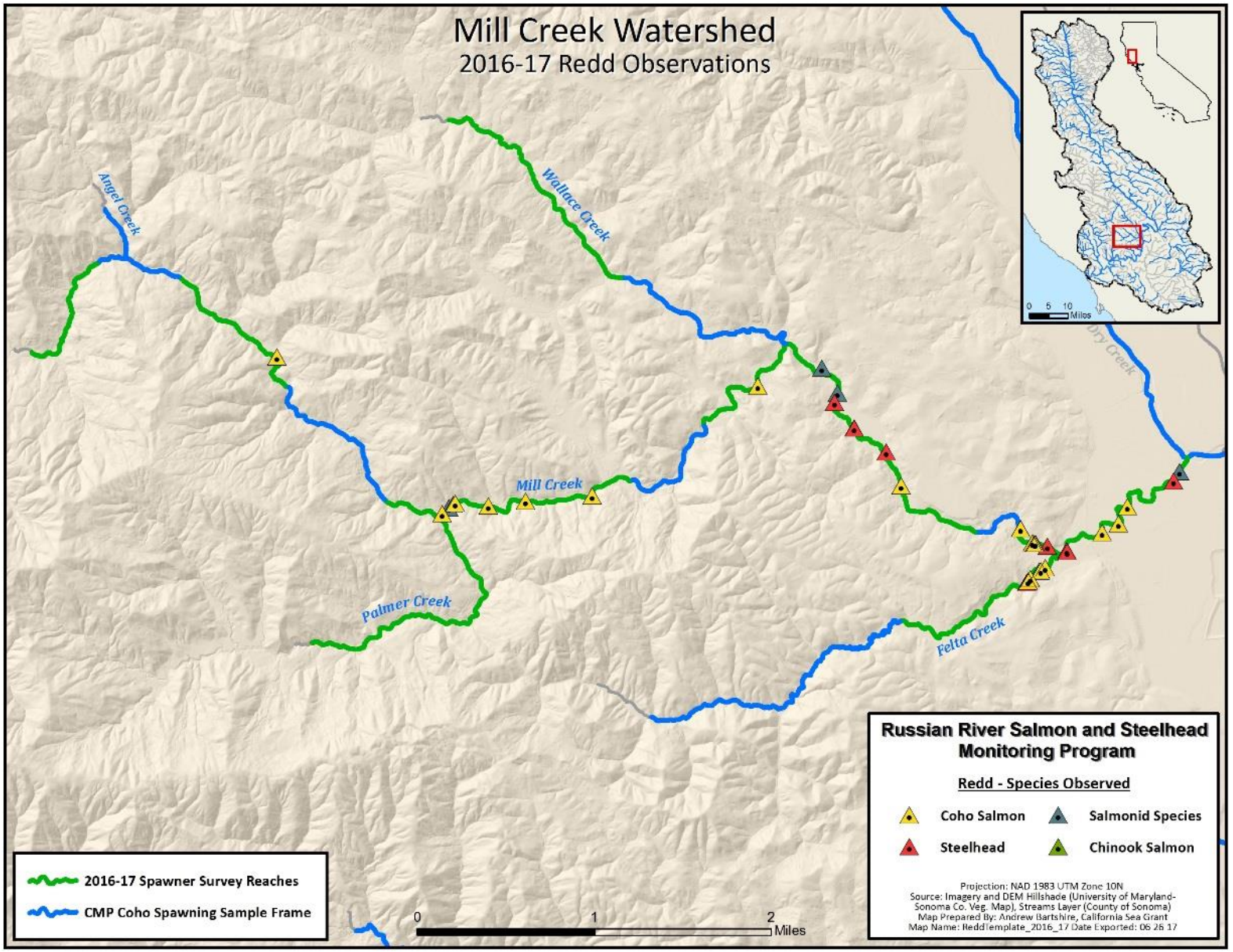

Figure 29. Salmonid redds observed in the Mill Creek system during the 2016/17 spawner season.

Discussion and Recommendations

The estimated number of coho salmon returning to the Russian River watershed during the winter of 2016/17 was one of the highest recorded in recent years (Figure 13). A total of 533 hatchery coho salmon adults were estimated to have passed the Duncans Mills antenna array (Table 7), and adult coho salmon redds and/or coho salmon adults were observed in 23 of 34 streams surveyed (Figure 21). Estimated adult coho salmon returns to the four Broodstock Program monitoring streams during the winter of 2016/17 were also high; either above average (Mill and Willow creeks, Figure 9, Figure 12) or the highest recorded since UC began monitoring (Dutch Bill and Green Valley creeks, Figure 10, Figure 11). Smolt to adult return (SAR) ratios were above average for Willow Creek (2.7%) but were low in Dutch Bill (0.8%), Green Valley (0.5%), and Mill (0.6%) creeks; therefore, the high number of returns is more likely explained by a high number of juvenile coho salmon released for the 2014 cohort which was returning as age-3 adults during the winter of 2016/17, rather than higher survival. A total of 235,324 juvenile coho salmon were released for the 2014 cohort which was significantly more than the eight-year average of 145,393.

As in previous years, adult coho salmon began entering the lower Russian River at Duncans Mills in September and October of 2016 (Figure 4). The winter of 2016/17 was an unusually wet winter (Figure 3), with early fall precipitation reconnecting the tributaries to the mainstem in mid-October, allowing earlier access to spawning habitat than in recent years when streams did not become reconnected until sometime between late-November and February. Although adult coho salmon were detected entering some of the spawning tributaries in late-October (Figure 5 - Figure 8), the first coho salmon redds were not observed until late-November, with the peak of coho salmon spawning activity occurring in December (Figure 23).

Significant straying of individuals occurred among tributaries, particularly in Dutch Bill Creek, where individuals released into six streams other than Dutch Bill Creek were detected as adults at the Dutch Bill Creek PIT tag antenna array (Table 4). Straying also occurred in Green Valley and Mill creeks but to a lesser extent (Figure 6, Figure 7), and straying was not observed in Willow Creek (Figure 4). Interestingly, we observed some straying of natural-origin adults as well. Of four age-3 natural-origin adults that were tagged at the Green Valley Creek smolt trap in 2015, one was detected in Green Valley Creek only, one was detected in Green Valley and Mill creeks, and two were detected only in Dry and/or Mill creeks. Of three age-2 natural-origin adults (jacks) that were tagged at the Willow Creek smolt trap in 2016, two were detected returning to Willow Creek and one was detected returning to Dutch Bill Creek.

By examining some of the detection histories of individual PIT-tagged coho salmon adults, we also found that several fish were entering more than one tributary during the winter season. Of 78 individual adults detected at one or more tributary antennas, 20 (26%) were detected in two different tributaries and five (6%) were detected in three or more tributaries. One notable age-3 adult was detected at Duncans Mills on 10/1/16, in Green Valley Creek on 11/21/16, in Mill Creek on 12/3/16, in an upper Dry Creek backwater on 12/9/16, in Felta Creek on 12/10/16, and in Dutch Bill Creek on 12/14/16.

Although there was an expectation for the Dry Creek smolt release group fish to return to Don Clausen Fish Hatchery as adults during the winter of 2016/17, only three adult coho salmon returned to the hatchery (Ben White unpublished data). Because we detected individual adults from this release group on multiple PIT antenna arrays in the watershed, we do not attribute this to poor survival of the release group. Based on expansions of PIT tag data, we estimate that a total of 144 Dry Creek smolt release fish returned to the Russian River watershed during the winter of 2016/17 (Table 7), representing 27% of all hatchery returns for

that year. A total of 21 unique adults from this release group were documented on the Duncans Mills, Mirabel, Dry, Dutch Bill, Green Valley, and/or Mill Creek antenna arrays. Fifteen of these fish (71%) were detected in the Dry Creek watershed. Two of these 15 individuals were also detected in Green Valley Creek, and one was detected in Dutch Bill Creek. The remaining six fish were only detected at the Duncans Mills antenna array. Because it is likely that these fish spawned in the watershed and they represented approximately one quarter of the returning adults in 2016/17, we recommend continuation of these releases each year.

Adult return monitoring data has been useful in helping to identify bottlenecks to coho salmon survival in specific watersheds and evaluate habitat enhancement projects once they are completed. For example, in the Mill Creek watershed, a partial fish passage barrier was identified in the middle reaches of Mill Creek by mapping annual redd distributions. Between the winter of 2011/12 and 2015/16, 93% of the observed coho salmon redds were downstream of an old flashboard dam. This posed a problem for progeny of spawning adults because the habitat below the barrier became dry nearly every summer, leaving juvenile offspring with little or no chance of surviving the summer (Obedzinski et al. 2016a). This data served as justification for remediation of the barrier by a partnership that included Trout Unlimited, Prenuske Chathum, Inc., NOAA Restoration Center, CDFW, and the Water Agency. With collaboration from local landowners residing at the project site, this barrier was remediated during the summer of 2016, allowing adult salmonids to access 11.2 miles of habitat that was previously only available during rare high flow events. Following the first rains in late October that reconnected Mill Creek to Dry Creek and the mainstem of the Russian River, five PIT-tagged coho salmon were detected on antenna arrays upstream of the project site. Based on ratios of PIT-tagged to nonPIT-tagged fish, we estimate that a total of 19 coho salmon passed upstream of the site. By the end of the spawner season, a total of seven coho salmon redds were observed upstream of the site, nearly twice as many redds as were observed in the previous five years combined. We expect access to the upper reaches of the Mill Creek watershed to significantly improve long-term recovery of coho salmon populations in Mill Creek. Progeny of adults that spawn in the upper reaches of Mill Creek will have a much better chance of surviving the summer season because upstream of the project site, pools tend to remain connected year-round even during extreme drought conditions.

Through the extensive CMP effort, we are also beginning to identify streams of high use by salmonids. Of the 34 stream surveyed during the winter of 2016/17, the greatest number of salmonid redds by far were observed in Pena Creek (163 of 404, or 40% of all redds observed in the Russian River watershed) (Table 8). We have consistently observed the highest number of salmonid redds in Pena Creek since we began surveys there during the winter of 2013/14 (Obedzinski et al. 2016b). Unfortunately, we have documented extreme stream drying during previous summers, which is likely acting as a bottleneck to summer survival of juvenile salmonids (Obedzinski et al. 2016a). Low streamflow, warm temperatures, lack of canopy, pools and instream cover all appear to be limiting factors for salmonids in Pena Creek. Because it is the last significant tributary to Dry Creek downstream of Warms Springs Dam, it is likely that adult salmonids will continue to return to Pena Creek, despite its poor habitat quality. Because of this, we recommend focusing resources in enhancing habitat in this stream.

IV. References

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