UC Coho Salmon and Steelhead Monitoring Report: Summer 2019

Photo Credit: Fred Greaves

Prepared by:

Andrew McClary, Zac Reinstein, Nick Bauer, Andrew Bartshire, and Mariska Obedzinski

California Sea Grant at University of California

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Contents

1 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 resource managers 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 release streams: Willow, Dutch Bill, Green Valley, and Mill creeks. Data collected from this effort are provided to the Broodstock Program for use in adaptively managing future releases.

Over the last decade, 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 (Partnership), 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 (Sonoma Water) and California Department of Fish and Wildlife (CDFW) to begin implementation of the California Coastal Monitoring Program (CMP), a statewide effort to document status and trends of anadromous salmonid populations using standardized methods and a centralized statewide database. These new projects have led to the expansion of our program, which now includes over 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 report, we provide preliminary results from our summer and fall Broodstock Program and CMP snorkel surveys, including relative abundance and spatial distribution of juvenile salmonids in Russian River tributaries. Additional information and previous reports can be found on our website.

2 Juvenile Presence and Distribution

Summer snorkel surveys were conducted in Russian River tributaries to document the relative abundance and spatial distribution of juvenile coho salmon and steelhead during the summer of 2019. These data were used to determine whether successful spawning occurred the previous winter and to track trends in relative abundance and occupancy over time.

2.1 Methods

2.1.1 Sampling Reaches

For Broodstock Program monitoring, we surveyed juvenile salmonid reaches of Willow, Dutch Bill, Green Valley, and Mill creeks (Figure 1). For CMP monitoring, a spatially-balanced random sample of juvenile coho salmon reaches in the Russian River sample frame (a sample frame of stream reaches identified by the Russian River CMP Technical Advisory Committee[1] as having coho salmon, steelhead, and/or Chinook salmon habitat) was selected using a generalized random tessellation stratified (GRTS) approach as outlined in Fish Bulletin 180 (Adams et al. 2011) (Figure 1). In 2019, we surveyed all juvenile salmonid reaches in the lower Russian River where landowner access could be secured, for a total of 76 reaches representing 45 streams. Of these reaches, 75 of the 76 reaches were classified as containing juvenile coho salmon habitat. One reach in East Austin Creek was considered to only contain juvenile steelhead habitat due to its steep gradient.

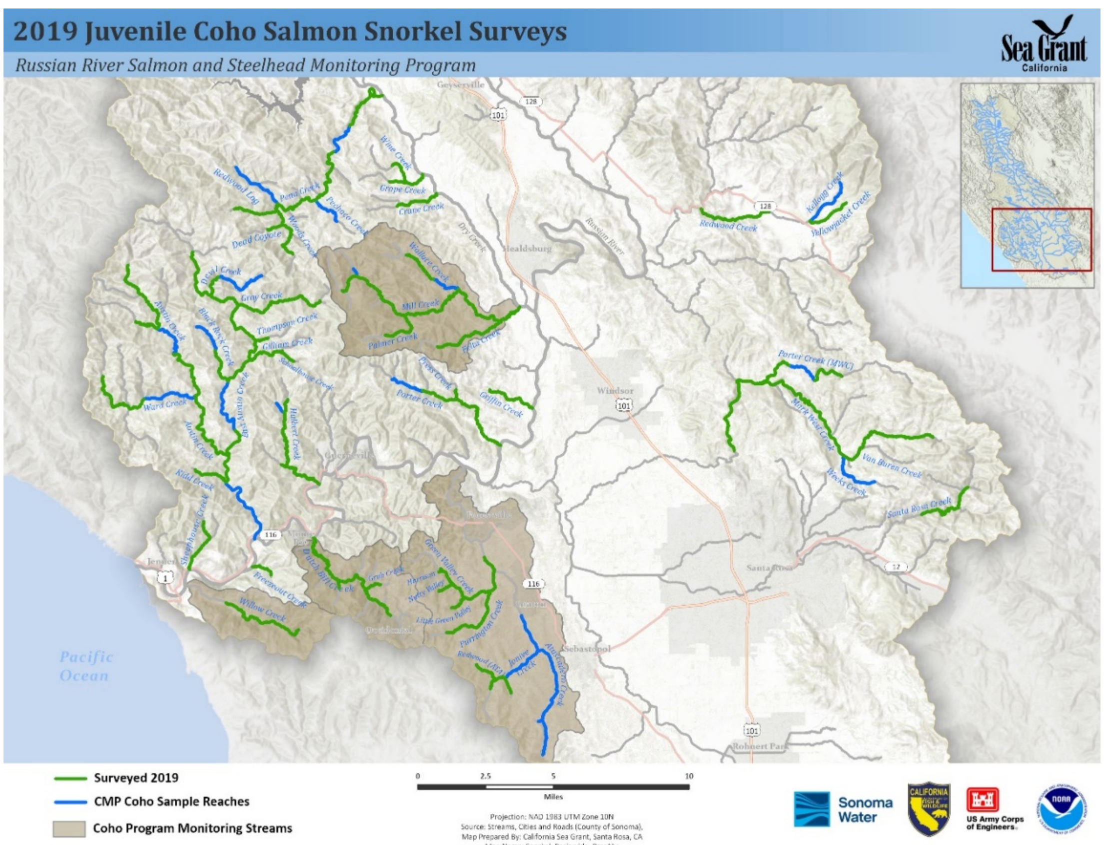

Figure 1. Snorkel survey reaches, 2019.

[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.

2.1.2 Field methods

Sampling was based on modifications of protocols in Garwood and Ricker (2014). In each survey reach, two independent snorkeling passes were completed. On the first pass, fish were counted in every other pool within the reach, with the first pool (one or two) determined randomly. Pools were defined as habitat units with a depth of greater than one foot in an area at least as long as the maximum wetted width and a surface area of greater than three square meters. For use in occupancy models, a second pass was completed the following day in which every other pool that was snorkeled during the first pass was snorkeled a second time. A GPS point was collected at the downstream end of each pool snorkeled on the first-pass survey.

During each survey, snorkeler(s) moved from the downstream end of each pool (pool tail crest) to the upstream end, surveying as much of the pool as water depth allowed. Dive lights were used to inspect shaded and covered areas. In order to minimize disturbance of fish and sediment, snorkelers avoided sudden or loud movements. Double counting was minimized by only counting fish once they were downstream of the observer. In larger pools requiring two snorkelers, two lanes were agreed upon and each snorkeler moved upstream through the lane at the same rate. Final counts for the pool were the sum of both lane counts. All observed salmonids were identified to species (coho salmon (Figure 2), Chinook salmon, steelhead) and age class (young-of-year (yoy) or parr (≥ age-1)), based on size and physical characteristics. Presence of non-salmonid species was documented at the reach scale. Allegro field computers were used for data entry and, upon returning from the field, data files were downloaded, error checked, and transferred into a SQL database. Spatial data was downloaded, error checked, and stored in an ArcGIS geodatabase for map production.

Figure 2. Coho salmon yoy observed in 2019 in Pena Creek.

2.1.3 Metrics

Relative abundance:

First-pass counts were used to document the minimum number of coho salmon and steelhead yoy and parr observed in each reach. Because only half of the pools were snorkeled, minimum counts were doubled for an expanded minimum count. Expanded minimum counts did not incorporate variation among pools or detection efficiency; therefore, they should only be considered approximate estimates of abundance useful for relative comparisons.

Spatial distribution:

Multiscale occupancy models were used to estimate the probability of juvenile coho salmon occupancy at the sample reach scale (ψ) and conditional occupancy at the sample pool scale (θ), given presence in the reach (Garwood and Larson 2014; Nichols et al. 2008). Detection probability (*p*) at the pool scale was accounted for using the repeated dive pass data in the occupancy models. The proportion of area occupied (PAO) was then estimated by multiplying the reach- and pool-scale occupancy parameters (ψ*θ).

2.2 Results

UC and Sonoma Water biologists surveyed a total of 76 reaches representing 212 km (132 mi) of stream and 45 tributaries between May 28th and August 7th. All juvenile coho salmon rearing reaches of Willow, Dutch Bill, Green Valley, and Mill creeks were surveyed for Broodstock Program monitoring, and 70 reaches within the Russian River sample frame that were considered to contain juvenile coho habitat (73% of coho reaches) were included in the occupancy estimate for CMP monitoring. Because our goal was to estimate occupancy of naturally-produced coho salmon yoy and we had no way of visually distinguishing hatchery- and natural-origin fish, we excluded any reaches in which hatchery releases occurred prior to snorkel surveys. Three juvenile coho salmon reaches on Gray Creek were not included in the occupancy estimate because coho salmon yoy were released from a remote streamside incubator (RSI) into those reaches prior to snorkeling, and two reaches on Mark West Creek were excluded because they were also stocked prior to snorkel surveys. One reach on East Austin Creek was classified as only containing steelhead habitat and was also excluded from the coho salmon occupancy estimate.

We observed 2,520 coho salmon yoy during the summer of 2019, with an expanded minimum count of 4,331 (Table 1), and we observed 41,732 steelhead yoy, with an expanded minimum count of 79,686 (Table 2). In streams where surveys were conducted before spring stocking occurred, all coho salmon yoy were presumed to be of natural-origin. Coho salmon yoy were observed in 36 of the 75 juvenile coho salmon *reaches* surveyed and in 23 of the 45 juvenile coho salmon *streams* snorkeled (48% and 51%, respectively) (Table 1, Figure 3). Steelhead yoy were observed in 75 of the 76 steelhead reaches and 44 of the 45 steelhead streams surveyed (99% and 98%, respectively) (Table 2). Natural-origin coho salmon counts were highest in Green Valley Creek, with the second highest counts in Willow Creek (Table 1). High numbers of coho salmon were observed in Mark West Creek; however, we believe these were hatchery-origin fish because we did not snorkel all of the reaches in this creek prior to hatchery releases. High coho numbers were also observed in Gray Creek but these fish likely originated from the RSI.

Based on results of the multiscale occupancy model, we estimate that the probability of coho yoy occupying a given reach within the basinwide Russian River coho stratum (ψ) in 2019 was 0.44 (0.33 - 0.56, 95% CI), and the conditional probability of coho yoy occupying a pool within a reach, given that the reach was occupied (θ), was 0.33 (0.29 – 0.38, 95% CI). The proportion of the coho stratum occupied (PAO) was 0.15. This was the lowest PAO observed over the last five years (Table 3).

Juvenile coho salmon were observed in all four Broodstock Program monitoring streams and spatial distribution varied among streams (Table 1, Figure 4 - Figure 7). In Willow Creek, coho salmon yoy were distributed throughout the stream with the highest concentrations found in the lower 75% of the sampled reaches (Figure 4). In Dutch Bill Creek, coho salmon yoy were observed throughout the stream in very low numbers, and in the lowest pool surveyed in Perenne Creek (Figure 5). In Green Valley Creek, coho salmon yoy were distributed throughout the stream as well as in two tributaries; Purrington and Nutty Valley creeks (Figure 6). In the Mill Creek watershed, the highest densities of coho yoy were found in the lower portions of lower Felta Creek, just upstream of the confluence with Mill Creek (Figure 7). They were also observed in low numbers upstream of Wallace and Palmer creeks.

Table 1. Number of coho salmon yoy and parr observed in Russian River tributaries and expanded counts, summer 2019.

Tributary	Number of Pools Snorkeled	Stream Length Snorkeled (km)	Yoy	Expanded Yoy[1]	Parr	Expanded Parr[1]
Austin Creek	149	16.9	3	6	0	0
Bearpen Creek	15	1.9	0	0	0	0
Black Rock Creek	32	2.5	3	6	0	0
Crane Creek (Dry)	36	3.2	0	0	0	0
Dead Coyote Creek	10	1.1	3	6	0	0
Devil Creek	15	1.5	0	0	0	0
Dutch Bill Creek	105	9.7	32	64	0	0
East Austin Creek	123	14.9	21	42	0	0
Felta Creek	97	5.2	74	148	2	4
Freezeout Creek	34	1.5	19	38	0	0
Gilliam Creek	34	2.6	0	0	0	0
Grape Creek	60	2.6	0	0	0	0
Gray Creek[2]	123	6.3	689	689	0	0
Green Valley Creek	95	7.0	311	622	2	4
Griffin Creek	26	3.6	0	0	1	2
Grub Creek	21	1.1	0	0	0	0
Harrison Creek	3	0.2	0	0	0	0
Hulbert Creek	113	8.2	9	18	0	0
Jonive Creek	22	1.5	10	0	0	0
Kidd Creek	29	2.5	14	28	0	0
Little Green Valley Creek	18	1.2	0	0	0	0
Mark West Creek[3]	229	22.1	714	1,428	1	2
Mill Creek	141	16.0	12	24	2	4
Mission Creek	3	0.4	0	0	0	0
Nutty Valley Creek	13	1.2	20	40	0	0
Palmer Creek	52	2.9	0	0	0	0
Pena Creek	114	15.1	34	68	0	0
Perenne Creek	12	0.5	2	4	0	0
Porter Creek	129	7.4	8	16	0	0
Porter Creek (MWC)	62	5.1	24	48	0	0
Press Creek	9	0.6	0	0	0	0
Purrington Creek	70	4.8	101	202	0	0
Redwood Creek	51	4.8	0	0	0	0
Redwood Creek (Atascadero)	30	1.9	0	0	2	4
Santa Rosa Creek	73	4.6	0	0	0	0
Schoolhouse Creek	13	1.1	0	0	0	0
Sexton Creek	4	1.0	0	0	0	0
Sheephouse Creek	71	3.7	100	200	0	0
Thompson Creek	15	0.9	0	0	0	0
Wallace Creek	31	2.5	0	0	0	0
Ward Creek	60	5.0	0	0	0	0
Willow Creek	110	6.0	211	422	0	0
Wine Creek	36	1.8	0	0	0	0
Woods Creek	81	4.1	106	212	0	0
Yellowjacket Creek	69	2.8	0	0	0	0
Total	**2,638**	**211.5**	**2,520**	**4,331**	**10**	**20**

[1] *Expanded count is the observed count multiplied by a factor of 2.*

[2] *Snorkel counts include yoy released as part of an RSI trial. Every pool was snorkeled as part of RSI monitoring.*

[3] *Snorkel surveys took place after stocking so observed count likely consists primarily of stocked fish.*

Table 2. Number of steelhead yoy and parr observed in Russian River tributaries and expanded counts, summer 2019.

Tributary	Number of Pools Snorkeled	Stream Length Snorkeled (km)	Yoy	Expanded Yoy[1]	Parr	Expanded Parr[1]
Austin Creek	149	16.9	2,216	4,432	233	466
Bearpen Creek	15	1.9	141	282	25	50
Black Rock Creek	32	2.5	532	1,064	16	32
Crane Creek (Dry)	36	3.2	287	574	1	2
Dead Coyote Creek	10	1.1	33	66	5	10
Devil Creek	15	1.5	152	304	1	2
Dutch Bill Creek	105	9.7	1,258	2,516	21	42
East Austin Creek	123	14.9	1,516	3,032	234	468
Felta Creek	97	5.2	748	1,496	45	90
Freezeout Creek	34	1.5	164	328	28	56
Gilliam Creek	34	2.6	20	40	43	86
Grape Creek	60	2.6	1,356	2,712	97	194
Gray Creek[2]	123	6.3	3,778	3,778	299	299
Green Valley Creek	95	7.0	857	1,714	332	664
Griffin Creek	26	3.6	2	4	8	16
Grub Creek	21	1.1	9	18	7	14
Harrison Creek	3	0.2	6	12	0	0
Hulbert Creek	113	8.2	3,768	7,536	87	174
Jonive Creek	22	1.5	41	82	9	18
Kidd Creek	29	2.5	14	28	6	12
Little Green Valley Creek	18	1.2	63	126	2	4
Mark West Creek	229	22.1	4,468	8,936	682	1,364
Mill Creek	141	16.0	1,290	2,580	66	132
Mission Creek	3	0.4	134	268	0	0
Nutty Valley Creek	13	1.2	10	20	0	0
Palmer Creek	52	2.9	343	686	59	118
Pena Creek	114	15.1	8,803	17,606	174	348
Perenne Creek	12	0.5	17	34	3	6
Porter Creek	129	7.4	1,059	2,118	59	118
Porter Creek (MWC)	62	5.1	1,118	2,236	200	400
Press Creek	9	0.6	6	12	1	2
Purrington Creek	70	4.8	662	1,324	161	322
Redwood Creek	51	4.8	703	1,406	253	506
Redwood Creek (Atascadero)	30	1.9	96	192	2	4
Santa Rosa Creek	73	4.6	2,402	4,804	275	550
Schoolhouse Creek	13	1.1	10	20	0	0
Sexton Creek	4	1.0	0	0	0	0
Sheephouse Creek	71	3.7	372	744	83	166
Thompson Creek	15	0.9	129	258	15	30
Wallace Creek	31	2.5	301	602	45	90
Ward Creek	60	5.0	364	728	99	198
Willow Creek	110	6.0	820	1,640	81	162
Wine Creek	36	1.8	711	1,422	28	56
Woods Creek	81	4.1	700	1,400	23	46
Yellowjacket Creek	69	2.8	253	506	108	216
Total	**2,638**	**211.5**	**41,732**	**79,686**	**3,916**	**7,533**

[1] *Expanded count is the observed count multiplied by a factor of 2.*

[2] *Every pool was snorkeled as part of RSI monitoring.*

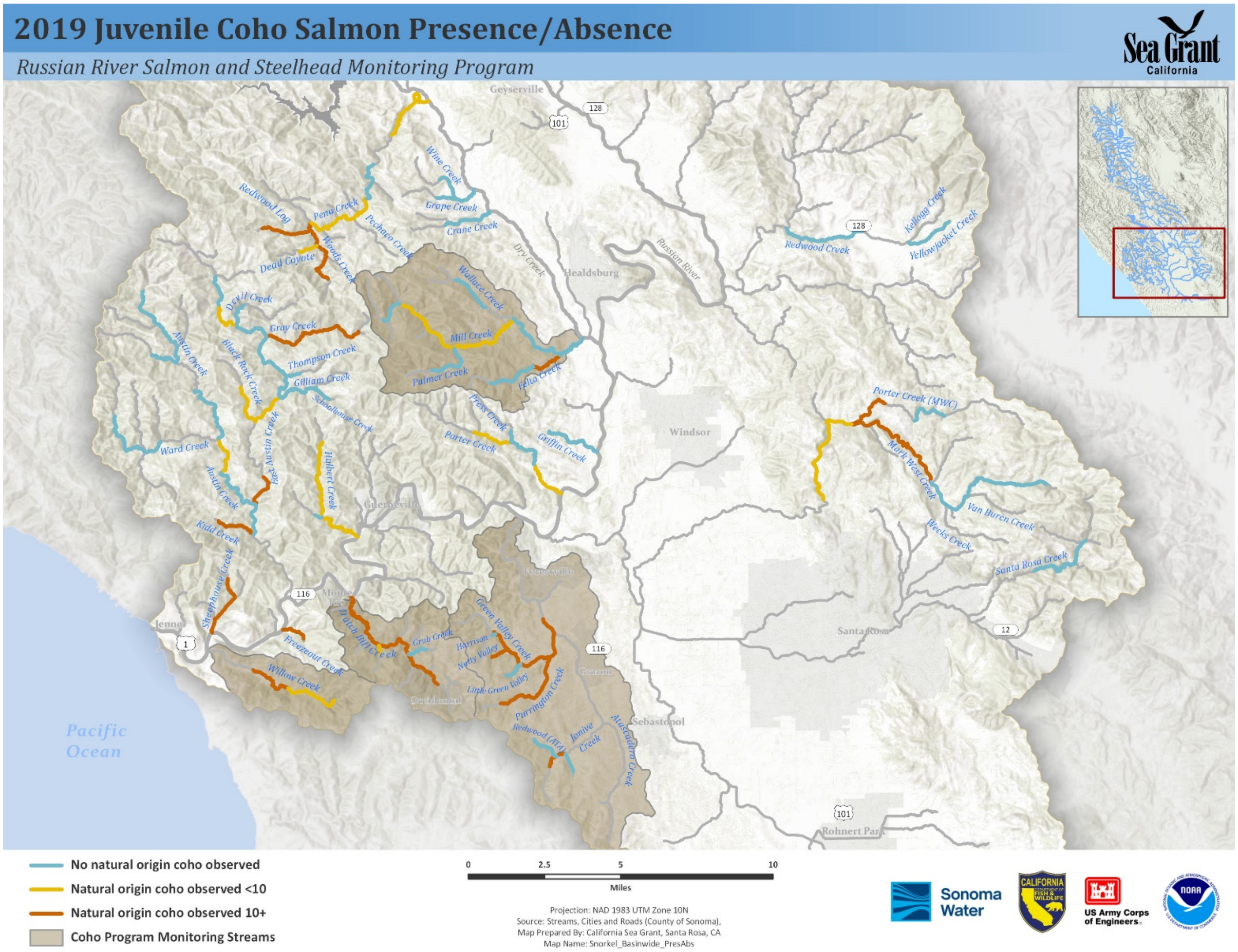

Figure 3. Natural-origin coho salmon presence by reach in surveyed Russian River tributaries, summer 2019.

Table 3. Percent of area occupied by coho salmon yoy within juvenile coho reaches of the Russian River sample frame, 2015-2019.

Year	Reaches Sampled	Stream Length Surved (km)	PAO
2015	58	167	0.37
2016	72	206	0.33
2017	73	214	0.2
2018	69	205	0.25
2019	70	211	0.15

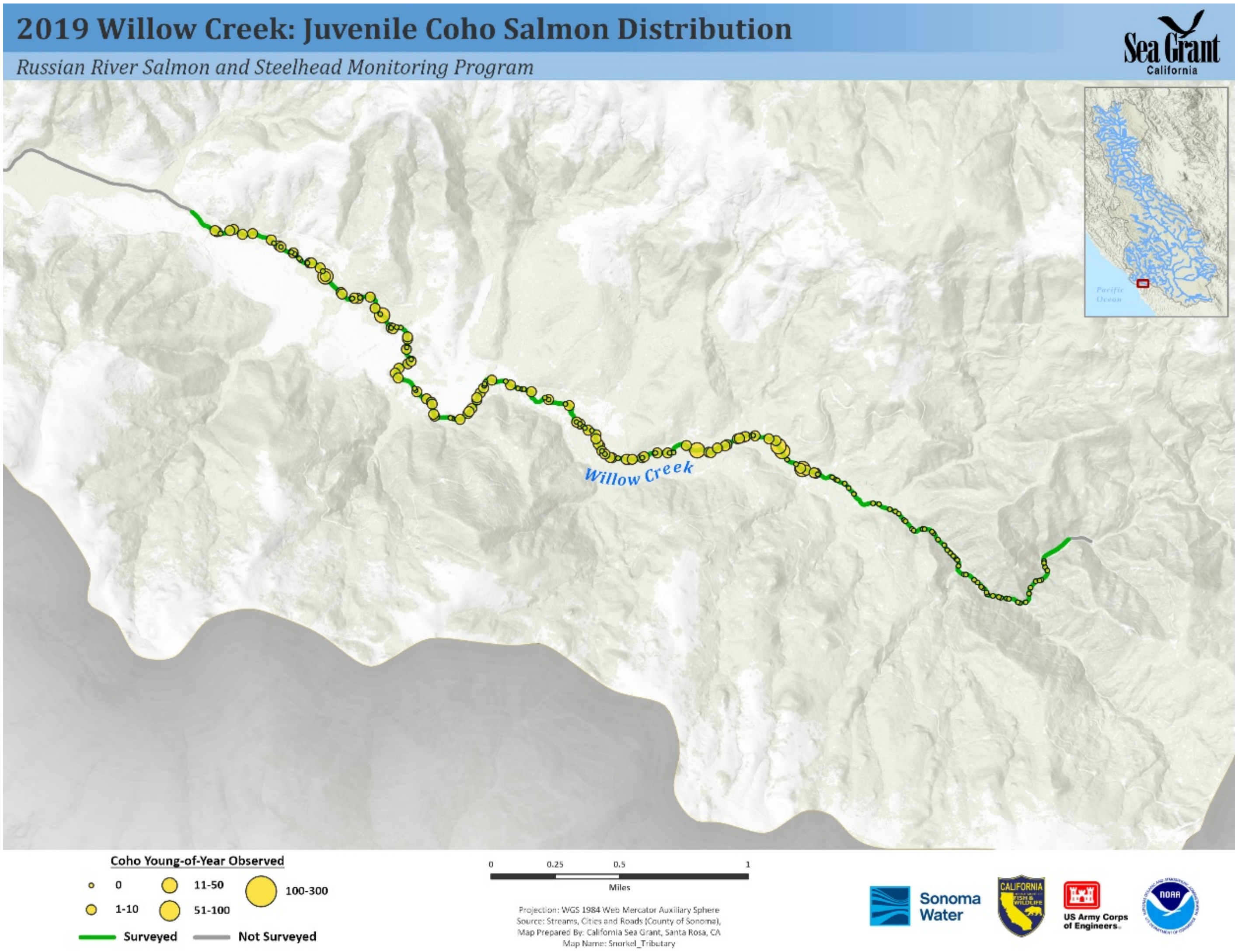

Figure 4. Density and distribution of juvenile coho salmon yoy observed in Willow Creek, 2019. Note that the smallest circle indicates no coho observations in the associated pool.

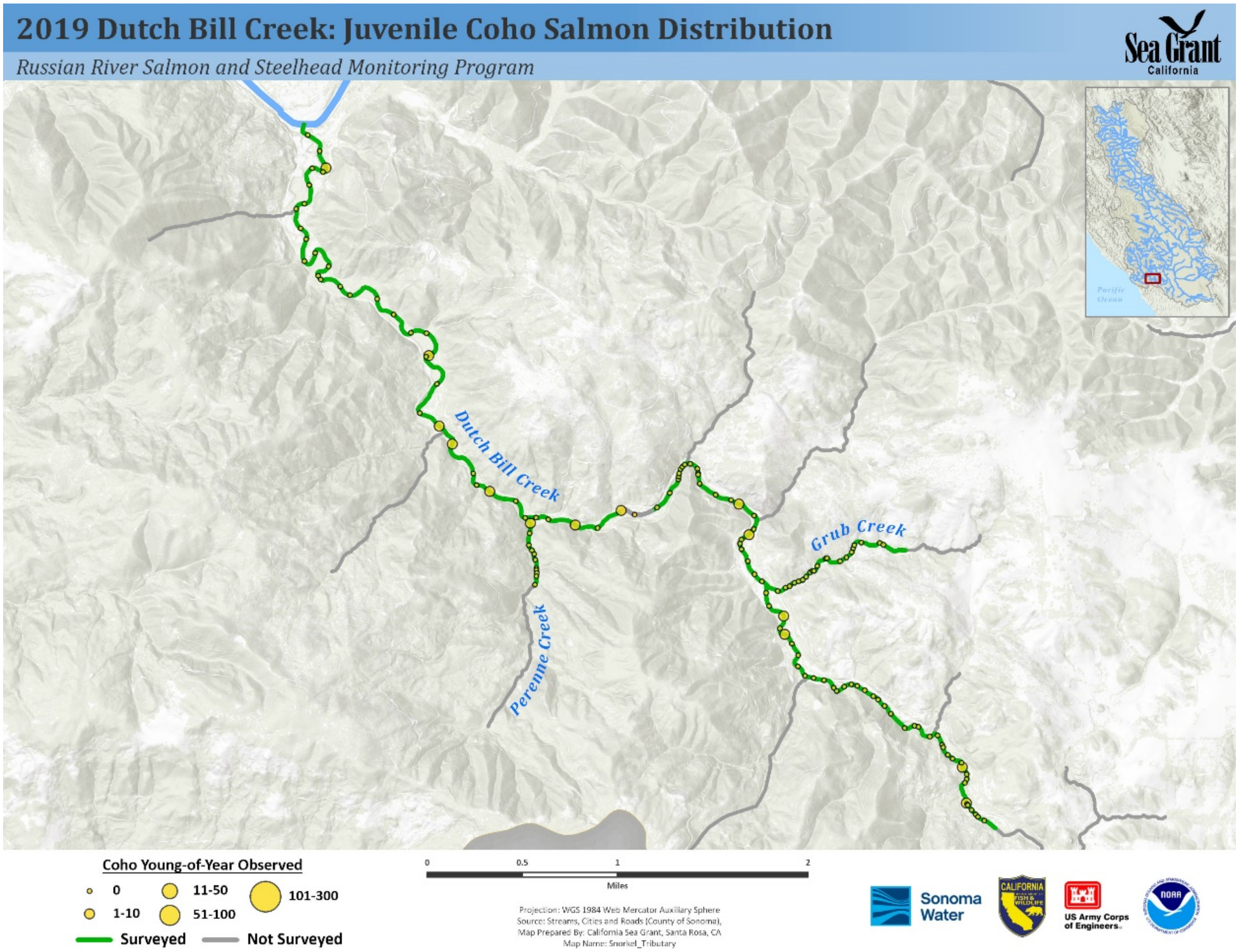

Figure 5. Density and distribution of juvenile coho salmon yoy observed in Dutch Bill Creek, 2019. Note that the smallest circle indicates no coho observations in the associated pool.

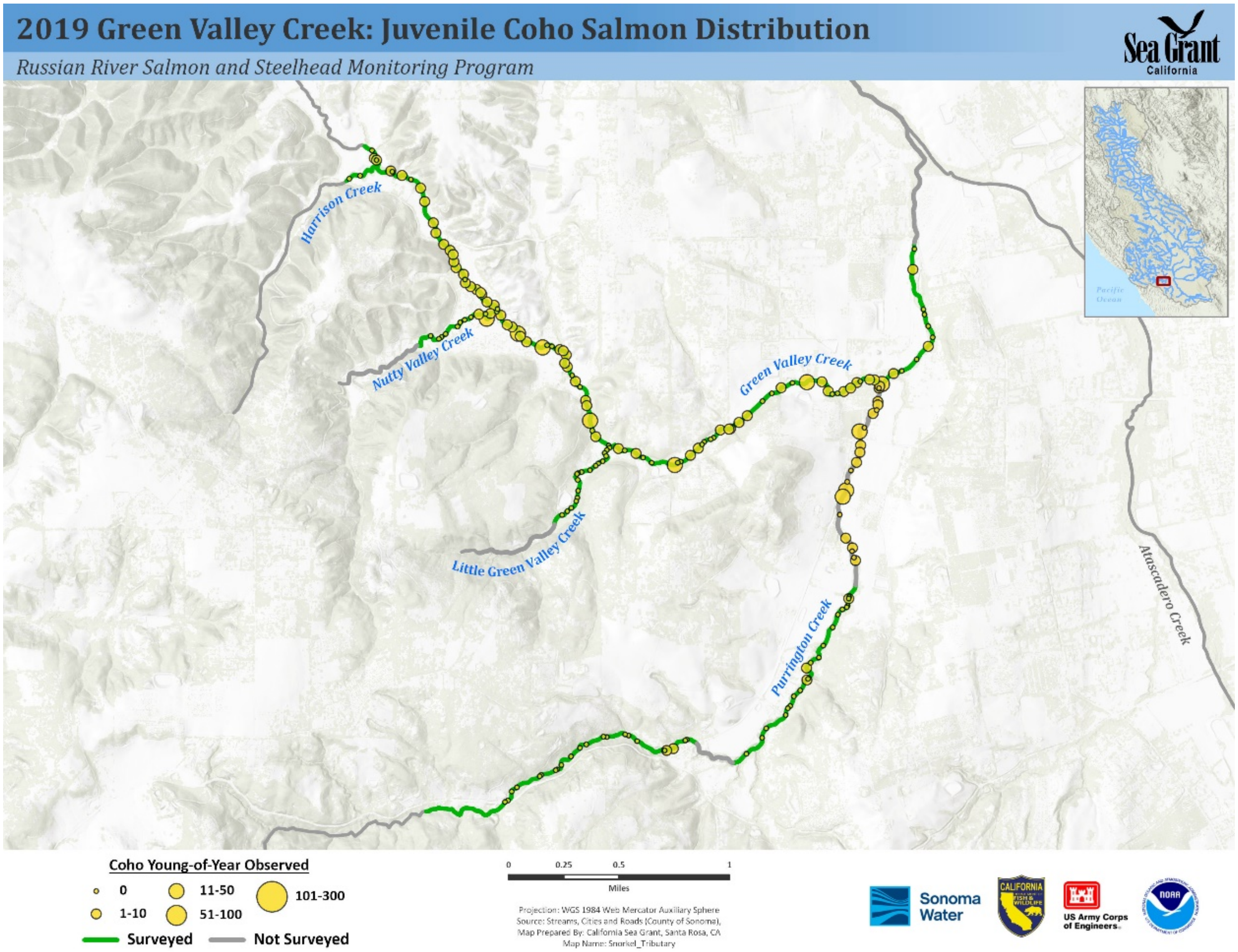

Figure 6. Density and distribution of juvenile coho salmon yoy observed in Green Valley Creek, 2019. Note that the smallest circle indicates no coho observations in the associated pool.

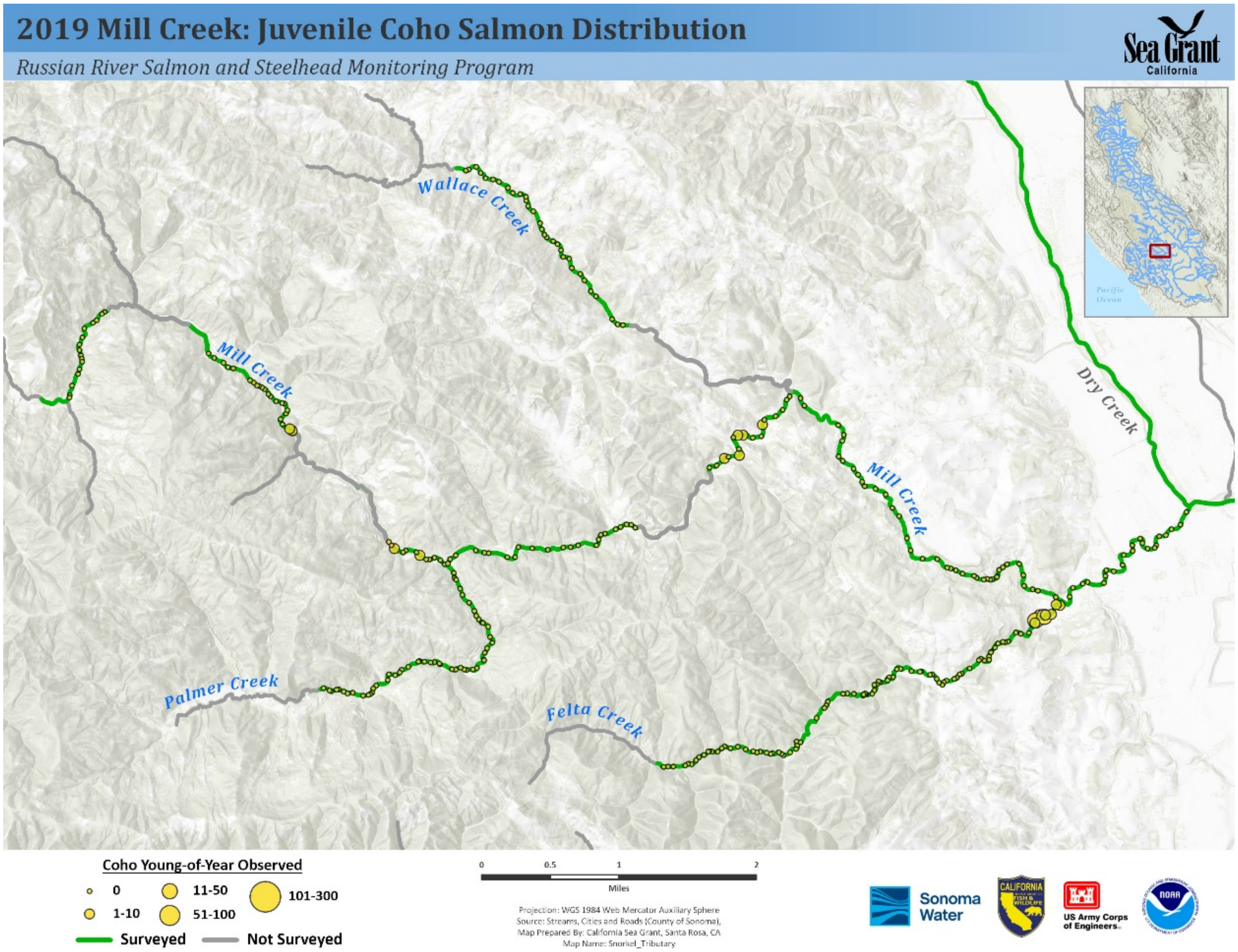

Figure 7. Density and distribution of juvenile coho salmon yoy observed in Mill Creek, 2019. Note that the smallest circle indicates no coho observations in the associated pool.

2.3 Discussion and Recommendations

Natural-origin juvenile coho salmon were present in all four Broodstock Program monitoring streams and in 23 of 45 juvenile coho salmon streams surveyed through the CMP Program in 2019, and ten or more coho salmon yoy were observed in 17 of the 45 coho salmon tributaries. This is a positive indication that successful spawning of adult coho salmon continued to occur in the Russian River watershed during the winter of 2018/19, and it represents a significant improvement in spatial distribution from the early 2000s when coho salmon were only known to occur in one to two streams per year. However, the total number and distribution of coho yoy observed during snorkel surveys in the summer of 2019 were significantly lower than in the previous four years (Table 3, Table 4). This was unexpected given that the coho basinwide redd estimate for the winter of 2018/19 (127) was only slightly below the five-year average of 139 redds (Table 4), and that the adult return estimate was the second highest observed in that period, with a high proportion of three-year old fish (California Sea Grant 2019).

Although expanded snorkel counts do not represent a true population estimate, we compared the ratio of coho salmon yoy observed in the summer to estimated redds from the previous winter to gain a relative understanding of spawner success and compared that with results from the previous four cohorts (Table 4). The ratio of coho salmon yoy observed during the summer of 2019 to coho salmon redds observed in the winter of 2018/19 was by far the lowest we have observed over the last five years, as was the ratio of yoy to estimated 2018/19 adult returns. One possible explanation for the apparent poor early life stage survival in the 2018/19 spawner season is high storm flows causing redd destruction and/or egg/alevin/fry mortality. Coho salmon redds are particularly vulnerable to sedimentation and scouring during the first few weeks after spawning and are vulnerable to scour until emergence (Koski 1966). Redds can be vulnerable to high flows even in relatively undeveloped watersheds, and with many of the changes in land use that have taken place in the Russian River watershed, such as urbanization and increased agricultural use, this vulnerability has likely increased (Booth and Jackson 1997; Hollis 1975).

In prior years, we have observed that redd-to-yoy survival in higher-gradient streams appears to be particularly sensitive to high flow events. Over the past four years, we observed a much more dramatic reduction in yoy-to-redd ratios in Mill Creek (1.2% gradient) as compared to Green Valley Creek (0.5% gradient) in 2016/17, when winter flows were high (Figure **8**). However, in 2018/19, also a winter with higher-than-average flow and storm events, spawning success was dramatically reduced in both streams, suggesting that some characteristics of the high flow events (e.g., timing, rate of increase) during this winter may have impacted redds in both high- and low-gradient streams or there are other factors influencing spawning success.

In order to further explore whether high flows may be influencing early life stage survival, we plotted weekly totals of new coho salmon redds observed during spawning surveys over the past three winters along with streamflow recorded at the United States Geological Survey (USGS) gaging station on Austin Creek, an undammed tributary in the lower Russian River basin (Figure 9, Figure 10, Figure 11). During the winter of 2018/19, there were two high flow events that took place after coho salmon spawned (32 and 44 days after peak spawning), supporting the possibility that early life stage survival may have been negatively impacted by high flows (in this case, over 9,000 ft^3/s in Austin Creek) (Figure 11). In contrast, during the winter of 2017/18, when flows were lower and later (maximum of 2,590 ft^3/s in Austin Creek, 72 days following the peak of spawning), the yoy-to-redd ratio was much higher (106 as compared to 18) (Table 4, Figure 10). However, in 2016/17, which, like 2018/19, had large storm events after coho salmon spawning (27 and 57 days after peak spawning) and an even higher maximum discharge than in 2018/19 (12,600 ft^3/s as compared to 9,780 ft^3/s in Austin Creek), the yoy-to-redd ratio was significantly higher (45 in 2016/17 as compared to 18 in 2018/19) (Table 4, Figure 9). Therefore, it is likely that factors other than peak discharge contributed to the low yoy-to-redd ratio for the 2018/19 spawning season, or that there was variation in peak discharge among streams that was not accurately represented by the Austin Creek gage. It is possible that the timing or number of storm events in relation to spawning and/or the nature of the storms (i.e., how quickly flows accelerate), may have also influenced spawning success. In 2018/19, the late storms were the only large events of the season, whereas in 2016/17, large events occurred in December, January, and February (Figure 9, Figure 11). Relatively small changes in the timing of high flow events may have a disproportionate impact on spawning success if the events take place at a critical time in the coho lifecycle. Further investigation into streamflow dynamics during storms in relation to spawn and emergence timing in the Broodstock Program monitoring streams is warranted to better understand this likely bottleneck to early life stage survival.

Another potential reason for poor spawning success is long duration of time in freshwater prior to spawning. Studies have shown lower fecundity rates after adult salmonids spend extended periods of time in freshwater and/or in warmer water (Fenkes et al. 2016). In the Russian River, in years when rain begins late (e.g., winter

2013/14 significant rain did not fall until mid-February), adult fish that have entered the mainstem of the river are unable to access the spawning tributaries and have been documented holding in the river for up to three months (UC unpublished data). During the winters of 2016/17 through 2018/19, timing of entry into the mainstem of the Russian River was similar and fish were able to access the spawning tributaries by early December; therefore, lower yoy-to-redd ratios are not likely due to adults experiencing an extended time in freshwater (California Sea Grant 2017; California Sea Grant 2019). In the future, understanding the thermal regimes of the estuary and lower river could help identify possible threats to fecundity, particularly in years when sufficient rains start late in the season and fish are unable to migrate upstream into the spawning tributaries until late in the winter.

Overall, the cause of the poor spawning success in 2018/19 does not appear to have a single straightforward explanation. One next step to better understanding the impacts of storm events on early life stage survival is to use known coho salmon development index equations to predict the timing of vulnerable life stages such as emergence. These predicted values could then be compared with different flow metrics, and ideally turbidity metrics. We recommend that winter streamflow, sediment-source, and turbidity monitoring be conducted in the Broodstock Program tributaries in order to better evaluate how storm events and sediment load are affecting early life stage survival.

Even in the absence of such studies, we recommend continuing efforts to slow and buffer winter streamflows, provide instream shelter, and reduce the amount of sediment that is currently entering streams. Reconnecting floodplain habitat could increase early life stage survival by slowing discharge rates during storm events and providing refuge for emergent fry. Stabilizing streambeds to prevent further channel incision can slow or halt additional floodplain disconnection. Creation of secondary high-flow channels that are more protected from streambed mobilizing floods and provide necessary habitat for over-wintering juveniles could also be beneficial. (Rosenfeld et al. 2008) Instream wood placement increases channel complexity, slows current velocities, and provides shelter for fry. Small-scale bioswales and retention pond projects could help to slow run-off into creeks and fill critical aquafers through infiltration, having the dual benefit of improving conditions for fish in both winter and summer. All of these efforts will be necessary to address the issue at a landscape scale in order to achieve self-sustaining populations of coho salmon that can persist without hatchery augmentation.

Table 4. Coho salmon redd and adult return estimates compared to juvenile coho salmon snorkel counts the following summer.

Spawner Season	Snorkel Year	Redd Estimate	Adult Return Estimate	Coho Yoy Expanded Count	Yoy to Redd Ratio	Yoy to Adult Ratio
2014/2015	2015	98	397	8,716[1]	88.9	22.0
2015/2016	2016	170	192	9,262[1]	54.5	48.2
2016/2017	2017	206	533	9,240	44.9	17.3
2017/2018	2018	93	763	9,824	105.6	12.9
2018/2019	2019	127	642	2,234[2]	17.6	3.5

[1] *Probable hatchery fish in Green Valley, Mill, and Dutch Bill creeks were removed from expanded count.*
[2] *Probable hatchery fish in Mark West and Gray creeks were removed from expanded count.*

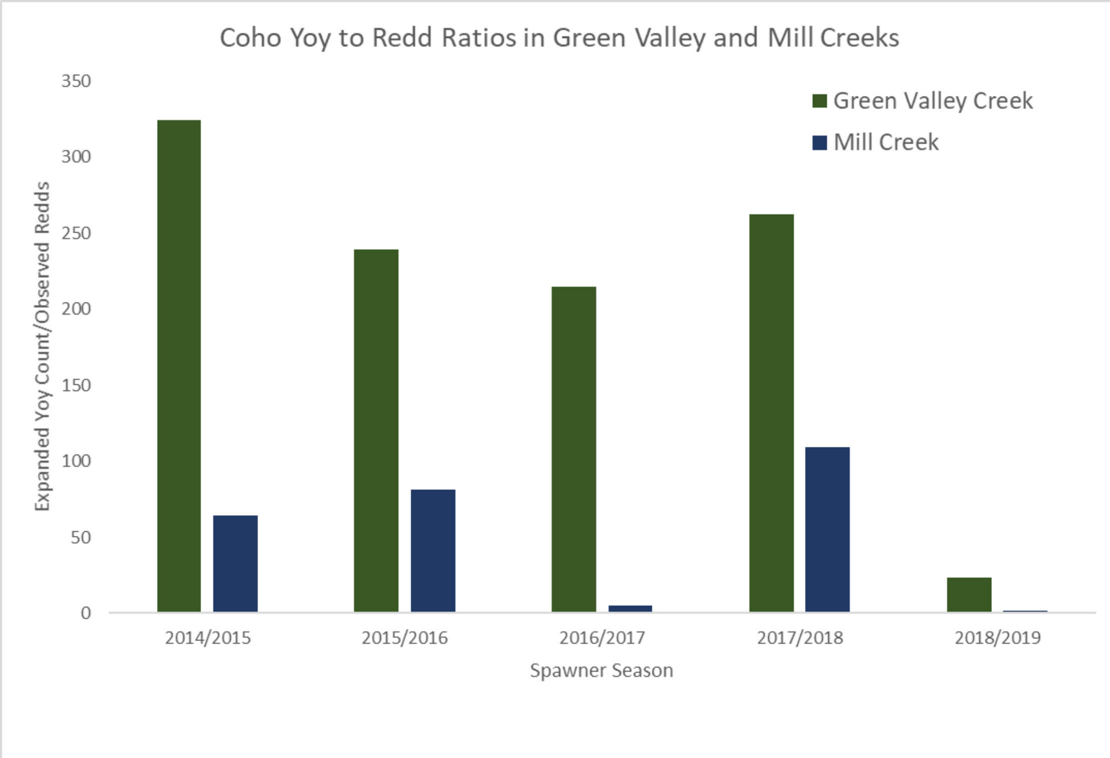

Figure 8. Coho salmon yoy-to-redd ratios for Green Valley and Mill creeks. Ratios were calculated using the expanded minimum count of coho salmon observed during summer snorkel seasons compared to the number of coho redds observed the previous winter.

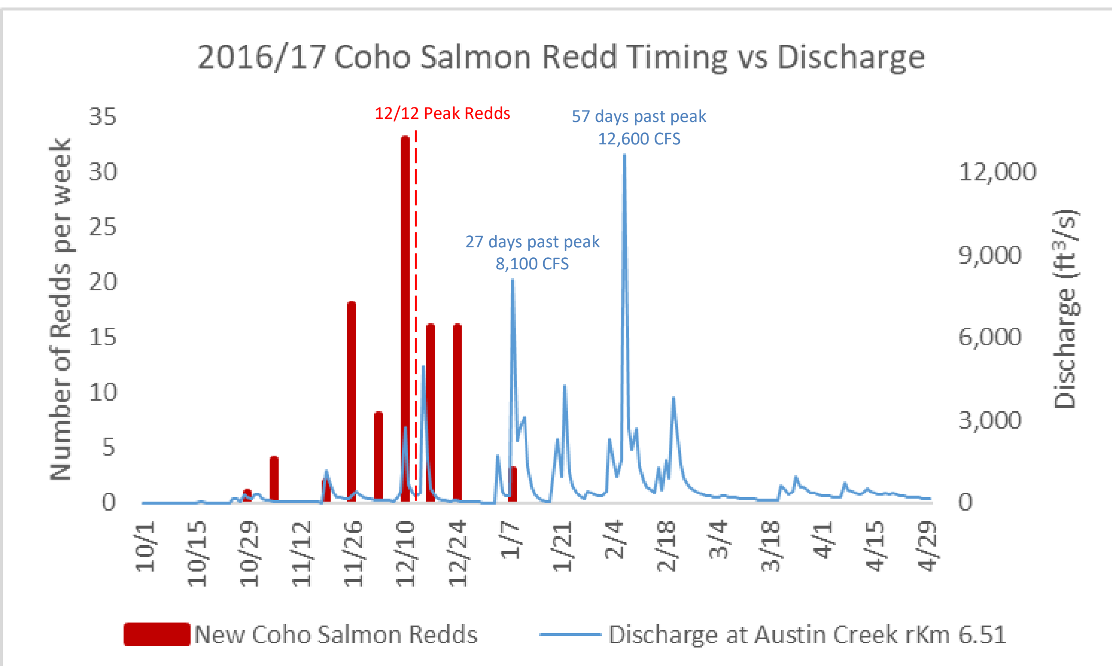

Figure 9. Weekly basinwide coho salmon redd counts in relation to streamflow during the winter of 2016/17. Discharge was obtained from USGS gaging station at Austin Creek river kilometer 6.51.

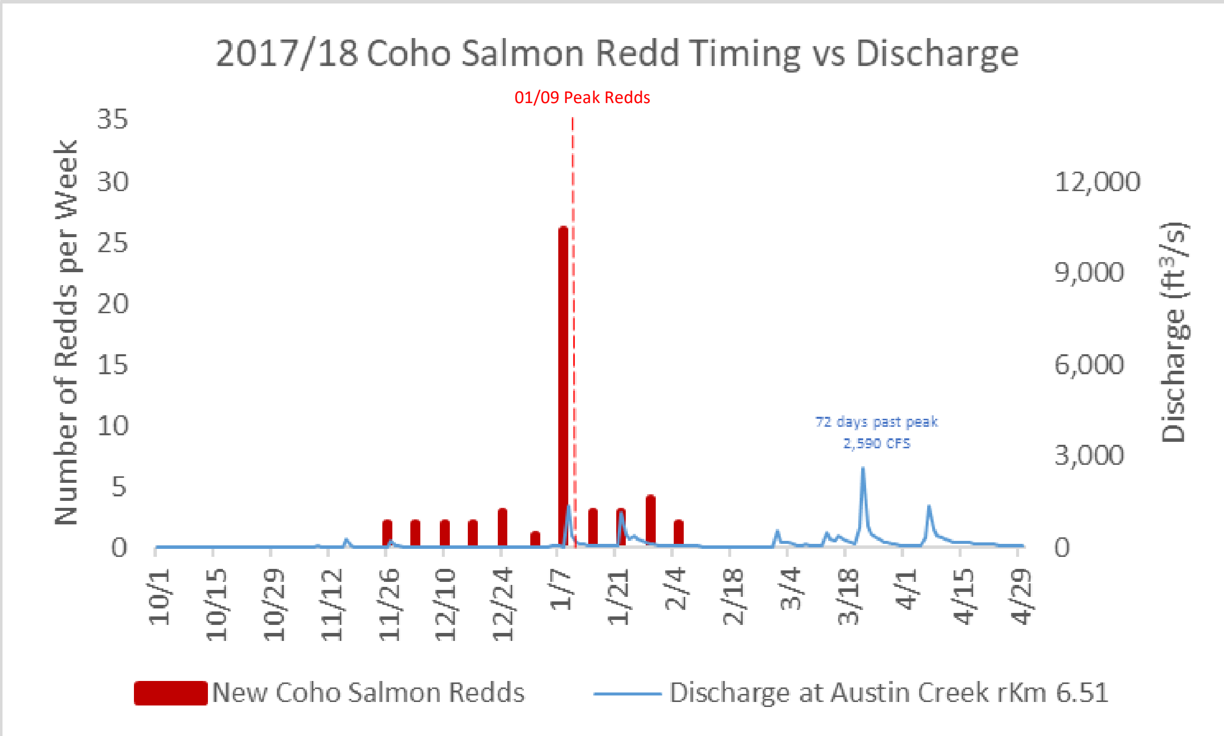

Figure 10. Weekly basinwide coho salmon redd counts in relation to streamflow during the winter 2017/18. Discharge was obtained from USGS gaging station at Austin Creek river kilometer 6.51

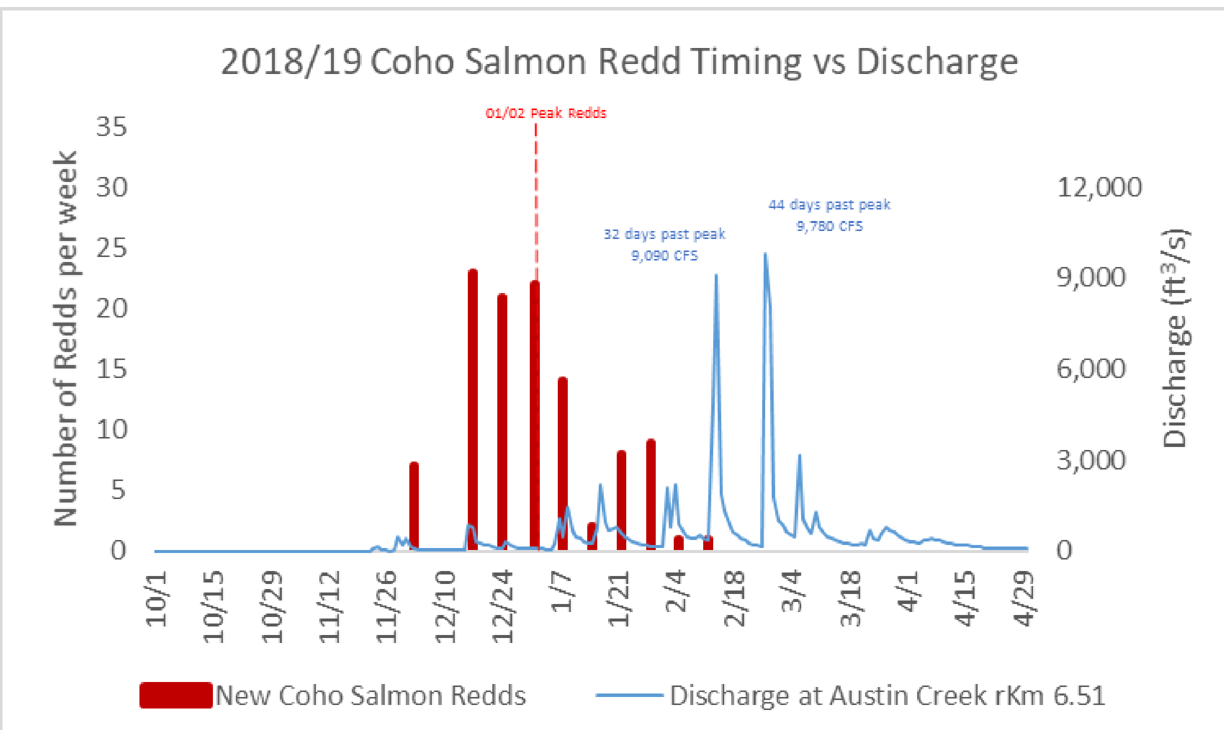

Figure 11. Weekly basinwide coho salmon redd counts in relation to streamflow during the winter of 2018/19. Discharge was obtained from USGS gaging station at Austin Creek river kilometer 6.51

3 References

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