UC Coho Salmon and Steelhead Monitoring Report: Summer-fall 2015


Fish biologist snorkeling an intermittent pool in Green Valley Creek.

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University of California Cooperative Extension and California Sea Grant

February 2016, Santa Rosa, CA.

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I. Background

In 2004, the Russian River Coho Salmon Captive Broodstock Program (Broodstock Program) began releasing juvenile coho salmon into tributaries of the Russian River with the goal of reestablishing populations that were on the brink of extirpation from the watershed. 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 index 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 (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 preliminary results from our summer and fall field activities, including summer snorkeling surveys conducted through both Broodstock Program and CMP monitoring efforts, and wetted habitat surveys conducted through the Partnership. In order to portray some of the effects of low stream flow on juvenile salmon populations, we also include a comparison of fish distribution with late summer wetted habitat conditions. Additional information and previous reports can be found on our website at http://ca-sgep.ucsd.edu/russianrivercoho.

II. Snorkeling Surveys

Objectives

Summer snorkeling surveys were conducted in Russian River tributaries to document the spatial distribution and relative abundance of juvenile coho salmon. These data help determine whether successful spawning occurred in specific coho release streams and throughout the Russian River basin. Collecting these data each year will enable us to track changes over time. Surveys were conducted in four index release streams for the Broodstock Program monitoring effort. For CMP monitoring, a sample of stream reaches in the Russian River juvenile coho sample frame (a sample frame of stream reaches identified by the Russian River CMP Technical Advisory Committee[1] as having juvenile 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 juvenile rearing reaches of Dutch Bill, Green Valley, Mill, and Willow Creeks, while CMP life cycle monitoring was conducted in tributaries of Dry Creek (Figure 1). For CMP basinwide monitoring, we soft-stratified the basin-wide sample frame to include only those reaches containing coho 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 of the 107 reaches comprising the Russian River coho sample frame (Figure 1). Our target sampling effort was 30% (32) of the reaches in the coho stratum (SCWA and UC 2014). 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 (with the first pool, one or two, determined randomly). On the second pass, we snorkeled every other pool that was snorkeled during the first pass; the second-pass information allowed us to account for imperfect detection probability. The resultant data facilitated use of the multi-scale occupancy model of Nichols et al. (2008) to estimate the overall area in the sample space that was occupied by coho.

Field methods

During surveys, snorkeler(s) moved from the downstream end of the pool (pool tail crest) to the upstream end, surveying as much of the pool as water depth allowed (Figure 2). A zigzag pattern was used by individual snorkelers as they moved through the pool and 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 pools requiring two snorkelers, two lanes were agreed upon and each snorkeler moved upstream through the lane at the same time and rate. Final counts for the pool were the sum of both lane counts. All observed salmonids were identified to species (coho, Chinook, steelhead) and age class (young-of-year (< age 1), parr (≥ age 1)), based on size and physical characteristics (Figure 3). Presence of non-salmonid species was documented at the reach scale. Allegro

[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.

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.

Metrics

Minimum counts: First-pass counts were used to document the minimum number of coho young-of-year (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 observer error or variation among pools nor did they incorporate detection efficiency; therefore they should only be considered approximate estimates useful for relative comparisons.

Spatial distribution: Multiscale occupancy models were used to estimate the probability of juvenile coho 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).

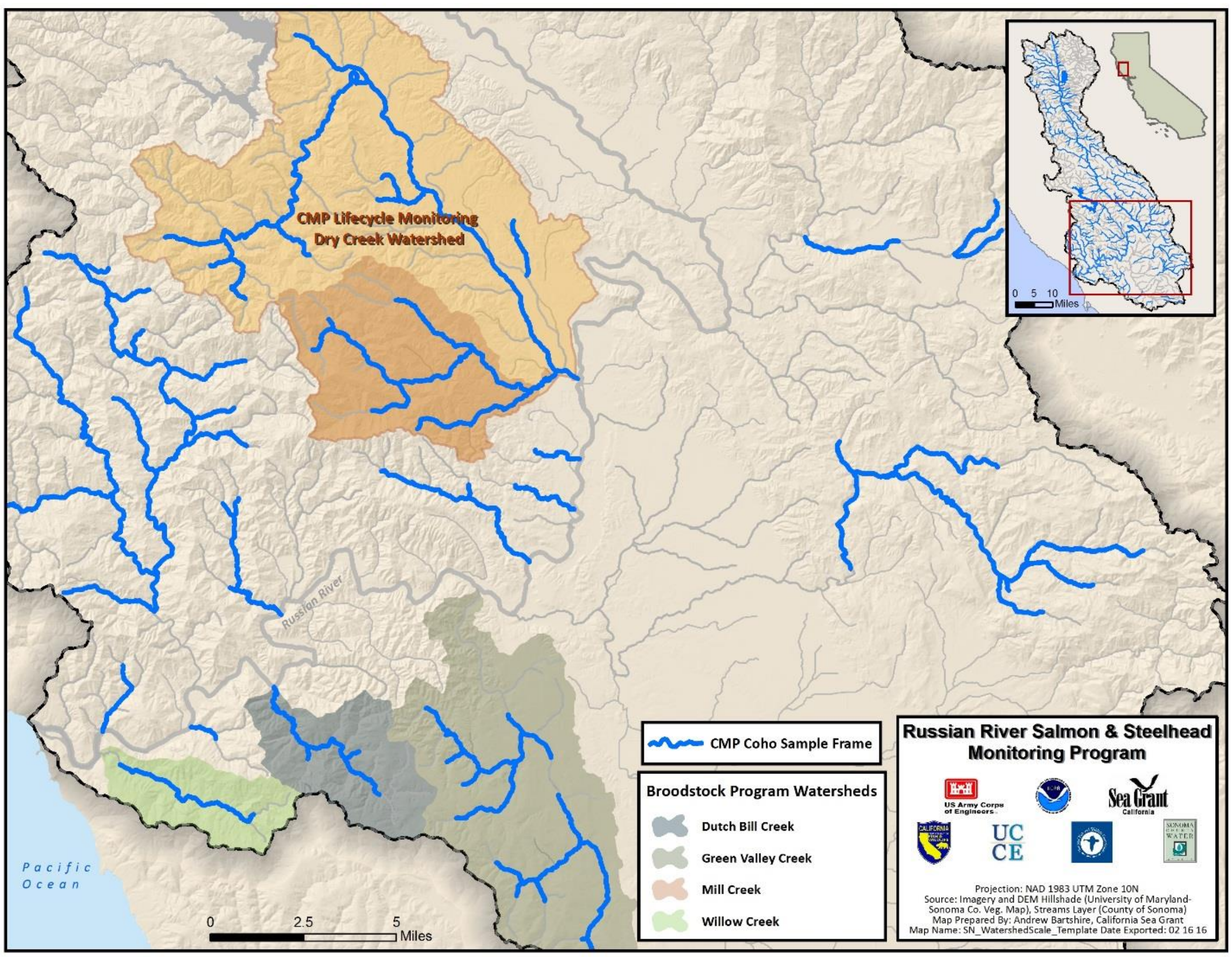

Figure 1. Russian River coho sample frame, CMP life cycle watershed, and Coho Broodstock Program index streams.

Figure 2. A diver conducts a survey in an isolated pool.

Figure 3. A naturally-spawned coho salmon YOY observed in Black Rock Creek.

Results

UC and Water Agency biologists surveyed a total of 58 reaches representing 155 km of stream between June 10 and August 27. All juvenile rearing reaches of Dutch Bill, Green Valley, Mill, and Willow were surveyed for Broodstock Program monitoring, and all reaches of Dry Creek tributaries where land owner access was acquired were surveyed for CMP life cycle monitoring. A total of 48 reaches (45% of the coho stratum) were surveyed for developing the basinwide estimate (45 reaches represented 16 more than our target of 32 reaches).

In addition to the 58 reaches sampled for broodstock and CMP monitoring, reconnaissance surveys were conducted on portions of Jonive, Redwood, Sexton, Horse Hill, and Sulphur Creeks between August 12 and November 5. Single-pass snorkel surveys were conducted, opportunistically, in all pool habitat where we had landowner permission and there was sufficient water. The snorkel survey distance comprised only 7 to 32 percent of a defined CMP reach in these streams. Horse Hill Creek was not snorkeled because it was dry. Data from these reaches was not included in basinwide estimates for CMP, but results can be found in Table 3.

We observed 5,063 naturally-spawned (wild) coho YOY in the summer of 2015, with an expanded minimum count of 10,126 (Table 1). We observed 13,609 steelhead YOY with an expanded minimum count of 27,218 (Table 2). For coho YOY, this represents a significant increase from the number observed during the summer of 2014 (Figure 4). Although there was generally higher abundance in 2011-2015 when compared to 2006-2010 (Figure 4), differences in the number of streams sampled each year mean that no trend can yet be established. In 2015, minimum counts were highest in Green Valley and Willow Creeks, and 10 or more coho YOY were observed in 20 of the 58 reaches and 19 of the 42 creeks snorkeled (44% and 45%, respectively) (Table 1, Figure 5). It is unlikely that successful spawning occurred in reaches (or streams) where fewer than 10 coho YOY were observed. It is most likely that juveniles observed in these reaches moved in from a different reach or stream or that coho parr (1-year-olds) were misclassified as YOY.

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 was 0.69 (0.54 - 0.81, 95% CI), and the conditional probability of coho YOY occupying a pool within a reach, given that the reach was occupied, was 0.52 (0.47 – 0.57, 95% CI). The proportion of the coho stratum occupied was 0.36.

Table 1. Summer 2015 observations of coho salmon YOY and parr in Russian River tributaries.

Stream	YOY	Expanded YOY [1]	Parr	Expanded parr [1]
Austin Creek	8	16	0	0
Black Rock Creek	123	246	18	36
Dead Coyote Creek	0	0	0	0
Devil Creek	45	90	0	0
Dutch Bill Creek [2]	650	1300	52	104
East Austin Creek	14	28	3	6
Felta Creek	50	100	15	30
Freezeout Creek	216	432	5	10
Gilliam Creek	201	402	23	46
Grape Creek	0	0	31	62
Gray Creek	329	658	11	22
Green Valley Creek [3]	1147	2294	327	654
Grub Creek	0	0	0	0
Harrison Creek	0	0	0	0
Hulbert Creek [4]	26	52	0	0
Kidd Creek	0	0	0	0
Little Green Valley Creek	31	62	1	2
Mark West Creek	22	44	16	32
Mill Creek [5]	297	594	46	92
Nutty Valley Creek	0	0	1	2
Palmer Creek	17	34	88	176
Pechaco Creek	0	0	1	2
Pena Creek	16	32	1	2
Perenne Creek	2	4	3	6
Porter Creek	504	1008	28	56
Porter Creek (MWC)	0	0	0	0
Press Creek	0	0	1	2
Purrington Creek	140	280	6	12
Redwood Creek	0	0	0	0
Sheephouse Creek	0	0	46	92
Thompson Creek	0	0	1	2
Wallace Creek	0	0	15	30
Willow Creek	1139	2278	119	238
Wine Creek	86	172	9	18
Woods Creek	0	0	0	0
Grand Total	**5063**	**10126**	**867**	**1734**

[1] *Expanded count is the observed number multiplied by 2.*

[2] *1008 coho YOY were stocked prior to snorkel surveys. This estimate does not exclude possible planted fish.*

[3] *305 coho YOY were stocked prior to snorkel surveys.*

[4] *Reach was snorkeled as part of a reconnaissance survey. 108 coho YOY were observed in all pools*

[5] *509 coho YOY were stocked prior to snorkel surveys. 55 wild YOY were observed prior to stocking.*

Table 2. Summer 2015 observations of steelhead YOY and parr in Russian River tributaries.

Stream	YOY	Expanded YOY [1]	Parr	Expanded parr [1]
Austin Creek	798	1,596	128	256
Black Rock Creek	65	130	28	56
Dead Coyote Creek	88	176	3	6
Devil Creek	218	436	23	46
Dutch Bill Creek	467	934	60	120
East Austin Creek	2,189	4,378	662	1,324
Felta Creek	217	434	20	40
Freezeout Creek	13	26	11	22
Gilliam Creek	376	752	68	136
Grape Creek	260	520	43	86
Gray Creek	981	1,962	97	194
Green Valley Creek	1,043	2,086	102	204
Grub Creek	4	8	1	2
Harrison Creek	0	0	1	2
Hulbert Creek [2]	2	4	4	8
Kidd Creek	90	180	4	8
Little Green Valley Creek	0	0	0	0
Mark West Creek	754	1,508	301	602
Mill Creek	2,388	4,776	102	204
Nutty Valley Creek	0	0	0	0
Palmer Creek	10	20	4	8
Pechaco Creek	2	4	2	4
Pena Creek	1,873	3,746	103	206
Perenne Creek	0	0	3	6
Porter Creek	549	1,098	65	130
Porter Creek (MWC)	191	382	29	58
Press Creek	0	0	2	4
Purrington Creek	52	104	35	70
Redwood Creek	106	212	11	22
Sheephouse Creek	8	16	9	18
Thompson Creek	13	26	8	16
Wallace Creek	0	0	1	2
Willow Creek	72	144	72	144
Wine Creek	104	208	6	12
Woods Creek	638	1,276	21	42
Grand Total	**13,571**	**27,142**	**2,029**	**4,058**

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

[2] *Reach was snorkeled as part of a reconnaissance survey.*

Table 3. Minimum count of naturally-spawned coho salmon and steelhead observed in streams that were partially snorkeled during the summer of 2015.

Stream	Coho YOY	Coho parr	Steelhead YOY	Steelhead parr	Total reach length [2] (km)	% of reach snorkeled
Jonive Creek	0	0	27	32	3.1	32%
Redwood Creek (Atascadero)	0	0	11	22	1.6	7%
Sexton Creek	0	0	0	0	1.0	10%
Sulphur Creek	0	0	0	0	2.0	20%
Weeks Creek	0	0	0	6	3.2	13%

[1] *Small portions of these streams were opportunistically snorkeled during reconnaissance surveys. Because reaches were not thoroughly sampled, results were not included in basinwide observation totals.*

[2] *Refers to defined reach of stream believed to have suitable salmon and steelhead rearing habitat.*

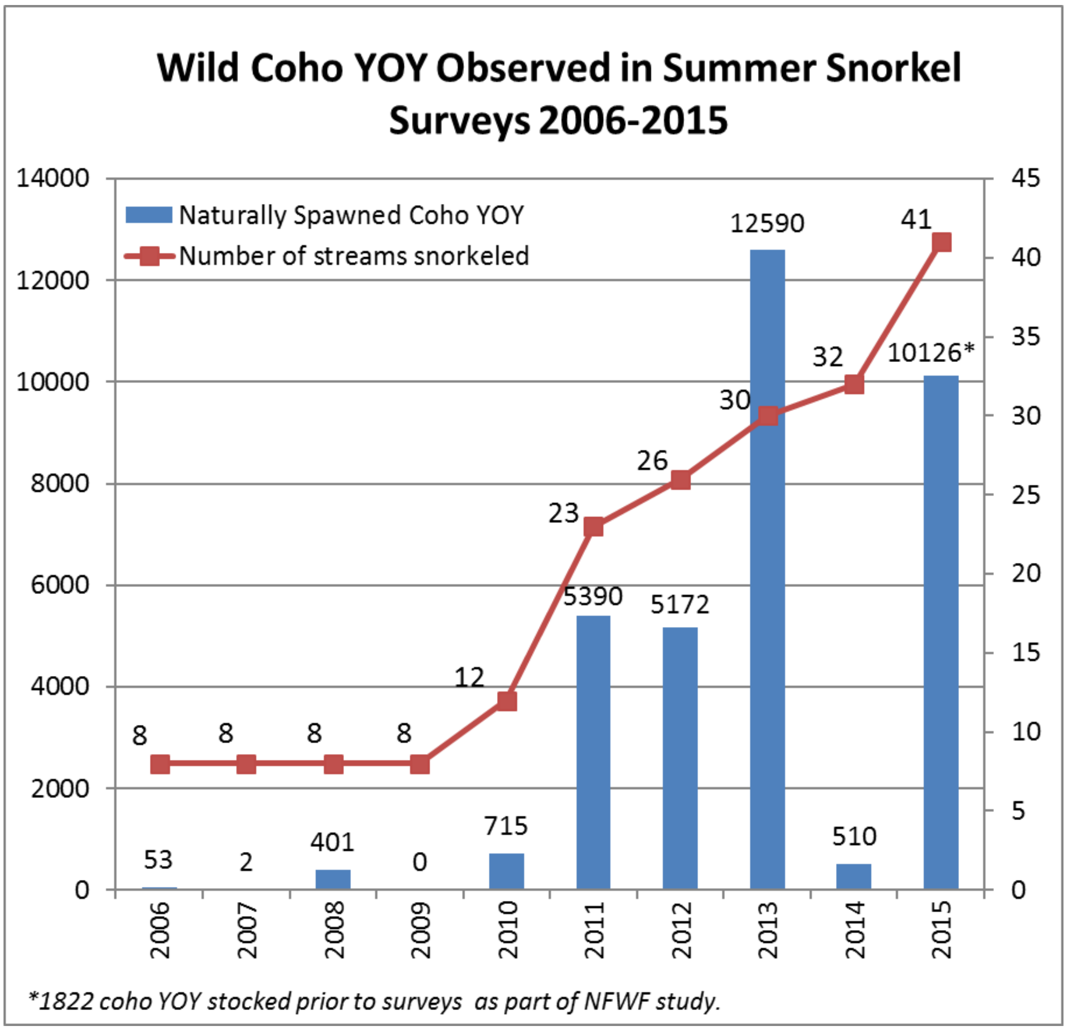

Figure 4. Naturally-spawned (wild) coho YOY observations from Russian River snorkel surveys (2006-2015). Methods for estimating wild juvenile coho counts varied among years and were based upon timing of hatchery stocking and snorkel methods. Refer to individual contract reports for more details.

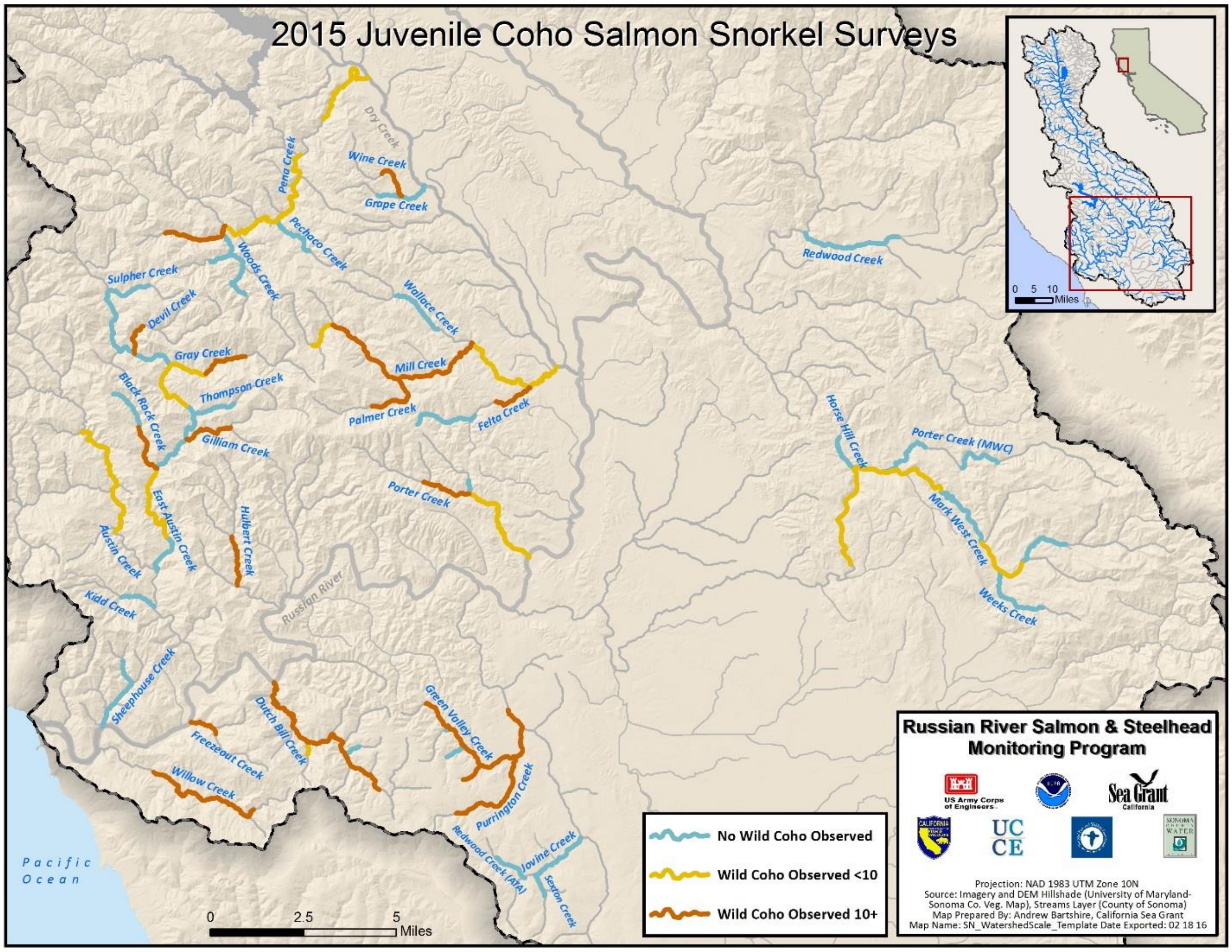

Figure 5. Map of 2015 wild coho salmon YOY observations.

III. Wetted Habitat Surveys

Objectives

In small coastal streams of California where surface flows frequently drop to levels at or just above zero, wetted habitat mapping provides a useful means of documenting stream flow conditions as experienced by juvenile fish rearing in streams. As part of the Partnership's monitoring efforts, UC has been mapping wetted habitat conditions of select Russian River tributaries during the late summer dry season since 2012. Data from these surveys has been used to identify flow-impaired stream reaches (which then become targets for flow enhancement), identify perennial reaches (which then become targets for protection and habitat enhancement work such as large wood projects that improve summer rearing), evaluate stream flow improvement projects, inform the Broodstock Program of suitable spring release streams, and guide fish rescue efforts by CDFW. Surveys were expanded to include additional streams in 2015 in order to support these multiple objectives. During the extreme drought conditions of 2015, snorkel data gathered for CMP surveys was overlaid with current wetted habitat conditions to provide real-time information on current and anticipated fish strandings. These maps became a useful tool for planning and prioritizing CDFW's efforts to relocate fish from drying pools.

Methods

Through the Partnership, wetted habitat surveys were conducted in Dutch Bill, Green Valley, Mark West, Mill and Grape Creeks during the summer of 2015. Additional surveys were conducted opportunistically in CMP and Broodstock Program reaches (Figure 6). Surveys were conducted using a protocol that UC developed for tributaries to the Russian River (UC 2015). During the driest time of the year (late August through September) and where landowner access allowed, surveyors walked each creek from the mouth to the upstream limit of anadromous fish habitat with the objective of documenting surface water conditions. Using a GPS unit, surveyors recorded the sections of the stream that were wet (connected by continuous surface flow), intermittent (pools containing water but not connected by surface flow), or dry (Figure 7 - Figure 9). Temperature and dissolved oxygen levels were measured at wetted sections of stream to determine suitability for juvenile salmonids. Data were then digitized in GIS to create a wetted habitat stream line for each survey.

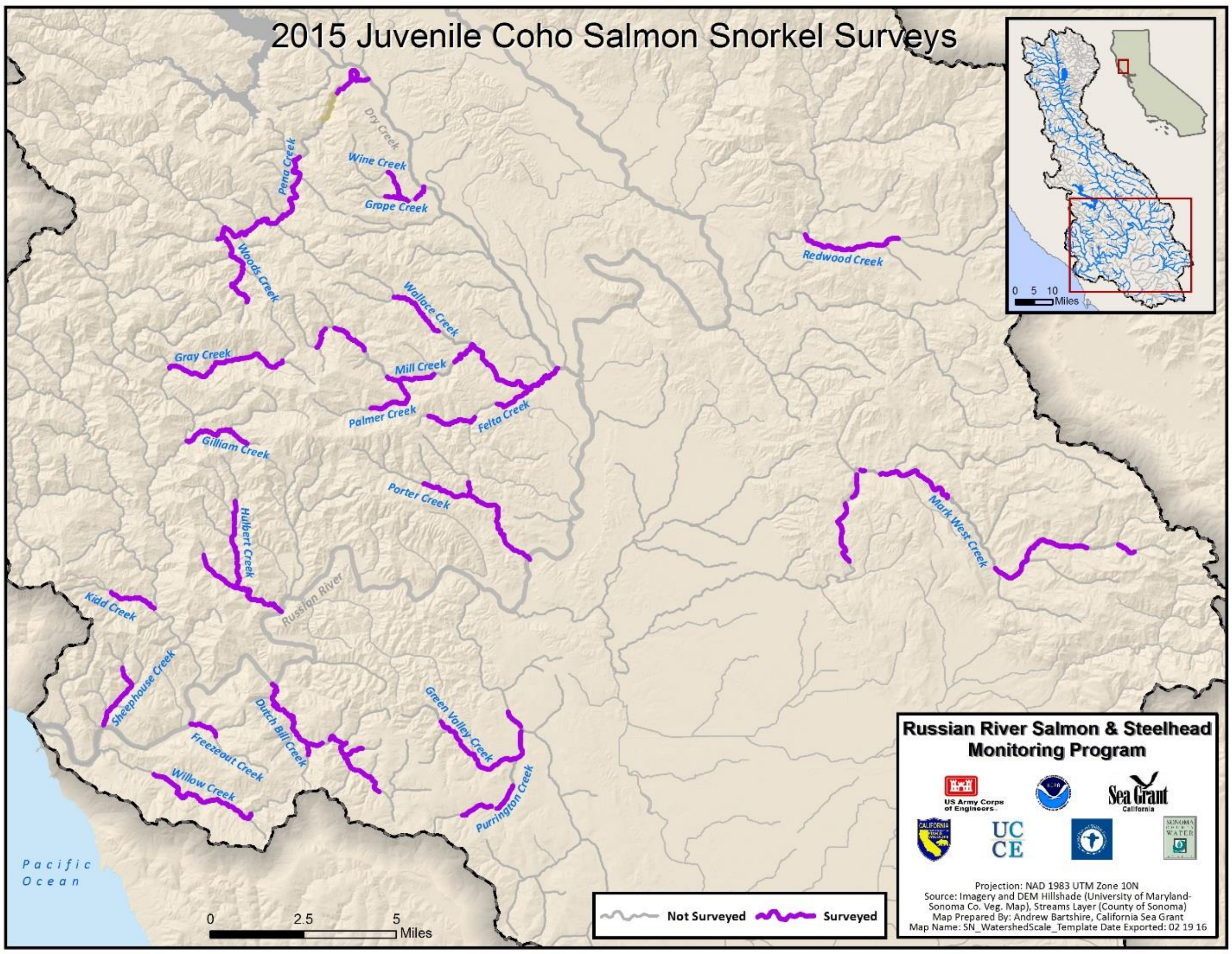

Figure 6. Map of 2015 wetted habitat survey reaches.

Figure 7. Wet habitat, Lower Mill Creek, 7/1/15.

Figure 8. Intermittent habitat, Lower Mill Creek, 8/3/15.

Figure 9. Dry habitat, Lower Mill Creek, 9/9/15.

Results

Wetted habitat data were collected on 25 streams in 14 Russian River tributary watersheds between August 28 and September 28, for a total of 107 kilometers of stream habitat surveyed (Table 4). Spatial data was used to generate maps depicting wet, intermittent, and dry habitat for each stream (Figure 10 - Figure 23). Of the 107 km of stream surveyed, 42 km (39%) were dry, 20 km (19%) were intermittent and 45 km (42%) were wet. Proportions of dry habitat varied by stream, with tributaries of Dry Creek and Porter Creek containing the highest proportions of dry habitat and Mark West and Austin Creek tributaries containing the least (Figure 24). Spot checks of temperature and dissolved oxygen in intermittent pools during surveys suggested that, in general, habitat suitability for juvenile salmonids was poor in intermittent reaches.

Table 4. Number of kilometers of stream habitat surveyed during late summer 2015.

Watershed	Tributary	Total km surveyed	Total km in CMP sample frame	Percent surveyed
Willow Creek	Willow Creek	5.7	5.7	100%
Sheephouse Creek	Sheephouse Creek	3.1	3.6	88%
Freezeout Creek	Freezeout Creek	1.4	1.4	100%
Kidd Creek	Kidd Creek	2.2	2.2	100%
Gilliam Creek	Gilliam Creek	2.3	2.3	100%
	Schoolhouse Creek	1.0	1.0	100%
Gray Creek	Gray Creek	5.9	5.9	100%
Dutch Bill Creek	Dutch Bill Creek	8.6	8.9	96%
	Perenne Creek	0.5	0.5	100%
	Duvoul Creek	0.2	0.2	100%
	Grub Creek	0.9	0.9	100%
Green Valley Creek	Green Valley Creek	6.9	8.2	85%
	Purrington Creek	2.7	4.5	61%
Mark West Creek	Mark West Creek	14.1	22.2	64%
Porter Creek	Porter Creek	6.8	6.9	99%
	Press Creek	0.6	0.6	98%
Mill Creek	Mill Creek	12.0	15.5	77%
	Felta Creek	4.1	4.9	82%
	Wallace Creek	2.7	4.4	61%
	Palmer Creek	2.8	2.8	100%
Grape Creek	Grape Creek	1.8	2.5	71%
	Wine Creek	1.3	1.6	81%
Pena Creek	Pena Creek	10.6	17.0	62%
	Woods Creek	4.1	4.1	100%
Redwood Creek	Redwood Creek	4.6	4.6	100%

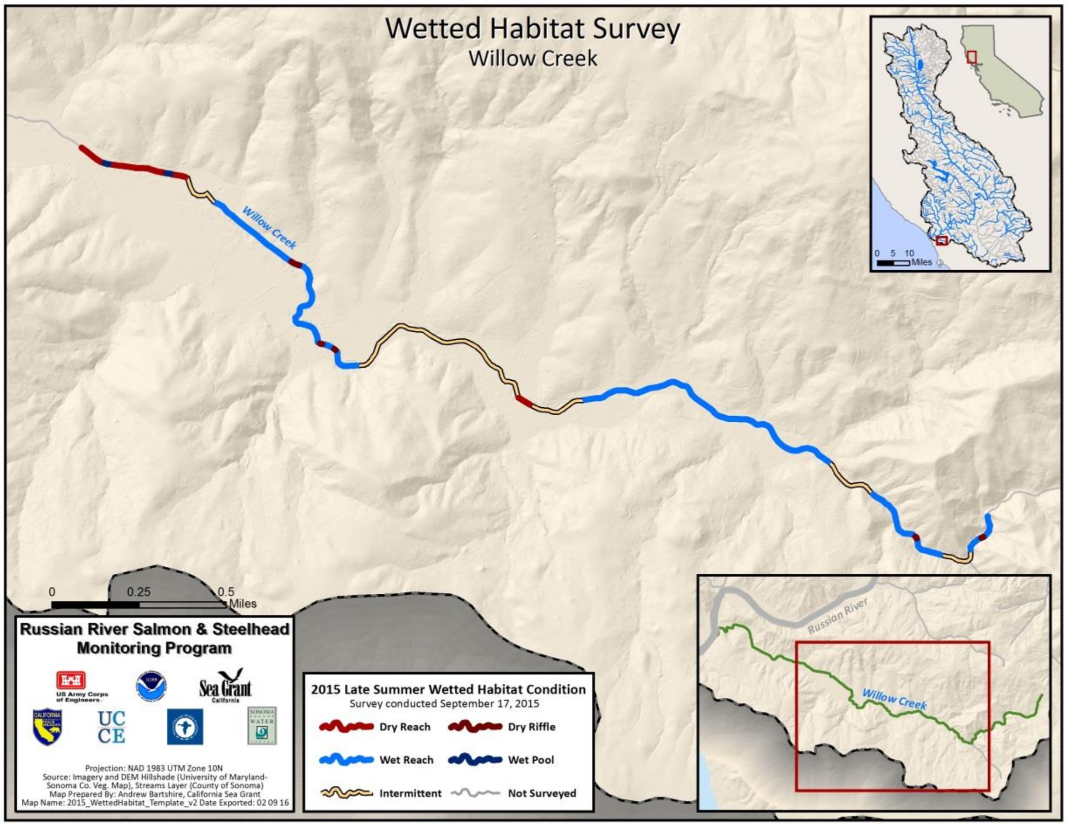

Figure 10. Willow Creek wetted habitat conditions, surveyed on September 17, 2015.

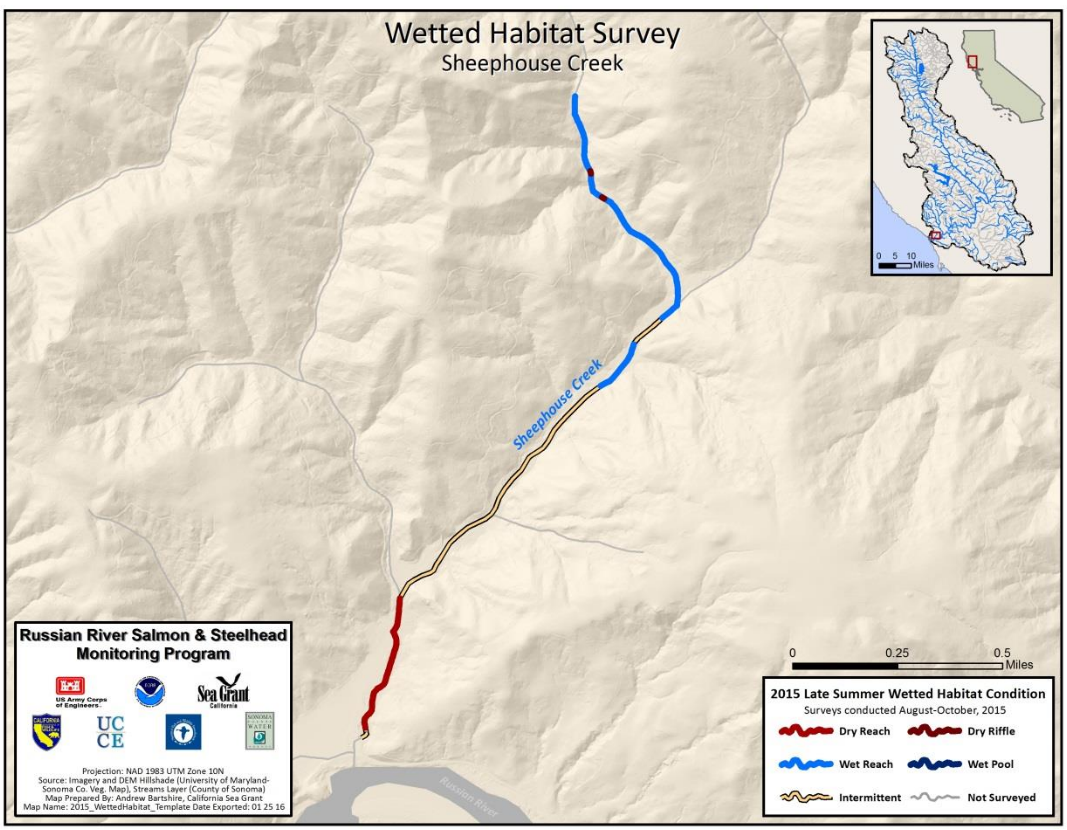

Figure 11. Sheephouse Creek wetted habitat conditions, surveyed on September 28, 2015.

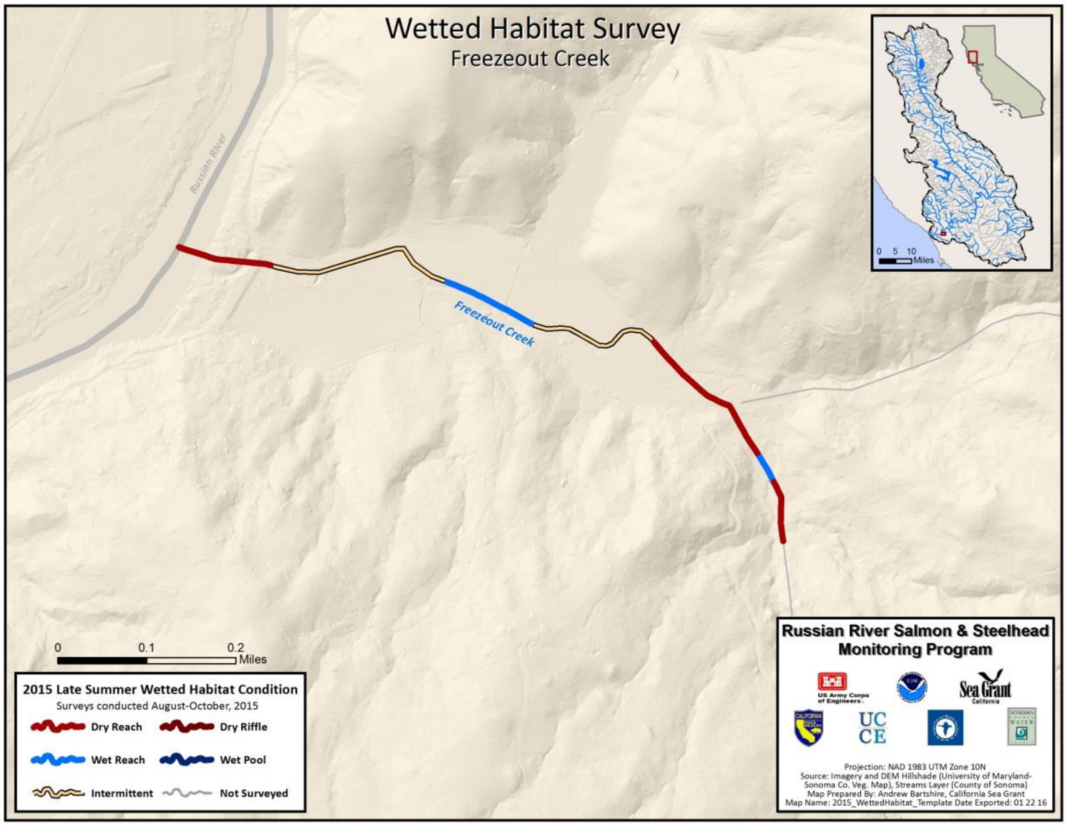

Figure 12. Freezeout Creek wetted habitat conditions, surveyed on September 11, 2015.

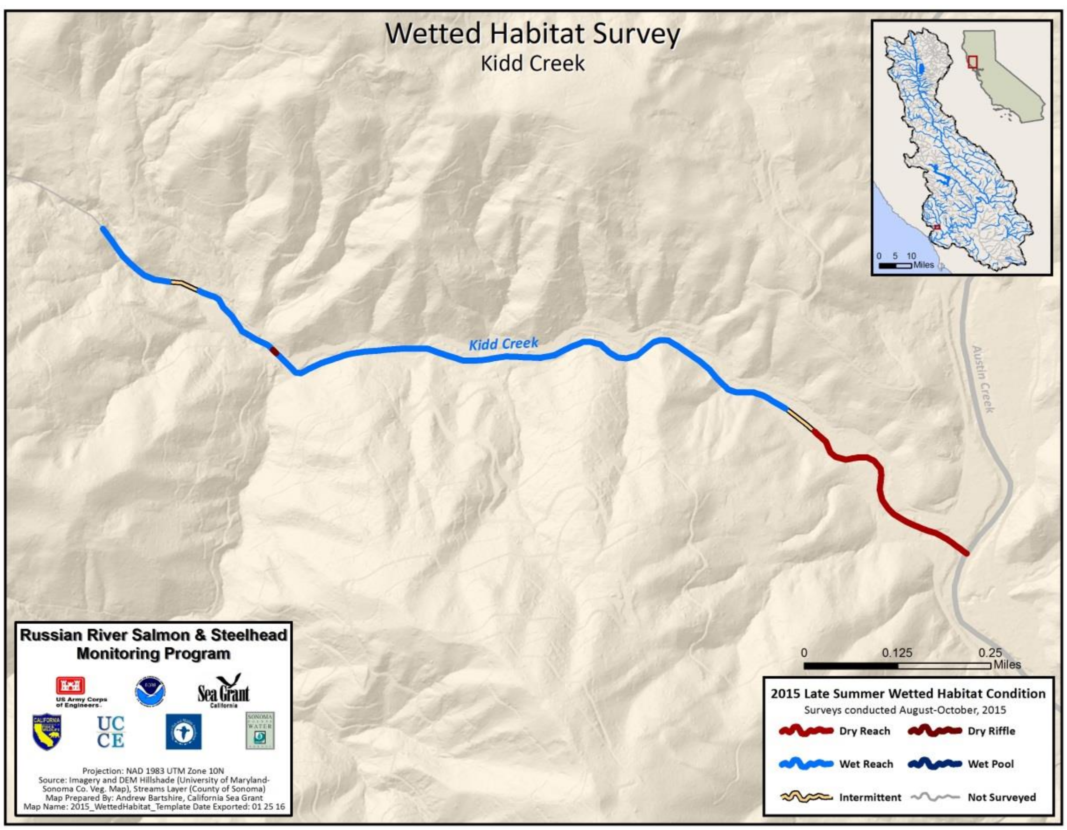

Figure 13. Kidd Creek wetted habitat conditions, surveyed on September 25, 2015.

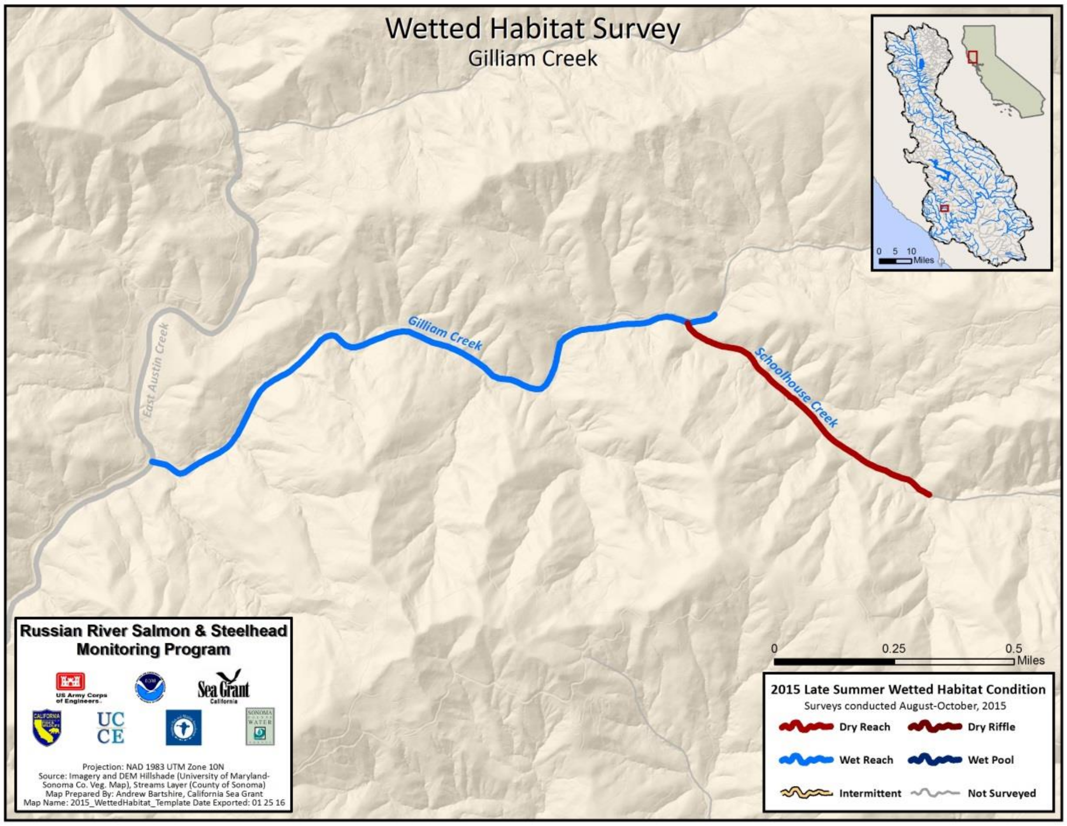

Figure 14. Gilliam Creek wetted habitat conditions, surveyed on September 18, 2015.

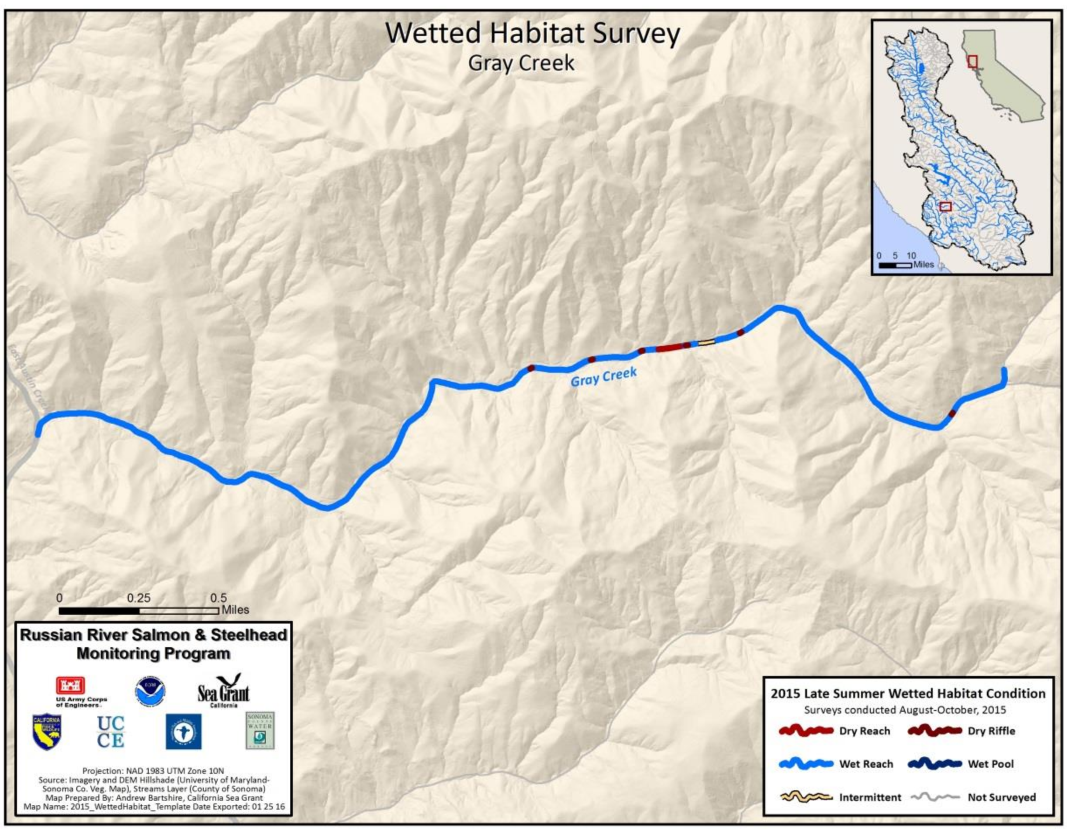

Figure 15. Gray Creek wetted habitat conditions, surveyed on September 23, 2015.

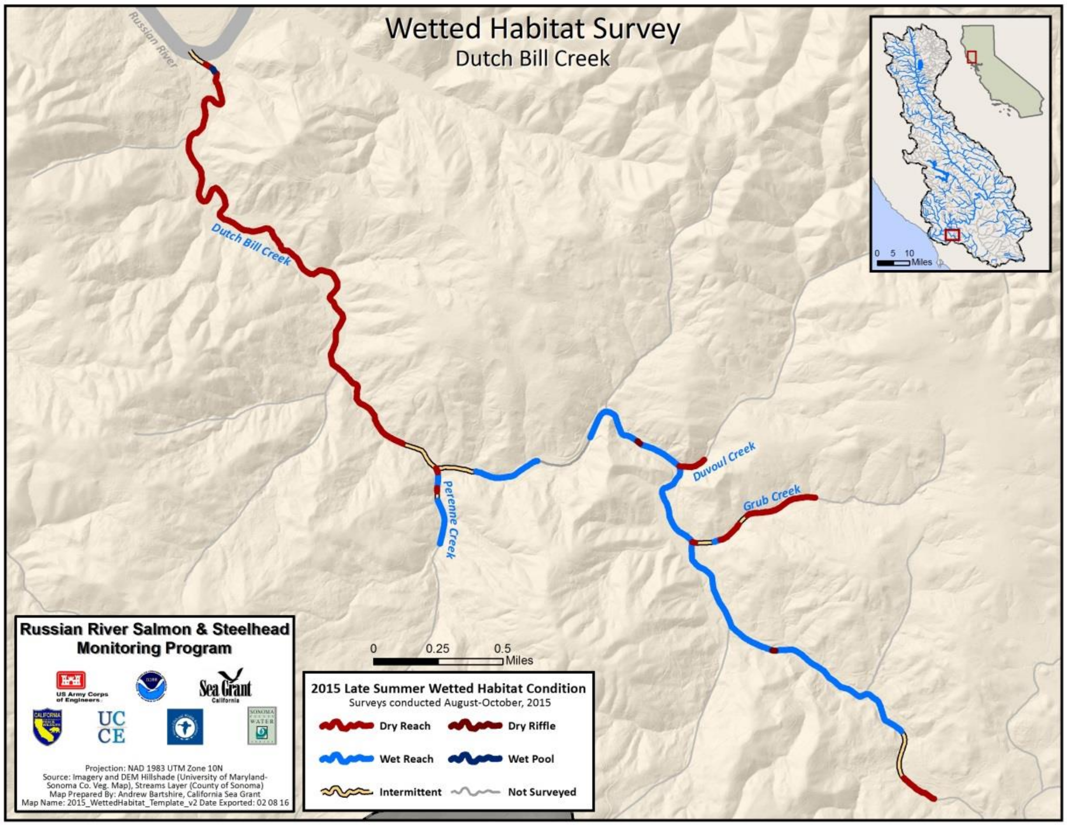

Figure 16. Dutch Bill Creek wetted habitat conditions, surveyed on September 14, 2015.

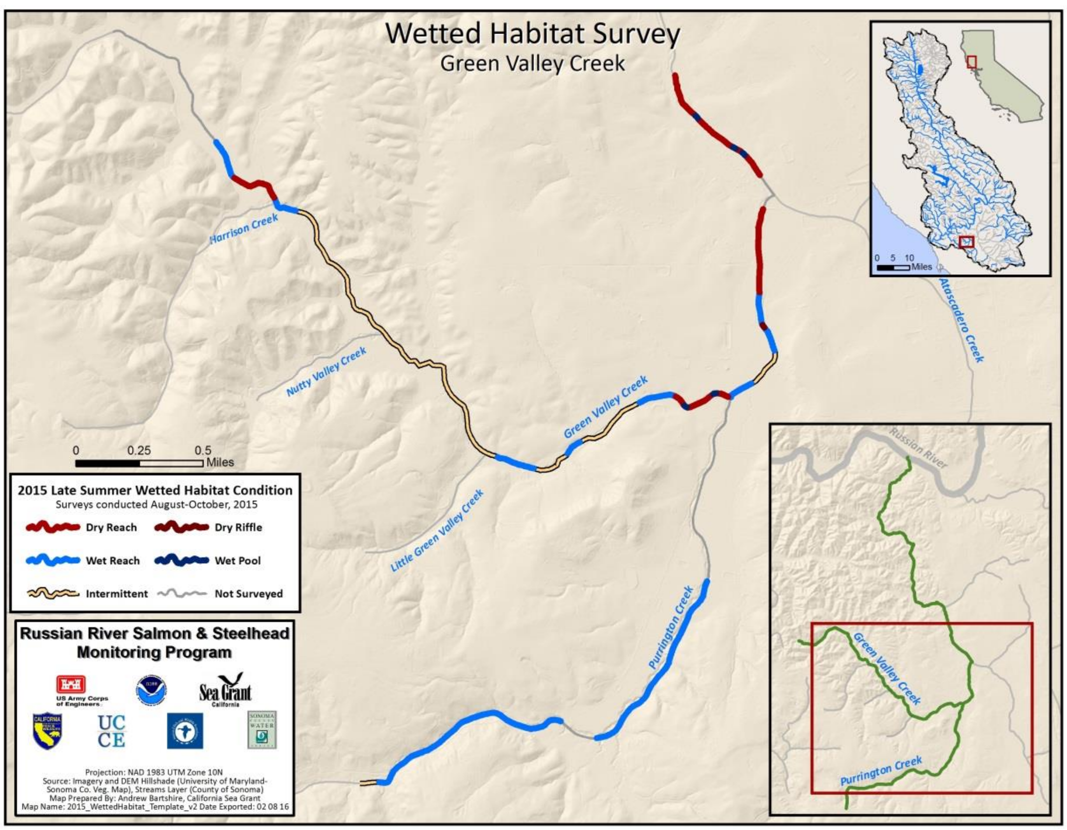

Figure 17. Green Valley Creek wetted habitat conditions, surveyed between August 28 and September 1, 2015.

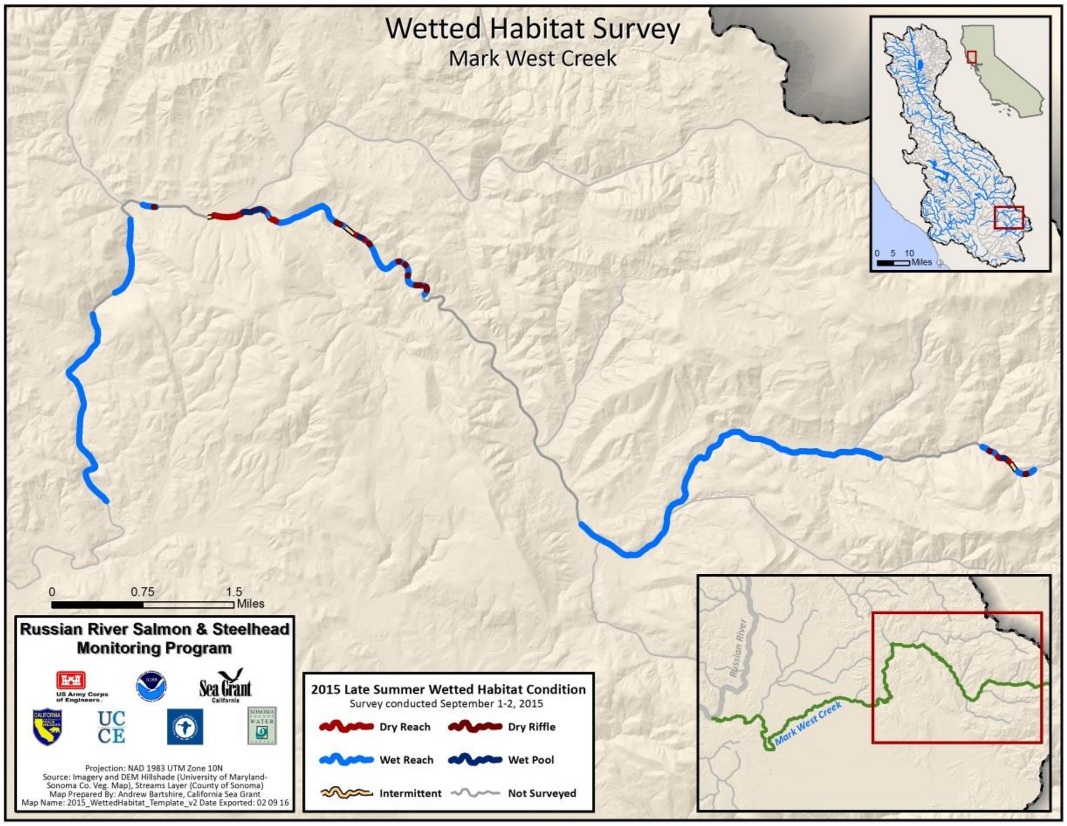

Figure 18. Mark West Creek wetted habitat conditions, surveyed between September 1 and September 2, 2015.

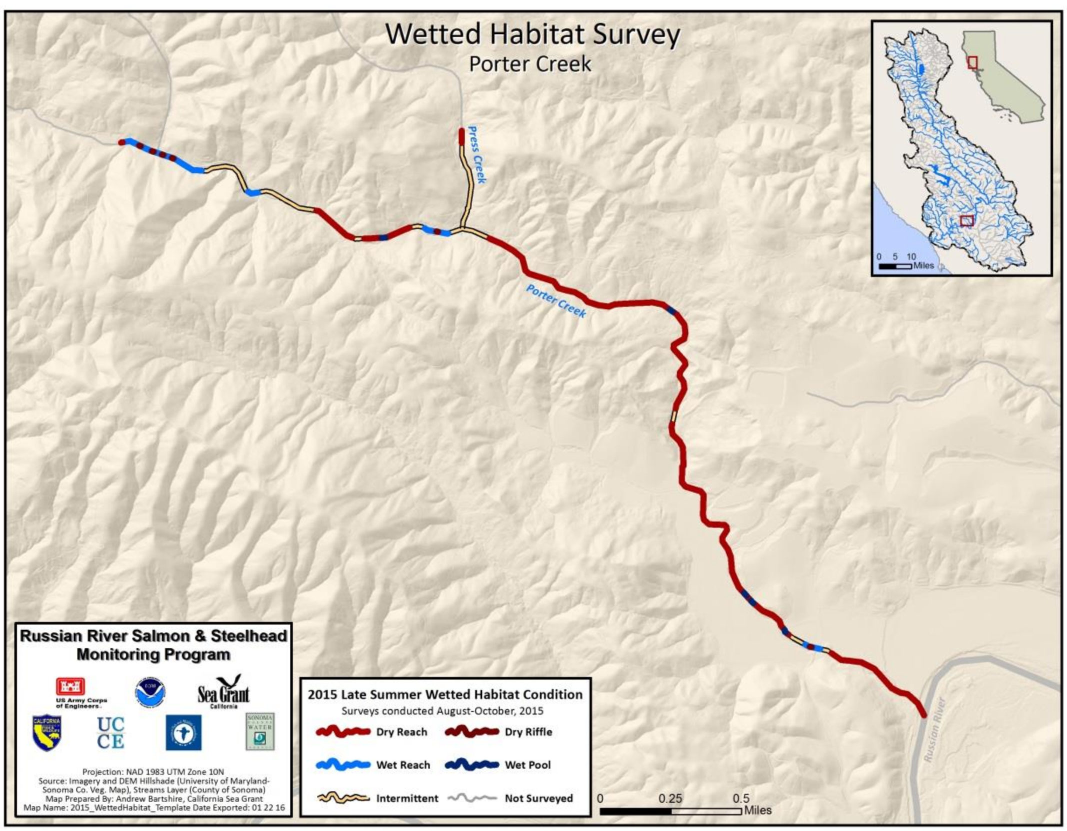

Figure 19. Porter Creek wetted habitat conditions, surveyed September 21, 2015.

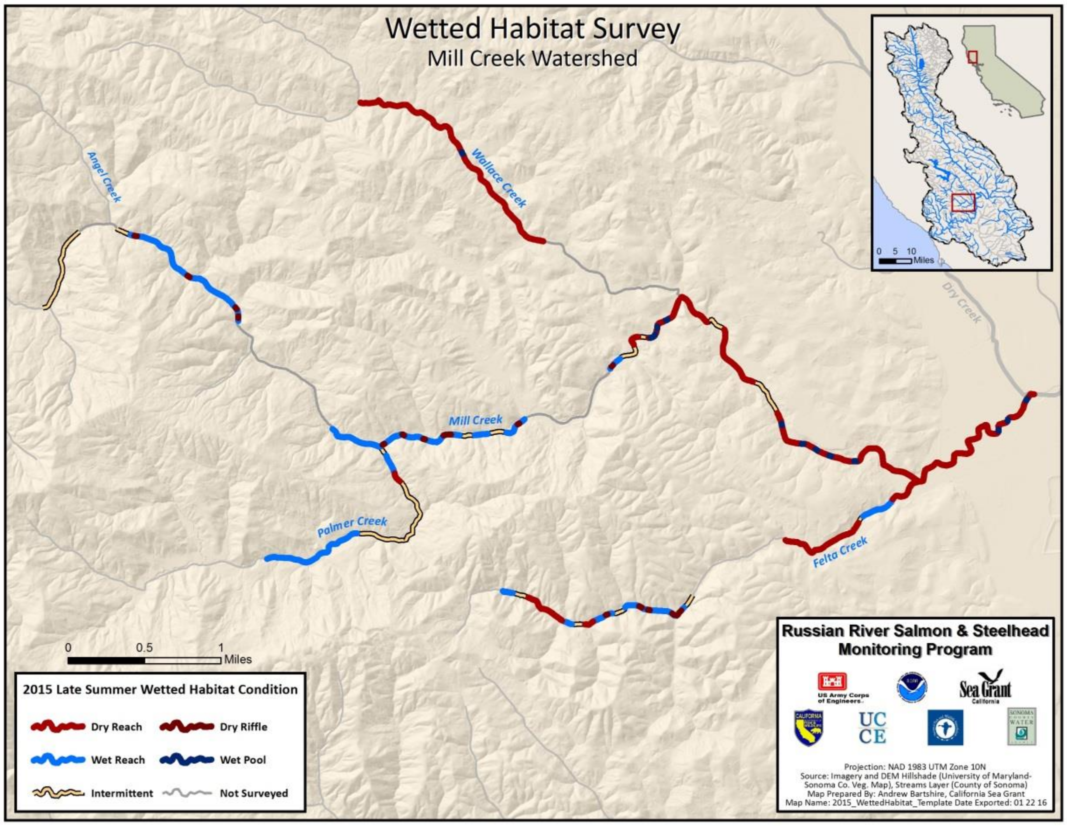

Figure 20. Mill Creek wetted habitat conditions, surveyed August 28 through September 22, 2015.

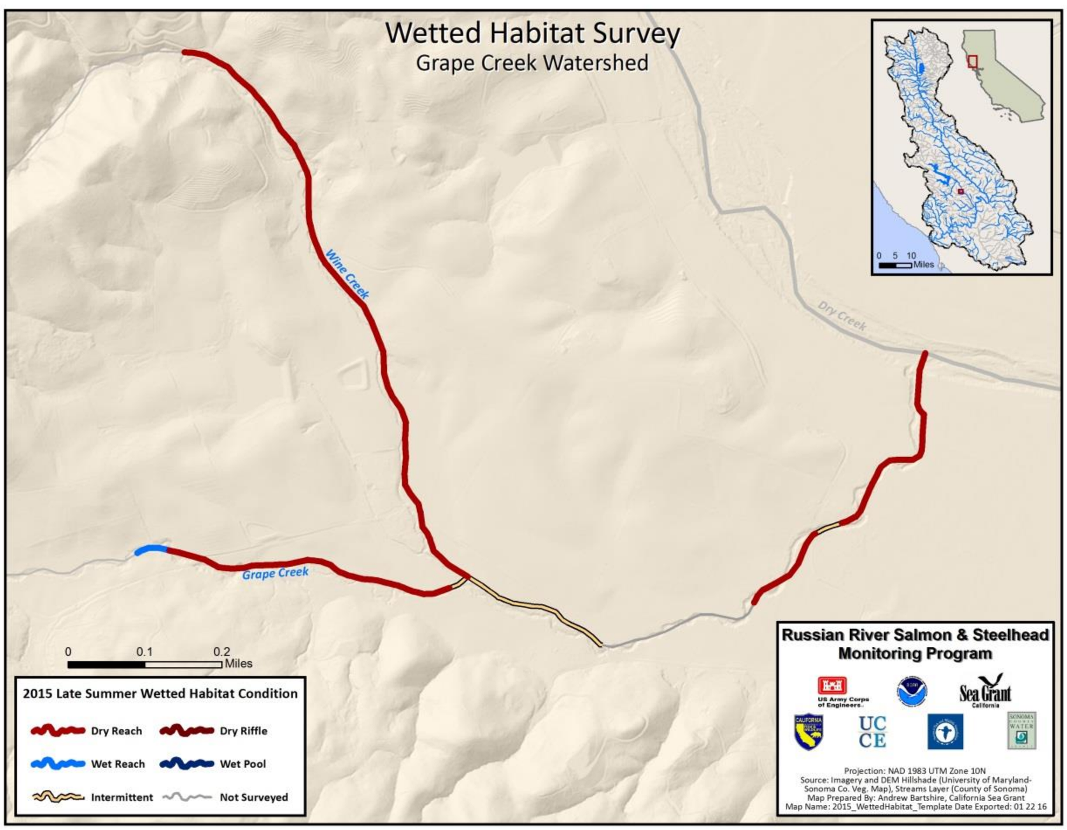

Figure 21. Grape Creek wetted habitat conditions, surveyed on September 18, 2015.

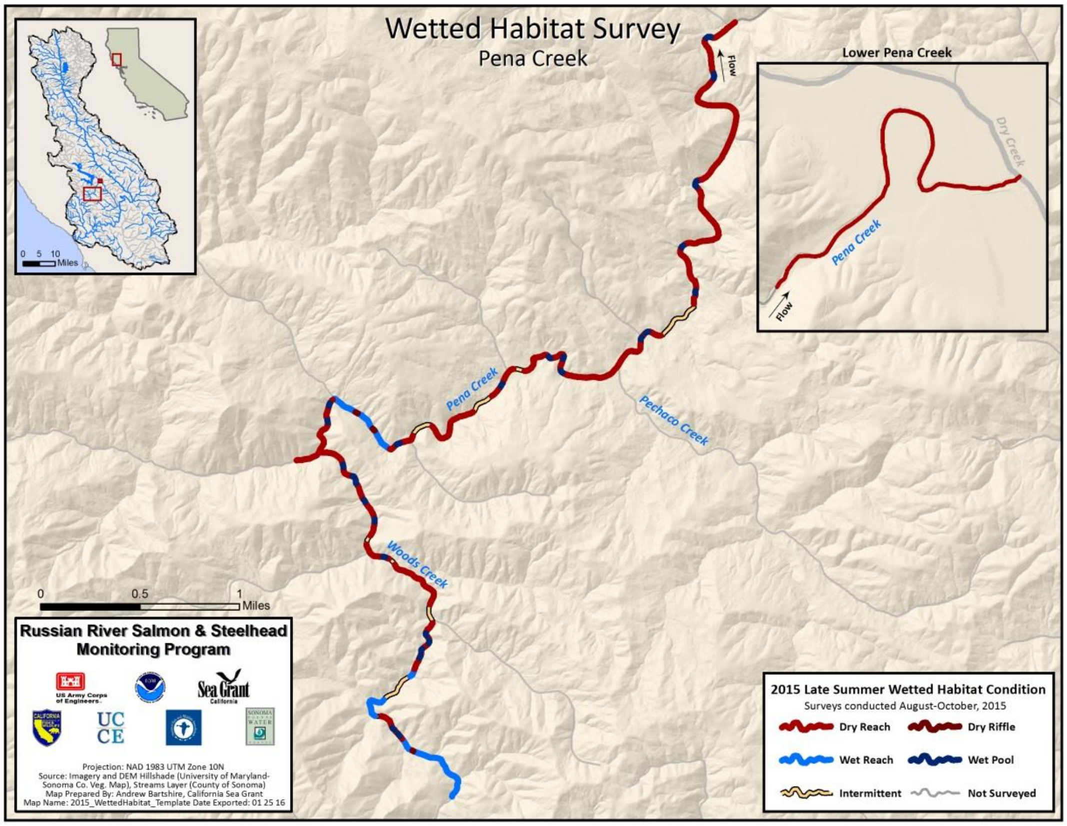

Figure 22. Pena Creek wetted habitat conditions, surveyed from September 15 through September 16, 2015.

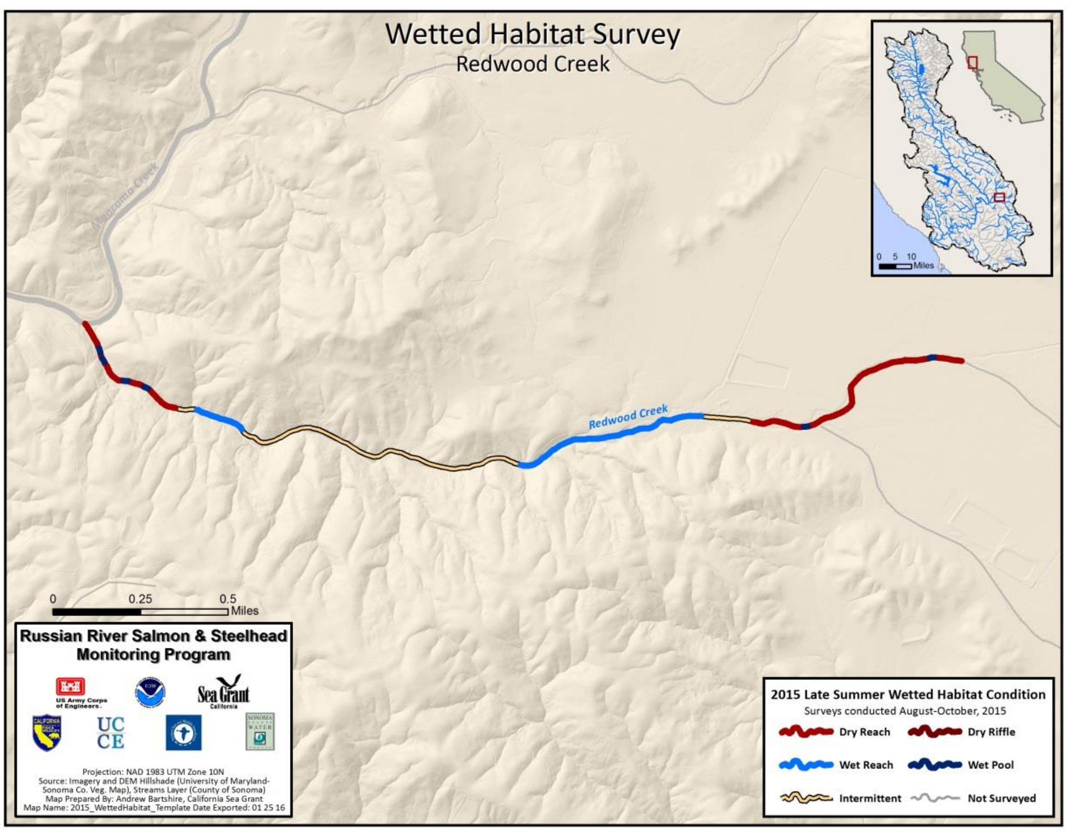

Figure 23. Redwood Creek wetted habitat conditions, surveyed on September 24, 2015.

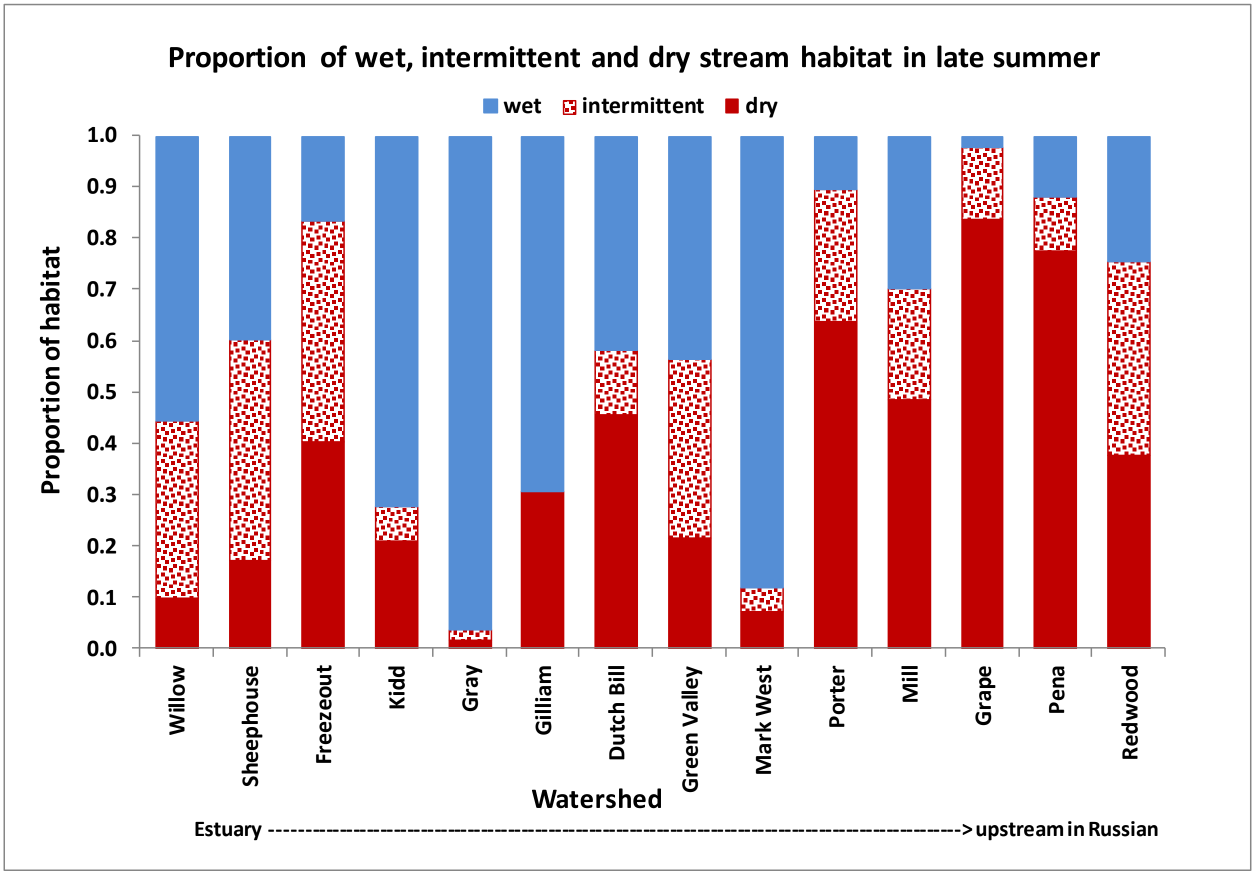

Figure 24. Proportion of wet, intermittent, and dry habitat in 14 Russian River tributary watersheds surveyed during late summer 2015.

IV. Fish distribution in relation to late summer wetted habitat conditions

Objectives

Since 2013, UC and the Water Agency have been documenting the relative abundance and distribution of salmon and steelhead in several Russian River tributaries by conducting winter redd surveys and summer snorkeling surveys for Broodstock Program and CMP monitoring efforts. Data from these surveys are used to generate maps that show the distribution of salmonid redds observed during the winter, and the relative abundance of naturally-spawned juveniles observed in pools during the summer. Through the Partnership, UC conducts wet/dry mapping on selected streams in late summer with the objective of documenting the amount of wetted habitat available to juvenile salmonids at the driest time of the year. In order to gain an understanding of the effects of low flow conditions on juvenile fish populations, we related spatial data from fish surveys to spatial data from our wetted habitat surveys.

Methods

Redd survey data were collected following protocols outlined in Fish Bulletin 180 (Adams et al. 2011) and the Russian River CMP Monitoring Plan (SCWA and UC 2014; SCWA and UC 2015). Snorkeling and wetted habitat surveys were conducted following the methods described in sections II and III of this report. In order to relate redd data and juvenile pool count data to wetted habitat data, spatial joins were conducted in GIS such that each redd (winter surveys) or snorkeled pool (summer surveys) was assigned a late summer wetted habitat condition (wet, dry, or intermittent). Redd counts and juvenile pool counts could then be summarized according to subsequent late summer wetted habitat condition. For example, redd data from surveys conducted during the winter of 2014-2015 were related to wetted habitat data collected during the late summer of 2015 in order to determine whether 2014-2015 returning adults spawned in locations where their offspring would experience suitable oversummer habitat conditions if they remained in the vicinity of the redd. Snorkel survey data collected between June and August of 2015 were related to wetted habitat data collected approximately two months later to infer the potential for juveniles observed during snorkel surveys to survive through the end of the summer season. Reaches where spring stocking occurred were excluded from this analysis.

Results

Late summer wetted habitat conditions were assigned to redd data collected in 10 tributary watersheds and pool count data collected in 14 tributary watersheds (Table 5, Figure 25- Figure 26). Maps were created to display the relationship between redds or juvenile counts with subsequent wetted habitat conditions (Green Valley, Mill, and Dutch Bill Creeks, Figure 27 - Figure 32). Maps for additional streams can be found at: http://ca-sgep.ucsd.edu/russianrivercoho.

A total of 224 salmonid redds were documented during the winter of 2014-2015 in streams where wetted habitat surveys occurred in the summer of 2015. Of these, 65% were observed in reaches that later went dry, 18% in reaches that became intermittent, and 17% in reaches that remained wet (Table 5). Of the 13,629 coho and steelhead YOY counted during summer snorkeling surveys in all wetted habitat survey streams combined, 38% were observed in reaches that later went dry, 24% in reaches that became intermittent, and 38% in reaches that remained wet (Table 5). The fact that a lower proportion of juveniles than redds were found in reaches that later went dry could mean that following emergence, some offspring dispersed to locations where habitat remained wet; however, variable spring mortality rates and observer error could also explain this difference.

Overall, spatial distribution of both redds and juveniles were similar within streams (Figure 27 - Figure 32) and generally reflected the proportions of wetted habitat conditions (wet, dry, or intermittent) present in each stream (Figure 24 - Figure 26). Dry Creek tributaries and Porter Creek had the highest proportions of redds and juveniles in reaches that later went dry, and Mark West and Austin Creek tributaries had the highest proportions of redds and juveniles in reaches that remained wet (Figure 24 - Figure 26). Kidd Creek and Dutch Bill Creeks were exceptions; however, samples sizes were very small for those streams, which may have skewed the results (Table 5, Figure 24 - Figure 26).

Salmonid distribution patterns in relation to late summer wetted habitat conditions varied by stream (Figure 27 - Figure 32). In Green Valley Creek, most redds were observed in reaches that became intermittent the following summer (60% coho and 80% steelhead) (Table 5, Figure 27). Distribution of salmonid YOY reflected redd distributions, with 66% of coho YOY and 61% of steelhead YOY found in reaches that were intermittent by the end of the summer (Table 5, Figure 28).

In the Mill Creek watershed, most redds were concentrated in stream reaches that went dry the following summer: 100% of coho redds and 62% of steelhead redds (Table 5, Figure 29). Of the 177 coho YOY observed, 50% were found in reaches that later went dry, and 68% of the steelhead YOY were observed in reaches that later went dry (Table 5, Figure 30). A likely explanation for high concentrations of spawning activity in the lower, summer-drying reaches of Mill Creek is a partial passage barrier located just downstream of the confluence with Wallace Creek. Plans are underway to remediate this barrier during the summer of 2016, which would allow greater access to perennial stream reaches.

Although only one redd was observed in Dutch Bill Creek during the winter of 2014-2015, 275 coho YOY and 369 steelhead YOY were found in reaches that remained wet throughout the summer season (76% and 80%, respectively). Based on observations in two Partnership study reaches on Dutch Bill Creek, it is likely that portions of these reaches would have become intermittent or dry without a flow augmentation effort that began on August 24, 2015 and continued through December.

At the time snorkeling surveys were conducted, surface flows were already extremely low and it is unlikely that fish had the opportunity to move out of drying reaches into reaches that remained wet. PIT tag antenna data on specific study reaches indicates that almost no movement occurred between mid-June and December of 2015 (UC unpublished data). We therefore conclude that salmonids observed in reaches that later became dry had no chance of surviving the summer. Previous research conducted by UC through the Partnership, has documented inverse relationships between juvenile coho survival and the number of days that pools are disconnected from surface flow (UC unpublished data). Given these relationships and the length of time that pools in intermittent reaches were disconnected during the summer of 2015 (over four weeks in most reaches), it is likely that most juveniles in intermittent reaches perished. We did not evaluate oversummer survival of juveniles in reaches that remained wet; however, based on previous survival studies, we have found that oversummer survival in wetted reaches averages approximately 0.5 (UC unpublished data).

These data suggest that, in many Russian River tributaries, low stream flow is a significant bottleneck to oversummer survival of juvenile salmonids, particularly in drought years such as 2015. Although it is encouraging that naturally-spawned coho were observed in close to 20 Russian River tributaries, over 60% of them were found in reaches that later became dry or intermittent, and survival would not have been possible without relocation efforts by CDFW. To further quantify the extent of low summer streamflow as a bottleneck to survival, it will be important to repeat this work in non-drought years.

Table 5. Number and percentage of salmonid redds and juvenile counts in relation to late summer wetted habitat conditions in 2015.

Watershed	Snorkeling survey date range	Wetted habitat survey date range	Average days between snorkeling and wetted habitat surveys	Wetted habitat condition	Stream length (km)	Coho redds	Steelhead redds	Chinook redds	All salmonid redds (includes redds not identified to species)	Coho yoy	Coho parr	Steelhead yoy	Steelhead parr	Chinook smolts	All juvenile salmonids
Willow Creek	7/8 - 7/9	9/17	71	dry	0.57 (10%)	1 (20%)	0 (0%)	0 (0%)	1 (6%)	87 (8%)	3 (3%)	2 (3%)	6 (8%)	0 (0%)	98 (7%)
				intermittent	1.97 (35%)	2 (40%)	5 (56%)	0 (0%)	8 (50%)	354 (31%)	74 (62%)	38 (53%)	19 (27%)	0 (0%)	485 (35%)
				wet	3.16 (55%)	2 (40%)	4 (44%)	0 (0%)	7 (44%)	698 (61%)	42 (35%)	32 (44%)	47 (65%)	0 (0%)	819 (58%)
Sheephouse Creek	8/3 - 8/4	9/28	56	dry	0.54 (17%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2 (5%)	0 (0%)	1 (11%)	0 (0%)	3 (5%)
				intermittent	1.35 (43%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	14 (30%)	2 (25%)	6 (67%)	0 (0%)	22 (35%)
				wet	1.24 (40%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	30 (65%)	6 (75%)	2 (22%)	0 (0%)	38 (60%)
Freezeout Creek	8/3 - 8/4	9/11	39	dry	0.56 (40%)	NA	NA	NA	NA	8 (4%)	0 (0%)	2 (15%)	1 (9%)	0 (0%)	11 (4%)
				intermittent	0.60 (43%)	NA	NA	NA	NA	110 (51%)	4 (80%)	9 (70%)	4 (36%)	0 (0%)	127 (52%)
				wet	0.23 (17%)	NA	NA	NA	NA	98 (45%)	1 (20%)	2 (15%)	6 (55%)	0 (0%)	107 (44%)
Kidd Creek	8/26 - 8/27	9/25	30	dry	0.47 (21%)	0 (0%)	1 (100%)	0 (0%)	1 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
				intermittent	0.15 (7%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
				wet	1.62 (72%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	90 (100%)	4 (100%)	0 (0%)	94 (100%)
Gray Creek	7/20 - 7/21	9/23	65	dry	0.11 (2%)	NA	NA	NA	NA	16 (5%)	0 (0%)	33 (3%)	1 (1%)	0 (0%)	50 (4%)
				intermittent	0.11 (2%)	NA	NA	NA	NA	68 (21%)	0 (0%)	46 (5%)	4 (4%)	0 (0%)	118 (8%)
				wet	5.72 (96%)	NA	NA	NA	NA	245 (74%)	11 (100%)	902 (92%)	92 (95%)	0 (0%)	1,250 (88%)
Gilliam Creek	7/29 - 7/30	9/18	50	dry	1.02 (31%)	NA	NA	NA	NA	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
				intermittent	0.00 (0%)	NA	NA	NA	NA	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
				wet	2.31 (69%)	NA	NA	NA	NA	201 (100%)	21 (100%)	373 (100%)	65 (100%)	0 (0%)	660 (100%)
Dutch Bill Creek	7/1 - 7/7	9/14	70	dry	4.56 (46%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	86 (24%)	22 (42%)	39 (9%)	19 (35%)	0 (0%)	166 (18%)
				intermittent	1.24 (12%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (2%)	51 (11%)	6 (10%)	0 (0%)	58 (6%)
				wet	4.17 (42%)	1 (100%)	0 (0%)	0 (0%)	1 (100%)	275 (76%)	30 (56%)	369 (80%)	30 (55%)	0 (0%)	704 (76%)
Green Valley Creek	6/22 - 6/30	8/28 - 9/1	64	dry	2.10 (22%)	1 (20%)	0 (0%)	0 (0%)	3 (10%)	92 (9%)	2 (1%)	154 (15%)	13 (10%)	0 (0%)	261 (11%)
				intermittent	3.35 (35%)	3 (60%)	12 (80%)	0 (0%)	17 (59%)	670 (66%)	119 (78%)	635 (61%)	54 (42%)	0 (0%)	1,478 (64%)
				wet	4.21 (44%)	1 (20%)	3 (20%)	0 (0%)	9 (31%)	249 (25%)	31 (21%)	247 (24%)	61 (48%)	0 (0%)	588 (25%)
Mark West Creek	7/13 - 8/19	9/1 - 9/2	39	dry	1.05 (7%)	NA	0 (0%)	0 (0%)	1(20%)	2 (12%)	0 (0%)	14 (3%)	1 (0%)	0 (0%)	17 (2%)
				intermittent	0.66 (5%)	NA	0 (0%)	0 (0%)	0 (0%)	2 (12%)	0 (0%)	12 (2%)	4 (2%)	0 (0%)	19 (2%)
				wet	12.41 (88%)	NA	3 (100%)	0 (0%)	4 (80%)	13 (76%)	5 (100%)	534 (95%)	226 (98%)	0 (0%)	856 (96%)
Porter Creek	7/6 - 7/28	9/21	63	dry	4.73 (64%)	0 (0%)	1 (50%)	0 (0%)	2 (67%)	66 (13%)	23 (79%)	264 (48%)	9 (13%)	0 (0%)	362 (32%)
				intermittent	1.90 (26%)	0 (0%)	1 (50%)	0 (0%)	1 (33%)	237 (47%)	2 (7%)	156 (28%)	20 (30%)	0 (0%)	415 (36%)
				wet	0.78 (11%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	201 (40%)	4 (14%)	129 (24%)	38 (57%)	0 (0%)	372 (32%)
Mill Creek	6/22 - 7/14	9/8 - 9/22	76	dry	10.45 (48%)	7 (100%)	18 (62%)	0 (0%)	31 (67%)	88 (50%)	43 (28%)	1,707 (68%)	81 (65%)	0 (0%)	1,919 (65%)
				intermittent	4.73 (22%)	0 (0%)	6 (21%)	0 (0%)	7 (15%)	58 (33%)	75 (49%)	460 (18%)	28 (22%)	0 (0%)	621 (21%)
				wet	6.38 (30%)	0 (0%)	5 (17%)	0 (0%)	8 (17%)	31 (18%)	35 (23%)	345 (14%)	16 (13%)	0 (0%)	427 (14%)
Grape Creek	7/8 - 7/9	9/18	72	dry	2.60 (84%)	0 (0%)	2 (100%)	0 (0%)	3 (100%)	86 (100%)	36 (92%)	221 (73%)	24 (51%)	0 (0%)	367 (77%)
				intermittent	0.43 (14%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	3 (8%)	78 (26%)	23 (49%)	0 (0%)	104 (22%)
				wet	0.07 (2%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	3 (1%)	0 (0%)	0 (0%)	3 (1%)

Table 5 (continued).

Watershed	Snorkeling survey date range	Wetted habitat survey date range	Average days between snorkeling and wetted habitat surveys	Wetted habitat condition	Stream length (km)	Coho redds	Steelhead redds	Chinook redds	All salmonid redds (includes redds not identified to species)	Coho yoy	Coho parr	Steelhead yoy	Steelhead parr	Chinook smolts	All juvenile salmonids
Pena Creek	7/15 - 7/23	9/15 - 9/16	58	dry	11.39 (78%)	5 (100%)	53 (84%)	19 (90%)	99 (87%)	16 (100%)	1 (100%)	2,187 (87%)	92 (74%)	357 (85%)	2,653 (86%)
				intermittent	1.56 (11%)	0 (0%)	4 (6%)	1 (5%)	7 (6%)	0 (0%)	0 (0%)	158 (6%)	15 (12%)	56 (13%)	229 (8%)
				wet	1.72 (12%)	0 (0%)	6 (10%)	1 (5%)	8 (7%)	0 (0%)	0 (0%)	166 (7%)	17 (14%)	10 (2%)	193 (6%)
Redwood Creek	8/10 - 8/25	9/24	38	dry	1.73 (38%)	0 (0%)	1 (50%)	3 (75%)	4 (67%)	0 (0%)	0 (0%)	16 (15%)	1 (9%)	2 (15%)	19 (15%)
				intermittent	1.73 (38%)	0 (0%)	1 (50%)	0 (0%)	1 (17%)	0 (0%)	0 (0%)	70 (66%)	10 (91%)	5 (39%)	85 (65%)
				wet	1.12 (24%)	0 (0%)	0 (0%)	1 (25%)	1 (17%)	0 (0%)	0 (0%)	20 (19%)	0 (0%)	6 (46%)	26 (20%)
All streams combined	**6/22 - 8/27**	**8/28 - 9/28**	**61**	**dry**	**41.88 (39%)**	**16 (64%)**	**76 (60%)**	**22 (88%)**	**145 (65%)**	**547 (13%)**	**132 (21%)**	**4,639 (48%)**	**249 (24%)**	**359 (70%)**	**5,926 (37%)**
				intermittent	**19.78 (19%)**	**5 (20%)**	**29 (23%)**	**1 (4%)**	**41 (18%)**	**1,499 (37%)**	**292 (46%)**	**1,715 (18%)**	**193 (18%)**	**62 (12%)**	**3,761 (24%)**
				wet	**45.14 (42%)**	**4 (16%)**	**21 (17%)**	**2 (8%)**	**38 (17%)**	**2,011 (50%)**	**210 (33%)**	**3,218 (34%)**	**604 (58%)**	**94 (18%)**	**6,137 (39%)**

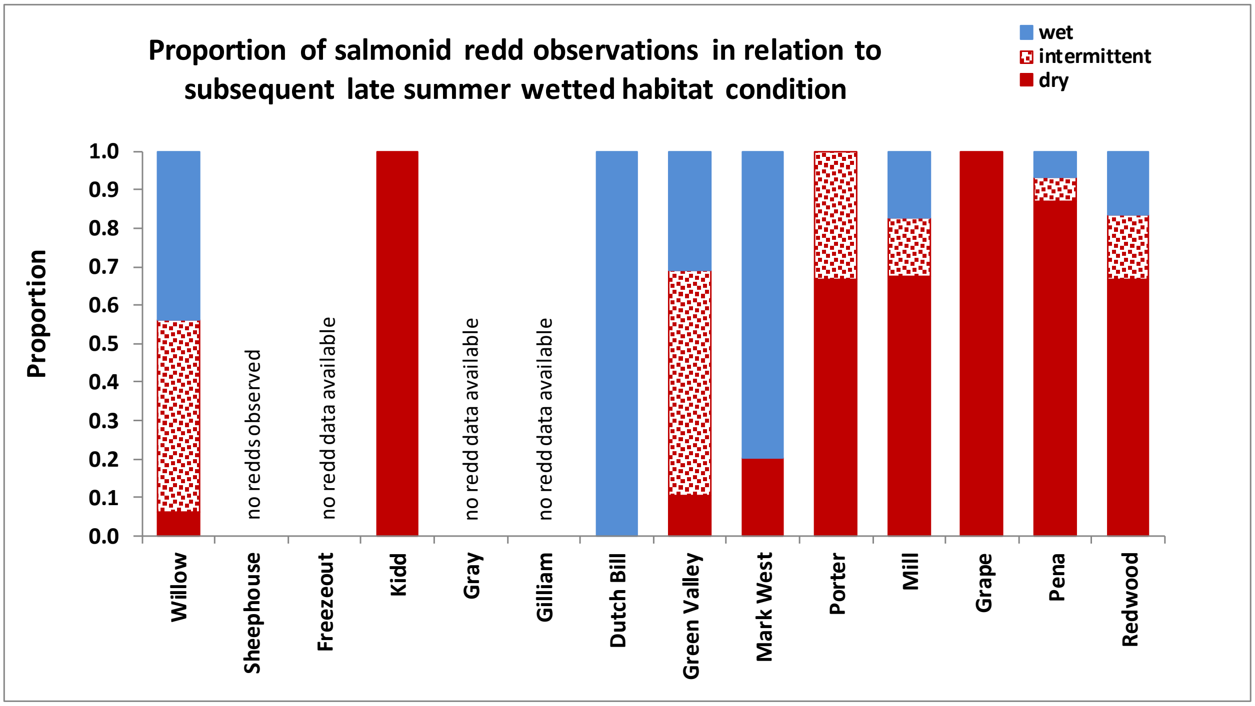

Figure 25. Proportion of winter 2014-2015 salmonid redds observed in habitat that was wet, intermittent, or dry during later summer surveys in 2015.

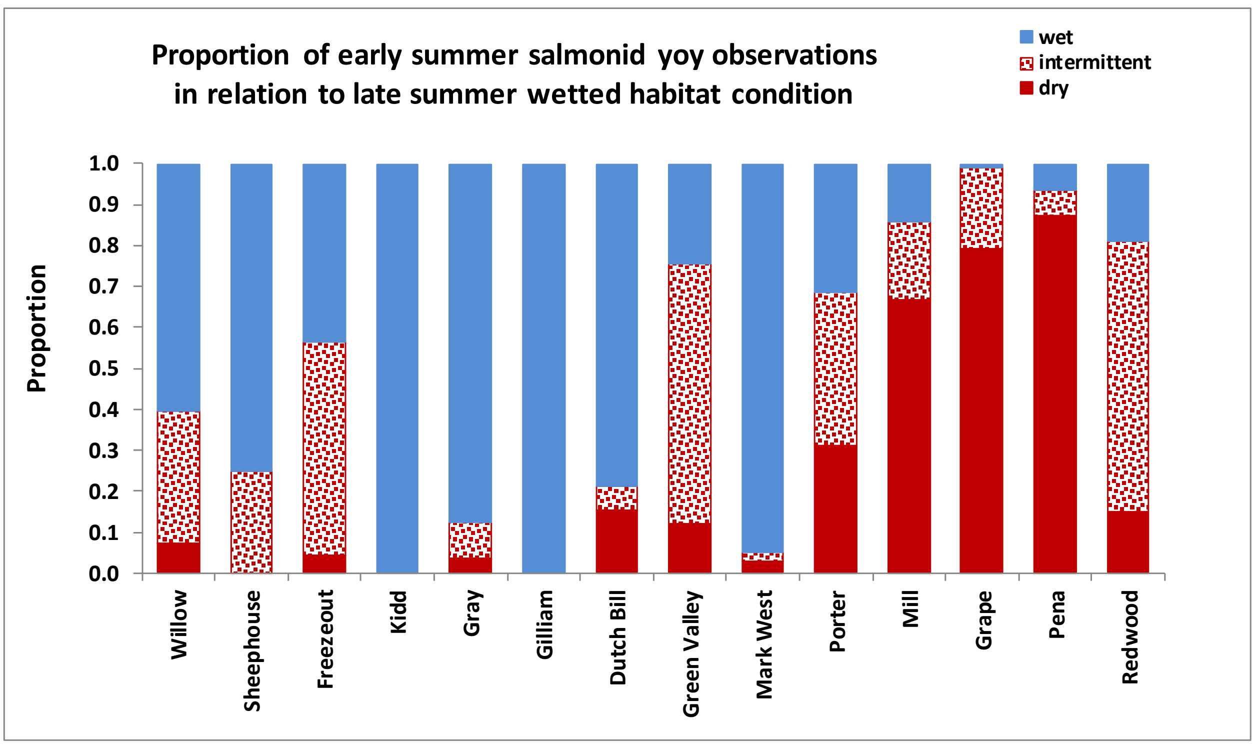

Figure 26. Proportion of early summer salmonid YOY observed in habitat that was wet, intermittent, or dry during late summer surveys in 2015.

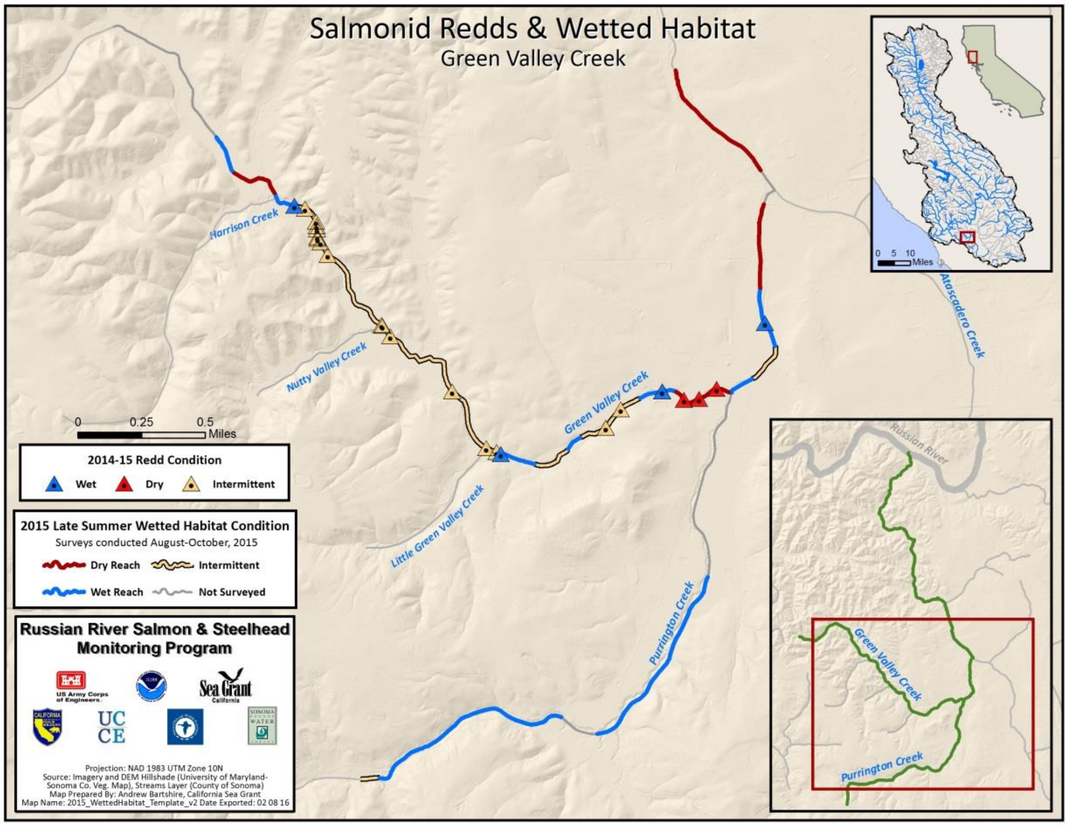

Figure 27. Winter 2014-2015 Green Valley Creek redd locations and wetted habitat conditions in late summer 2015.

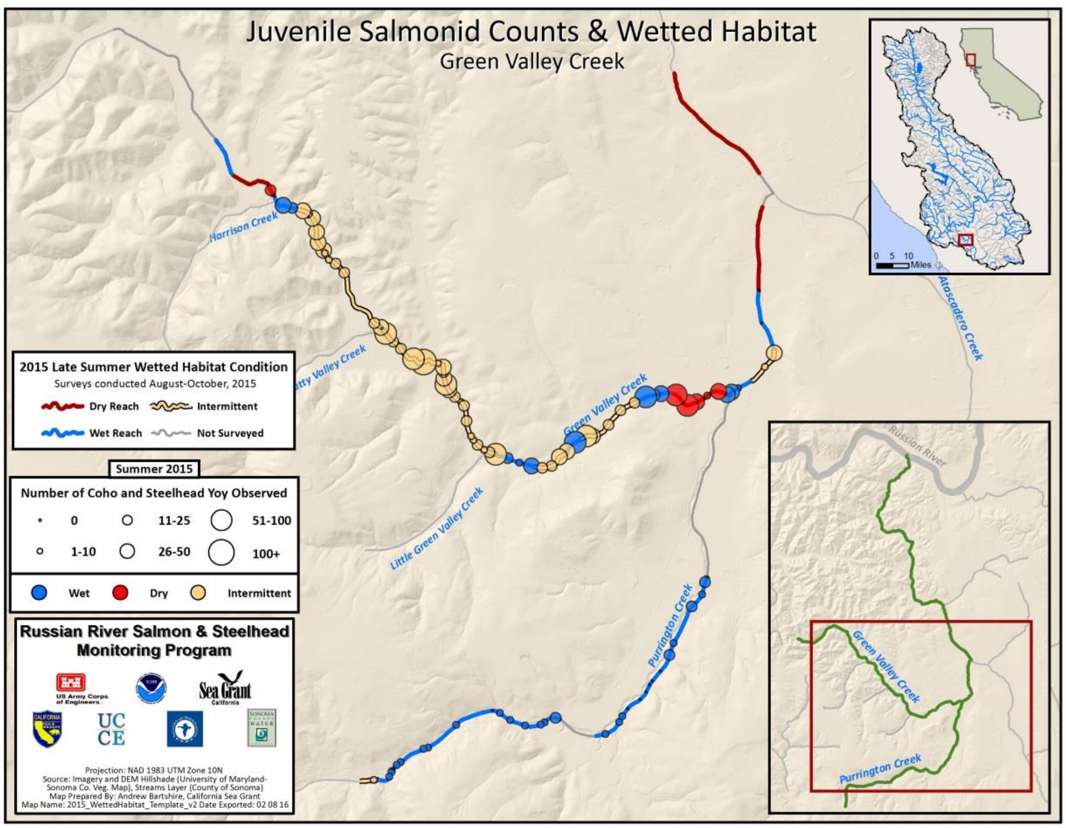

Figure 28. Early summer salmonid YOY and late summer wetted habitat conditions, Green Valley Creek 2015.

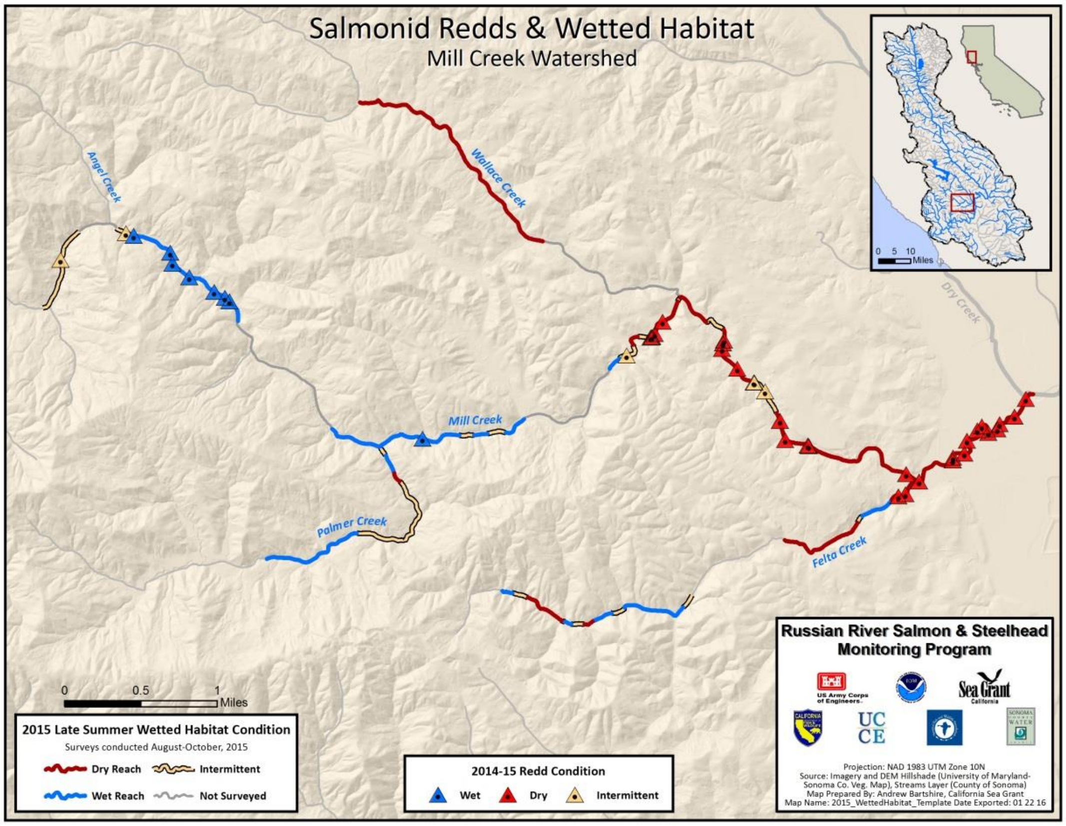

Figure 29. Winter 2014-2015 Mill Creek redd locations and wetted habitat conditions in late summer 2015.

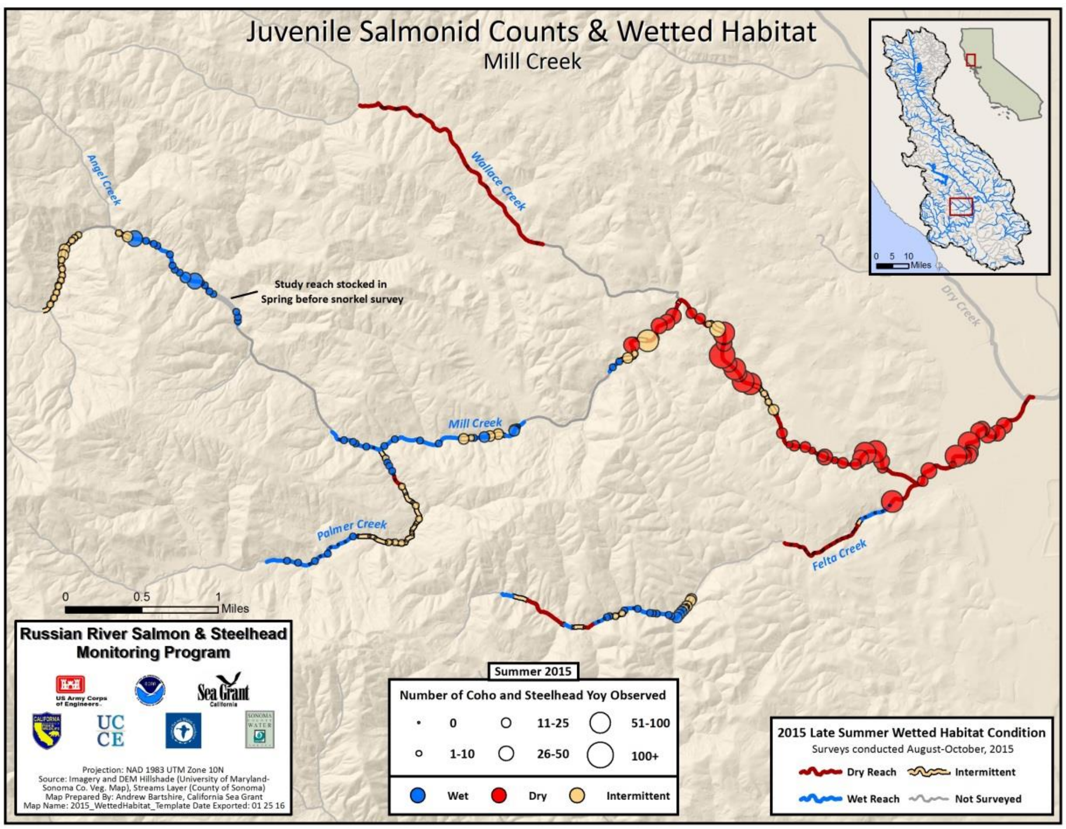

Figure 30. Early summer salmonid YOY and late summer wetted habitat conditions, Mill Creek 2015.

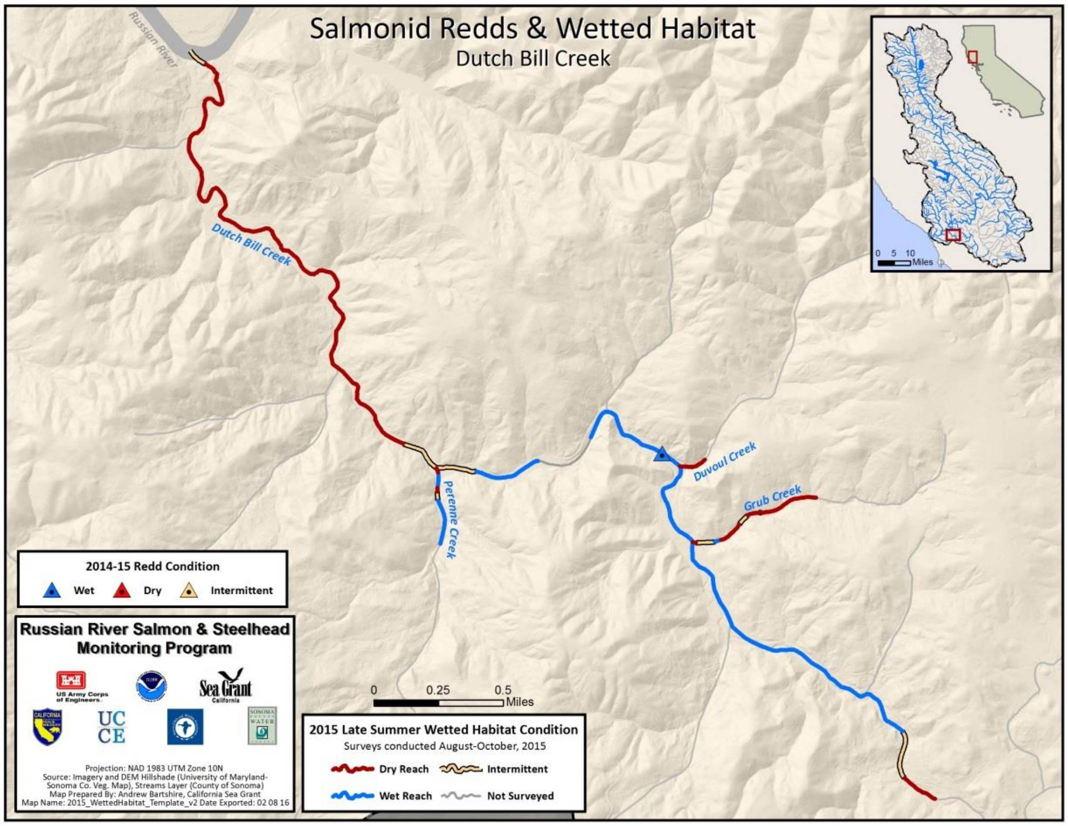

Figure 31. Winter 2014-2015 Dutch Bill Creek redd locations and wetted habitat conditions in late summer 2015.

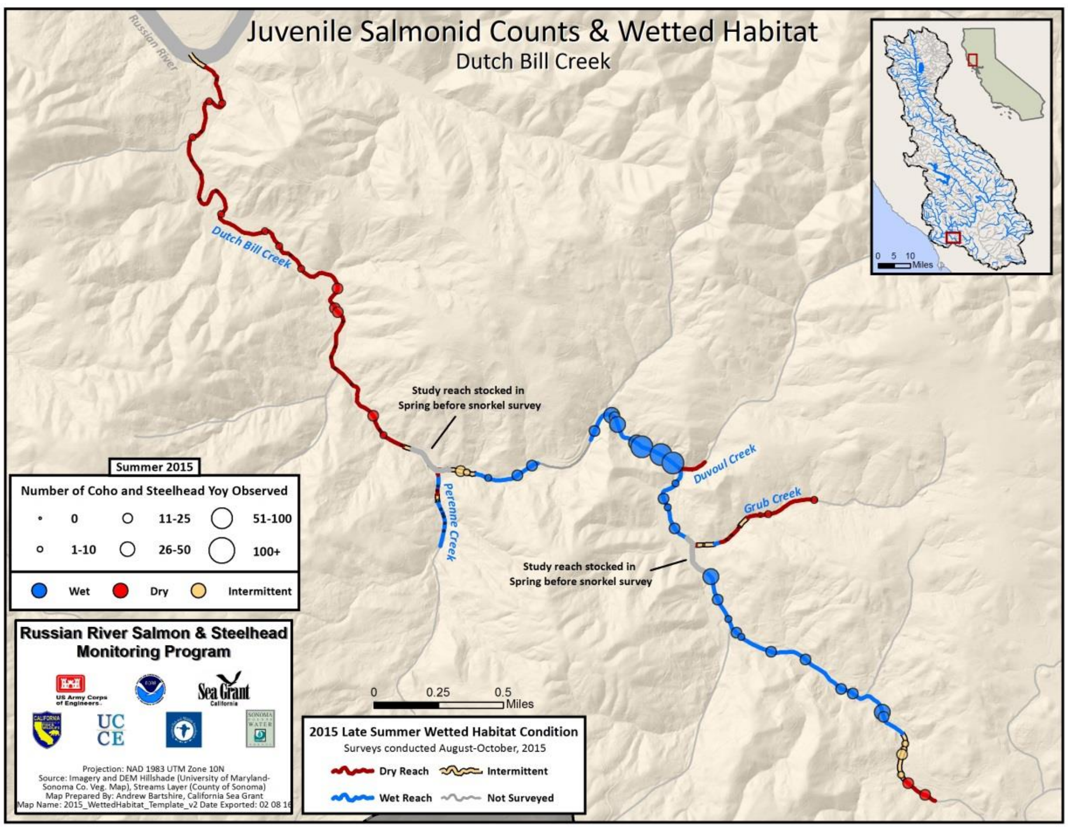

Figure 32. Early summer salmonid YOY densities and late summer wetted habitat conditions, Dutch Bill Creek 2015.

V. References

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