FLOW AND SURVIVAL STUDIES TO SUPPORT ENDANGERED COHO RECOVERY IN FLOW-IMPAIRED TRIBUTARIES OF THE RUSSIAN RIVER BASIN

Annual Report for Wildlife Conservation Board Grant WC-1663CR

May 1, 2017 – April 30, 2018

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INTRODUCTION

In 2017, California Sea Grant (CSG) and University of California at Berkeley (UC Berkeley) were awarded three years of funding by the Wildlife Conservation Board (WCB) to conduct streamflow and coho salmon survival studies in Russian River tributaries. These studies are designed to aid in increasing streamflow in flow-impaired streams critical for the recovery of endangered coho salmon populations. With the assistance of this award, we are building upon previous research and an established monitoring infrastructure in the Russian River watershed, and are collecting and analyzing long-term datasets to determine which streamflow and related environmental metrics (dissolved oxygen, temperature, wetted volume) best predict summer survival of juvenile coho salmon. In addition, we are conducting sequential wet/dry mapping, snorkeling, and spawner surveys to document changes in wetted habitat conditions in relation to streamflow, fish distribution, flow augmentations and other streamflow improvement projects over the three years of the grant. The intention of this work is to aid resource managers and recovery partners in the prioritization, design, and evaluation of stream flow enhancement projects, allow optimization of the timing and quantity of water released from upstream storage ponds and wells, inform instream flow recommendations and water policy, and support planning for emergency actions in times of drought.

This report includes a summary of the first year of progress for WCB award WC-1663CR during the period of May 1, 2017 – April 30, 2018.

TASK 1: DEVELOP PREDICTIVE MODELS RELATING STREAMFLOW, ENVIRONMENTAL METRICS AND JUVENILE COHO SALMON SURVIVAL IN SMALL COASTAL CALIFORNIA STREAMS

BACKGROUND

From 2011 through 2016, California Sea Grant (CSG) collected juvenile coho salmon survival data in study reaches of Dutch Bill, Green Valley and Mill creeks for comparison with environmental metrics such as streamflow, wetted volume, dissolved oxygen and water temperature. These data have been used to determine that hydrologic connectivity is critical in supporting rearing juvenile coho salmon throughout the summer season, and that relationships between survival and environmental metrics vary among reaches and streams (Obedzinski et al. 2018). Field observations lead us to believe that hydrogeological factors (e.g., clay substrate v. alluvium, riparian cover, land use, etc.) play a strong role in influencing this variation. Through this grant funding, CSG has been working with the Carlson and Grantham labs at UC Berkeley to develop models to identify which environmental factors and streamflow metrics best predict coho salmon survival in small coastal California streams. Data used to build the models include a six-year coho salmon survival and environmental data set collected by CSG through funds from Trout Unlimited (TU) and the National Fish and Wildlife Foundation, and hydrogeological and watershed-level data available in GIS. New data was also collected in 2017 to support model development. Although relationships have been identified in specific reaches in some years, the goal of the modeling is to quantify general relationships across streams so that instream flow thresholds for juvenile salmonid persistence throughout the summer season can be estimated at stream-wide and regional scales.

Year 1 Activities

Juvenile coho salmon survival surveys

Methods

Through its work with the Russian River Coho Salmon Captive Broodstock Program (Coho Broodstock Program) and the Coho Water Resources Partnership (Coho Partnership), CSG previously established two oversummer survival study reaches on Dutch Bill, Green Valley and Mill creeks (Figure 1- Figure 4). Each reach is approximately 250m long and contains between six and twelve pools (Table 1). In the summer of 2017, through Coho Partnership funding (via a contract with TU), water quality and streamflow data were collected in all six study reaches in late June and late September, and fish habitat and juvenile coho salmon survival data were collected in five of the six reaches (all but GRE-12.16, which was anticipated to experience the most significant drying and, as a result, be unsuitable for stocking fish).

In early June, approximately 500 PIT-tagged juvenile coho salmon were released from Don Clausen Fish Hatchery into five of the survival study reaches. Stationary PIT tag antennas placed at the upstream and downstream reach boundaries were operated throughout the summer season to account for any emigration or immigration of PIT-tagged fish. Paired PIT-tag wanding surveys were conducted in late June and late September in order to estimate oversummer survival of tagged juvenile coho (Obedzinski and Nossaman 2012; RRCWRP 2015). Data collected on stationary and portable PIT tag transceivers were downloaded onto field computers as text files, imported to Microsoft Excel for QAQC procedures, and then imported into a SQL database. The robust design mark-recapture model (Kendall et al. 1997; Lebreton et al. 1992) in Program MARK (White and Burnham 1999) was used to estimate survival at the reach scale.

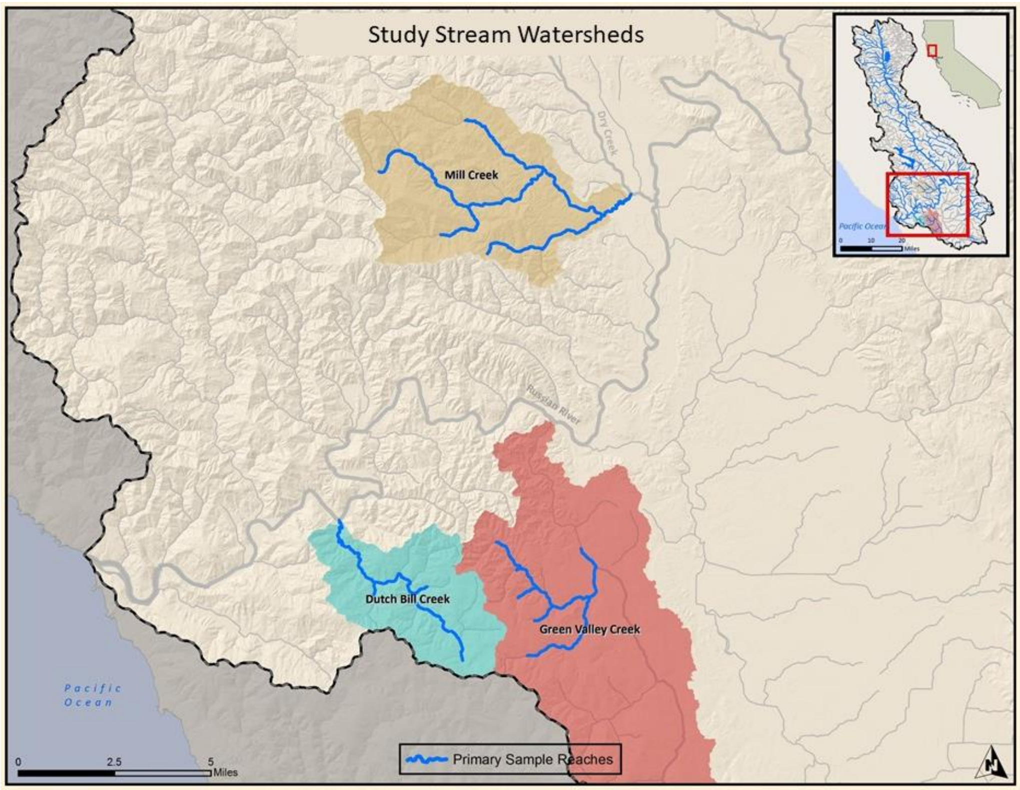

FIGURE 1. STUDY STREAMS IN THE LOWER RUSSIAN RIVER WATERSHED.

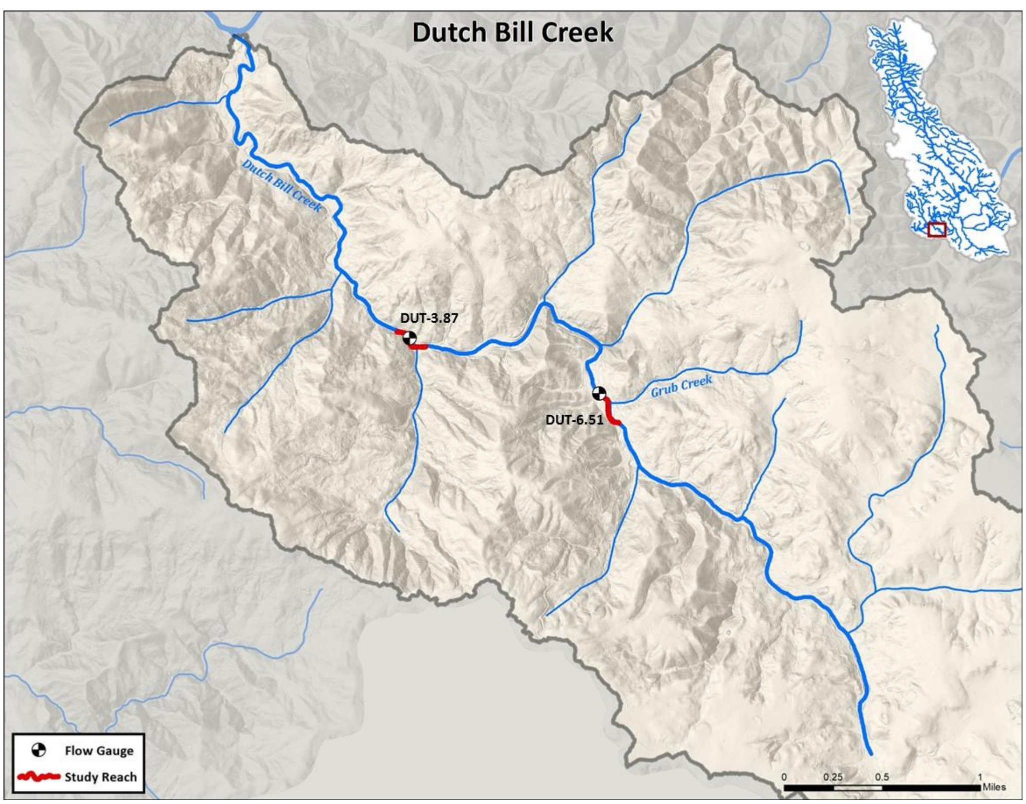

FIGURE 2. DUTCH BILL CREEK SURVIVAL AND HABITAT STUDY REACHES, AND ASSOCIATED FLOW GAUGES.

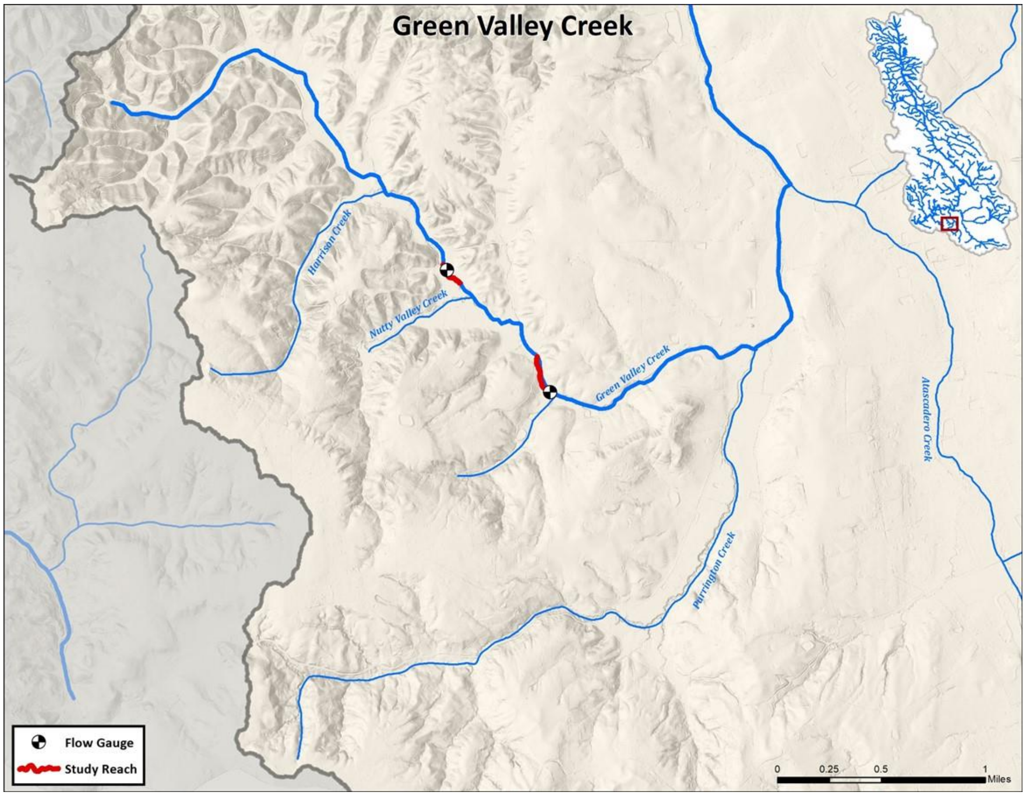

FIGURE 3. GREEN VALLEY CREEK SURVIVAL AND HABITAT STUDY REACHES, AND ASSOCIATED FLOW GAUGES.

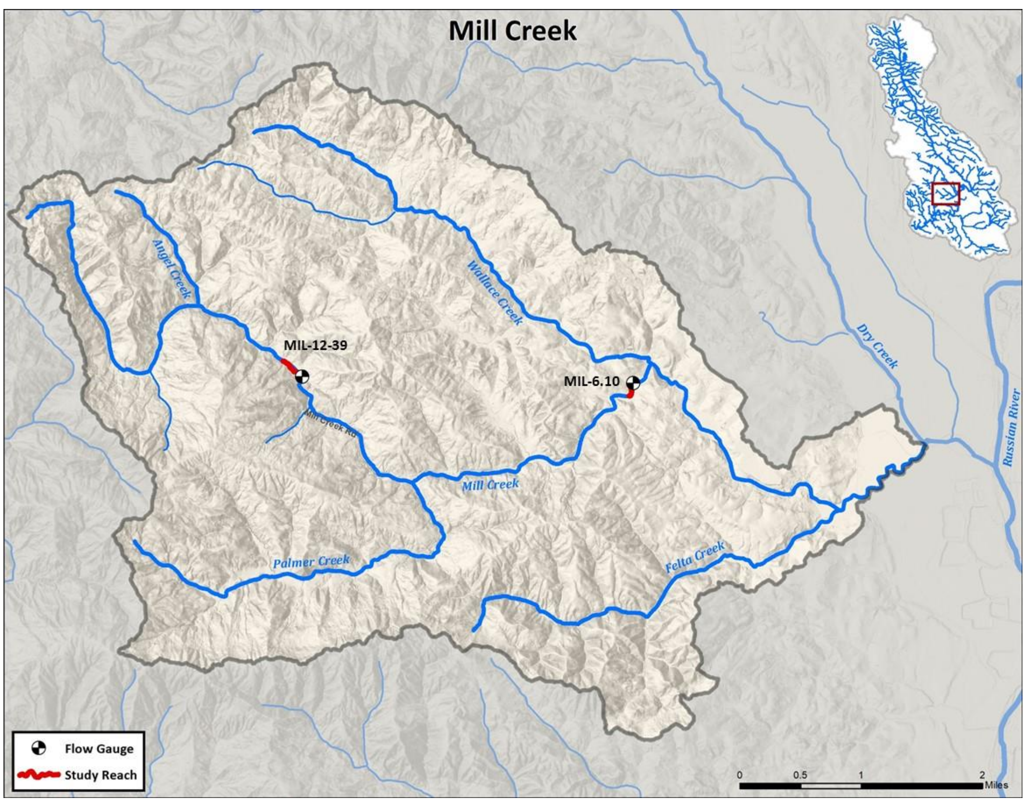

FIGURE 4. MILL CREEK SURVIVAL AND HABITAT STUDY REACHES, AND ASSOCIATED FLOW GAUGES.

TABLE 1. STUDY REACH CHARACTERISTICS.

Tributary	Reach[1]	Length (m)	Catchment area (km^2)	Slope (%)	Geomorphic reach type	Channel type[2]	Number[3] of pool and flatwater units
Dutch Bill Creek	DUT-3.87	290	24.8	0.4	alluvial	F4	6
Dutch Bill Creek	DUT-6.51	260	14.9	1.3	bedrock	F3	7
Green Valley Creek	GRE-13.40	220	8.0	0.3	clay	B4	11
Mill Creek	MIL-6.10	210	30.0	0.7	bedrock	F4	6
Mill Creek	MIL-12.39	240	10.4	1.1	bedrock	F4	12

[1] *Reach code based on distance upstream of mouth along stream channel (km).*

[2] *Rosgen stream channel classification (Rosgen 1996).*

[3] *Total number in reach in summer 2017.*

Results and Discussion

Between June 15 and October 15, 2017, estimated survival in the study reaches averaged 0.58 and ranged from 0.44 to 0.72 (Figure 5). Survival was highest in the MIL-12.39 reach and similar among the other four reaches (Figure 5). These data, along with the previous six years of data collected through the Coho Partnership, will be incorporated into the survival models described in the **Development of survival models** section below. Because 2017 was a relatively wetter year than previous years of this study, it will be valuable for inclusion in the models.

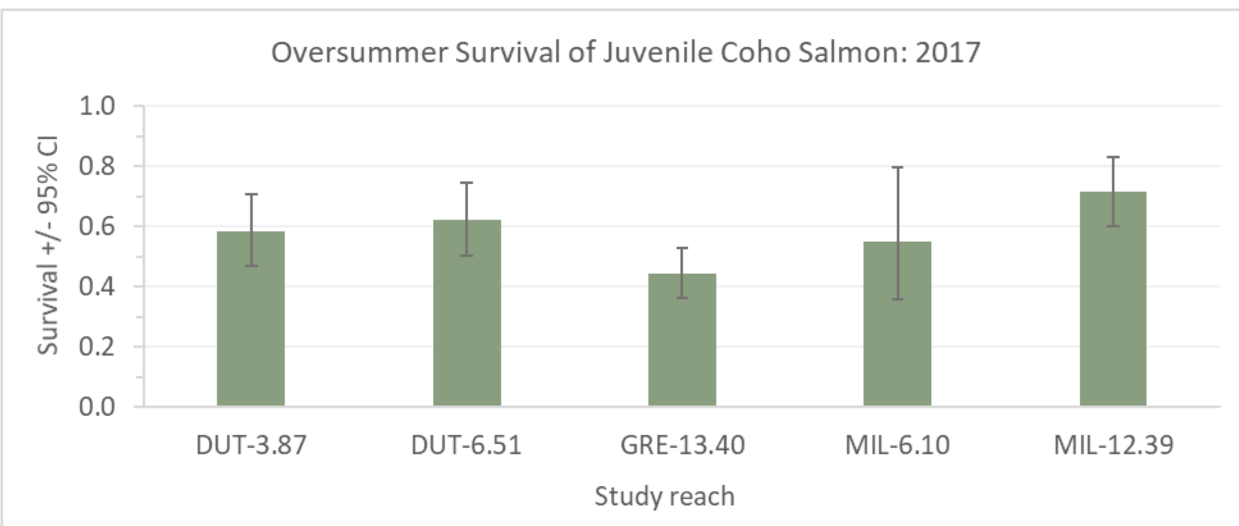

FIGURE 5. ESTIMATED JUVENILE COHO SALMON SURVIVAL IN RUSSIAN RIVER STUDY REACHES BETWEEN JUNE 15 AND OCTOBER 15, 2017.

Environmental data collection

Methods

In the summer of 2017, habitat, water quality and streamflow data were collected in the fish survival study reaches in late June and late September, through Coho Partnership funding (via a contract with

TU). Fish survival and habitat were not sampled in the GRE-12.16 reach during the summer of 2017, but water quality and streamflow data were collected using continuous data loggers.

Dissolved oxygen (DO) data were collected in every pool within each study reach using a handheld YSI DO Pro20 logger, on the same days as the late-June and late-September survival samples, using Coho Partnership funds. These funds were also used to measure fish habitat, including wetted volume and maximum depths, in each of the five survival study reaches. Habitat survey protocols were adapted from CDFW's California Salmonid Stream Restoration Manual (Flosi et al. 1998). Habitat data were collected on field computers, downloaded into a Microsoft Access database, where they underwent QAQC procedures, and then imported into a SQL database. Summary values and oversummer changes were calculated for all habitat and water quality parameters sampled for use as covariates in the survival analysis.

Continuous temperature and DO data were collected for each of the six study reaches on Dutch Bill, Green Valley and Mill creeks between June and October of 2017. Onset temperature loggers and DO loggers were deployed in a representative pool in each of the six study reaches to measure temperature and DO concentrations at 15-minute intervals over the summer dry season. These data were downloaded from the loggers into Microsoft Excel using HOBOware software, then imported into a SQL database.

Results and Discussion

Total wetted volume for all pool and flatwater units in each of the survival study reaches is shown in Figure 6. On average across all reaches, wetted volume decreased 18% between June and September. The MIL-12.39 was most stable, losing 15% of total wetted volume, and the MIL-6.10 reach experienced the greatest water loss, at 24% (Figure 6). Early summer (June) reach-scale average maximum depths ranged from 86 cm in the DUT-3.87 reach to 56 cm in the DUT-6.51 and remained relatively stable over the summer season (Figure 7). While patterns in survival between reaches did not follow patterns in wetted volume (i.e., reaches with highest wetted volume did not have higher survival and vice-versa), DO appeared to be related to survival (Figure 5, Figure 6, Table 2). For example, the MIL-12.39 reach had high survival and high DO, while the GRE-13.40 reach had lower survival and lower DO (Figure 5 and Table 2).

Table 2 shows average DO concentrations measured with a handheld meter during late morning hours in all pools in each of the survival study reaches, both in late-June and late-September. DO was lower in the September sample in all reaches except for MIL-6.10; it is not clear why that reach had lower DO in the June sample.

Continuous DO and temperature data *from a single pool* in each survival study reach were plotted for the summer period, along with the Regional Water Control Board's minimum daily DO objective for the North Coast (6.0 mg/L; RWQCB 2015) and observed salmonid mortality thresholds (3.0 mg/L; McMahon 1983) (Figure 8 - Figure 13). DO remained above the regional objective for the entire summer in the MIL-6.10 and MIL-12.39 study pools, and for 92% of 15-minute-interval samples between June 15 to October 15 in the DUT-6.51 pool; dipping below the mortality threshold in that reach briefly during the early-September heat spell (Figure 9, Figure 12 and Figure 13). DO concentrations were lowest in the DUT-3.87 and GRE-13.40 reaches (Figure 8 and Figure 11). In the logger pool in the DUT-3.87 reach, DO fell below the regional objective in late July and remained low through early October; 42% of all 15-minute samples were below 6.0 mg/L and 15% of all 15-minute samples were below the 3.0 mg/L mortality threshold for coho salmon (Figure 8). In the logger pool in the GRE-13.40 reach, DO was below the regional objective throughout the season, and plummeted in September; 37% of all 15-minute samples were below the regional objective and 18% were below the mortality threshold (Figure 11). The GRE-12.16 reach also experienced DO impairment for most of the season with, 39% of DO all 15-minute samples below the regional objective and 5% below the mortality threshold (Figure 10).

Water temperatures were within the tolerance range for salmon and, generally, well below the 25.5° C mortality threshold (McMahon 1983) in all reaches. Temperatures remained fairly consistent throughout the summer season, increasing slightly during the early-September heat spell and declining with the onset of cooler air temperatures in the fall (Table 2, Figure 8 - Figure 13).

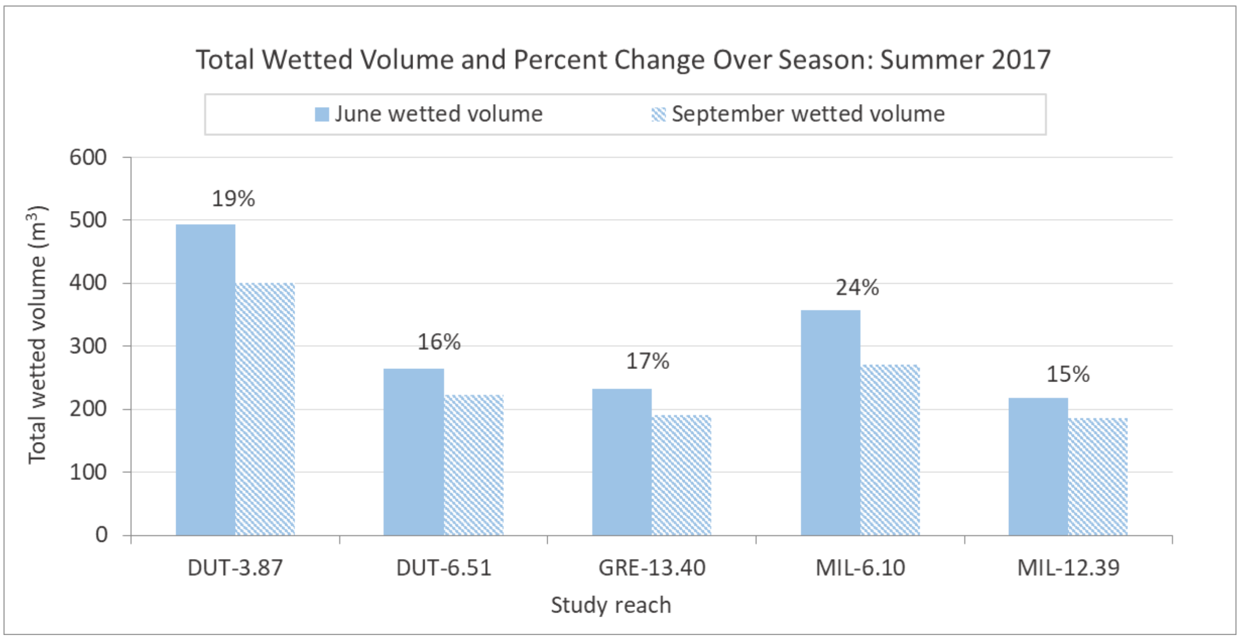

FIGURE 6. TOTAL REACH-SCALE WETTED VOLUME OF POOL AND FLATWATER UNITS IN EACH SURVIVAL STUDY REACH IN JUNE AND SEPTEMBER 2017, AND TOTAL PERCENT DECREASE OVER THE SUMMER SEASON.

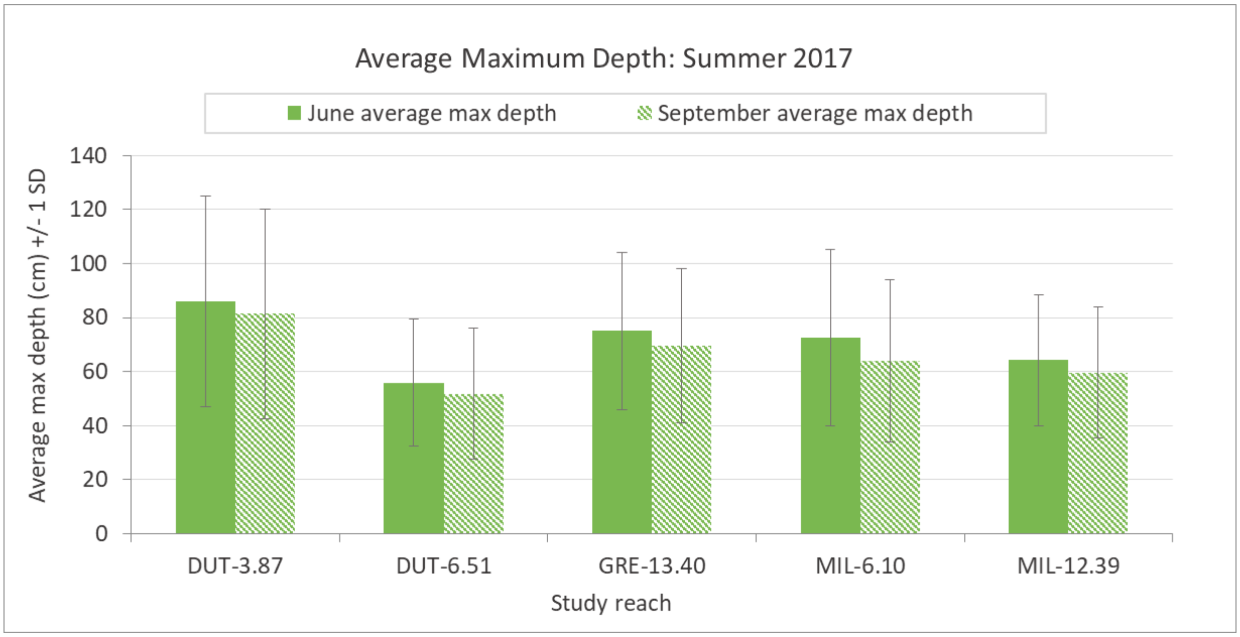

FIGURE 7. REACH-SCALE AVERAGE MAXIMUM DEPTH AND STANDARD DEVIATION OF POOL AND FLATWATER UNITS IN EACH SURVIVAL STUDY REACH IN JUNE AND SEPTEMBER 2017.

TABLE 2. REACH-SCALE AVERAGE AND MINIMUM DISSOLVED OXYGEN CONCENTRATIONS MEASURED IN POOLS WITH HANDHELD METERS, SUMMER 2017.

	Dissolved Oxygen (mg/L)			
Reach	**June Average (+/- 1 SD)**	**June Reach Minimum**	**Sept Average (+/- 1 SD)**	**September Reach Minimum**
DUT-3.87	7.76 (+/- 0.36)	7.39	5.81 (+/- 1.27)	4.34
DUT-6.51	8.94 (+/- 0.11)	8.75	8.40 (+/- 0.29)	8.04
GRE-13.40	7.13 (+/- 0.38)	6.35	3.98 (+/- 1.60)	1.36
MIL-6.10	6.66 (+/- 0.05)	6.61	9.28 (+/- 0.22)	8.93
MIL-12.39	9.55 (+/- 0.05)	9.48	9.31 (+/- 0.10)	9.17

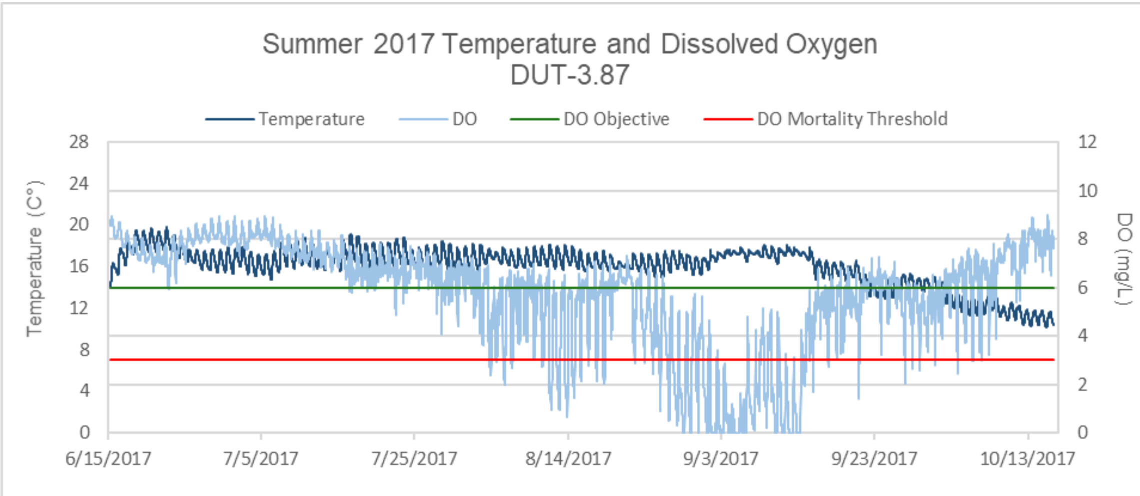

FIGURE 8. CONTINUOUS TEMPERATURE AND DISSOLVED OXYGEN MEASUREMENTS FROM GAGE POOL IN THE DUT-3.87 STUDY REACH, PLOTTED WITH REGIONAL DO OBJECTIVE (6.0 MG/L) AND SALMONID MORTALITY THRESHOLD (3.0 MG/L), SUMMER 2017.

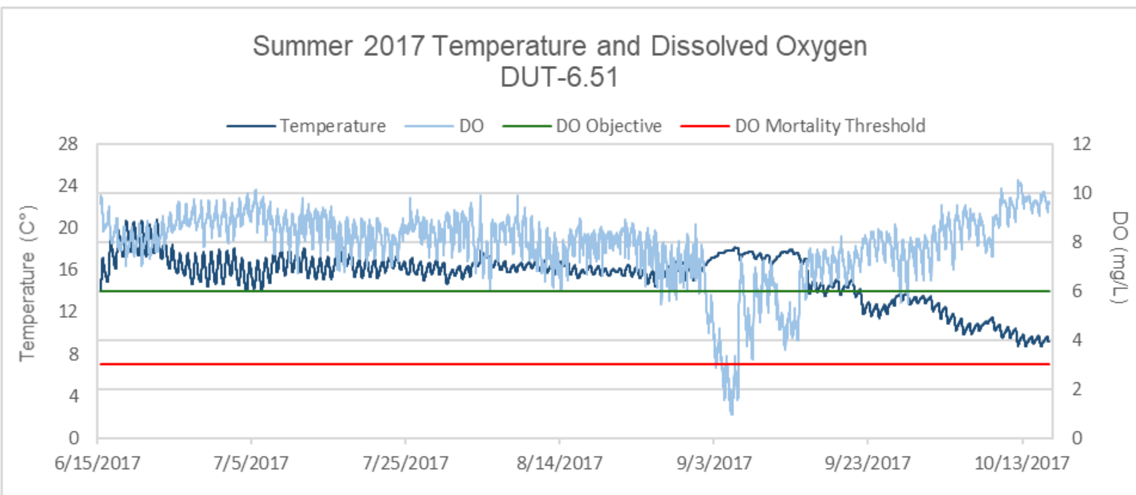

FIGURE 9. CONTINUOUS TEMPERATURE AND DISSOLVED OXYGEN MEASUREMENTS FROM GAGE POOL IN THE DUT-6.51 STUDY REACH, PLOTTED WITH REGIONAL DO OBJECTIVE (6.0 MG/L) AND SALMONID MORTALITY THRESHOLD (3.0 MG/L), SUMMER 2017.

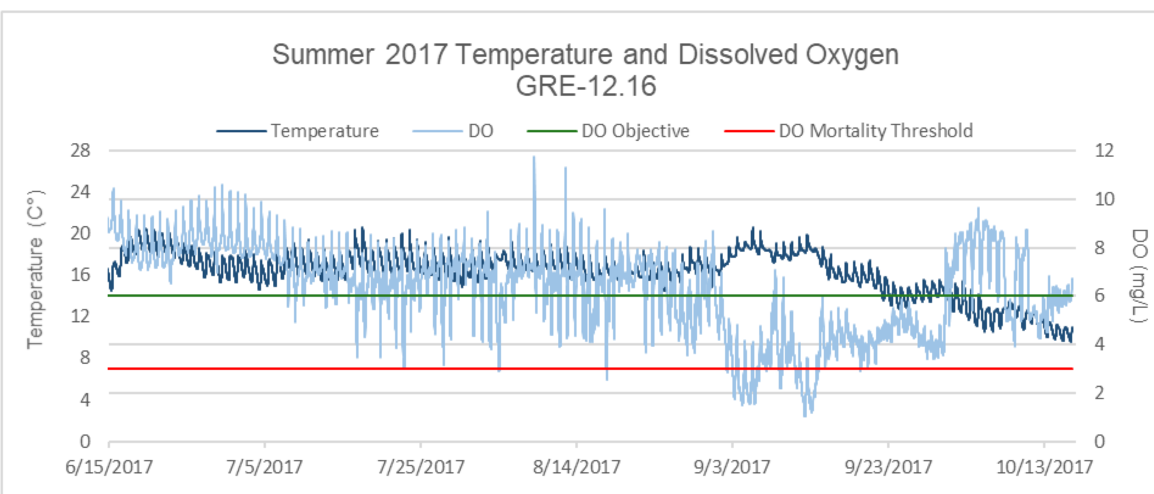

FIGURE 10. CONTINUOUS TEMPERATURE AND DISSOLVED OXYGEN MEASUREMENTS FROM GAGE POOL IN THE GRE-12.16 STUDY REACH, PLOTTED WITH REGIONAL DO OBJECTIVE (6.0 MG/L) AND SALMONID MORTALITY THRESHOLD (3.0 MG/L), SUMMER 2017.

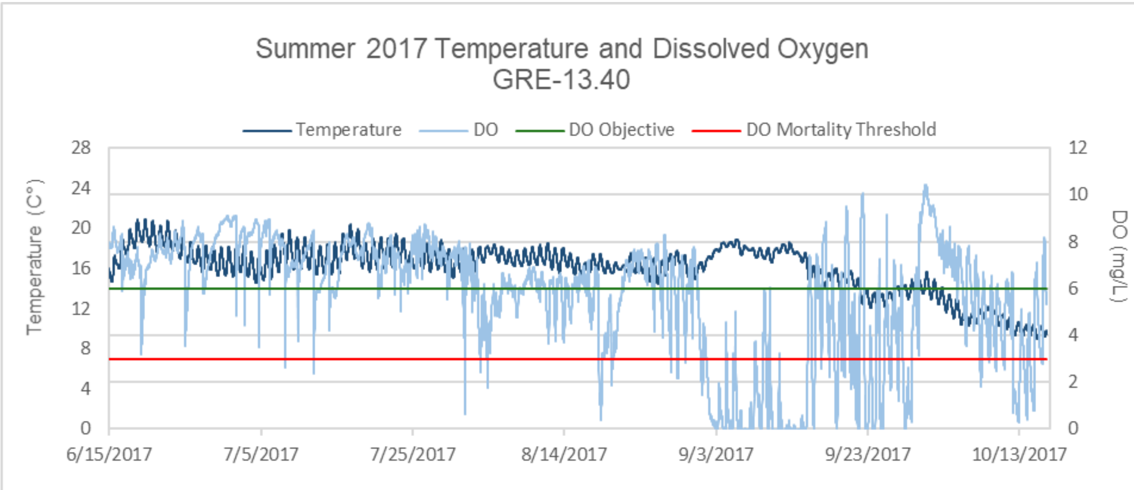

FIGURE 11. CONTINUOUS TEMPERATURE AND DISSOLVED OXYGEN MEASUREMENTS FROM GAGE POOL IN THE GRE-13.40 STUDY REACH, PLOTTED WITH REGIONAL DO OBJECTIVE (6.0 MG/L) AND SALMONID MORTALITY THRESHOLD (3.0 MG/L), SUMMER 2017.

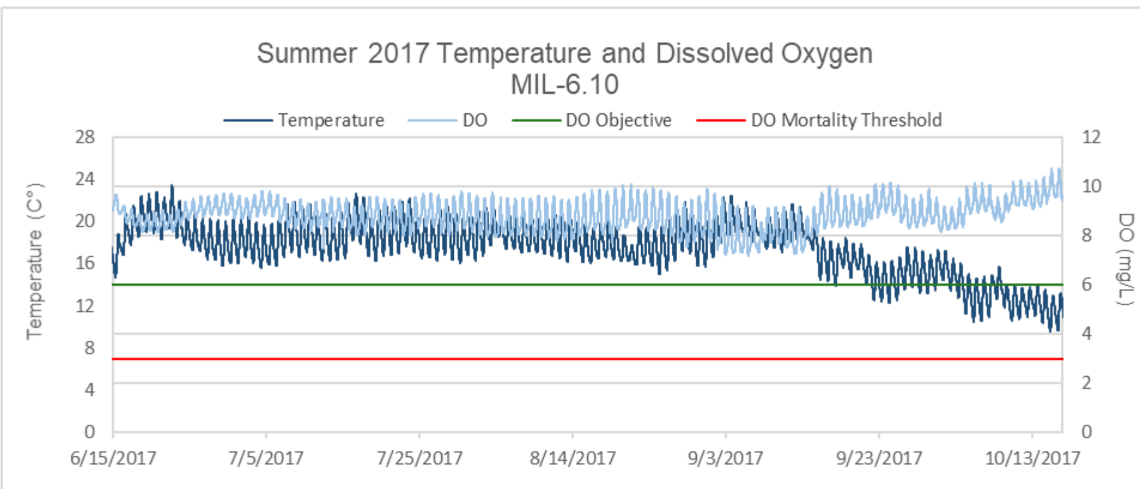

FIGURE 12. CONTINUOUS TEMPERATURE AND DISSOLVED OXYGEN MEASUREMENTS FROM GAGE POOL IN THE MIL-6.10 STUDY REACH, PLOTTED WITH REGIONAL DO OBJECTIVE (6.0 MG/L) AND SALMONID MORTALITY THRESHOLD (3.0 MG/L), SUMMER 2017.

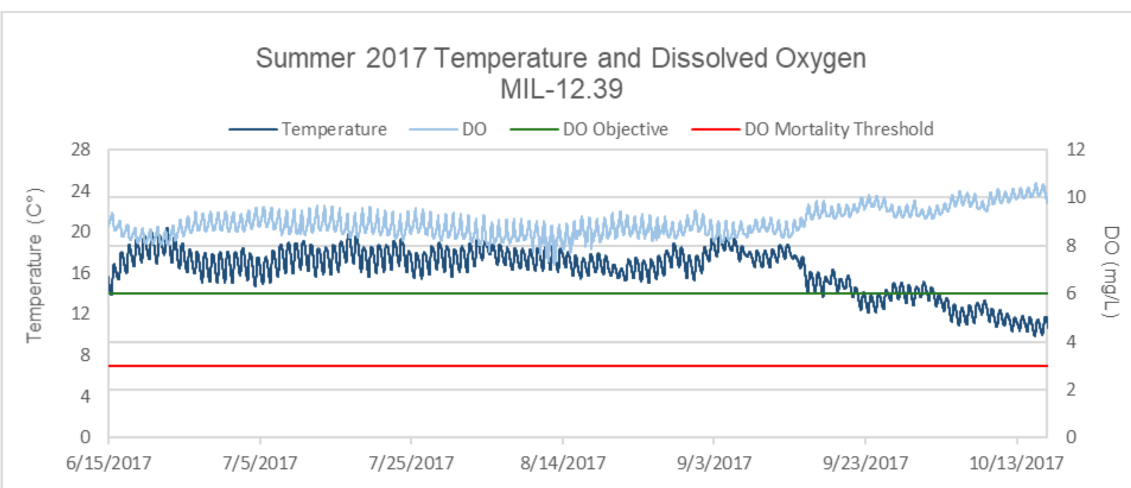

FIGURE 13. CONTINUOUS WATER TEMPERATURE AND DISSOLVED OXYGEN MEASUREMENTS FROM GAGE POOL IN THE MIL-12.39 STUDY REACH, PLOTTED WITH REGIONAL DO OBJECTIVE (6.0 MG/L) AND SALMONID MORTALITY THRESHOLD (3.0 MG/L), SUMMER 2017.

STREAMFLOW DATA COLLECTION

METHODS

Pressure transducers were operated throughout the summer season in Dutch Bill, Green Valley and Mill creeks by TU staff through the Coho Partnership effort. In-Situ Level Troll 500 vented pressure transducers recorded stream stage (water level) within a stable pool in each of the six study reaches at 15-minute intervals throughout the 2017 dry season (May through October). Staff plates were also installed at each site to correct for pressure transducer drift and other factors that could cause phase shifts (i.e., changes in the relationship between stage and streamflow) over the course of the project.

TU hydrologists visited each pressure transducer site at approximately monthly intervals, beginning in May, to download stage data, record staff plate depths and measure streamflow following protocols adapted from the CDFW Standard Operating Procedures for Discharge Measurements in Wadeable Streams (CDFW 2013). Rating curves were developed based on correlations of discharge and stage at each gaging site and were used to generate estimates of streamflow throughout the summer season.

RESULTS AND DISCUSSION

The following hydrographs show streamflow from May through October in each of the study reaches (Figure 14 - Figure 19). Streamflow was below 1.0 ft^3/s in all study reaches for most of the summer season, and below 0.5 ft^3/s for most of the summer in all reaches except for MIL-6.10. Flow in the Green Valley Creek study reaches fell below 1.0 ft^3/s in the first week of June, flow in the Dutch Bill Creek study reaches fell below 1.0 ft^3/s in the first week of July, and flow in the Mill Creek study reaches fell below 1.0 ft^3/s in mid-July (MIL-12.39) and the first week of August (MIL-6.10) (Figure 14 - Figure 19).

In September, which is generally the driest month in an average summer season in the study area, average streamflow was under 0.5 ft^3/s in all reaches, ranging from just 0.03 ft^3/s in the GRE-13.40 reach to 0.48 ft^3/s in the MIL-6.10 reach (Figure 20).

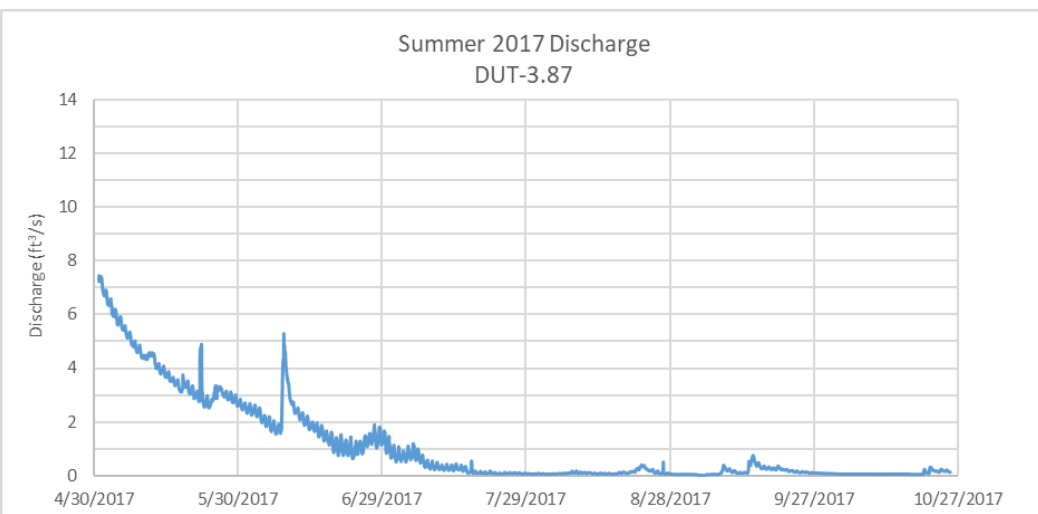

FIGURE 14. MAY THROUGH OCTOBER STREAMFLOW IN THE DUT-3.87 STUDY REACH.

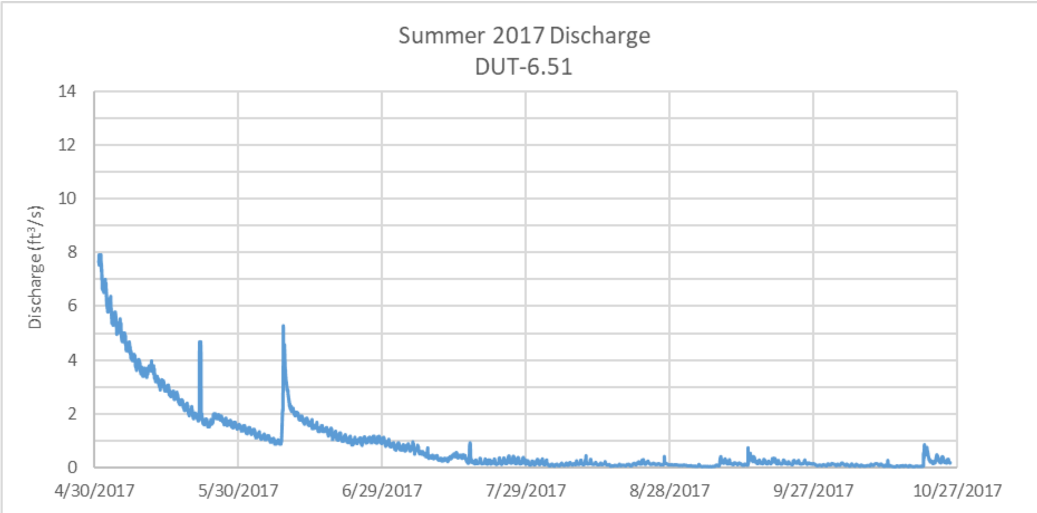

FIGURE 15. MAY THROUGH OCTOBER STREAMFLOW IN THE DUT-6.51 STUDY REACH.

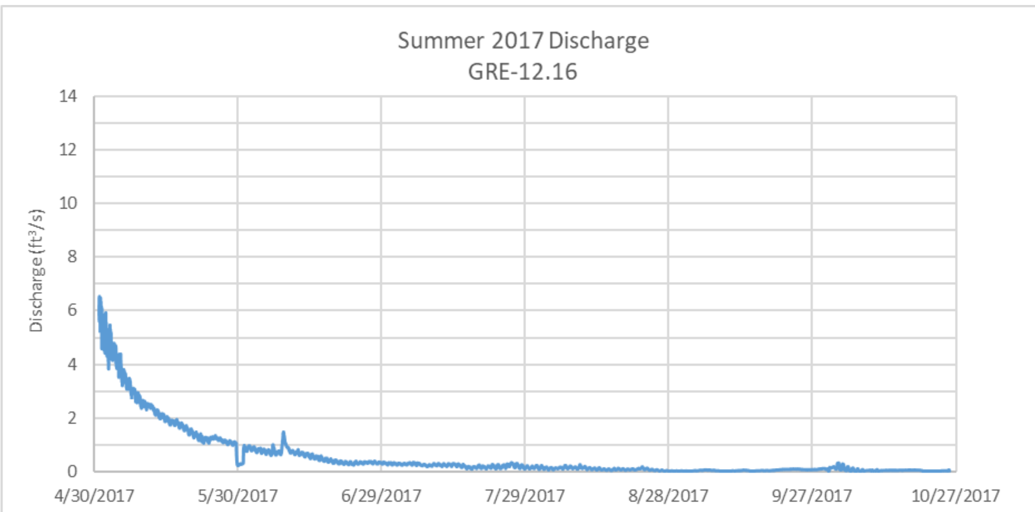

FIGURE 16. MAY THROUGH OCTOBER STREAMFLOW IN THE GRE-12.16 STUDY REACH.

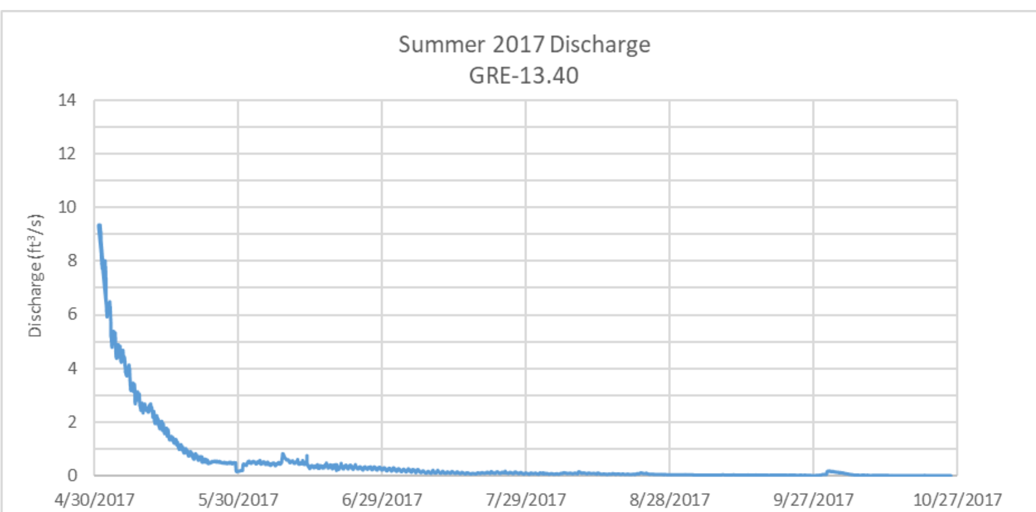

FIGURE 17. MAY THROUGH OCTOBER STREAMFLOW IN THE GRE-13.40 STUDY REACH.

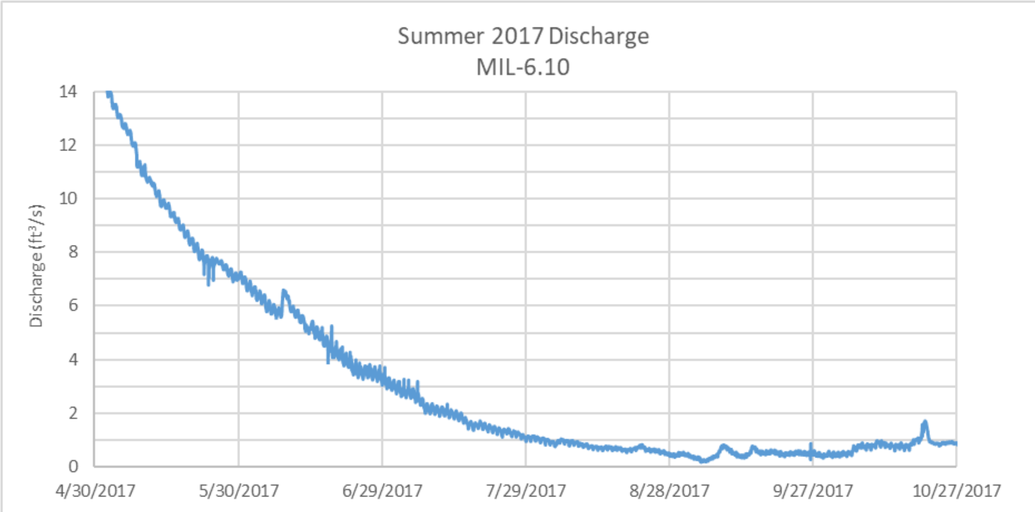

FIGURE 18. MAY THROUGH OCTOBER STREAMFLOW IN THE MIL-6.10 STUDY REACH.

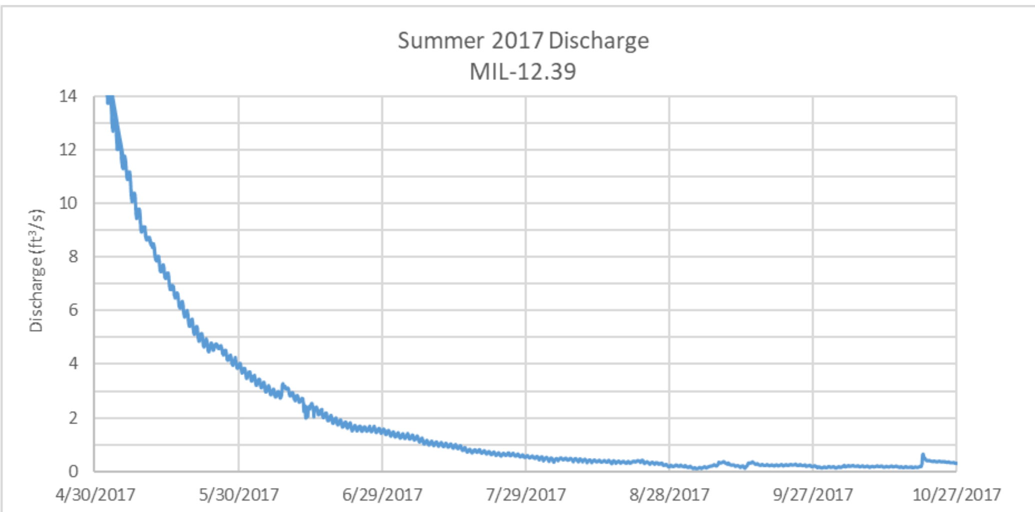

FIGURE 19. MAY THROUGH OCTOBER STREAMFLOW IN THE MIL-12.39 STUDY REACH.

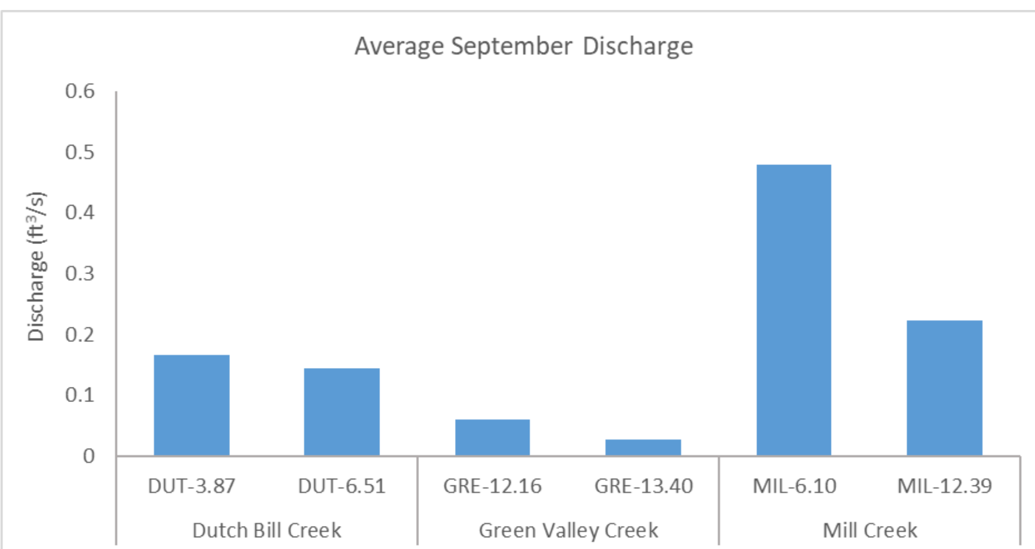

FIGURE 20. AVERAGE DISCHARGE BY STUDY REACH IN SEPTEMBER, 2017.

Development of survival models

During the first year of the project, CSG and UC Berkeley compiled a long term-survival, flow and habitat dataset, hired a postdoctoral scholar, and began analysis to determine which flow and other environmental metrics best predict summer survival of juvenile coho salmon rearing in small coastal California streams. CSG staff completed the compilation, formatting and transfer of seven years of PIT tag wanding, habitat and streamflow data from individual Excel spreadsheets and/or Access databases to a common SQL database where it can be linked for analysis. In November of 2017, CSG and UC Berkeley hired a postdoctoral scholar, Dr. Ross Vander Vorste, to assist with data analyses, modeling and dissemination of project results. Since Dr. Vorste began in November, our team has met regularly, including multiple on-site meetings in Santa Rosa and at UC Berkeley to discuss our approach and assign tasks towards meeting our goals.

The first phase of our analysis was to use past and current PIT-tag data collected by CSG (years 2011-2017) to estimate juvenile coho salmon survival for individual pools for each sampling interval in each reach and year sampled. Because this represented over one thousand survival estimates, a program was written to automate running survival estimates in batches for each year of data collection. We used the robust design in program MARK (White and Burnham 1999) to estimate fish survival (and uncertainty) over multiple intervals for each pool/reach/year combination.

Because fish moving from one habitat unit to another between sampling occasions could potentially bias our pool-scale survival estimates, we conducted a preliminary analysis to test for movement bias. Movement among units was found to bias survival estimates in units where higher levels of movement occurred so we developed an approach for accounting for movement in Program MARK and then re-ran the estimates to eliminate bias. One final step towards completing the survival component of the analysis will be to evaluate the validity of estimates with very low sample size (i.e, < 5 fish) to determine if it is appropriate to include them in our final analysis. This will be completed in year two of the project.

In addition to generating survival estimates, we have generated numerous environmental metrics for use as correlates of salmon survival and growth, including metrics that characterize flow, climate and land use at our study sites. Preliminary analyses and modeling of salmon survival using a general additive modeling (GAM) approach indicated several important environmental correlates that limit the survival of juvenile salmon during summer months. We used these results to create a draft manuscript and Dr. Vorste presented our preliminary results at a Society for Freshwater Science meeting in Detroit, Michigan in late May. During our investigation into the potential for salmon movement to influence survival estimates, we revealed interesting patterns that showed movement varied seasonally and across years. These patterns may merit a second manuscript and we plan to perform more analyses on this topic. In the coming year, we plan to finalize our first manuscript focused on environmental correlates of salmon survival and to make progress on a second manuscript related to salmon movement within study sites.

TASK 2: DOCUMENT WETTED HABITAT CONDITIONS IN DUTCH BILL, GREEN VALLEY AND MILL CREEKS IN RELATION TO STREAMFLOW AND FISH DISTRIBUTION, AND BUILD A PREDICTIVE MODEL FOR SURFACE WATER RECESSION.

BACKGROUND

Over the past four years, CSG has refined a protocol to document the dynamic wetted habitat conditions of Russian River tributaries during the summer season, also referred to as wet/dry mapping. Wet/dry mapping surveys are performed by walking the stream channel and recording the transitions between wet and dry points, or lines, in the stream channel on a GPS unit. Data from these surveys can be used to create maps and compare wetted habitat conditions at different points in time. In the Russian River, where surface flows frequently drop to levels hovering at or just above zero (levels that are within the measurement error of most current meters), wetted habitat maps provide an alternative approach to informing and evaluating the effectiveness of streamflow enhancement projects. Through Coho Partnership funding, CSG has conducted a single wet/dry mapping survey on each of the study streams during September of the last four years. While this has been useful in documenting wetted habitat conditions at the driest time of year (i.e., worst case conditions), it has not allowed us to document drying patterns over the course of the summer, nor sufficiently inform and evaluate flow augmentation projects that are occurring in the study streams. Based on the demand by resource managers over the last few years for these sequential surveys throughout the dry season, this grant funded us to conduct wet/dry mapping at biweekly intervals between May and October, and to make those maps available to the public electronically on a weekly basis throughout the summer season. In the third year of the project, wetted habitat data from these repeated surveys, streamflow data, time lapse imagery of drying riffles, precipitation data and watershed-characterization data will be used to produce a model to predict when drying will occur in each stream under variable environmental conditions.

Wet/dry mapping, snorkeling surveys to document the distribution and relative abundance of juvenile salmonids, and spawner surveys to document the distribution of redds collectively provide useful information to resource managers. During drought emergencies, this paired data can help determine when the relocation of fish from drying pools is required and how to prioritize efforts. The information can also be used to evaluate whether streamflow improvement programs are increasing the extent of wetted habitat available to, and utilized by, fish. During the spring and summer seasons, CSG receives frequent requests from CDFW and NOAA Fisheries for current data displaying the numbers and distribution of fish in relation to current streamflow conditions. WCB grant funding allowed us to bring together snorkeling and spawner survey data collected by the Coho Broodstock and Coastal Monitoring Programs with wetted habitat data collected through this project to produce maps displaying fish distribution in relation to drying stream conditions. This information helps resource managers to prioritize and plan efforts to relocate fish from drying pools, as well as to identify flow-related survival bottlenecks and determine whether streamflow improvement projects are benefiting fish.

Year 1 Activities

Wet/dry mapping

Methods

To document changes in wetted habitat conditions throughout the summer season, wet/dry mapping surveys were conducted on the primary reaches of Dutch Bill, Green Valley and Mill creeks (Figure 1) at two-week intervals between May and October using a protocol developed by CSG for the Russian River tributaries (CSG 2016). A crew of two 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 field computer and GPS unit, surveyors recorded each wet or dry stream section, or "line". Temperature and DO concentrations were measured in the wetted sections of stream at 5-minute intervals to determine suitability for juvenile salmonids. Upon return to the office, field crews uploaded data the ArcGIS Online server where, using code developed by CSG staff, it was then transferred to a cloud-based database. Raw data was then visually inspected and any extraneous line segments were manually corrected. The lines were run through a customized geospatial tool to fine-tune continuity of line segments and provide statistics for wetted habitat condition lengths and proportions.

Results and Discussion

Over the course of the summer, maps of wetted habitat conditions were generated for every biweekly survey. As an example, Figure 21 through Figure 23 show three maps generated for Dutch Bill Creek: the first survey of the season (Figure 21), the survey where disconnection was first observed (Figure 22), and the last survey of the season (Figure 23). Pdf version of all maps from the 2017 summer season are posted at https://caseagrant.ucsd.edu/sites/default/files/2017_WettedHabitat_MapBook.pdf and the project is summarized on CSG's website at https://caseagrant.ucsd.edu/project/coho-salmon-monitoring/summer-streamflow-and-survival.

The proportion of stream channel that remained wet through the summer season varied by stream (Table 3). Across all of the seven streams surveyed, the majority (72%) of the channel remained wet through the dry season, with 12% of total surveyed length becoming intermittent and only 16% going completely dry. This was a substantial improvement in wetted fish habitat from previous drought years (Obedzinski et al. 2016a), and is likely attributed to the wetter-than-average winter of 2016-2017.

Wetted habitat maps were shared in weekly emails to partners from multiple branches of CDFW, the Regional and State Water Quality Control Boards, NOAA Fisheries, Sonoma County Water Agency, Gold Ridge and Sonoma Resource Conservation Districts, TU, Occidental Arts and Ecology Center's WATER Institute, US Army Corps of Engineers, UC Berkeley and the Camp Meeker Recreation and Parks District.

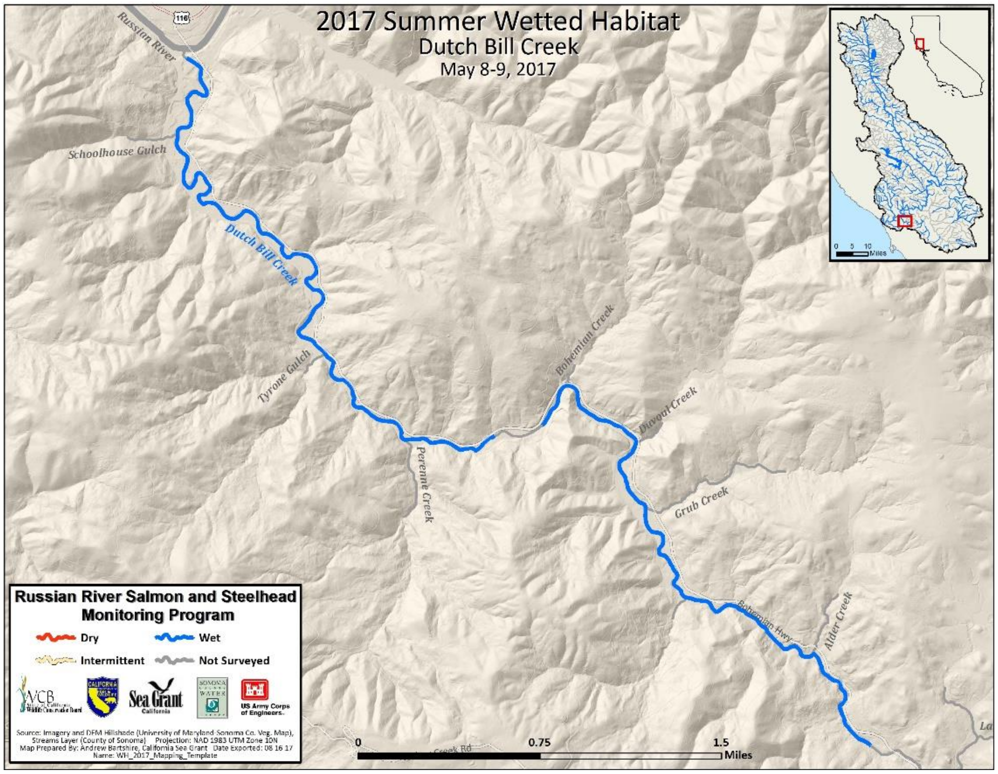

FIGURE 21. WETTED HABITAT CONDITIONS ON DUTCH BILL CREEK ON MAY 8-9, 2017; FIRST SURVEY OF THE SEASON.

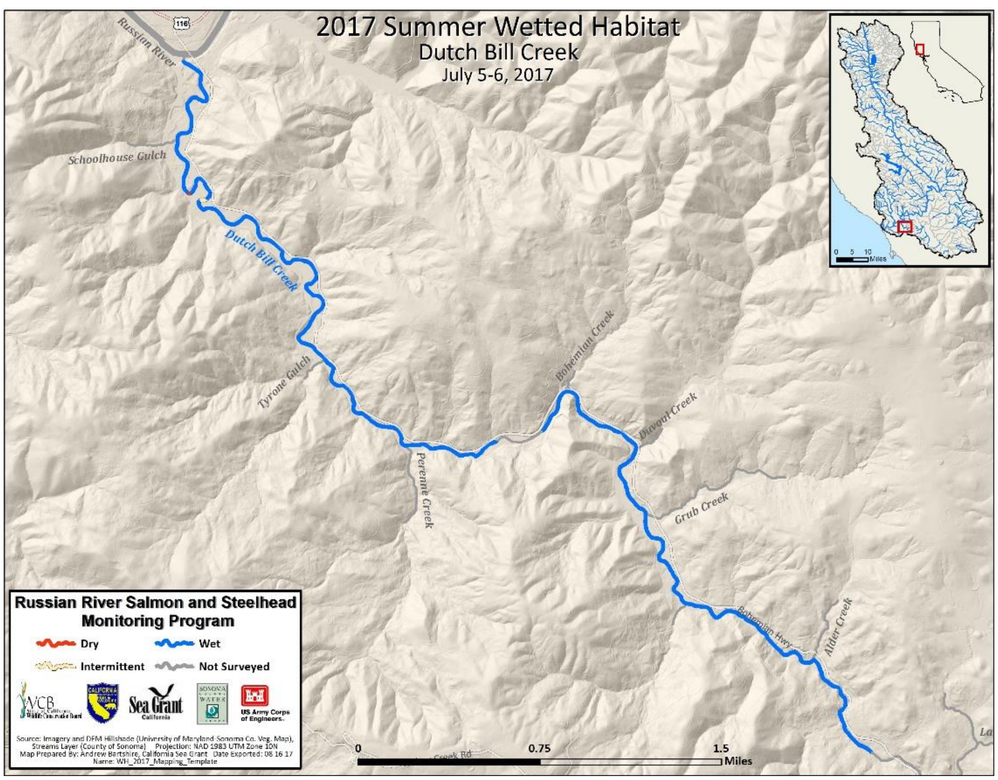

FIGURE 22. WETTED HABITAT CONDITIONS ON DUTCH BILL CREEK ON JULY 5-6, 2017; FIRST SURVEY OF THE SEASON WHERE DISCONNECTION WAS OBSERVED.

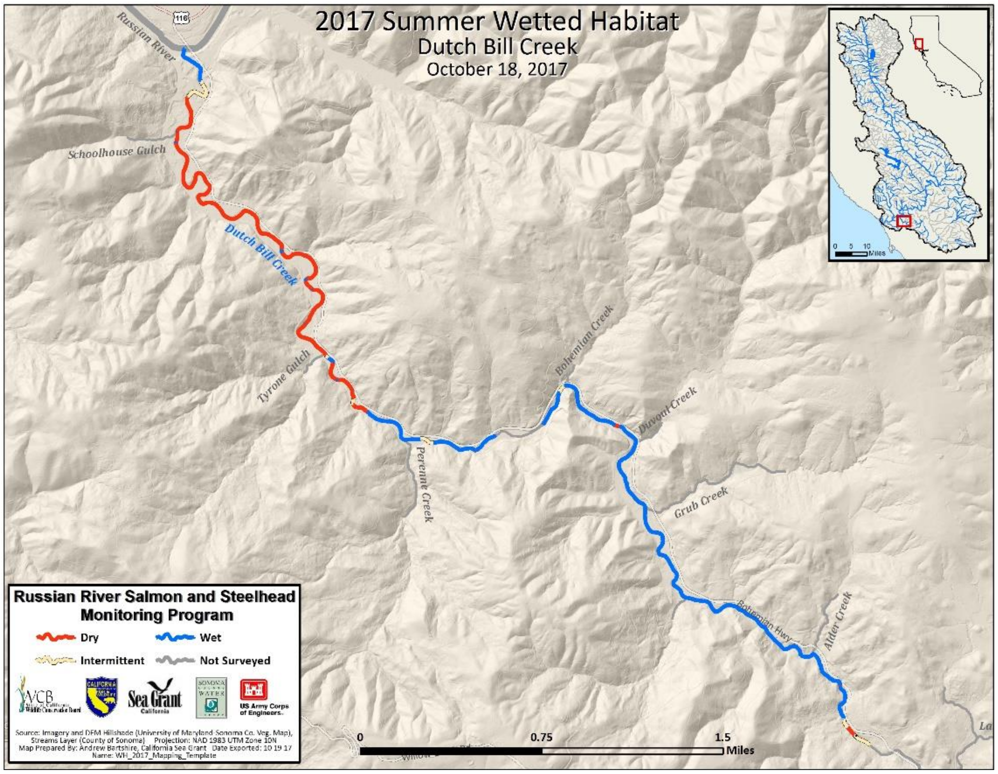

FIGURE 23. WETTED HABITAT CONDITIONS ON DUTCH BILL CREEK ON OCTOBER 18, 2017; THE FINAL AND DRIEST SURVEY OF THE SEASON.

TABLE 3. LENGTH AND PERCENTAGE OF DRY, INTERMITENT, AND WET HABITAT OBSERVED DURING THE DRIEST, LATE-SUMMER SAMPLE, 2017.

Tributary	Survey Date[1]	Driest Survey Wetted Habitat Condition (length in m, % of stream sampled)		
		Dry	Intermittent	Wet
Dutch Bill Creek	10/30/2017	3,422 (37%)	647 (7%)	5,208 (56%)
Green Valley Creek	10/17/2017	167 (3%)	1,174 (22%)	4,057 (75%)
Purrington Creek	8/29/2017	0 (0%)	0 (0%)	2,899 (100%)
Mill Creek	10/16/2017	1,687 (13%)	486 (4%)	10,530 (83%)
Felta Creek	11/1/2017	828 (23%)	520 (14%)	2,275 (63%)
Wallace Creek	9/6/2017	2,076 (92%)	168 (7%)	21 (1%)
Palmer Creek	9/14/2017	0 (0 %)	0 (0 %)	2,936 (100%)

[1] Purrington, Wallace and Palmer creeks were only surveyed once during summer 2017.

STREAMFLOW DATA COLLECTION

METHODS

Discharge data was collected during the summer months, in conjunction with the wet/dry mapping, to inform partners who are managing flow releases on appropriate timing in relation to receding streamflows and to aid in identifying pool connectivity thresholds. A Sonic Flowtracker Handheld-ADV was purchased in summer 2017 to improve the level of accuracy of extremely low velocity measurements (e.g., < 0.2 ft^3/s). Due to the length of the order process for this custom-made piece of equipment, it was not received in time to use for the entire summer period. Rather than use potentially conflicting discharge data from two different instruments, TU and CSG used a Price pygmy current meter to measure streamflow through the end of October 2017. In the fall of 2017, CSG staff conducted comparative surveys, generated training materials and trained staff in the use of the FlowTracker instrument. Beginning in summer 2018, the FlowTracker will be used exclusively to measure discharge for this project.

Two telemetered pressure transducer gauge systems were purchased and installed by TU. Online data will be available to project partners and resource managers to help inform in-season management decisions. In the summer of 2018, TU and CSG staff will measure discharge at these sites, in order to facilitate development of seasonal rating curves.

Game cameras purchased by Anthropocene Institute were installed in early summer, along with intermittency loggers, at representative riffle crests within each study reach where drying could occur. Time lapse images and intermittency logger data were evaluated to determine the date of drying at the target riffle crests in every reach in which stream disconnection was observed. This information will allow us to identify the streamflow at which pools become disconnected in different study reaches in order to support the development of connectivity thresholds for the Coho Partnership.

Results and Discussion

The first point of stream disconnection was noted during wet/dry mapping surveys and streamflow from both gages on each stream was assigned for that date (Table 4). The date of first observed disconnection varied by stream, with Felta Creek in the Mill Creek watershed disconnecting the earliest (6/15) and Green Valley Creek disconnecting the latest (8/2) (Table 4). The streams also disconnected at different flow levels at the gage sites with Mill Creek disconnecting at the highest flows (0.96 – 1.98 ft^3/s) and Green Valley Creek disconnecting at the lowest flows (0.07 – 0.13 ft^3/s) (Table 4). This data is being used to help build connectivity thresholds for high priority salmonid-bearing stream reaches.

Telemetered gages were installed on Green Valley Creek and Mill creeks in May 2018 (Figure 24) and real-time stage data are available online at https://www.hydrovu.com/.

TABLE 4. DATE OF FIRST DISCONNECTION POINT OBSERVED DURING 2017 WETTED HABITAT SURVEYS, AND AVERAGE DAILY STREAMFLOW AT THE LOWER (FURTHER DOWNSTREAM) AND UPPER (FURTHER UPSTREAM) GAGE SITES ON DISCONNECTION DATES. PURRINGTON, WALLACE AND PALMER CREEKS WERE ONLY SURVEYED ONCE IN LATE SUMMER SO THE FIRST DATE OF DISCONNECTION WAS NOT IDENTIFIED.

Tributary	Date of Disconnection	Daily Average Streamflow (ft^3/s) on Date of Disconnection	
		Lower Gage	Upper Gage
Dutch Bill Creek	7/5/2017	0.85	0.72
Green Valley Creek	8/2/2017	0.13	0.07
Purrington Creek	N/A	N/A	N/A
Mill Creek	7/13/2017	1.98	0.96
Felta Creek	6/15/2017	N/A	N/A
Wallace Creek	N/A	N/A	N/A
Palmer Creek	N/A	N/A	N/A

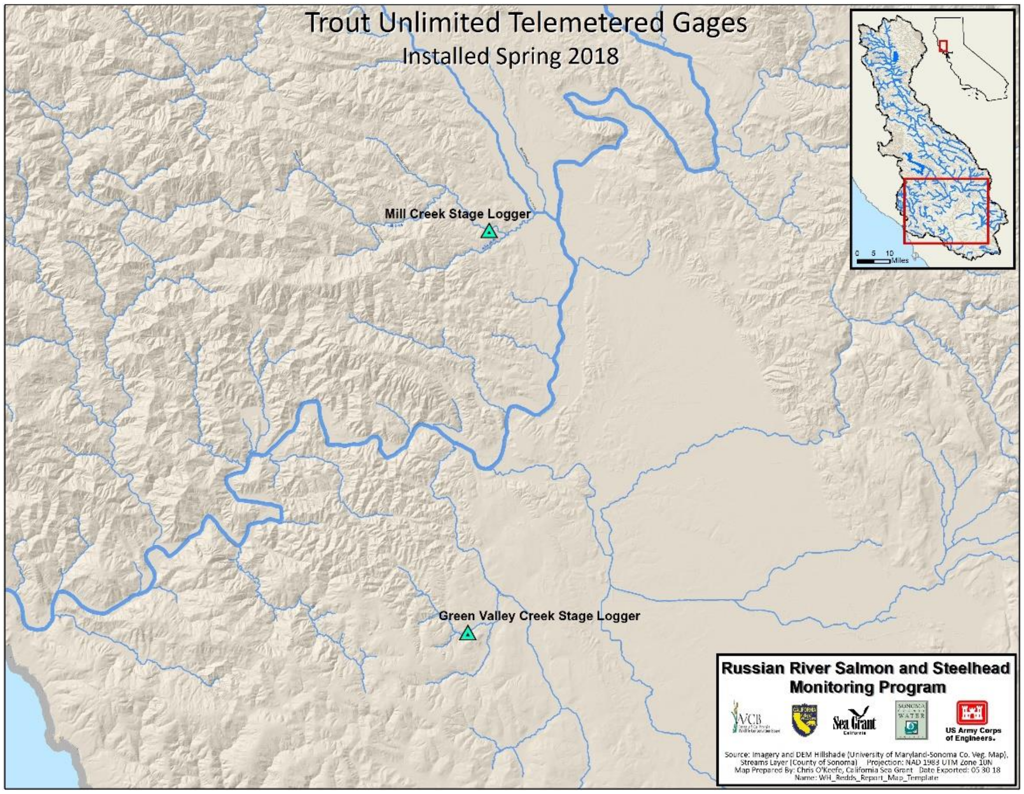

FIGURE 24. ONLINE PRESSURE TRANSDUCER GAGES ON GREEN VALLEY AND MILL CREEKS, INSTALLED 2018.

SPAWNER SURVEYS

METHODS

In the winter of 2016-17, spawner surveys were conducted by the Coho Broodstock and Coastal Monitoring Programs in all accessible reaches within the Dutch Bill, Green Valley and Mill creek watersheds that are defined as juvenile coho salmon habitat by the Russian River Coastal Monitoring Program effort (Adams et. al. 2011; SCWA and UC 2015;, Obedzinski et. al. 2016b). Each reach was surveyed at an interval of 10-14 days throughout the spawning season. On each survey, CSG and Sonoma County Water Agency biologists hiked reaches from downstream to upstream looking for adult salmon individuals (live or carcass) and redds. Redds were identified to species based on the presence of identifiable adult fish or from observed redd morphology. All observed salmonids were identified to species (coho salmon, Chinook salmon or steelhead) or as an unknown salmonid if identification was not possible. Geospatial coordinates were recorded for all redd and fish observations. Allegro field computers were used for data entry and, upon returning from the field, data files were downloaded, error checked in Microsoft Excel and transferred into a SQL database.

RESULTS

Salmonid redds observed during spawner surveys throughout the winter of 2016-2017 were totaled by species; coho salmon, steelhead or unknown salmonid (Table 5). Figure 25 - Figure 27 show distribution of observed redds by species used for comparison with 2017 wetted habitat spatial data. Further summaries of adult return data can be found in a summary report on our website: https://caseagrant.ucsd.edu/sites/default/files/2016-2017_WinterReport_CA%20SeaGrant.pdf.

TABLE 5. TOTAL COHO SALMON, STEELHEAD AND UNKNOWN SALMONID REDDS OBSERVED IN THE DUTCH BILL, GREEN VALLEY AND MILL CREEK WATERSHEDS DURING WINTER 2016-2017.

Tributary	Coho Salmon	Steelhead	Unknown Salmonid
Dutch Bill Creek	5	7	2
Green Valley Creek	13	2	4
Purrington Creek	2	2	0
Mill Creek	17	9	5
Felta Creek	4	1	2
Wallace Creek	0	0	0
Palmer Creek	0	0	0

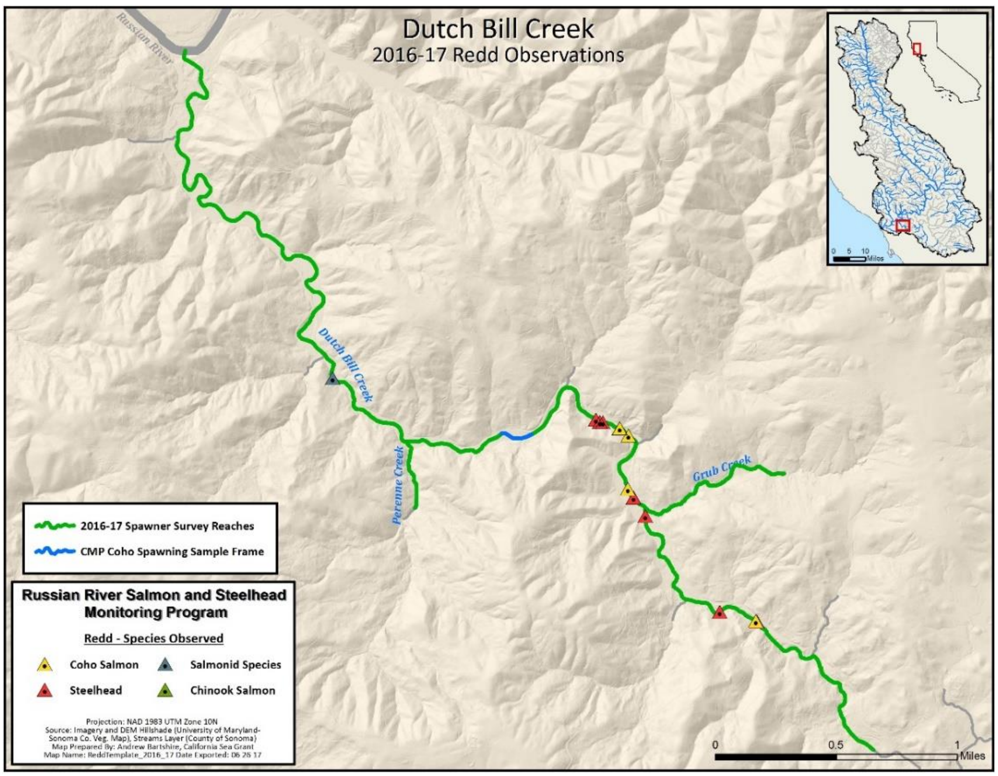

FIGURE 25. SALMONID REDDS OBSERVED IN THE DUTCH BILL CREEK WATERSHED DURING THE 2016-2017 SPAWNER SEASON.

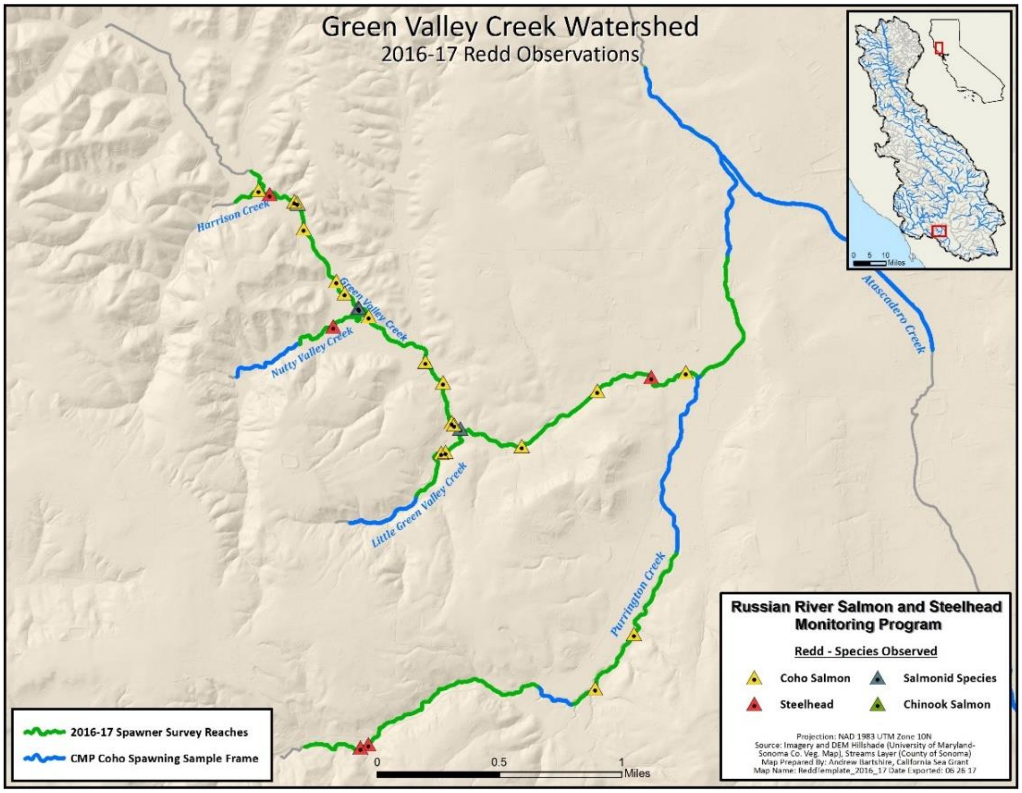

FIGURE 26. SALMONID REDDS OBSERVED IN THE GREEN VALLEY CREEK WATERSHED DURING THE 2016-2017 SPAWNER SEASON.

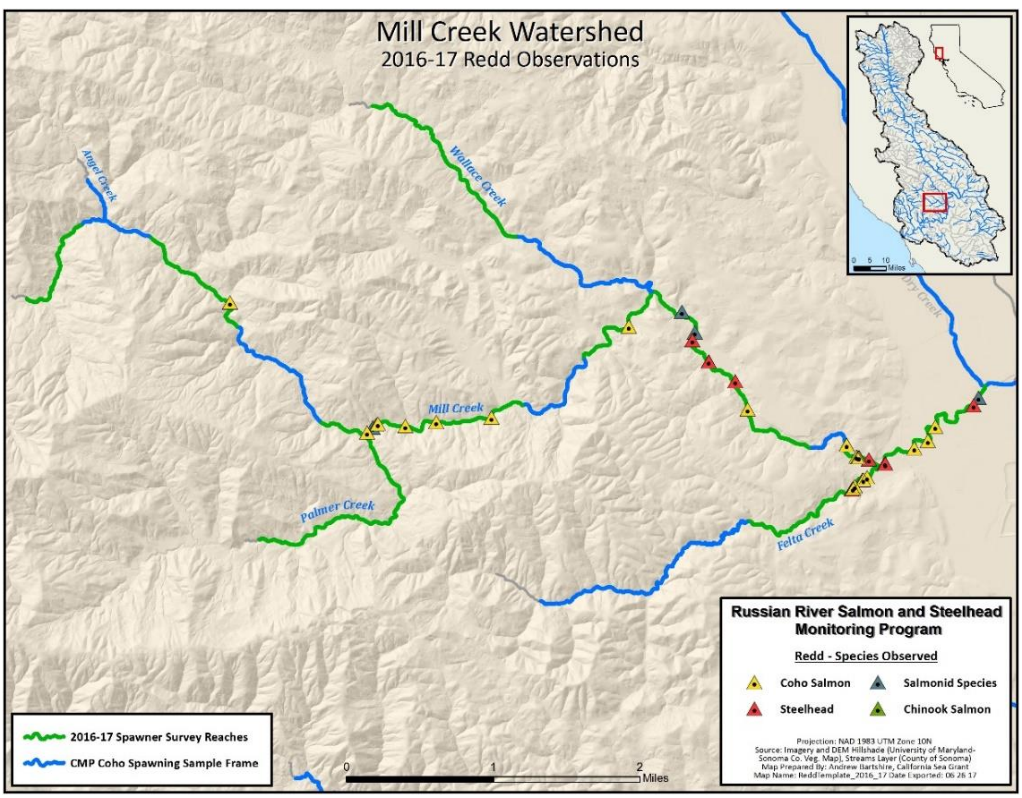

FIGURE 27. SALMONID REDDS OBSERVED IN THE MILL CREEK WATERSHED DURING THE 2016-2017 SPAWNER SEASON.

Snorkeling surveys

Methods

Between late May and July of 2017, snorkeling surveys were conducted by the Coho Broodstock and Coastal Monitoring Programs to document the relative abundance and spatial distribution of juvenile coho salmon and steelhead in all accessible reaches within the Dutch Bill, Green Valley and Mill creek watersheds that are defined as juvenile coho salmon habitat by the Russian River Coastal Monitoring Program effort (Adams et. al. 2011; SCWA and UC 2015; Obedzinski et. al. 2016b). CSG and Sonoma County Water Agency biologists snorkeled every other pool in each stream reach and counted the number of coho salmon and steelhead young-of-year (YOY) present. GPS points were collected at each survey pool so that juvenile densities could be spatially displayed. Data was entered into field computers and, upon return to the office, downloaded, error-checked and uploaded into a SQL database.

Results

Minimum and expanded counts of coho and steelhead young-of-the-year observed during summer 2017 snorkel surveys in the target tributaries are shown in Table 6. Expanded counts were generated by doubling the observed counts (to account for 50% of pools being sampled). Figure 28 - Figure 30 show density and distribution of juvenile salmonids in the Dutch Bill, Green Valley and Mill creek watersheds during summer 2017.

TABLE 6. OBSERVED AND EXPANDED COUNTS OF COHO SALMON AND STEELHEAD YOUNG-OF-THE-YEAR IN THE DUTCH BILL, GREEN VALLEY AND MILL SYSTEMS IN THE SUMMER OF 2017.

Tributary	Number of Pools Snorkeled [1]	Coho Salmon Yoy	Expanded [2] Coho Salmon Yoy	Steelhead Yoy	Expanded [2] Steelhead Yoy
Dutch Bill Creek	96	61	122	239	478
Green Valley Creek	92	1,876	3,752	723	1,446
Purrington Creek	88	172	344	482	964
Mill Creek	145	48	96	776	1,552
Felta Creek	102	172	344	981	1,962
Wallace Creek	28	0	0	232	464
Palmer Creek	65	7	14	178	356

[1] *Every second pool was snorkeled. Number varies based on presence of wet pools in accessible stream reaches at time of survey.*

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

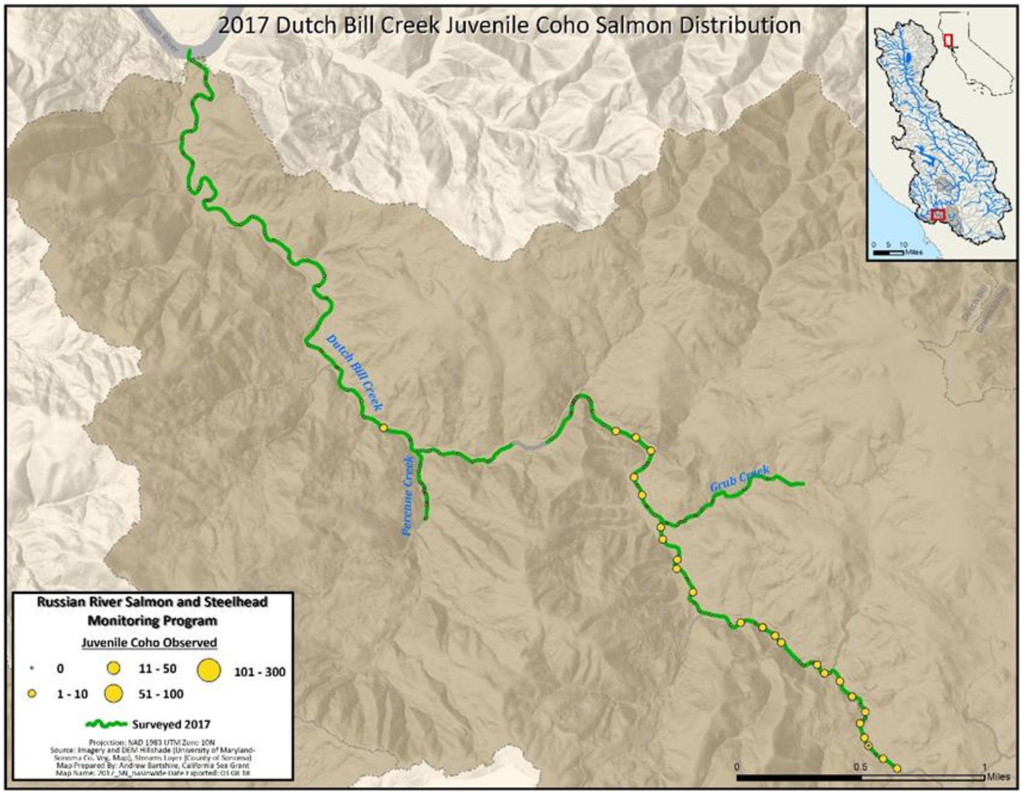

FIGURE 28. DENSITY AND DISTRIBUTION OF JUVENILE COHO SALMON YOY OBSERVED IN DUTCH BILL CREEK, 2017.

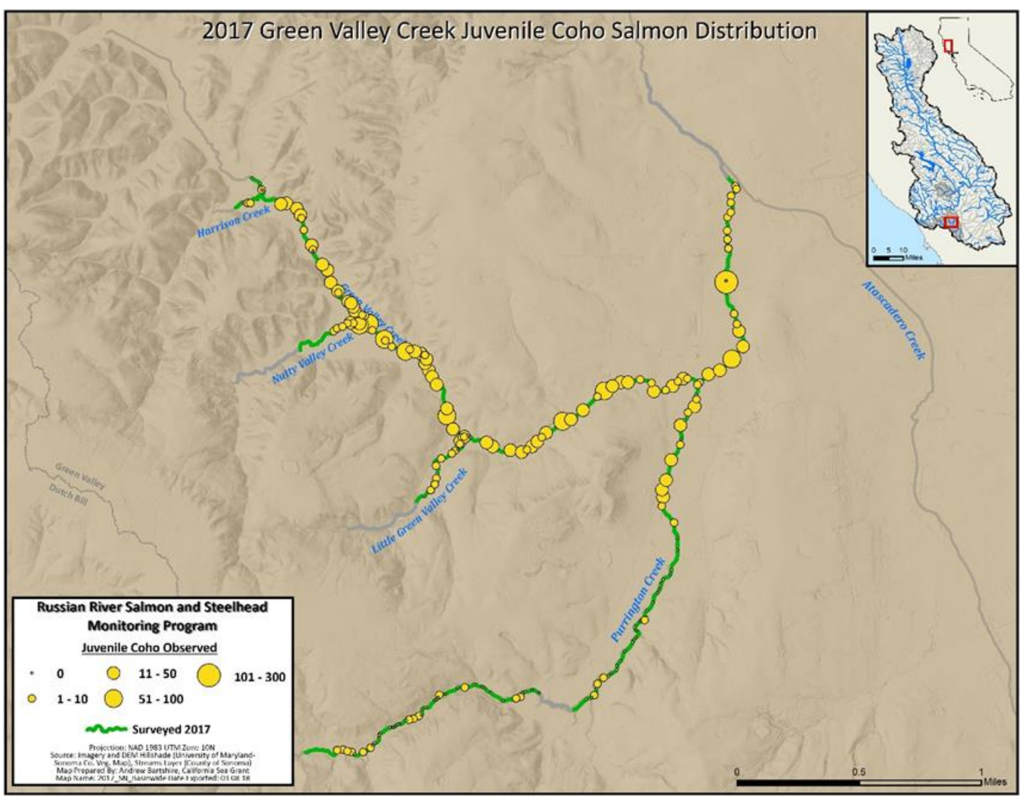

FIGURE 29. DENSITY AND DISTRIBUTION OF JUVENILE COHO SALMON YOY OBSERVED IN GREEN VALLEY CREEK, 2017.

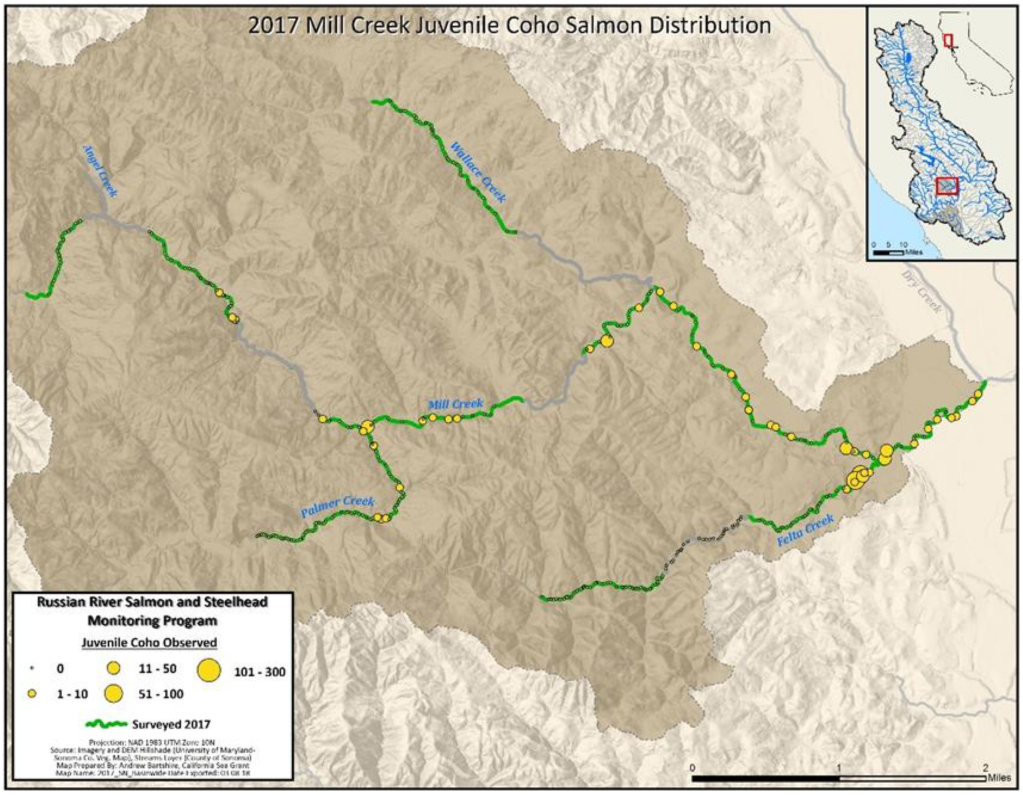

FIGURE 30. DENSITY AND DISTRIBUTION OF JUVENILE COHO SALMON YOY OBSERVED IN MILL CREEK, 2017.

FISH DISTRIBUTION IN RELATION TO WETTED HABITAT CONDITIONS

METHODS

In order to relate redd and juvenile salmonid distribution data to wetted habitat data, spatial joins were conducted in GIS such that each redd observed during spawner surveys and each pool snorkeled was assigned a wetted habitat condition (wet, intermittent or dry) according to the wetted habitat survey of interest. Data were then summarized to determine 1) what proportion of returning adults spawned in locations where their offspring would have access to sufficient wetted habitat throughout the summer (presuming that they remained in the vicinity of the redd); and 2) what proportion of rearing juvenile salmon and steelhead were potentially impacted by drying stream conditions given their location during snorkeling surveys. While it is possible that fish observed in early summer snorkeling surveys may have had the opportunity to move to other locations within the streams, we think that this was unlikely based on previous PIT tag monitoring work during the summer season and common observations of fish strandings in previous years.

RESULTS AND DISCUSSION

To evaluate the greatest impact of low flow conditions on rearing salmonids during the 2017 season, redd observations from winter 2016-2017 spawner surveys and juvenile distribution data from summer 2017 snorkeling surveys were overlaid with wetted habitat maps from the *driest* survey of the 2017 season (Table 3, Figure 31 - Figure 36). This data was then summarized to determine proportion of all redds and juvenile fish that were observed in areas that went completely dry, became intermittent or remained wet (Table 7). Over all streams, 70% of both redds and juveniles were observed in locations where habitat remained wet throughout the summer season, and 30% were observed in locations that became dry or intermittent. The greatest percentage of redds and fish observed in locations that became dry was in the Mill Creek watershed (Table 7).

In order to relate changes in wetted habitat conditions over the season with streamflow, we plotted the proportion of wetted habitat conditions on each wet/dry mapping survey with continuous discharge data for each creek (Figure 37 - Figure 39). To gain a better understanding of the timing and flow levels that potentially impact summer rearing fish, we also plotted streamflow with the proportion of juvenile salmonids (observed during our single snorkeling event) found in locations that were dry, intermittent or wet on each wet/dry mapping survey (Figure 40 - Figure 42).

In general, as streamflow declined, drying conditions increased at a steady rate in all creeks beginning in July (Dutch Bill and Mill) or August (Green Valley) (Figure 37 - Figure 39). The rate and proportion of drying was greatest in Dutch Bill Creek. Green Valley Creek had a higher proportion of intermittent habitat than dry habitat whereas the opposite was true in both Dutch Bill and Mill creeks. The flow levels at which the streams disconnected were lowest in Green Valley Creek and highest in Mill Creek (Figure 37 - Figure 39). During the final survey of the season in late October, wetted habitat conditions improved either slightly (Dutch Bill and Mill) or more dramatically (Green Valley) from the previous survey, possibly due to cooling conditions, leaf drop within the riparian zone and/or reductions in water use.

In Dutch Bill Creek, the proportion of dry habitat in the later samples of the season summer season was greater than the proportion of juveniles observed in habitat that later went dry (Figure 37, Figure 40), suggesting that juveniles were more concentrated in stream reaches that remained wet. The opposite was observed in Mill Creek (Figure 39, Figure 42) suggesting that juveniles were more concentrated in reaches that went dry.

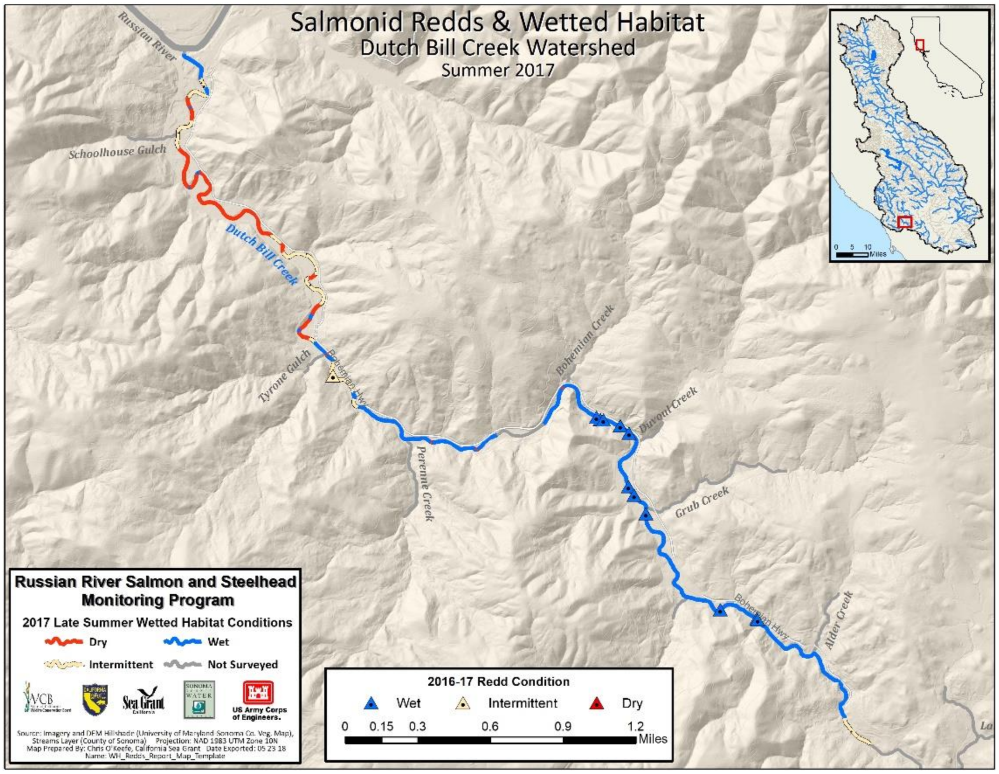

FIGURE 31. WINTER 2016-2017 DUTCH BILL CREEK REDD LOCATIONS IN RELATION TO LATE-SUMMER 2017 WETTED HABITAT CONDITIONS.

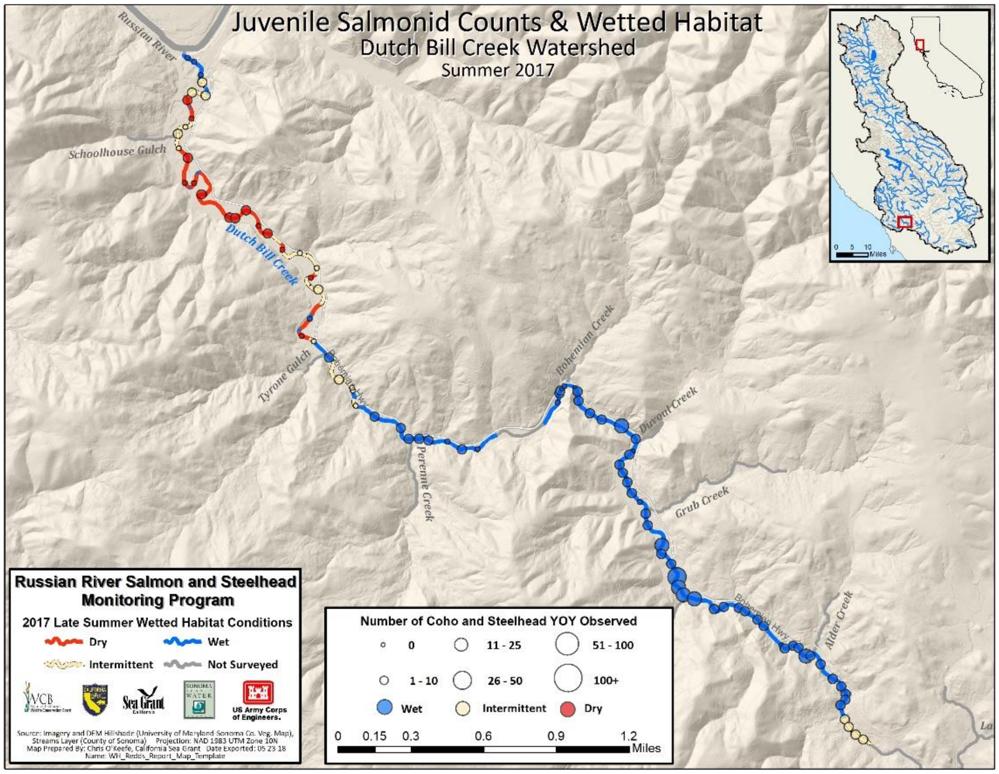

FIGURE 32. EARLY-SUMMER SALMONID YOUNG-OF-YEAR DISTRIBUTION IN DUTCH BILL CREEK IN RELATION TO LATE-SUMMER WETTED HABITAT CONDITIONS, 2017.

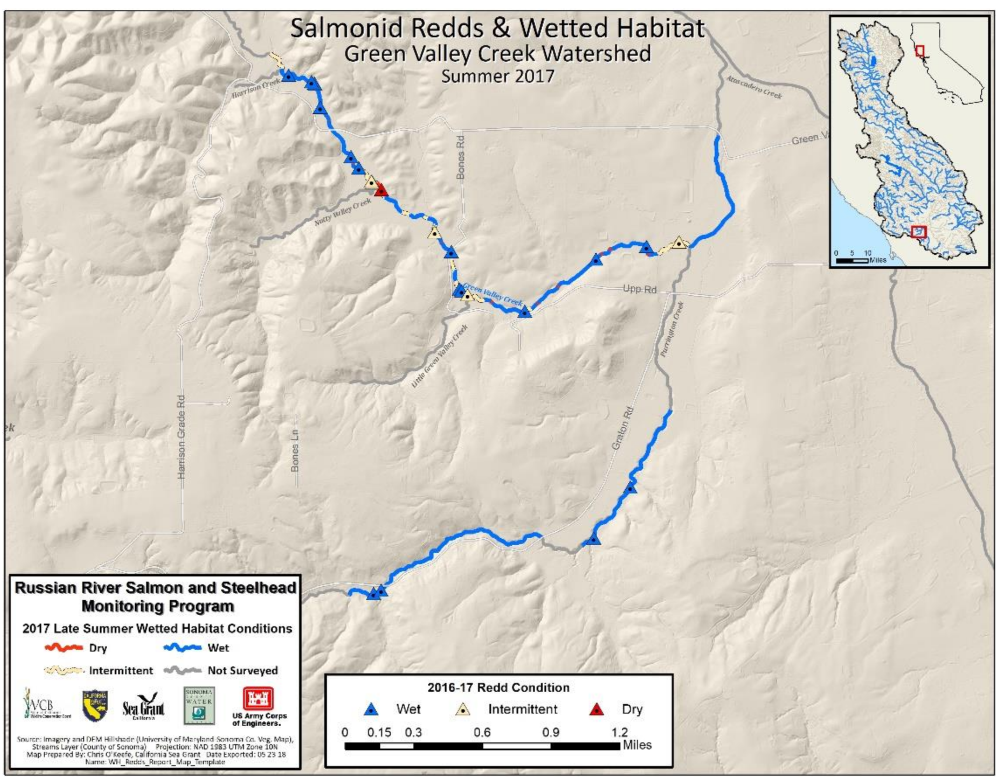

FIGURE 33. WINTER 2016-2017 GREEN VALLEY CREEK REDD LOCATIONS IN RELATION TO LATE-SUMMER 2017 WETTED HABITAT CONDITIONS.

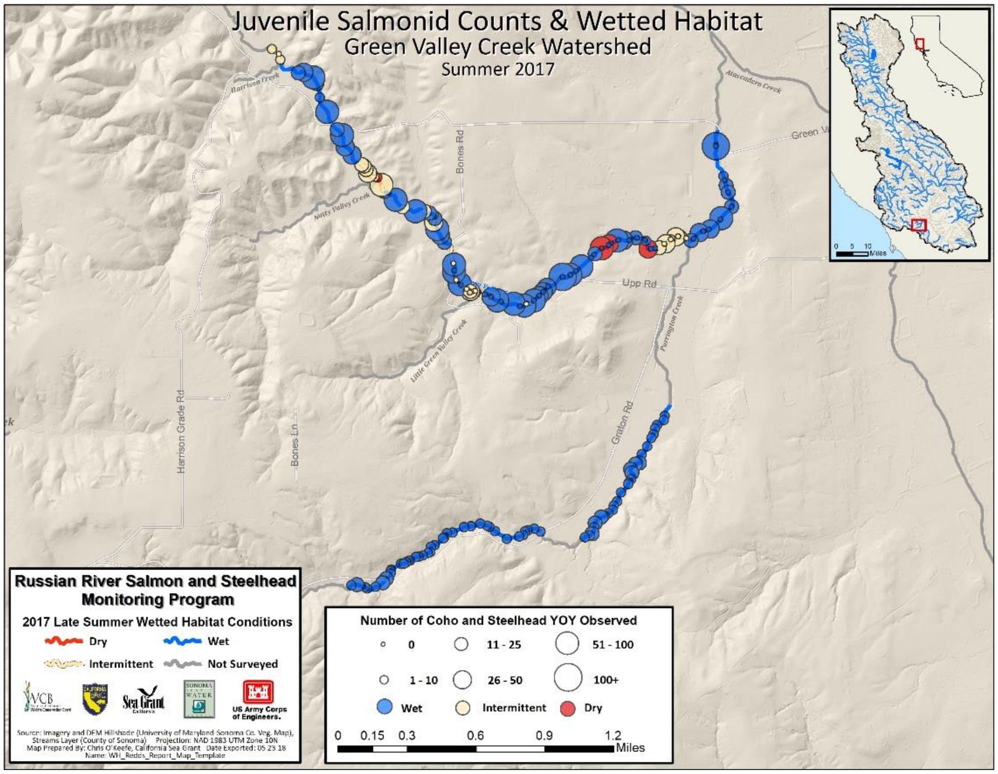

FIGURE 34. EARLY-SUMMER SALMONID YOUNG-OF-YEAR DISTRIBUTION IN GREEN VALLEY CREEK IN RELATION TO LATE-SUMMER WETTED HABITAT CONDITIONS, 2017.

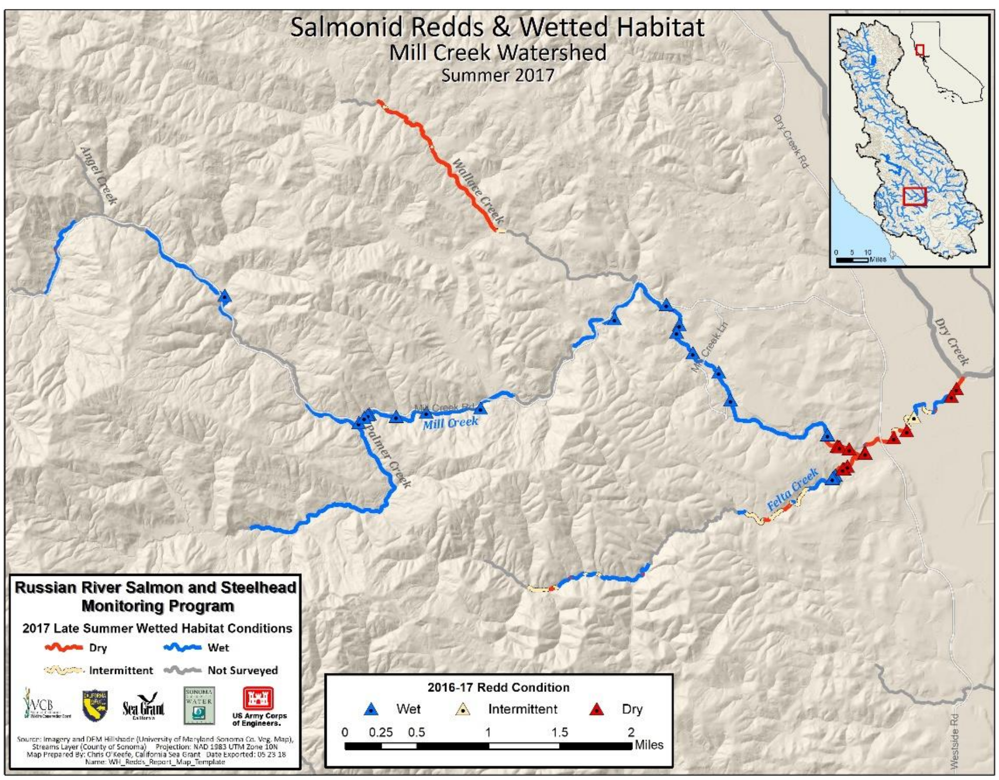

FIGURE 35. WINTER 2016-2017 MILL CREEK REDD LOCATIONS IN RELATION TO LATE-SUMMER 2017 WETTED HABITAT CONDITIONS.

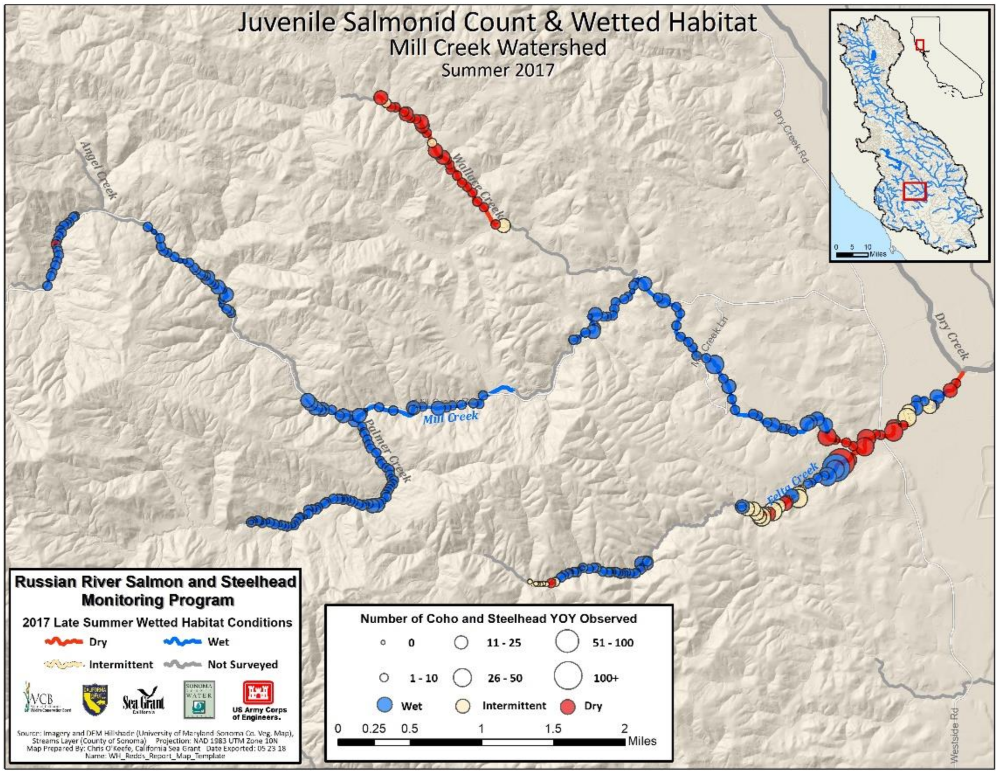

FIGURE 36. EARLY-SUMMER SALMONID YOUNG-OF-YEAR DISTRIBUTION IN MILL CREEK IN RELATION TO LATE-SUMMER WETTED HABITAT CONDITIONS, 2017.

TABLE 7. NUMBER AND PERCENTAGE OF SALMONID REDDS OBSERVED IN WINTER 2016-2017 AND JUVENILE SALMONIDS OBSERVED IN 2017 IN RELATION TO LATE SUMMER WETTED HABITAT CONDITIONS IN 2017.

	Salmonid Redds			Juvenile Salmonids		
Tributary	**Dry**	**Intermittent**	**Wet**	**Dry**	**Intermittent**	**Wet**
Dutch Bill Creek	0 (0%)	1 (7%)	13 (93%)	12 (4%)	34 (10%)	280 (86%)
Green Valley Creek	1 (5%)	5 (26%)	13 (68%)	185 (7%)	418 (15%)	2,180 (78%)
Purrington Creek	0 (0%)	0 (0%)	4 (100%)	0 (0%)	0 (0%)	442 (100%)
Mill Creek	11 (35%)	1 (3%)	19 (61%)	223 (20%)	58 (5%)	826 (75%)
Felta Creek	4 (57%)	0 (0%)	3 (43%)	333 (34%)	283 (29%)	366 (37%)
Wallace Creek	N/A	N/A	N/A	210 (88%)	29 (12%)	0 (0%)
Palmer Creek	N/A	N/A	N/A	0 (0%)	0 (0%)	231 (100%)
All streams combined	**16 (21%)**	**7 (9%)**	**52 (70%)**	**963 (16%)**	**822 (14%)**	**4,253 (70%)**

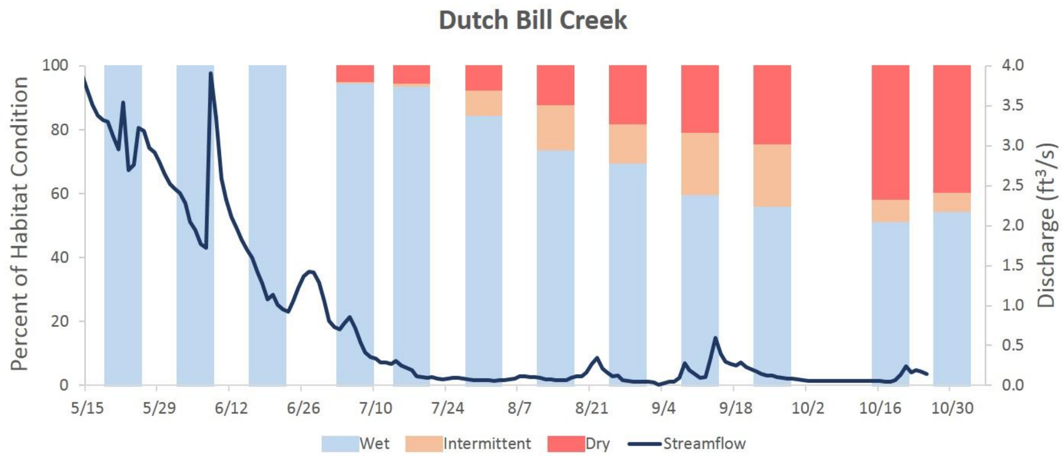

FIGURE 37. STREAMFLOW AND PERCENT OF WET, INTERMITTENT AND DRY STREAM HABITAT OBSERVED ON BIWEEKLY SURVEYS ON DUTCH BILL CREEK, 2017. STREAMFLOW DATA WAS GENERATED FROM GAGE IN REACH DUT-3.87.

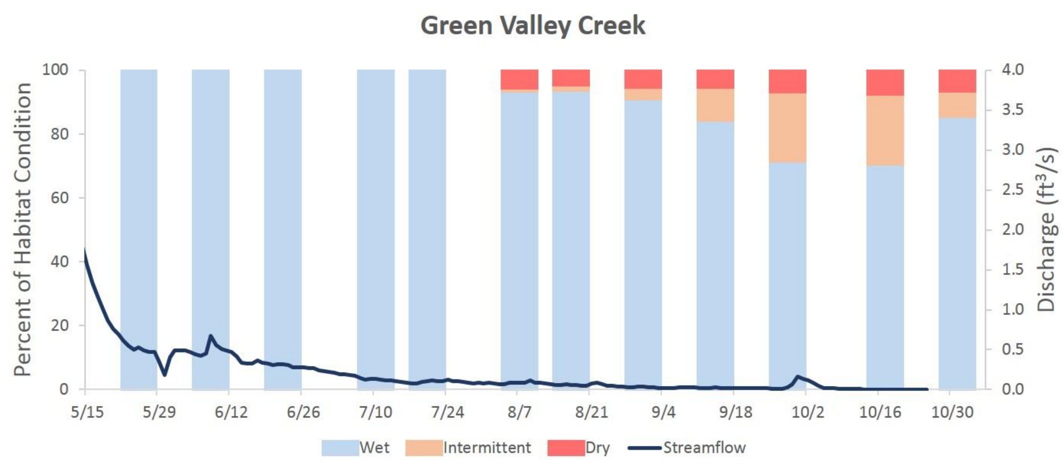

FIGURE 38. STREAMFLOW AND PERCENT OF WET, INTERMITTENT AND DRY STREAM HABITAT OBSERVED ON BIWEEKLY SURVEYS ON GREEN VALLEY CREEK, 2017. STREAMFLOW DATA WAS GENERATED FROM GAGE IN REACH GRE-13.40.

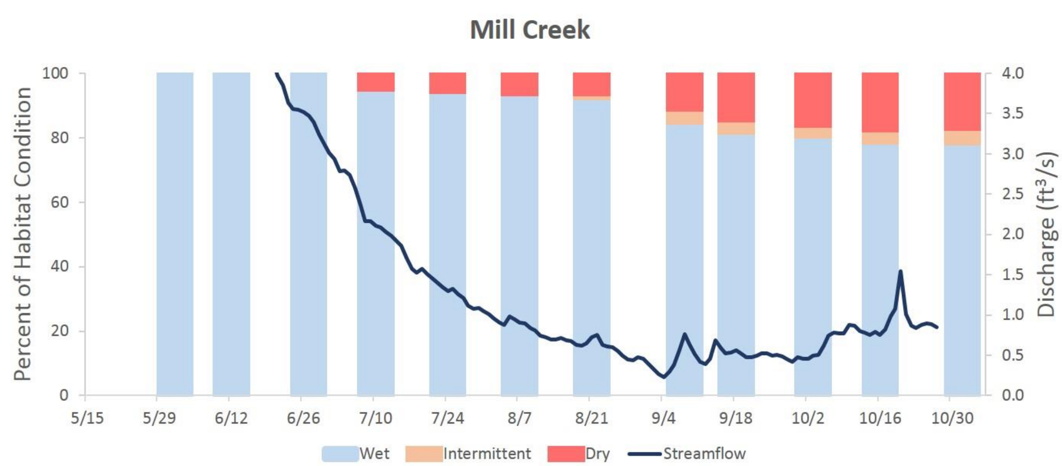

FIGURE 39. STREAMFLOW AND PERCENT OF WET, INTERMITTENT AND DRY STREAM HABITAT OBSERVED ON BIWEEKLY SURVEYS ON MILL CREEK, 2017. STREAMFLOW DATA WAS GENERATED FROM GAGE IN REACH MIL-6.10.

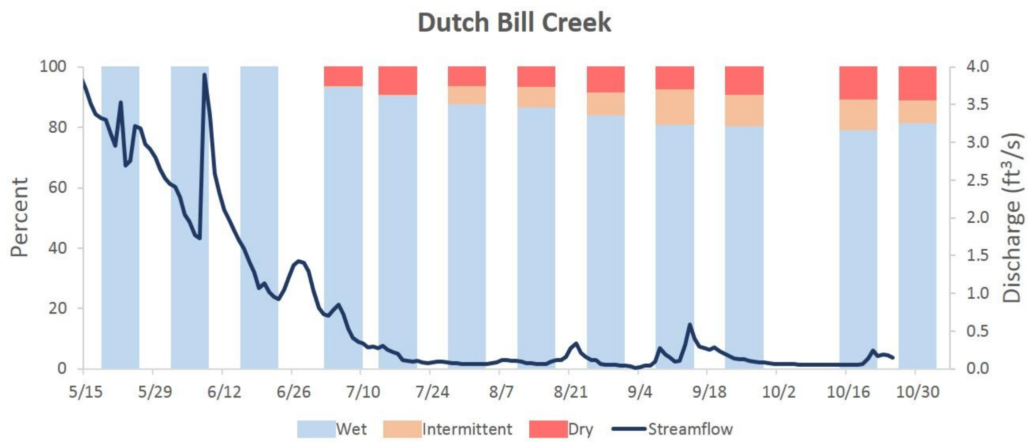

FIGURE 40. STREAMFLOW AND PERCENT OF EARLY SUMMER JUVENILE SALMONID OBSERVATIONS IN RELATION TO WETTED HABITAT CONDITION OBSERVED ON BIWEEKLY SURVEYS IN DUTCH BILL CREEK, 2017. STREAMFLOW DATA WAS GENERATED FROM GAGE IN REACH DUT-3.87.

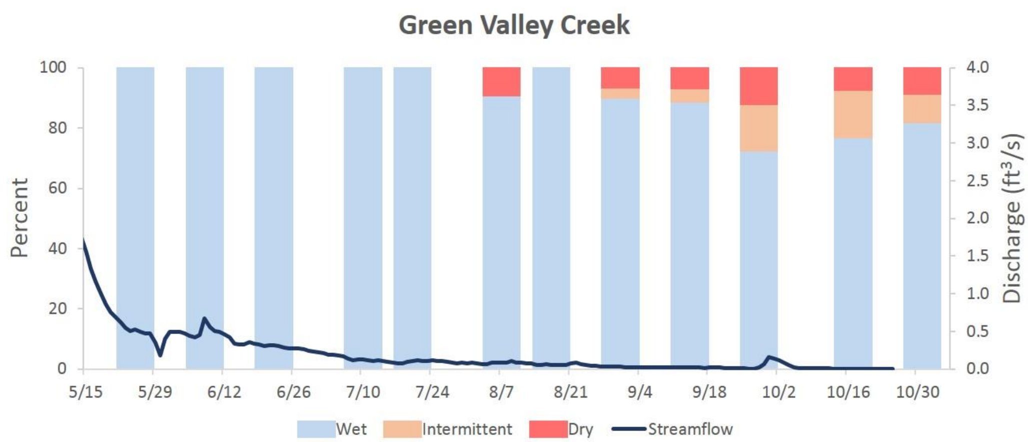

FIGURE 41. STREAMFLOW AND PERCENT OF EARLY SUMMER JUVENILE SALMONID OBSERVATIONS IN RELATION TO WETTED HABITAT CONDITION OBSERVED ON BIWEEKLY SURVEYS IN GREEN VALEY CREEK, 2017. STREAMFLOW DATA WAS GENERATED FROM GAGE IN REACH GRE-13.40.

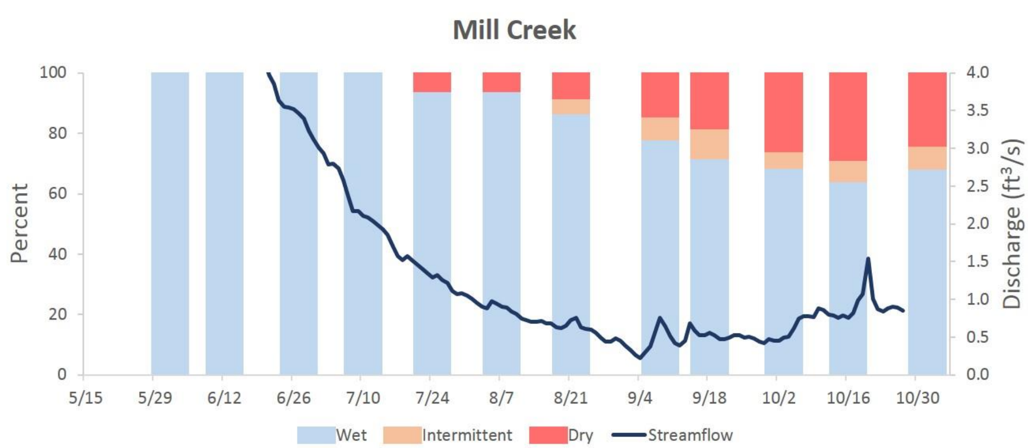

FIGURE 42. STREAMFLOW AND PERCENT OF EARLY SUMMER JUVENILE SALMONID OBSERVATIONS IN RELATION TO WETTED HABITAT CONDITION OBSERVED ON BIWEEKLY SURVEYS IN MILL CREEK, 2017. STREAMFLOW DATA WAS GENERATED FROM GAGE IN REACH MIL-6.10.

INFORMING AND EVALUATING FLOW RELEASES

CSG researchers were able to use data from the 2017 biweekly wet/dry mapping effort to support the initiation of two small-scale instream flow releases into Green Valley Creek and to document the effects of those releases. While stream habitat units typically exhibit a general downward trend in DO concentrations over the summer season, the date at which DO falls below fish impairment levels in priority stream reaches varies annually, depending on weather and environmental conditions. Frequent wetted habitat surveys allowed us to identify the onset of DO impairment and inform resource managers. While conducting biweekly wet/dry mapping on Green Valley Creek, we were able to document that DO readings on the surveys dates were at or above the North Coast Regional Water Quality Control Board objective of 6.0 mg/L (ref) through the mid-August survey. By the August 30-31 survey, however, the stream-scale average DO concentration was 5.3 mg/L, 28% of sample pools had fallen below known salmonid impairment levels of 4.5 mg/L, and 3% of sample pools had concentrations below the mortality threshold of 3.0 mg/L (McMahon 1983; Figure 43).

During the June snorkel survey, CSG biologists had documented more than 3,700 juvenile salmon and steelhead distributed throughout the stream. At the time of the snorkel survey, there was not sufficient flow for fish to move out of the stream reaches in which they were rearing so, with DO steadily decreasing as the stream grew drier, it was clear that thousands of fish were facing potential mortality or, at the least, production impairment, stress and/or disease. Given that the winter of 2016-2017 had been particularly wet, there were no plans in place to release water into the stream, but we communicated the urgency of the situation to our partners at the resource agencies and they began working with streamside landowners to facilitate two flow releases.

By the September 13-14 wet/dry mapping survey, DO had dropped to a stream-scale average of 3.9 mg/L, 65% of sample pools had fallen below known salmonid impairment levels, 21% of sample pools had concentrations below the mortality threshold and fish in the stream were observed gasping at the water's surface (Figure 44). On September 28 and 29, agency partners were able to implement two small-scale flow releases in upper Green Valley Creek (Figure 39). The first wet/dry mapping surveys after the releases on Green Valley Creek were postponed a week, due to catastrophic wildfires, and conducted on October 17. By that time, stream-scale average DO had risen to 5.4 mg/L, with just 36% of sample pools below impairment thresholds (Figure 45). On a stream-wide scale, it should be noted that we have no means of determining how much of this improvement could be attributed to the release versus a change in seasonal environmental conditions associated with early-fall cooling, and rewetting due to leaf-loss. While changes in surface flow and DO documented during wet/dry mapping surveys can provide useful documentation of direct improvements to water quantity and quality as a result of flow augmentations, in this case seasonality and length of time since release were confounding factors. However, the fact that we observed a greater improvement in wetted habitat conditions in Green Valley in late October as compared to the other two creeks, suggests that there may have been an overall benefit from the flow releases (Figure 37 - Figure 39).

To evaluate the effects of the flow releases on a finer scale, data from continuous DO loggers in pools closest to the release points were reviewed to determine whether pool DO concentrations increased around the time of the augmentations. The logger deployed 120 meters below the September 28 release, in the GRE-12.16 study reach, recorded an increase in DO concentrations beginning the day after the release (when DO was 4.0 mg/L), peaking one week later at 8.5 mg/L, and remaining above impairment thresholds until the October rains (Figure 46). The logger deployed 830 meters below the September 29 release, in the GRE-12.16 study reach, showed a spike in DO almost immediately following the release; average daily DO went from 1.4 mg/L the day before the release to 9.8 mg/L the day after and remained slightly higher than pre-release concentrations until the onset of the rains in mid-October (Figure 47). These data indicate that both flow releases provided relief for the fish that still remained alive in stream reaches within relatively close proximity to the release sites.

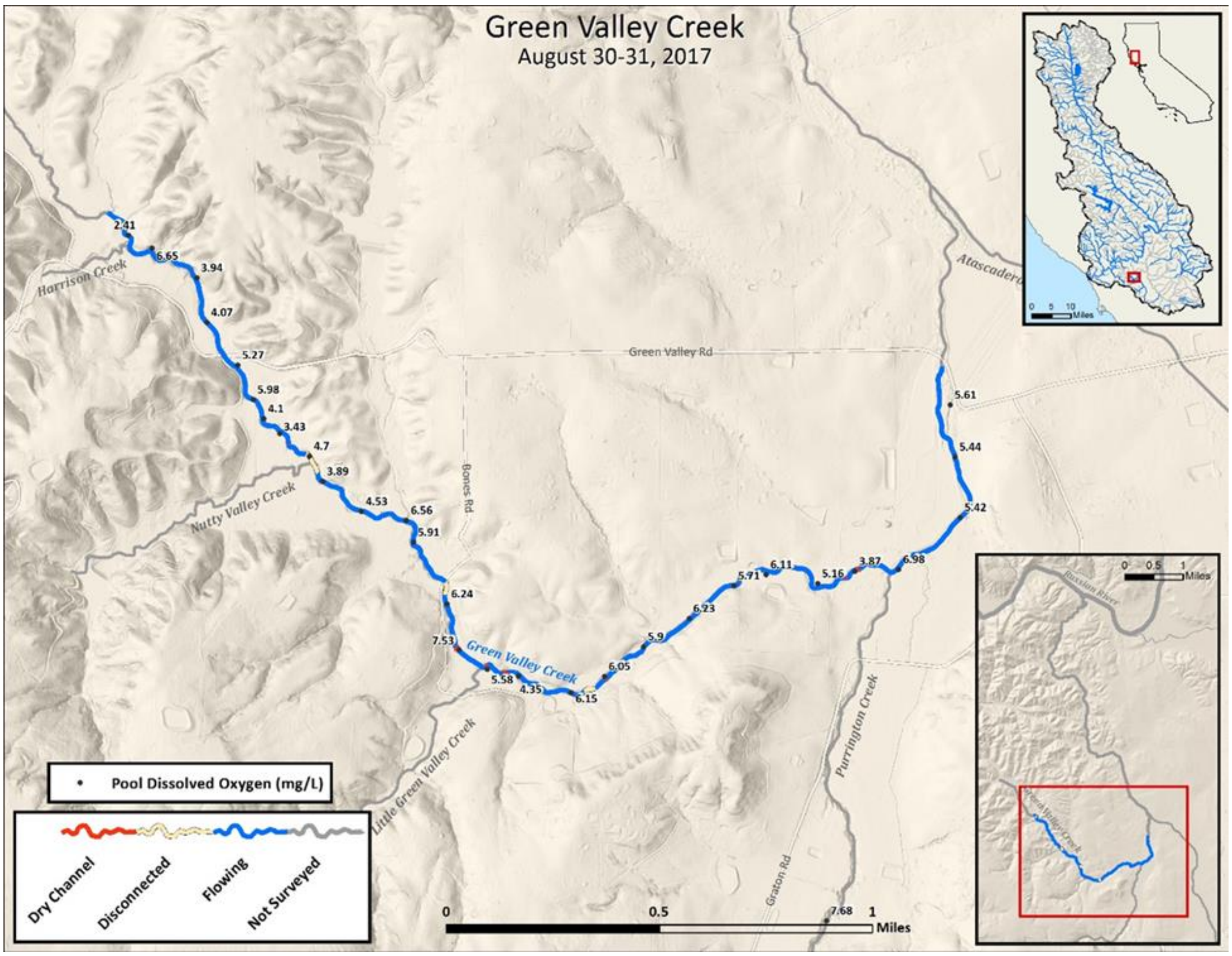

FIGURE 43. GREEN VALLEY CREEK WETTED HABITAT CONDITIONS AND DO MEASUREMENTS ON AUGUST 30-31, 2017.

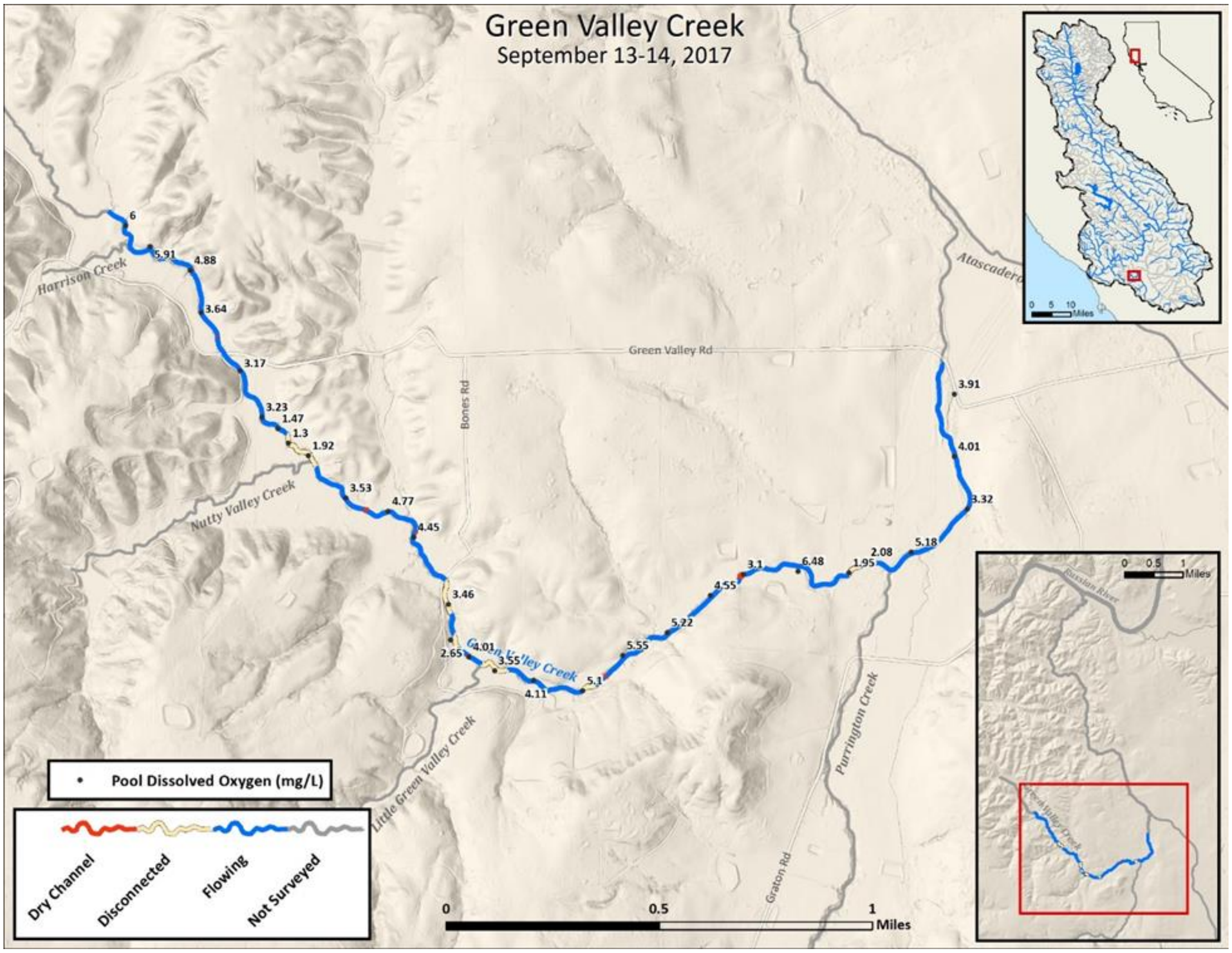

FIGURE 44. GREEN VALLEY CREEK WETTED HABITAT CONDITIONS AND DO MEASUREMENTS ON SEPTEMBER 13-14, 2017.

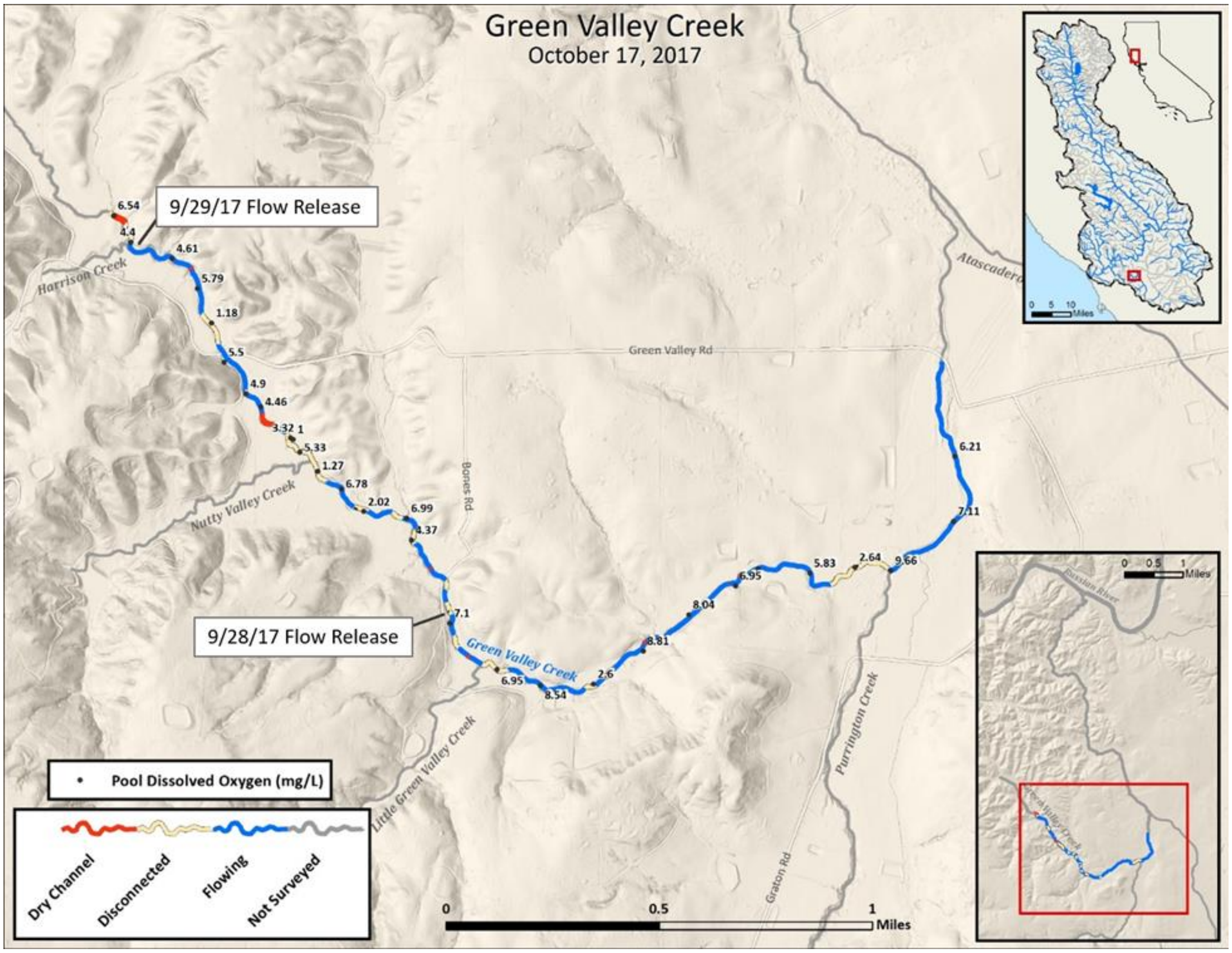

FIGURE 45. GREEN VALLEY CREEK WETTED HABITAT CONDITIONS AND DO MEASUREMENTS ON OCTOBER 17, 2017, AND LOCATIONS AND DATES OF FLOW RELEASES.

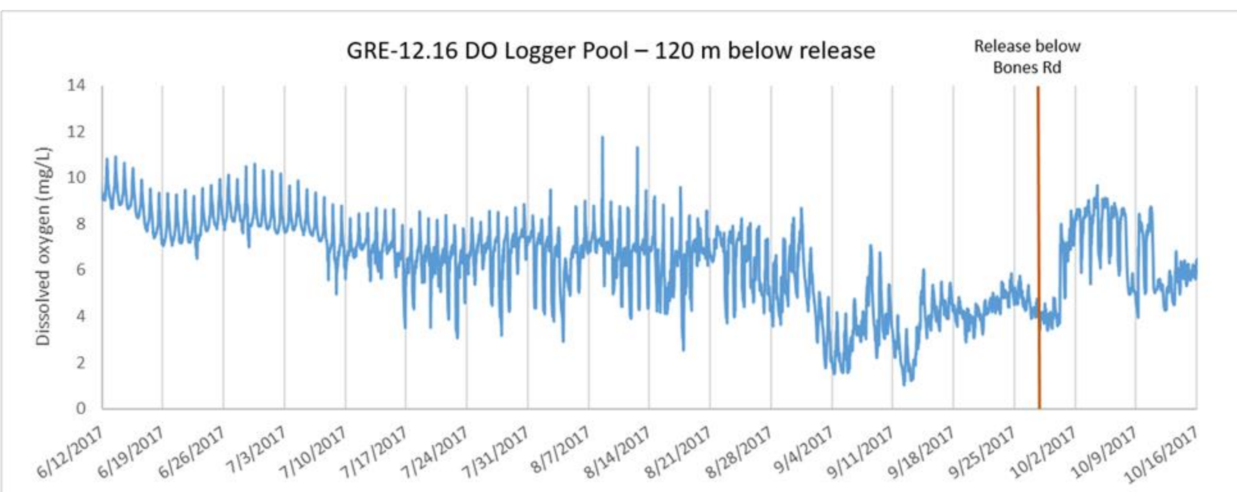

FIGURE 46. DO MEASUREMENTS FROM CONTINUOUS LOGGER IN STUDY POOL 120 METERS DOWNSTREAM OF THE FLOW RELEASE INITIATED ON UPPER GREEN VALLEY CREEK ON SEPTEMBER 28, 2017. RED LINE INDICATES RELEASE DATE. NOTE INCREASE IN DO AFTER FLOW AUGMENTATION.

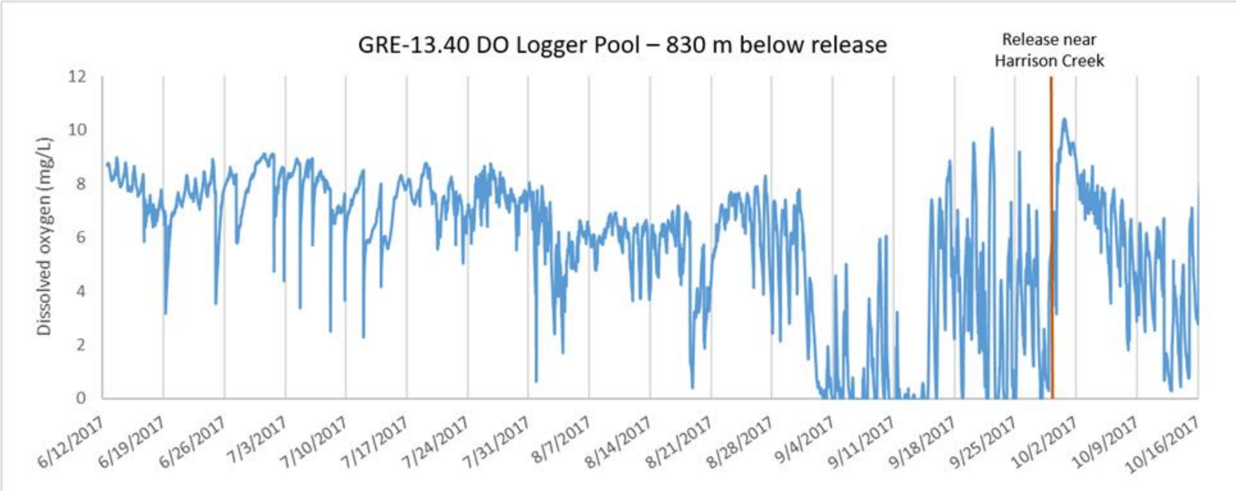

FIGURE 47. DO MEASUREMENTS FROM CONTINUOUS LOGGER IN STUDY POOL 830 METERS DOWNSTREAM OF THE FLOW RELEASE INITIATED ON UPPER GREEN VALLEY CREEK ON SEPTEMBER 29, 2017. RED LINE INDICATES RELEASE DATE. NOTE INCREASE ID DO AFTER FLOW AUGMENTATION.

TECHNICAL ADVISORY COMMITTEE MEETING AND 2018 MONITORING PLAN

On March 14, CSG held a meeting to share updates on WCB-funded grant activities conducted over the summer of 2017, and to coordinate related low-flow activities among cooperating partners for the 2018 summer season. Thirty-five individuals from nine different partner agencies and organizations attended. CSG staff presented outcomes from the 2017 wet/dry mapping effort, along with results of dissolved oxygen and flow monitoring. Four branches of CDFW also shared outcomes from 2017, as did staff from the Regional and State Water Quality Control Boards and NOAA Fisheries. CSG staff also facilitated discussion and coordination of 2018 low-flow season activities and priorities, and development of a general summer monitoring plan.

CSG's monitoring plan for 2018 is to continue to conduct wet/dry mapping of the same stream reaches at the same intervals as 2017. One minor change to the 2017 protocol will be to measure pool tail crest depths and inflowing riffle crest thalweg depths in pools where DO is measured. This measurement will add a nominal amount of time and will help researchers identify which of those parameters, if either, have a greater influence over DO concentrations when DO impairment occurs under low-flow conditions. Wetted habitat maps will be disseminated among all coordinating partners at weekly intervals and DO values will be included in 2018, in order to help guide management decisions (e.g., fish rescues and flow releases).

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