UC Coho Salmon and Steelhead Monitoring Report: Winter 2015/16

WSP AmeriCorps member measuring a redd in Redwood Creek.

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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. University of California Cooperative Extension and California Sea Grant (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 public resource agencies, non-profit organizations, and 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, 2015, through March 1, 2016, 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) survival 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 (a.k.a., Warm Springs 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 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 2013 and 2014 (fish that would return during the winter of 2015/16 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 (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 20" during baseflow conditions. During storm events, stream depths exceeded 20", so if PIT-tagged fish were travelling in the water column above that 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, 2015 through March 1, 2016, 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%

[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
2013	Willow Creek	fall	10,092	2,990	30%
2013	Sheephouse Creek	fall	2,532	381	15%
2013	Freezeout Creek	fall	2,576	378	15%
2013	Austin Creek	smolt	10,117	1,518	15%
2013	Black Rock Creek	spring	4,078	803	20%
2013	Gilliam Creek	spring	4,040	805	20%
2013	Thompson Creek	spring	2,037	405	20%
2013	Gray Creek	spring	4,033	802	20%
2013	Devil Creek	spring	4,017	795	20%
2013	Dutch Bill Creek	spring	1,019	1,002	98%
2013	Dutch Bill Creek	fall	12,083	2,997	25%
2013	Dutch Bill Creek	smolt	6,201	912	15%
2013	Green Valley Creek	spring	210	209	100%
2013	Green Valley Creek	fall	7,146	2,997	42%
2013	Green Valley Creek	smolt	6,220	906	15%
2013	Purrington Creek	fall	3,041	453	15%
2013	Mark West Creek	fall	15,143	2,254	15%
2013	Porter Creek	fall	8,045	1,207	15%
2013	Dry Creek	fall	3,036	1,009	33%
2013	Dry Creek	smolt	29,463	4,384	15%
2013	Mill Creek	spring	1,017	1,011	99%
2013	Mill Creek	fall	18,151	2,995	17%
2013	Palmer Creek	spring	7,027	1,409	20%
2013	Grape Creek	spring	410	410	100%
2013	Pena Creek	fall	10,112	1,504	15%
2014	Willow Creek	spring	15,393	2,255	15%
2014	Willow Creek	pre-smolt	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%

Table 2 (*cont*). 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	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	pre-smolt	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%

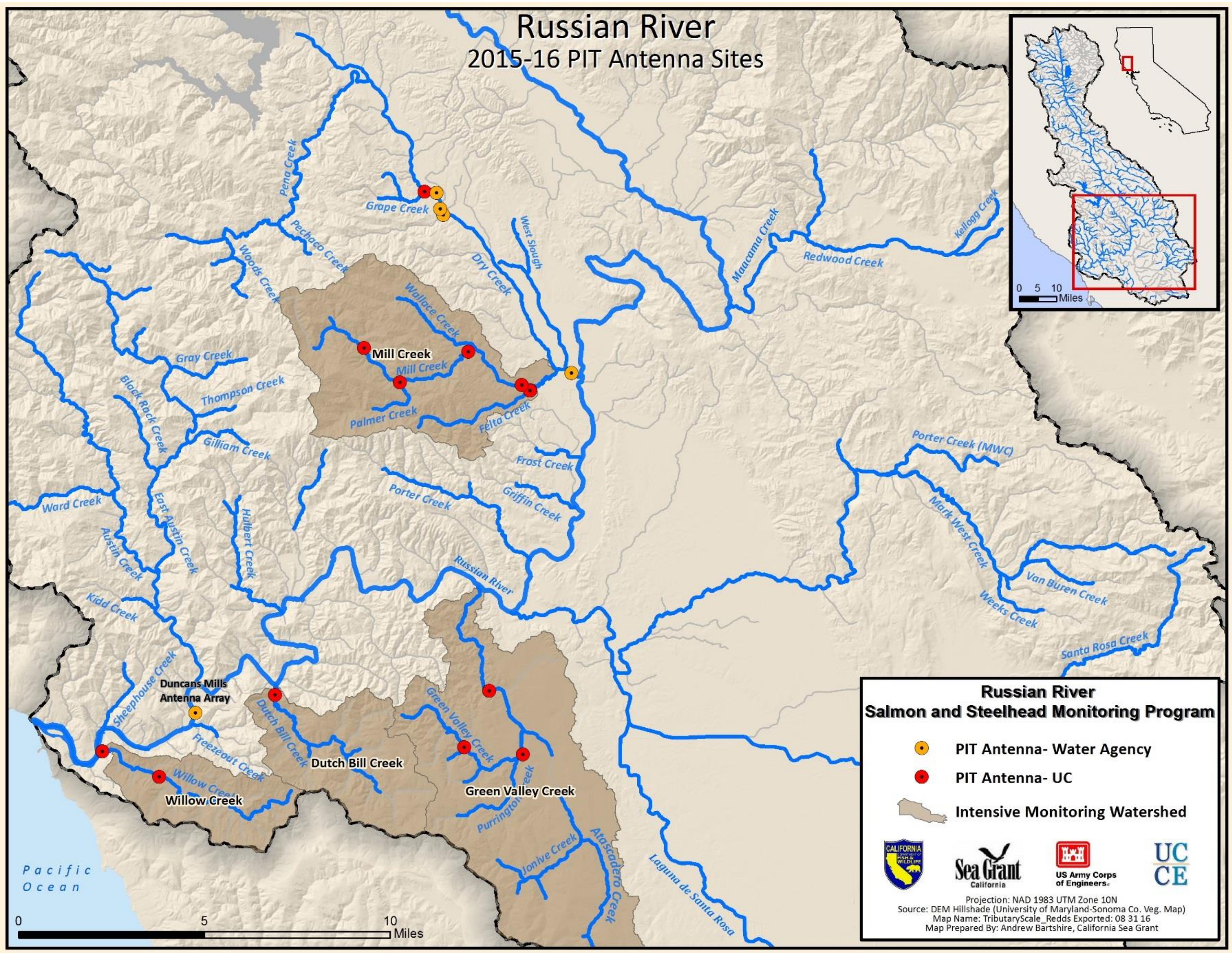

Figure 1. Passive Integrated Transponder detection system antenna locations in the Russian River watershed, September 15, 2015 - March 1, 2016.

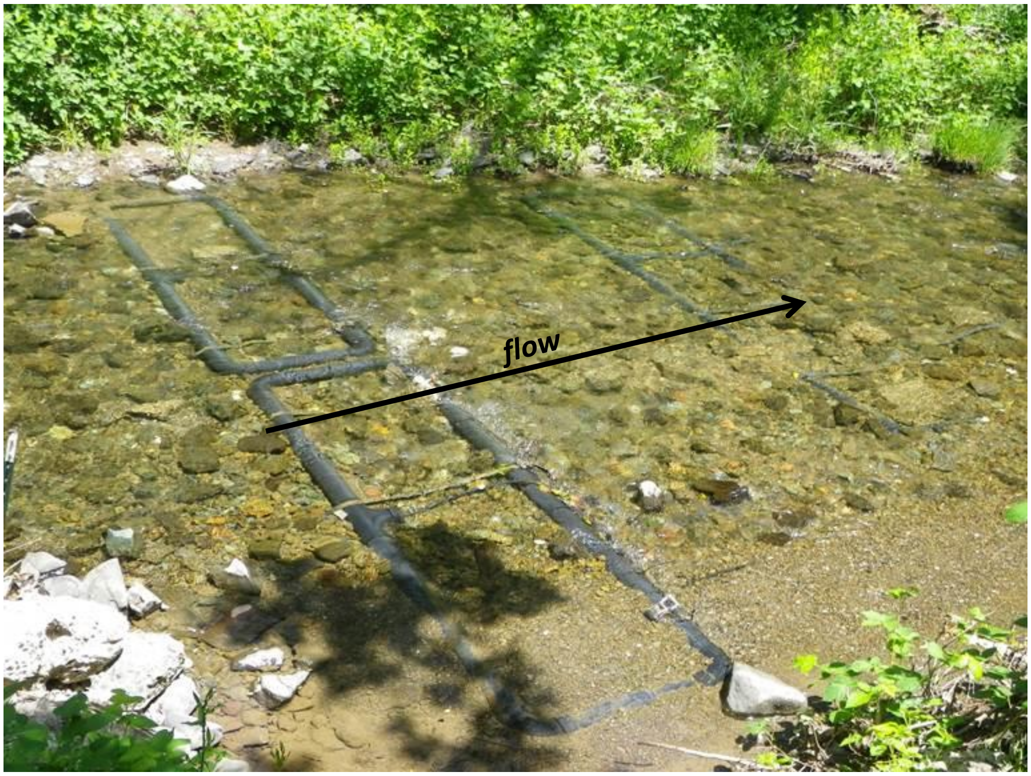

Figure 2. Paired flat-plate antenna array on Mill Creek at spring base flows.

Data Analysis

First, all records of two- and three-year old PIT-tagged coho salmon detected on antenna arrays between September 15, 2015 and March 1, 2016 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 smolts 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 (dead tags) and were removed from the adult return dataset.

Adult Return Timing Relative to Flow Conditions:

The first detection between September 15, 2015 and March 1, 2016 of each returning PIT-tagged hatchery adult coho salmon was plotted with streamflow or stage data from the nearest streamflow gauge at each antenna site.

Adult Return Minimum and Estimated Numbers:

Estimates of the number of adult hatchery 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 (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. Due to low efficiency at Duncans Mills in October and November 2015 (see results section), we used detections at all antenna sites to make comparisons of release age and season.

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 2014/15 and three-year old hatchery adults returning during the winter of 2015/16 was divided by the estimated number of hatchery smolts migrating from each stream between March 1 and June 30 of 2014 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 tributaries as adults. In Green Valley Creek, smolt traps were not operated between 2011 and 2013; therefore, a SAR ratio could not be estimated for this stream.

Results

<u>Adult Return Timing Relative to Flow Conditions</u>
As in previous years, adult coho salmon began entering (and likely continued to enter) the mainstem of the Russian River and Dry Creek before the first significant winter storm event, and began entering the smaller tributaries after the first storm event, once stream connectivity with the mainstem was established (Figure 3 - Figure 8). Unfortunately, U.S. Navy testing between October 13 and November 13, 2015 caused radio frequency interference with PIT transceivers and, as a result, antenna efficiencies dropped close to zero at all antenna sites during that period. Because this extended data gap occurred

during the period of expected peak adult migration into the mainstem, the majority of tagged adults passing the Duncans Mills antenna site were likely not detected (Figure 3). Tag detections in the smaller tributaries were not affected by this data gap because these streams were inaccessible to adult migrants during this period and did not become connected to the mainstem until the first significant rainstorm in early December. Once connectivity to the tributaries was established, entry of tagged adults was detected a few days earlier in streams that were closer to the estuary (Willow and Dutch Bill) than in Green Valley and Mill creeks (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 9, 33, 17, and 14, respectively (Table 3 - Table 6), and the estimated number returning to the Russian River Basin was 192 (Table 7). Although sample size of PIT-tagged fish was small, some straying was detected in all streams with the exception of Green Valley Creek (Table 3 - Table 6), as indicated by release tributary origins compared to return tributaries. By examining detections of all unique PIT-tagged adults detected on any antenna within the Russian River basin between September 15, 2015 and March 1, 2016, we observed multiple life history strategies including age-2 and age-3 adults from a variety of release seasons and release streams (Table 8). In all but Dutch Bill Creek, estimated adult returns during the fall/winter of 2015/16 were lower than the previous winter (Figure 9 - Figure 12), mirroring a similar pattern observed in Russian River basin estimates (Figure 13). In Dutch Bill Creek, we have observed an increasing trend in adult coho salmon returns over the last three years (Figure 10). As in previous winters, the proportion of two-year old adults returning remained high, ranging from 58 to 85 percent in Willow, Green Valley and Mill creeks (Figure 9, Figure 11, Figure 12). Dutch Bill was the exception, with all PIT-tagged adults returning at age-3 (Figure 10). The proportion of two-year old adults returning to the Russian River was 51 percent, which was slightly lower than in the previous two years (Figure 14). Note that Figure 14 includes only fish that we were able to age; therefore, totals adult return estimates and age ratios may differ than those shown in Figure 13.

Smolt to Adult Return (SAR) Ratio

Overall, SAR estimates were low, ranging from zero to 1.6 percent over all of the streams and years we have sampled (Figure 15 - Figure 17). For the 2013 cohort that returned as three-year olds during the winter of 2015/16, SAR estimates of hatchery coho salmon was similar among creeks, ranging from 0.7 percent in Mill Creek to 1.0 percent in Dutch Bill Creek (Figure 15 - Figure 17).

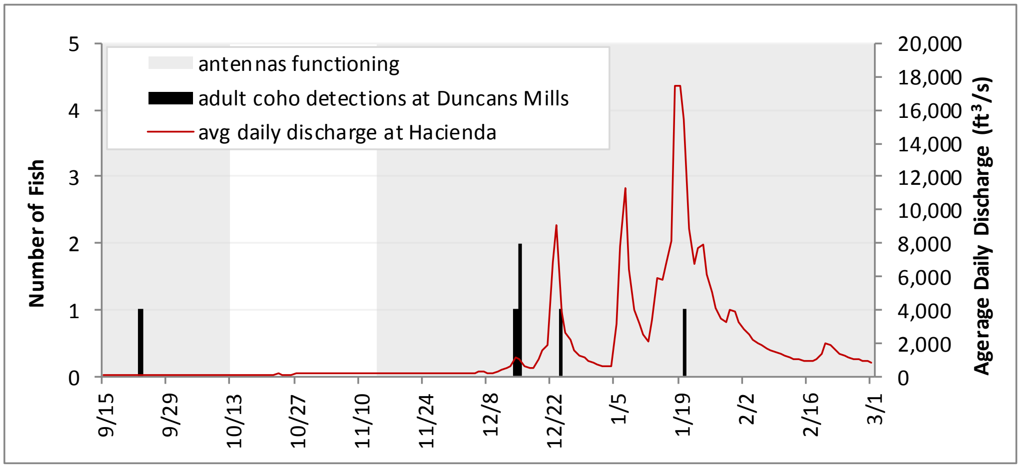

Figure 3. Detections of PIT-tagged coho salmon adults passing upstream of the Duncans Mills antenna array, September 15, 2015 - March 1, 2016. Discharge data downloaded from USGS website: http://waterdata.usgs.gov.

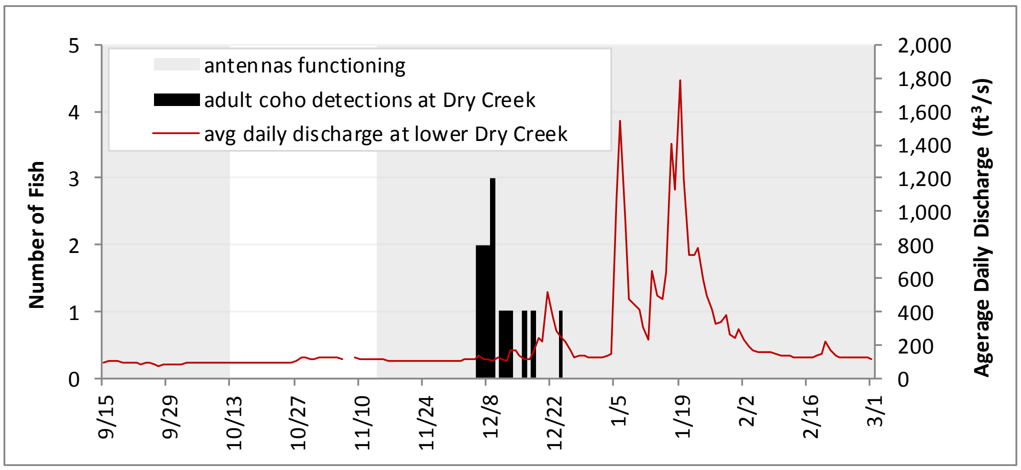

Figure 4. Detections of PIT-tagged coho salmon adults passing upstream of the Dry Creek antenna array, September 15, 2015 - March 1, 2016. Discharge data downloaded from USGS website: http://waterdata.usgs.gov.

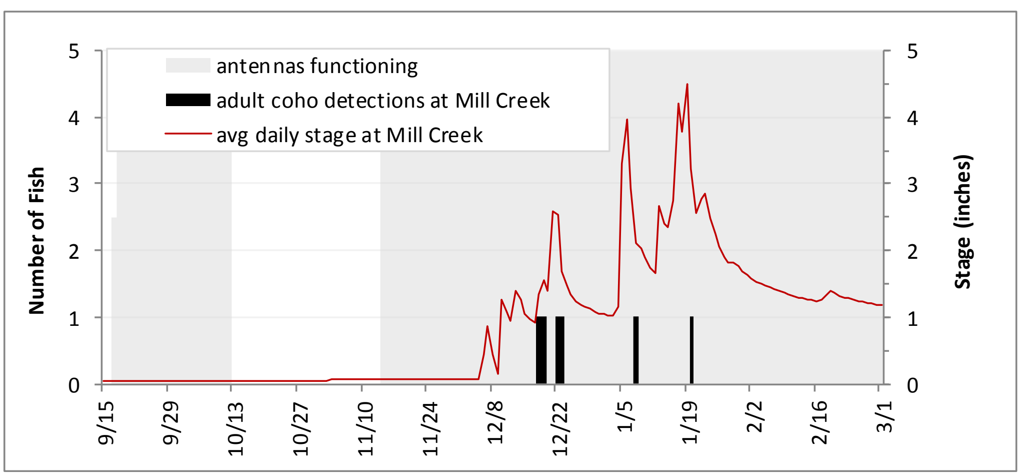

Figure 5. Detections of PIT-tagged coho salmon adults passing upstream of the Mill Creek antenna array, September 15, 2015 - March 1, 2016. Stage data provided by the Regional Water Quality Control Board and CA Sea Grant.

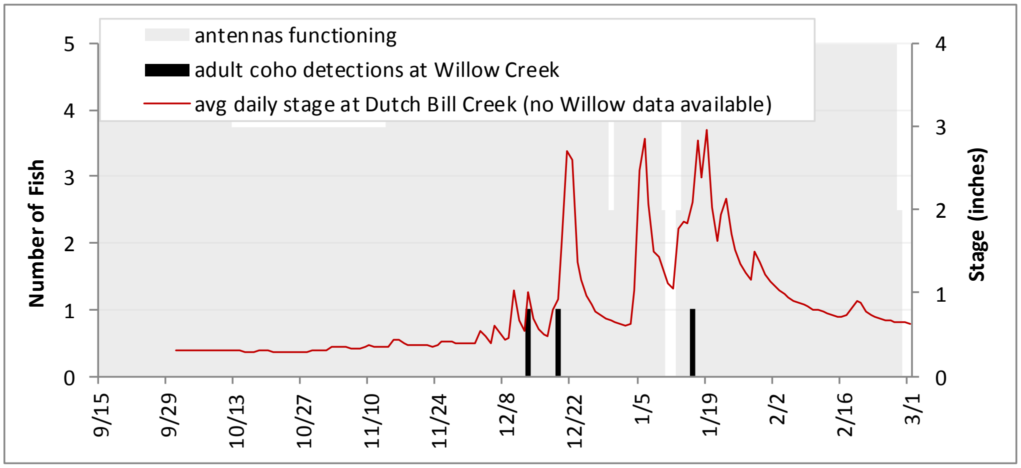

Figure 6. Detections of PIT-tagged coho salmon adults passing upstream of the Willow Creek antenna array, September 15, 2015 - March 1, 2016. Stage data provided by Trout Unlimited.

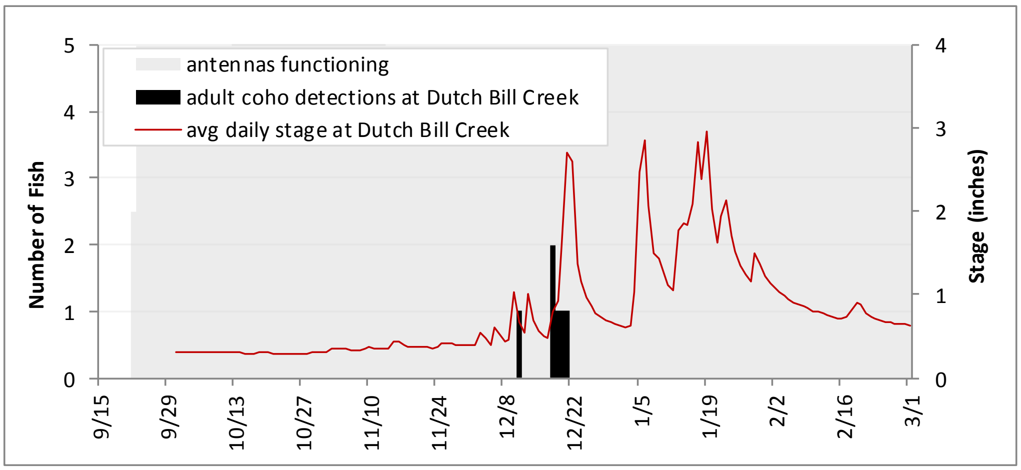

Figure 7. Detections of PIT-tagged coho salmon adults passing upstream of the Dutch Bill Creek antenna array, September 15, 2015 - March 1, 2016. Stage data provided by Trout Unlimited.

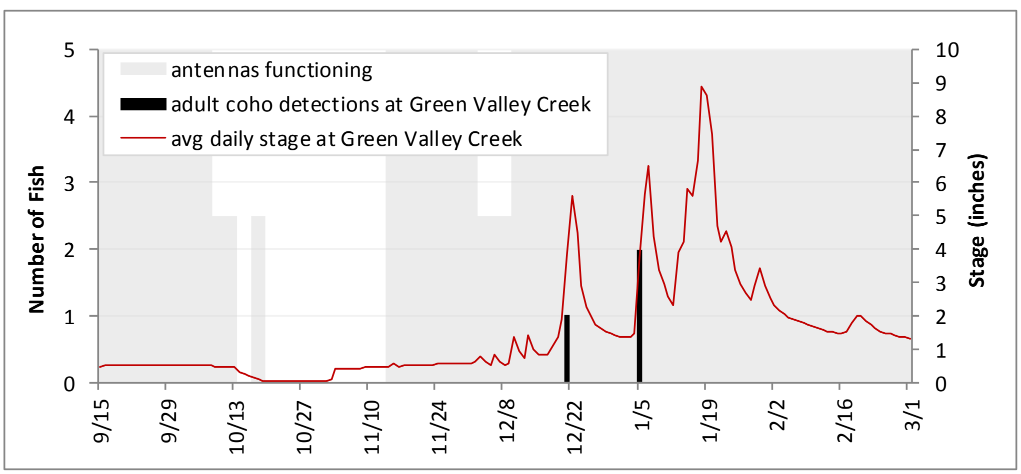

Figure 8. Detections of PIT-tagged coho salmon adults passing upstream of the Green Valley Creek antenna array, September 15, 2015 - March 1, 2016. Stage data collected by CA Sea Grant.

Table 3. Minimum, expanded, and estimated counts of adult coho salmon returning to Willow Creek between September 15, 2015 and March 1, 2016. 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	Release Season	Minimum Count	Percent PIT-tagged	Expanded Count	Estimated Antenna Efficiency	Estimated Count
3	Willow Creek	tagged at smolt trap	2	83%	2	100%	2
2	Sheephouse Creek	fall	1	15%	7	100%	7
						Estimated adult returns (age-3):	2
						Estimated adult returns (age-2):	7
						Total estimated adult returns:	**9**

Table 4. Minimum, expanded, and estimated counts of adult coho salmon returning to Dutch Bill Creek between September 15, 2015 and March 1, 2016. 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	Release Season	Minimum Count	Percent PIT-tagged	Expanded Count	Estimated Antenna Efficiency	Estimated Count
3	Dutch Bill Creek	fall	3	25%	12	100%	12
		winter	2	15%	14	100%	14
	Freezeout Creek	fall	1	15%	7	100%	7
						Estimated adult returns (age-3):	33
						Estimated adult returns (age-2):	0
						Total estimated adult returns:	**33**

Table 5. Minimum, expanded, and estimated counts of adult coho salmon returning to Green Valley Creek between September 15, 2015 and March 1, 2016. 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	Release Season	Minimum Count	Percent PIT-tagged	Expanded Count	Estimated Antenna Efficiency	Estimated Count
3	Green Valley Creek	fall	2	42%	5	67%	7
2	Green Valley Creek	presmolt	1	15%	7	67%	10
						Estimated adult returns (age-3):	7
						Estimated adult returns (age-2):	10
						Total estimated adult returns:	**17**

Table 6. Estimated adult coho salmon returns to Mill Creek, September 15, 2015-March 1, 2016.

Age	Release Tributary	Release Season	Minimum Count	Percent PIT-tagged	Expanded Count	Estimated Antenna Efficiency	Estimated Count
3	Mill Creek	spring	1	99%	1	100%	1
2	Dry Creek	fall	3	54%	6	100%	6
	Green Valley Creek	presmolt	1	15%	7	100%	7
	Mill Creek	tagged at smolt trap	1	85%	1	100%	1
						Estimated adult returns (age-3):	1
						Estimated adult returns (age-2):	13
						Total estimated adult returns:	**14**

Table 7. Minimum, expanded, and estimated counts of adult coho salmon returning to the Russian River mainstem at Duncans Mills between September 15, 2015 and March 1, 2016. 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. 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 Season	Minimum Count	Percent PIT-tagged	Expanded Count	Estimated Antenna Efficiency	Estimated Count
3	Freezeout Creek	fall	1	15%	7	16%	43
	Green Valley Creek	fall	1	42%	2	16%	15
2	Green Valley Creek	presmolt	1	15%	7	16%	42
	Mill Creek	winter	1	15%	7	16%	42
	Porter Creek	fall	1	15%	7	16%	42
						Estimated adults passing Duncans Mills (age-3):	57
						Estimated adults passing Duncans Mills (age-2):	125
						Estimated adults returning to Willow Creek (age-3):	2
						Estimated adults returning to Willow Creek (age-2):	7
						Estimated adult returning to the Russian River:	**192**

Table 8. Number of unique PIT-tagged adult coho salmon detected on any Russian River Basin PIT tag antenna array (not only those detected on lower arrays used in population estimates), proportion of releases PIT tagged, and expanded counts, September 15, 2015 - March 1, 2016.

Age	Release Tributary	Release Season	Number Unique PIT Tag Detections	Proportion PIT Tagged	Expanded Count
3	Willow Creek	tagged at smolt trap	3	0.83	4
	Freezeout Creek	fall	1	0.15	7
	Dutch Bill Creek	fall	3	0.25	12
	Dutch Bill Creek	winter	2	0.15	14
	Green Valley Creek	fall	4	0.42	10
	Mill Creek	spring	1	0.99	1
	Mill Creek	tagged at smolt trap	1	0.85	1
	Dry Creek	winter	3	0.15	20
2	Sheephouse Creek	fall	1	0.15	7
	Green Valley Creek	presmolt	4	0.15	27
	Green Valley Creek	winter	1	0.15	7
	Porter Creek	fall	1	0.15	7
	Dry Creek	fall	4	0.54	7
	Mill Creek	winter	1	0.15	7

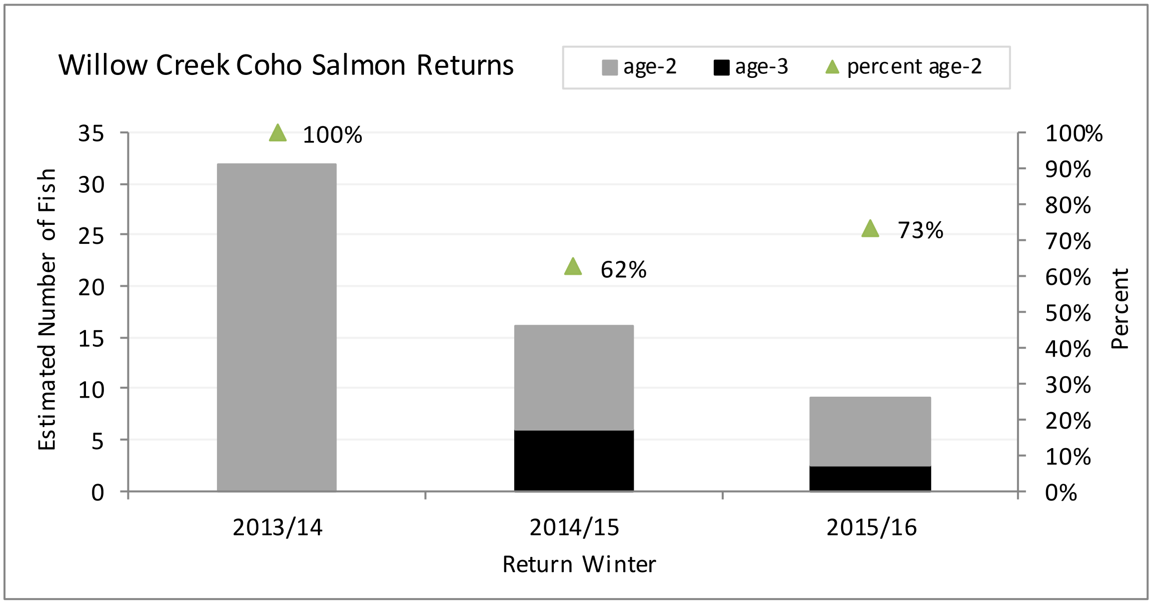

Figure 9. Estimated annual Willow Creek adult hatchery coho salmon returns by age, return seasons 2013/14 - 2015/16.

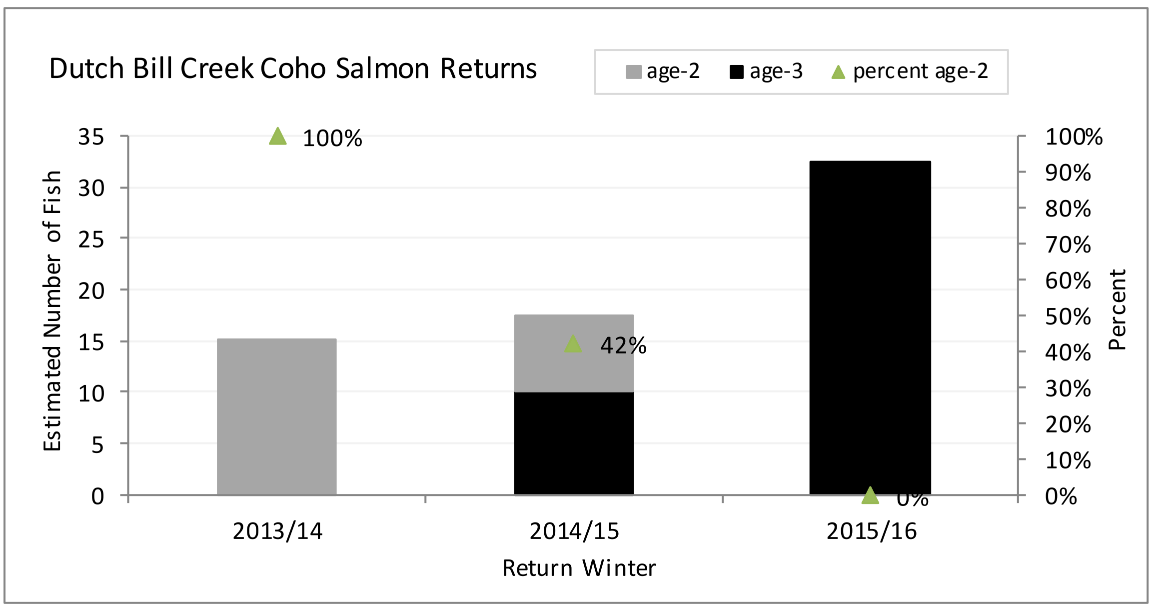

Figure 10. Estimated annual Dutch Bill Creek adult hatchery coho salmon returns by age, return seasons 2013/14 - 2015/16.

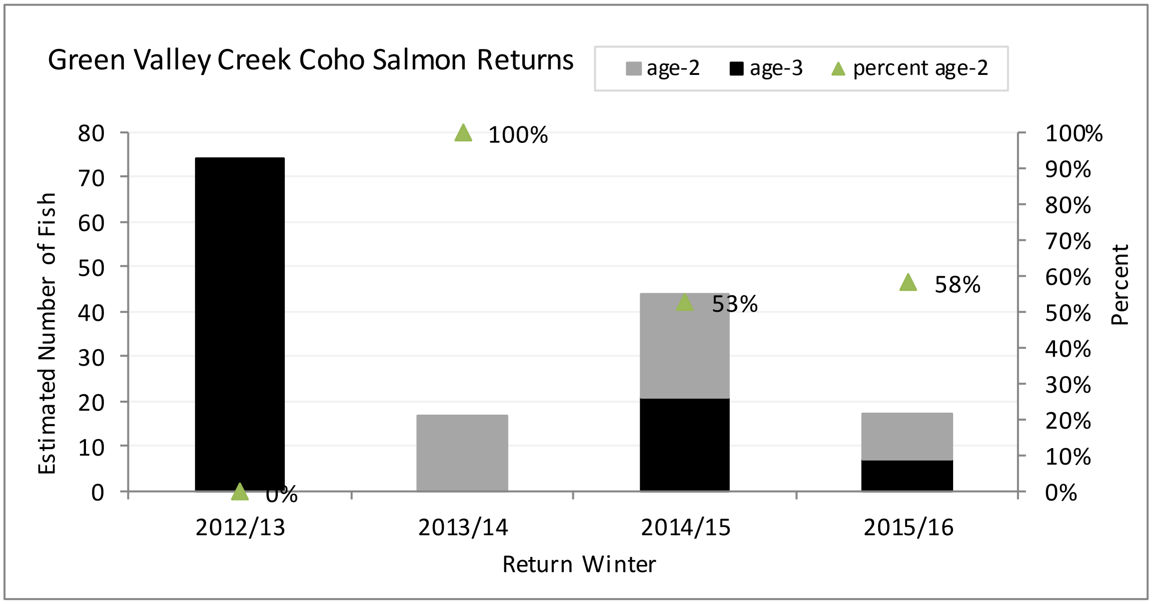

Figure 11. Estimated annual Green Valley Creek adult hatchery coho salmon returns by age, return seasons 2013/14 - 2015/16.

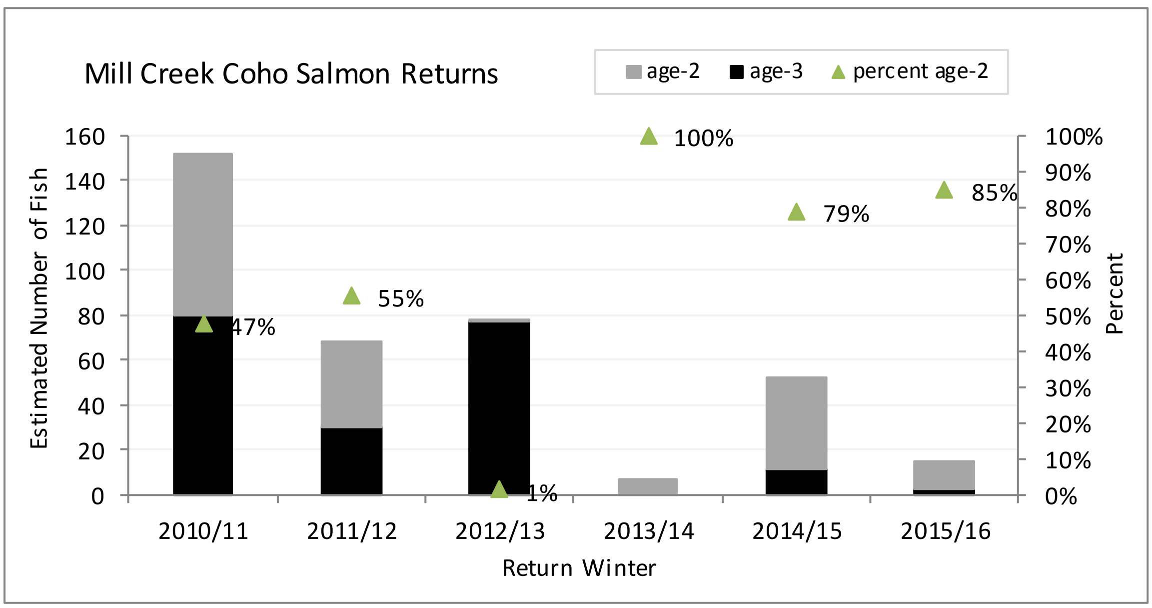

Figure 12. Estimated annual Mill Creek adult hatchery coho salmon returns by age, return seasons 2010/11 - 2015/16.

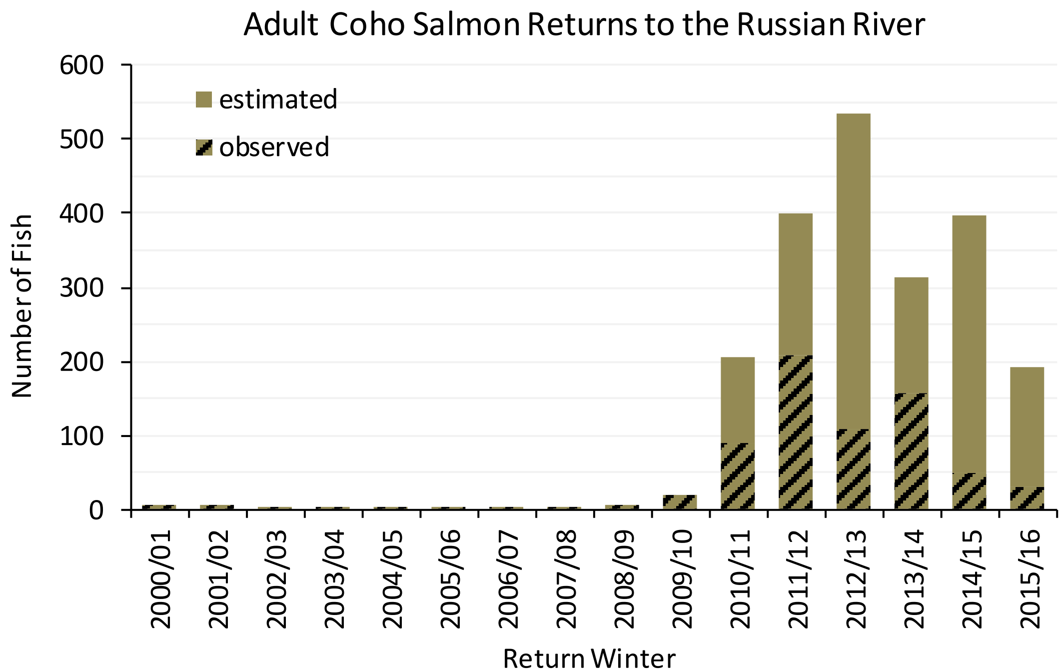

Figure 13. Estimated annual adult hatchery coho salmon returns to the Russian River, return seasons 2000/01-2015/16. Note that methods for counting/estimating the number of returning adult coho salmon were not consistent among years; prior to 2009/10, spawner surveys were the primary method, from 2009/10 – 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.

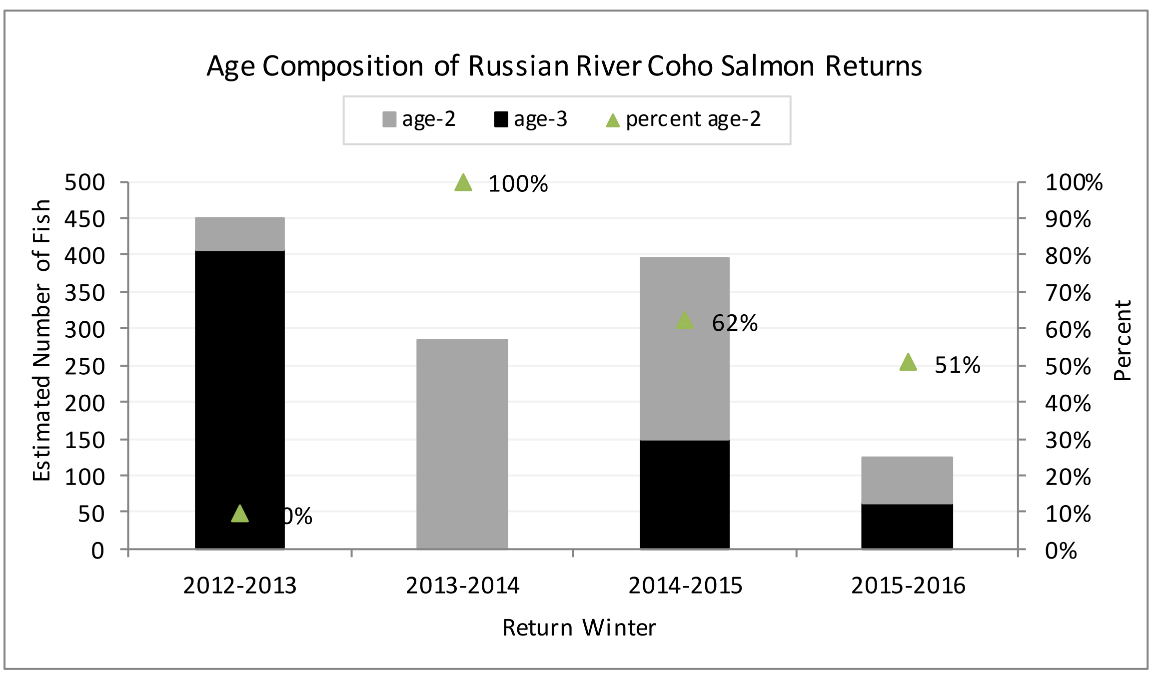

Figure 14. Estimated annual Russian River adult hatchery coho salmon returns by age, return seasons 2012/13-2015/16. Note that this figure includes only fish that we were able to age; therefore, totals will be less than adult return estimates shown in Figure 13.

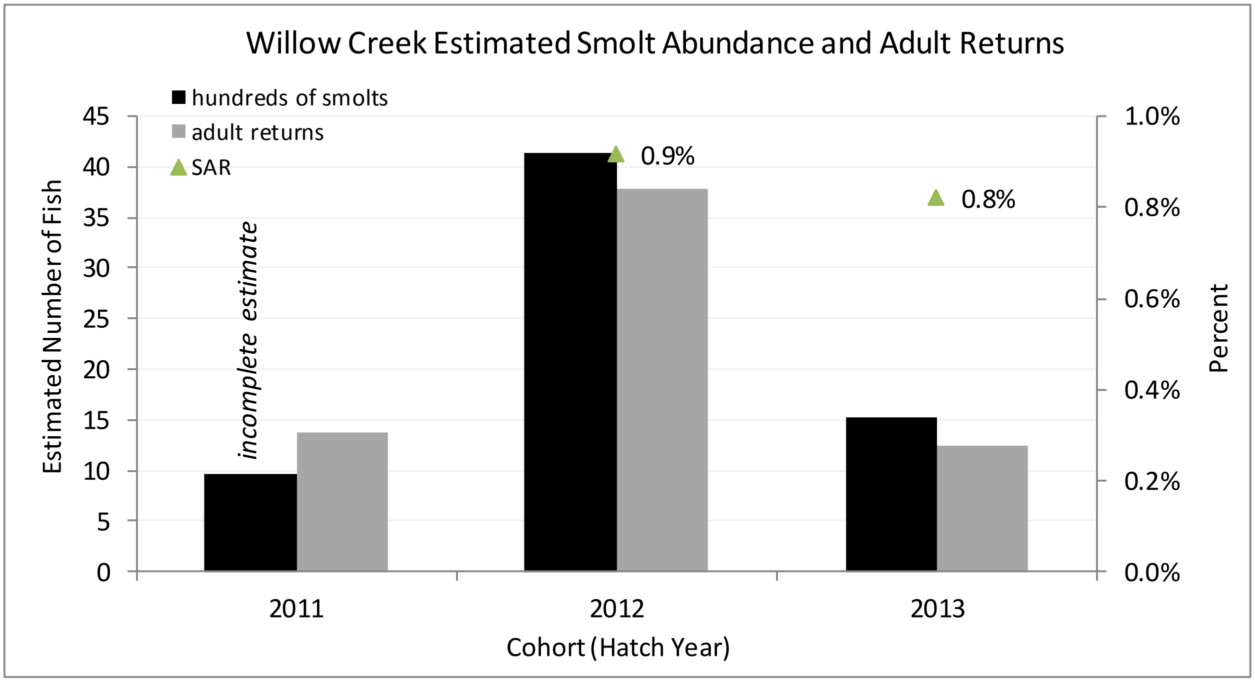

Figure 15. Estimated coho salmon smolt abundance, adult returns and smolt to adult (SAR) survival ratios in Willow Creek, cohorts 2011-2013.

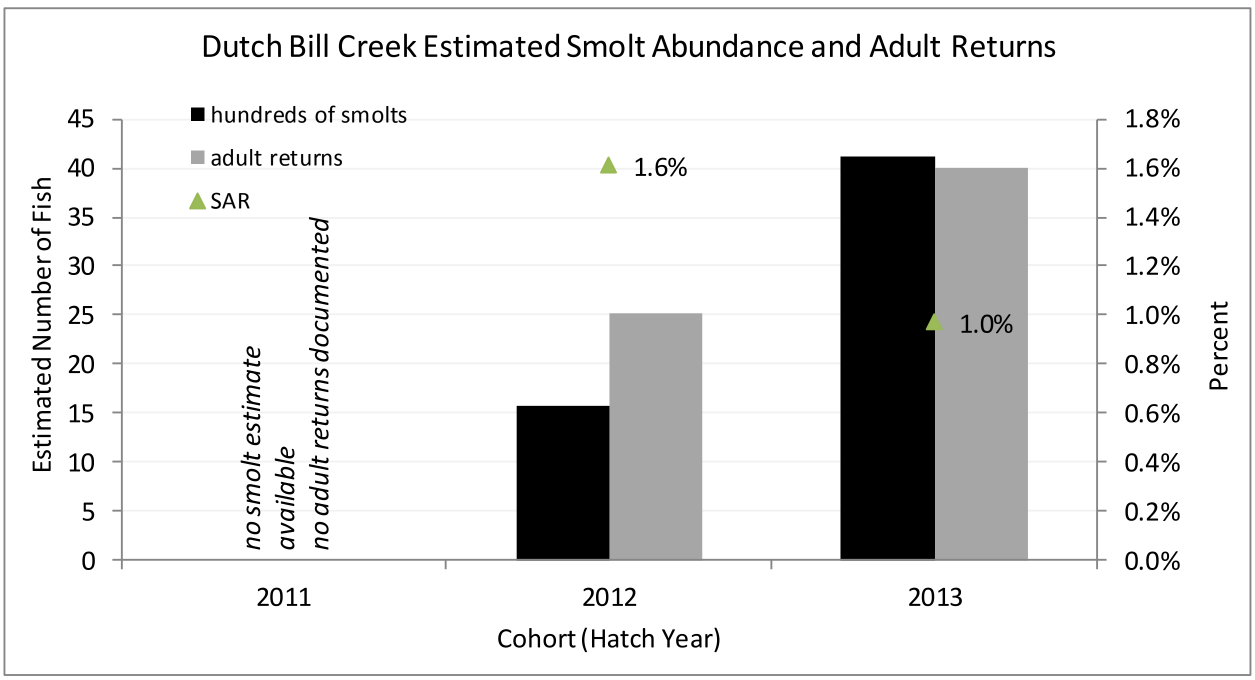

Figure 16. Estimated coho salmon smolt abundance, adult returns and smolt to adult (SAR) survival ratios in Dutch Bill Creek, cohorts 2011-2013.

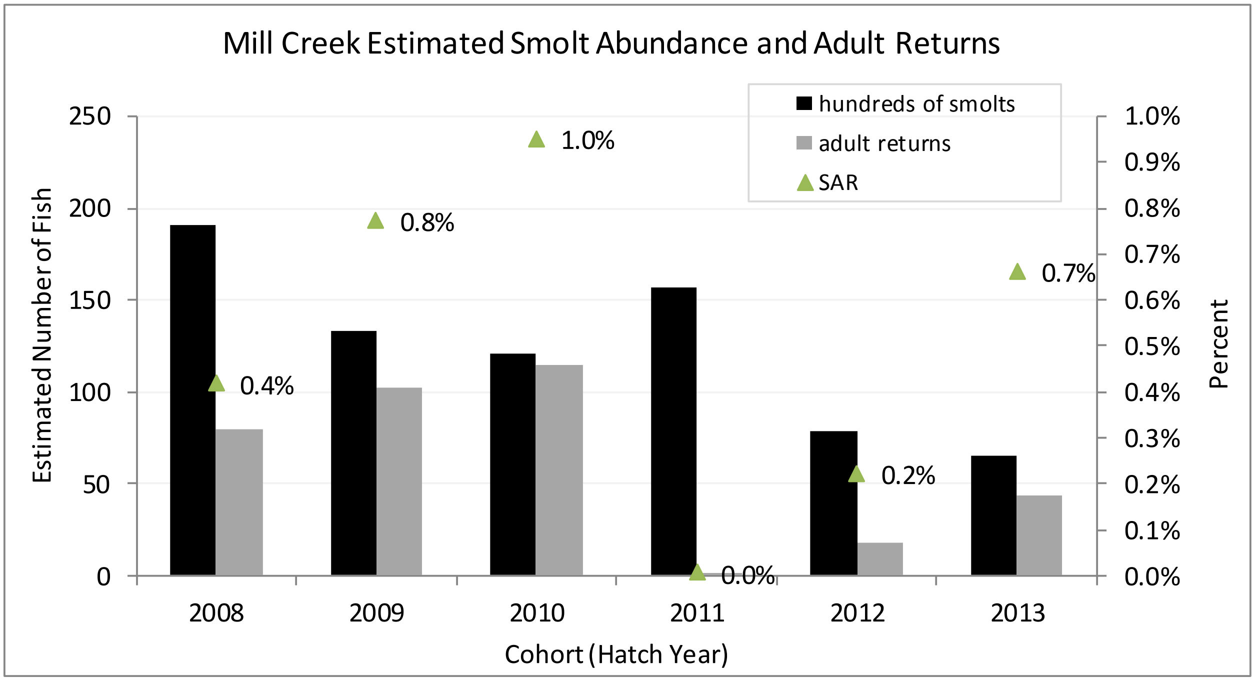

Figure 17. Estimated coho salmon smolt abundance, adult returns and smolt to adult (SAR) survival ratios in Mill Creek, cohorts 2008-2013.

Discussion and Recommendations

Despite the gap in data at Duncans Mills due to low efficiency between October and November, timing of adult hatchery coho salmon entry into the Russian River during the 2015/16 spawner season appeared similar to previous years, with adults first detected entering the mainstem of the Russian River during the fall season (September – November), moving into Dry Creek beginning in late November/December, and then into the spawning tributaries following the first significant rain event of the fall/winter when the smaller streams reconnected to the mainstem (Figure 3 - Figure 8, CA Sea Grant unpublished data). Although sample size was too small to draw definitive conclusions, we suspect that adults entered Willow and Dutch Bill creeks approximately one week earlier than Green Valley and Mill creeks due to the shorter distance from the estuary to the spawning grounds in those two streams.

During the 2015/16 spawner season, we detected PIT-tagged adult hatchery coho salmon returning to all four Broodstock Program monitoring streams as well as to the Russian River mainstem. In the majority of streams, return numbers were lower than in most recent years but still far from the near-zero returns observed prior to the inception of the Broodstock Program releases in the early 2000s (Figure 13). Drought may have played a role in the lower numbers of adults returning from the spring release groups, as spring-released juveniles spend a full summer season in the tributaries where wetted habitat conditions and juvenile coho salmon oversummer survival have been poor during the last three years (Obedzinski et al. 2016). Lower returns for fall and smolt release groups (which reside in the hatchery over the summer dry season) suggest that higher mortality is occurring in the mainstem of the Russian River or in the ocean environment. We are uncertain why we are observing an increasing trend in adult returns to Dutch Bill Creek. It is possible that improvements to overwinter habitat by Gold Ridge RCD in recent years, as well as the shorter migration distance to the ocean as compared to Mill and Green Valley creeks, may play a role.

Our adult return estimate for the Russian River mainstem may have been compromised by low efficiencies at the Duncans Mills site for an extended period. Between October 13 and November 13 of 2015, when adult coho salmon are typically entering the river and being detected on the Duncans Mills array, the U.S. Navy was conducting testing that compromised the ability of the PIT tag transceivers to detect tagged fish. As a result, efficiency at Duncans Mills was extremely low and only six individual PIT-tagged adults were detected throughout the season. Fortunately, all antennas, including Duncans Mills, were fully functioning prior to the first storm event that reconnected the tributaries with the mainstem and 25 adults were detected at sites upstream of Duncans Mills after November 13. However, because detection efficiency was so low at the Duncans Mills antenna array, the Russian River mainstem estimate was based on a very small sample size and could be biased low. Unfortunately, confidence intervals cannot be calculated using this estimation method, so we are unable to estimate a range of returns.

Low survival from the smolt through returning-adult life stage continues to pose a threat to recovering coho salmon populations in the Russian River Basin. SAR estimates represent survival from the time that smolts leave a given tributary, migrate downstream through the river and estuarine environments, reside in the ocean, and then migrate back upstream through the estuarine and riverine environments. Given such a variety of conditions experienced during these phases, it would be very informative to be able to separate out riverine, estuarine, and ocean survival to identify whether mortality, particularly of juveniles, is high in the mainstem of the river and/or in the estuary. Estimation of smolt survival through the river has been attempted by operating PIT antennas at Duncans Mills; however, we have been unable to successfully span the entire river channel with antennas, and detection efficiencies of smolts, which travel high in the water column, have been too low to estimate smolt abundance for the entire river. The Water Agency is seeking an additional year-round antenna site further upstream in the watershed with the intention of estimating smolt survival through a portion of the river. Radio and/or acoustic tracking of smolts to estimate survival as they travel through the river and estuary would be a useful method of teasing apart survival in the multiple habitat-types smolts inhabit after they migrate from the tributaries.

In recent years, low SAR ratios have resulted in a very low sample size of returning adult PIT-tagged fish. This has prohibited our ability to adequately evaluate the success of different release strategies, including whether there are differences in survival of returning adults relative to release season and/or release stream. Current tagging rates have been sufficient for making release group comparisons of freshwater survival (Obedzinski 2012; Obedzinski et al. 2015); however, we would need to increase tag rates in order to make adequate comparisons of SAR ratios for different release groups. To address this, we suggest that the Broodstock Program Release Workgroup revisit a set of simulations prepared to help decide appropriate tagging rates for the program. Additionally, we propose increasing tag rates by applying tags to coho salmon captured in the smolt traps on Willow, Dutch Bill, Green Valley and Mill creeks. This could increase the number of PIT-tagged adult returns to those four streams without adding a significant expense. An additional, more costly approach would be to increase tag rates of all fish released from the hatchery.

III. Spawning Surveys

Objectives

Spawning adult and redd surveys were conducted in Russian River tributaries to document spatial distribution and abundance of redds, and to generate estimates of adult coho salmon and steelhead returns. These data help determine 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. Collecting these data each year will enable us to track population changes over time. 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

<u>Sampling framework</u>

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 the 92 reaches comprising the Russian River adult coho salmon sample frame (Figure 18). Our target sampling effort was 25% (28) of the reaches in the coho salmon sample frame (SCWA and UC 2014).

<u>Field methods</u>

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 carcass) 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, Chinook salmon, and steelhead) (Figure 20), 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 Microsoft Access database.

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[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.

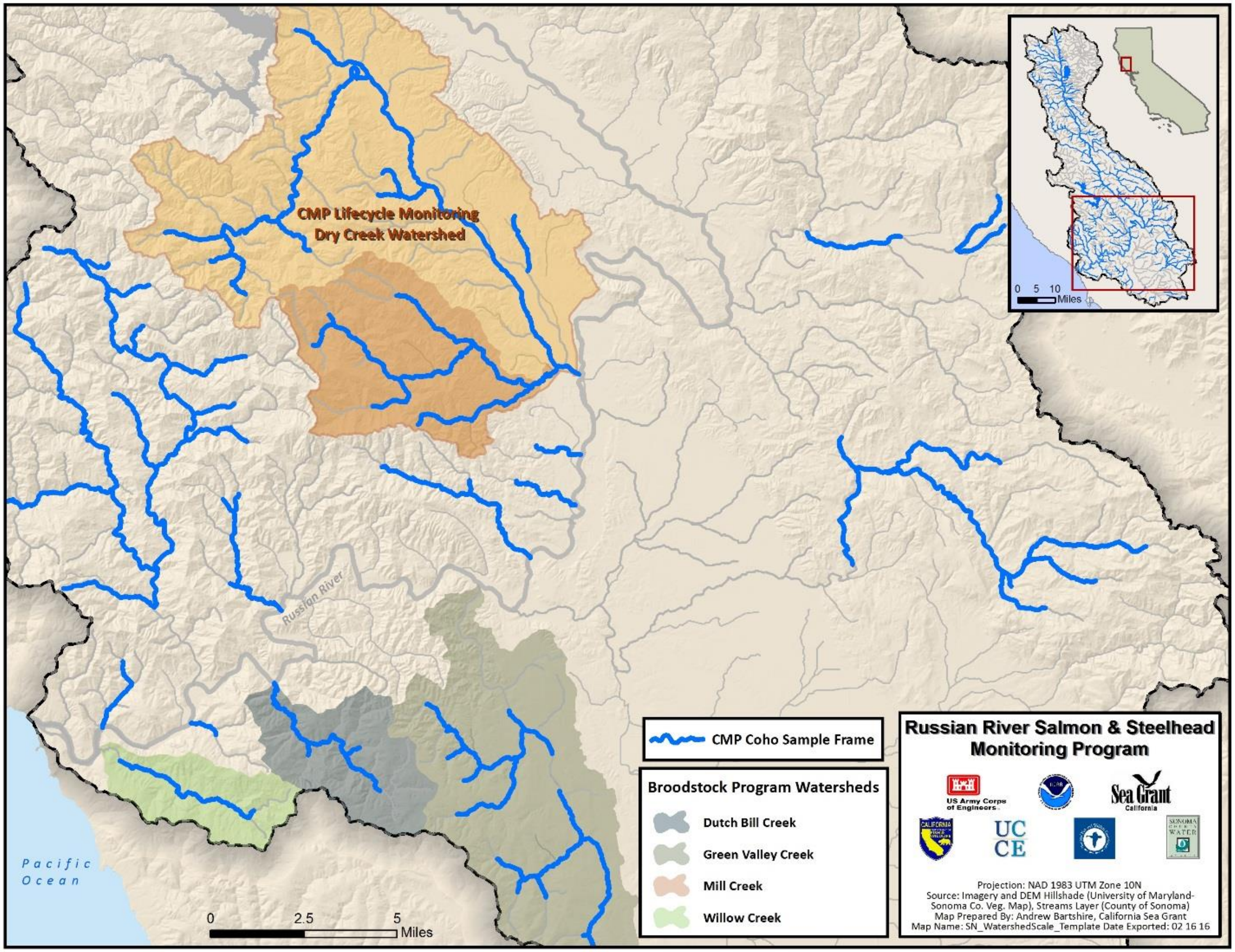

Figure 18. Broodstock Program watersheds and CMP sample frame for 2015-2016 spawner survey in the Russian River.

Figure 19. A spawner crew measures and records data on a redd in Grape Creek (photo credit: Sonoma County Water Agency).

Figure 20. An adult coho salmon observed in Felta Creek during 2015/16 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). Where redd measurements were not taken, known nearest neighbor (kNN) (Cover and Hart 1967) was used to assign redd species. 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 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 on December 7, 2015, and continued through April 15, 2016. Between December 2015 and April 2016, UC and Water Agency biologists completed a total of 447 salmonid spawning ground surveys on 41 reaches (45% of coho sample frame) in 31 streams throughout the Russian River basin. A total of 347 salmonid redds were observed: 46 coho salmon redds, 182 steelhead redds, 11 Chinook salmon redds, and 108 redds of unknown salmonid species origin (Table 9). Coho salmon redds were observed in 17 of the 31 streams surveyed (55%), steelhead redds were observed in 23 of the 31 streams surveyed (74%), and Chinook salmon redds were observed in four of the 31 streams surveyed (13%) (Table 9, Figure 21, Figure 22).

Coho salmon redd estimates in Broodstock Program monitoring streams ranged from seven in Green Valley Creek to 23 in Willow Creek, and coho salmon adult return estimates ranged from 17 in Dutch Bill Creek to 54 in Willow Creek (Table 10). Steelhead redd estimates in Broodstock Program monitoring streams ranged from zero in Willow Creek to 48 in Mill Creek, and steelhead adult return estimates ranged from zero in Willow Creek to 59 in Mill Creek (Table 10). Basinwide, we estimated the number of redds in all of the reaches to be 162 coho salmon redds and 587 steelheads redds (Table 11). Basinwide adult spawner estimates were 377 coho salmon and 716 steelhead (Table 11).

The proportion of natural to hatchery origin adult coho returns could not be determined because only one coho salmon carcass was recovered during the 2015/16 spawner survey season (Table 12). It did not have a CWT.

Redd distribution varied by stream (Figure 23 - Figure 26). In Willow Creek, there was a cluster of coho salmon redds lower in the reach and another cluster of redds high up in the reach near the end of anadromy (Figure 23). In Dutch Bill Creek, coho salmon redds were distributed evenly throughout the middle portions of the creek, while a majority of the steelhead redds were located in the lower reaches (Figure 24). In Green Valley Creek watershed, the majority of coho salmon redds were observed high upstream in the mainstem of Green Valley Creek, while steelhead redds were observed lower down in Green Valley Creek and in Purrington Creek (Figure 25). In the Mill

Creek watershed, the majority of coho salmon redds were observed in the lower reaches of the stream, downstream of the confluence with Wallace Creek (Figure 26). Redds of unknown salmonid species were distributed fairly evenly throughout all streams. Spatial distribution of redds for other CMP survey reaches can be found on our website: (http://www.cohopartnership.org).

Table 9. Total salmonid redds observed per species during 2015/16 spawner surveys in Russian River tributaries.

Tributary	Coho Salmon	Steelhead	Chinook Salmon	Unknown Salmonid	Total
Austin Creek	3	8	0	8	19
Dead Coyote Creek	0	0	0	0	0
Dutch Bill Creek	3	5	0	5	13
East Austin Creek	0	1	0	0	1
Felta Creek	1	7	0	4	12
Gilliam Creek	2	1	0	3	6
Grape Creek	0	9	0	2	11
Gray Creek	1	3	0	3	7
Green Valley Creek	3	5	0	5	13
Grubb Creek	0	0	0	0	0
Harrison Creek	0	0	0	0	0
Hulbert Creek	1	3	1	1	6
Little Green Valley	0	0	0	0	0
Mark West Creek	2	14	0	10	26
Mill Creek	10	12	0	8	30
Nutty Valley Creek	1	0	0	0	1
Palmer Creek	0	2	0	1	3
Pechaco Creek	0	2	0	1	3
Pena Creek	1	58	8	25	92
Perenne Creek	0	0	0	0	0
Porter Creek (Mark West)	0	0	0	0	0
Porter Creek	2	10	0	5	17
Press Creek	0	0	0	0	0
Purrington Creek	1	6	0	0	7
Redwood Creek	2	3	1	9	15
Santa Rosa Creek	0	1	0	3	4
Schoolhouse Creek	0	2	0	1	3
Wallace Creek	1	1	0	0	2
Willow Creek	11	4	0	8	23
Wine Creek	1	23	0	2	26
Woods Creek	0	2	1	4	7
TOTAL	46	182	11	108	347

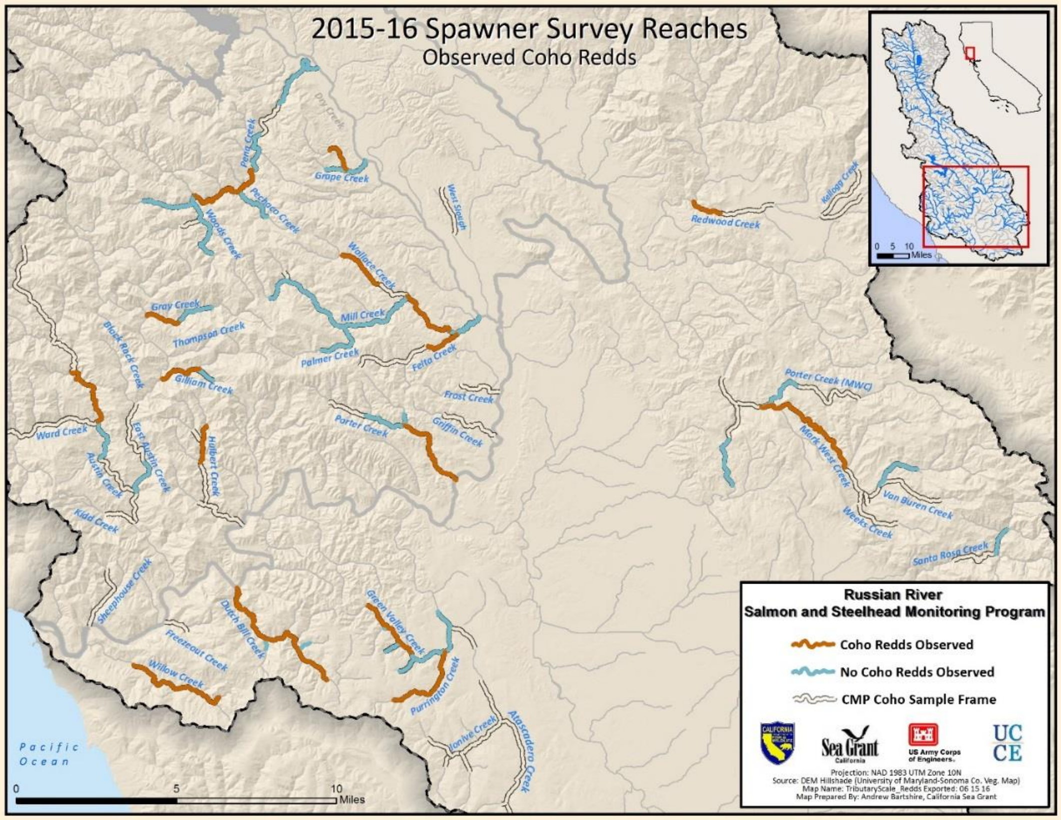

Figure 21. 2015/16 Spawner survey reaches where coho salmon redds were observed.

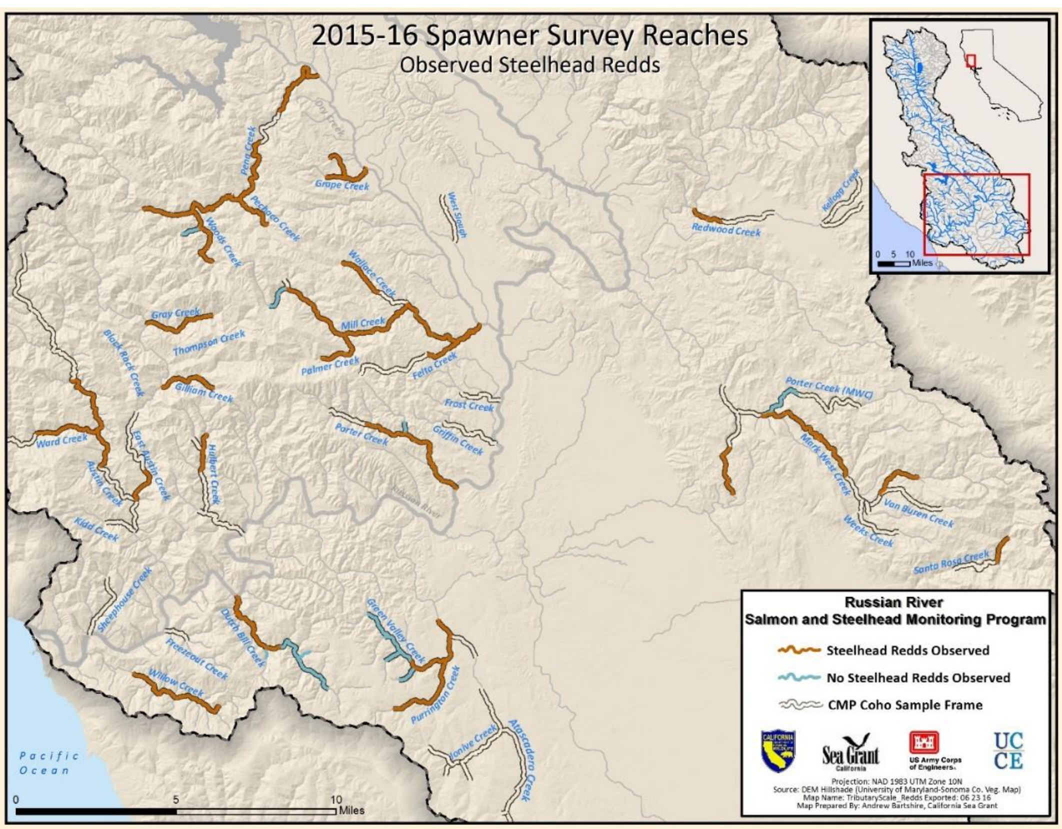

Figure 22. 2015/16 Spawner survey reaches where steelhead redds were observed.

Table 10. 2015/16 Broodstock Program monitoring stream redd and adult coho salmon and steelhead estimates.

Stream Name	Species	Estimate of Redds	Estimate of Adult Spawners
Willow Creek	coho salmon	23	54
Willow Creek	steelhead	0	0
Dutch Bill Creek System	coho salmon	7	17
Dutch Bill Creek System	steelhead	12	15
Green Valley Creek System	coho salmon	9	21
Green Valley Creek System	steelhead	14	17
Mill Creek System	coho salmon	12	28
Mill Creek System	steelhead	48	59

Table 11. 2015/16 Russian River basin redd and adult coho salmon and steelhead estimates.

Species	95%LCL	Redd Estimate	95%UCL	95%LCL	Fish Estimate	95%UCL
coho salmon	88	162	236	205	377	550
steelhead	281	587	893	343	716	1,089

Table 12. Number of coho salmon carcasses observed relative to CWT presence/absence during 2015/16 spawner surveys in Russian River tributaries.

Stream Name	Species	CWT Present	CWT Not Present
Willow Creek System	coho salmon	0	0
Dutch Bill Creek System	coho salmon	0	0
Green Valley Creek System	coho salmon	0	0
Mill Creek System	coho salmon	0	1

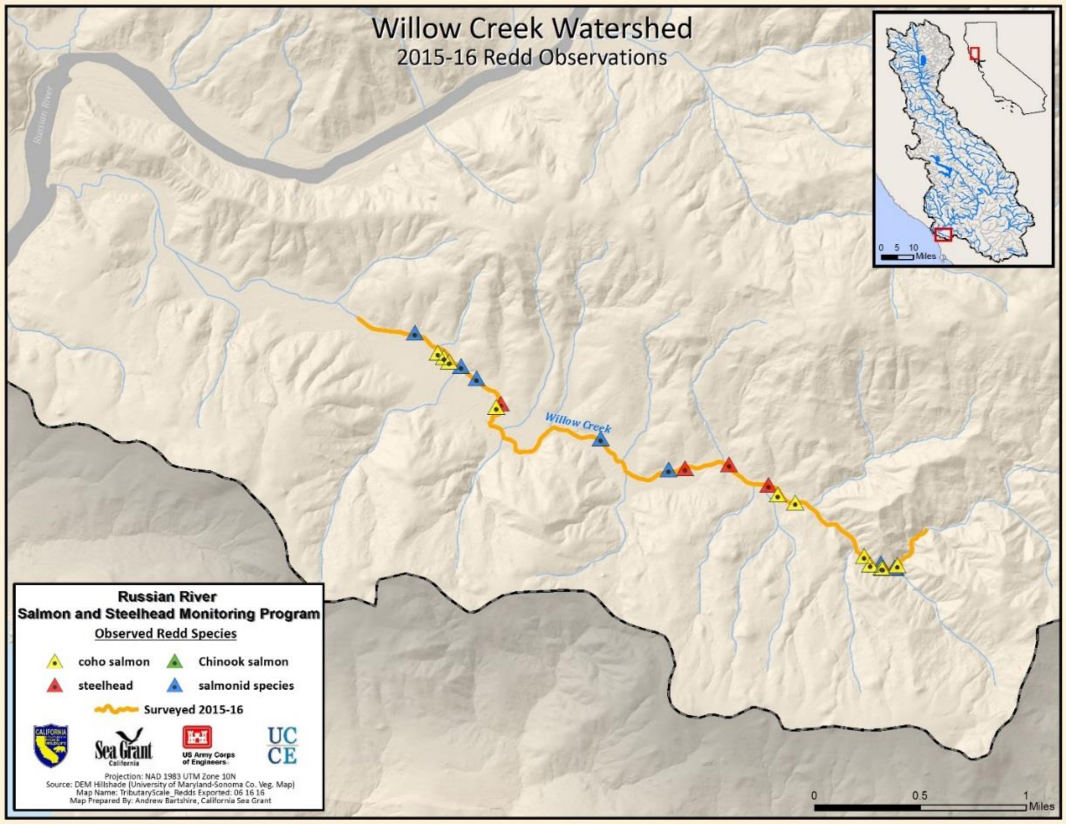

Figure 23. Salmonid redds observed in the Willow Creek during the 2015/16 spawner season.

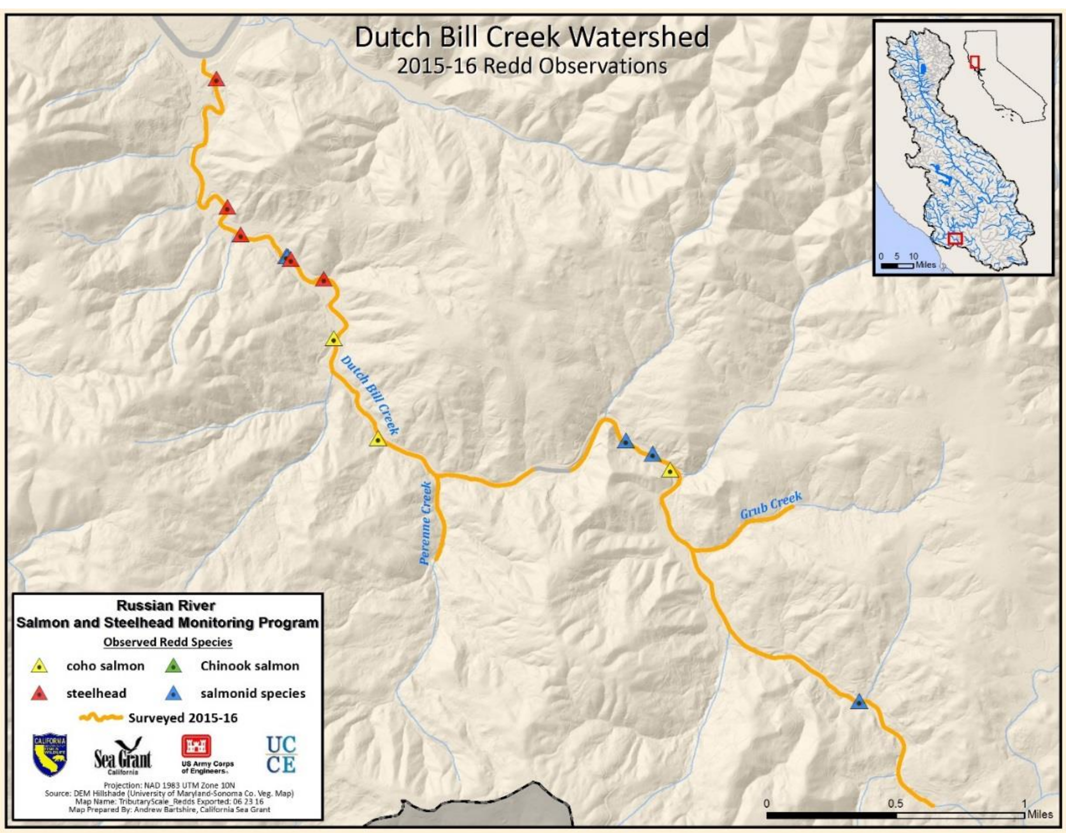

Figure 24. Salmonid redds observed in the Dutch Bill Creek system during the 2015/16 spawner season.

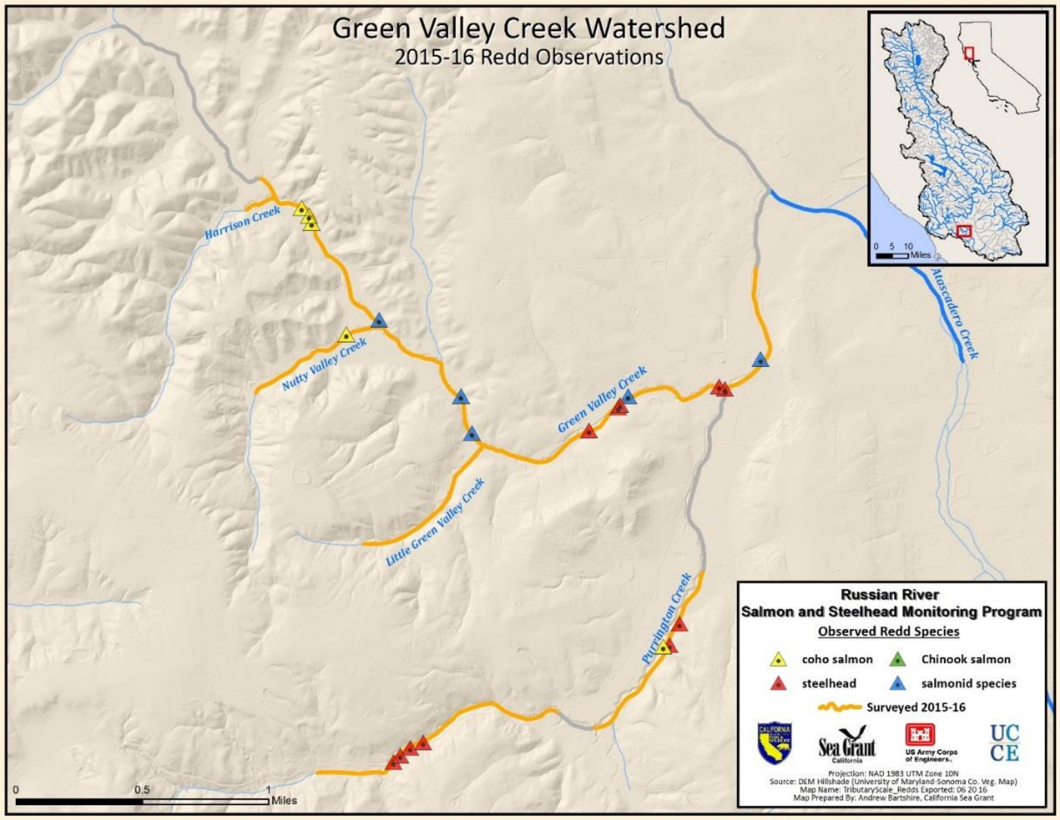

Figure 25. Salmonid redds observed in the Green Valley Creek system during the 2015/16 spawner season.

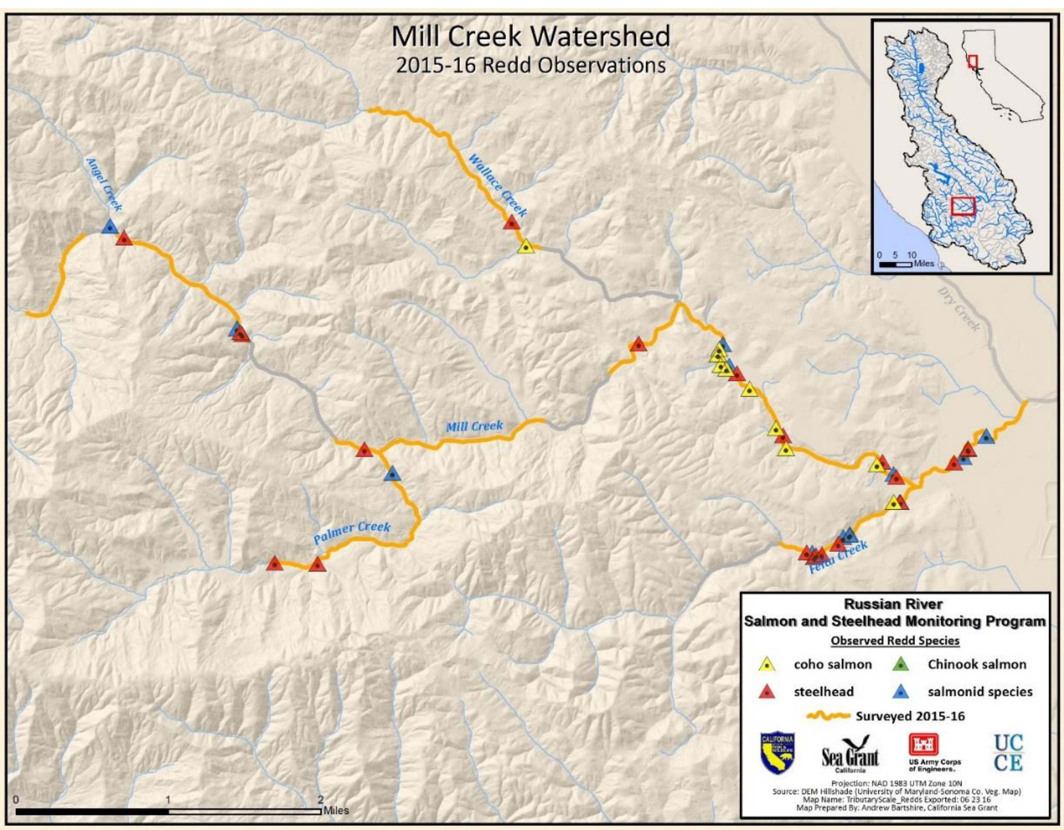

Figure 26. Salmonid redds observed in the Mill Creek system during the 2015/16 spawner season.

Discussion and Recommendations

During the 2015/16 spawner season, Broodstock Program stream monitoring in combination with CMP monitoring allowed us to complete more surveys over a wider array of streams than in any previous year of surveying. The combination of these two programs will allow us to address specific questions related to the Broodstock Program (e.g., release group comparisons and survival) as well as begin to document basinwide status and trends of coho in both stocked and unstocked streams within the Russian River.

Although we have observed a decline in overall returns of coho to the Russian River during the last three years, returns are still significantly higher than during the early 2000s (Figure 13) and we attribute this general success to the Broodstock Program releases as well as to habitat enhancement work that has been completed in the watershed. Environmental factors outside of our control, such as marine survival and drought can have a strong influence on the number of adults returning each year and, as in wild populations, we anticipate ongoing cycles in the number of returns. As described in Obedzinski et al. (2016), low streamflow is a significant bottleneck to rearing juveniles and must be addressed for long-term recovery of coho populations in the Russian River.

The estimated number of adult hatchery coho returning to the mainstem of the river based on PIT tag detections (192) was approximately half of the estimated number of all coho adults (hatchery and natural-origin) using the redd-based estimation approach (377). We do not attribute this discrepancy in estimates to a high proportion of natural-origin coho returning to the basin. Rather, this discrepancy may be attributed to one or more of the following factors: low confidence in the 2015/16 PIT tag estimate (given the low efficiency at Duncans Mills), low sample size, and/or inherent differences between the two different estimation methods.

A lacking component of our monitoring program is the ability to estimate the proportion of naturally-spawned adults returning to the basin. Although, theoretically, we could estimate this ratio by scanning recovered carcasses for the presence of a CWT, in practice we have never recovered a sufficient number of carcasses to generate this estimate. Through smolt trapping efforts in the spring, we have sufficient sample size to estimate this ratio at the juvenile stage on the four Broodstock Program monitoring streams. The Broodstock Program should discuss the appropriateness of applying these results to adult return data for the entire basin, or adopting some alternative methods of estimating this ratio for returning adults.

The flashy nature of Russian River tributaries makes redd observations difficult because redds are easily and quickly obscured after storm events. Based on our study design, we survey each reach approximately once every 10-14 days. To account for redds missed because of our sampling frequency, we use an in-reach expansion approach based upon the average "life span" of a redd. However, if we never observe any redds, there is nothing to expand upon, which, in turn, may bias our estimates. In past seasons, we have observed a majority of the coho salmon spawners return to smaller, spawning tributaries during and immediately following the first large storm, after which the run typically ends quickly. The extreme flows during and after these events often prevent surveying for several days due to safety issues, lack of visibility, and the risk of trampling unseen redds. In order to address this issue, we intend to increase the frequency of our surveys during expected peak runs so that our redd observation rate is higher. One such survey took place in the 2015/16 season on a Sunday just before a large storm front, and the crew observed 27 redds that became undetectable less than 24 hours later. Adopting a more flexible spawner survey schedule during suspected peak spawning events in future years will help us to document redds before they become obscured in high flow events. This should allow for more accurate counts of salmonid redds in future years.

In Mill Creek, the majority of the coho salmon redds observed were downstream of a partial barrier that is below the Wallace Creek confluence. These results are similar to what we have observed in previous spawner seasons and it appears that this barrier likely hindered passage of adult coho salmon. This summer (2016), modifications to the barrier are underway to allow better adult passage, and we anticipate that this will allow coho salmon better access to higher quality spawning and rearing reaches upstream.

Since we began conducting spawner surveys in Pena Creek during the 2013/14 spawning season, we have consistently observed high numbers of salmonid redds as well as adults of all three salmonid species. These high numbers are likely due to Pena Creek's proximity to the uppermost extent of anadromy in Dry Creek at the Don Claussen Fish Hatchery. Although Pena Creek has an abundance of suitable spawning habitat and we are observing high numbers of adults returning, the majority of the stream appears to dry out and/or become unsuitable for juvenile salmonids rearing in the stream during the summer season. We have observed extremely dry conditions in this stream during the past three years in September, when we conduct wetted habitat surveys to document the lowest flow conditions of the year (Obedzinski et al. 2016). Although a much smaller watershed than Pena Creek, Grape Creek is also a stream where we have observed spawning adults followed by extreme drying of habitat during the summer season. We compared 2015/16 redd locations with wetted habitat conditions observed in previous years to determine whether adults spawned in locations where their off-spring would have suitable wetted habitat in which to rear if they remained in the vicinity of the redd (Figure 27, Figure 28). Of 102 redds observed in Pena Creek, 83 (81%) were located in reaches that went dry in 2015, and of the 37 redds observed in Grape Creek, 31 (83%) were located in reaches that went dry in 2015. Based on these results, we expect that juveniles resulting from 2015/16 redds will have a very low probability of surviving. Given this bottleneck, we recommend that, until streamflows improve, the Broodstock Program should consider discontinuation of stocking in Pena Creek, Grape Creek, and other stream reaches where large areas of drying occur.

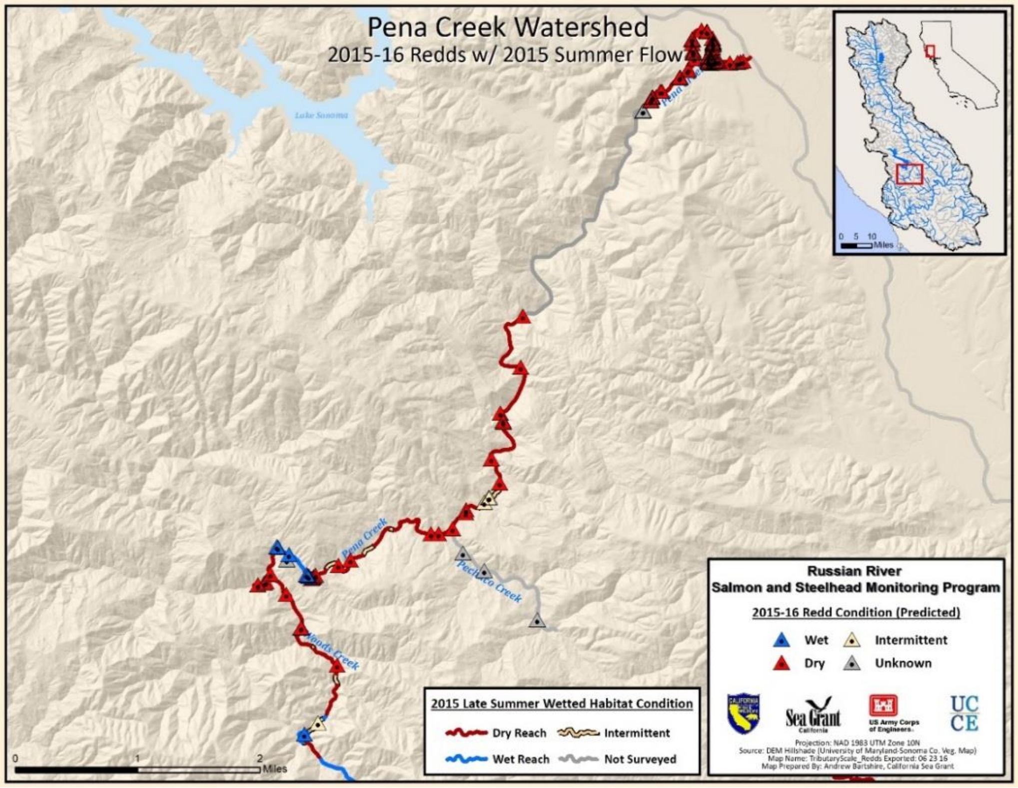

Figure 27. Winter 2015/16 Pena Creek salmonid redd distribution and wetted habitat conditions in late summer 2015.

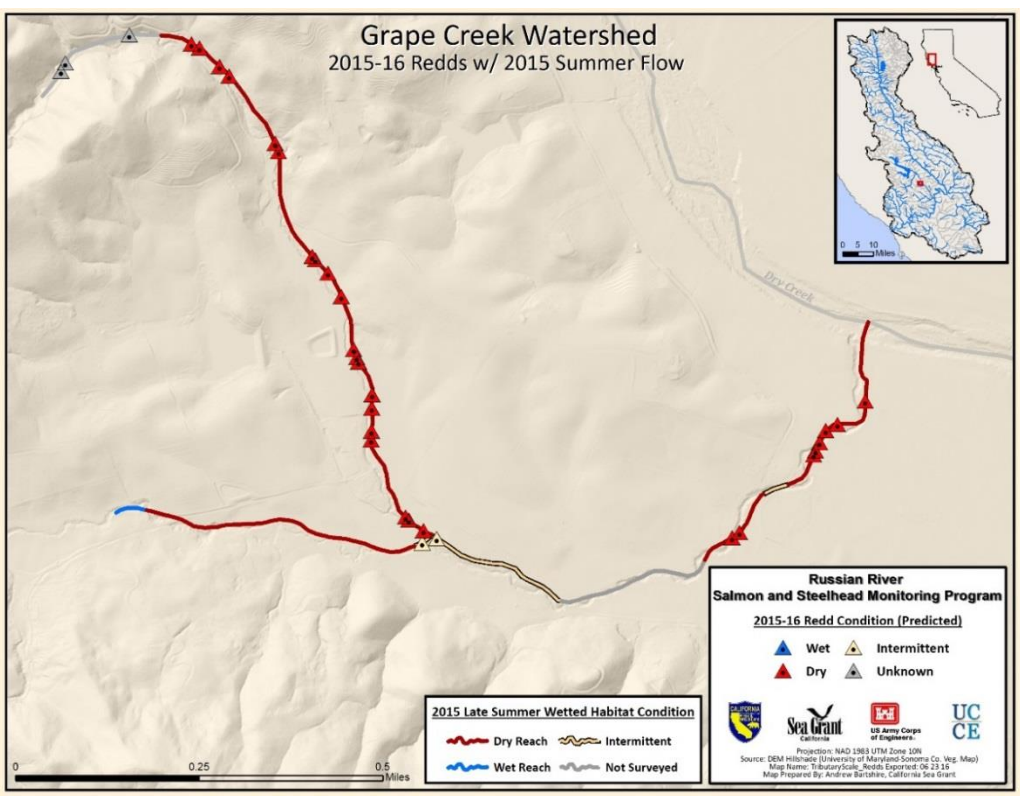

Figure 28. Winter 2015/16 Grape Creek salmonid redd distribution and wetted habitat conditions in late summer 2015.

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