Drought monitoring in support of salmonid recovery actions

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1. Background

In 2004, the Russian River Coho Salmon Captive Broodstock Program (Broodstock Program) began releasing juvenile coho salmon (*Oncorhynchus kisutch*) raised at the US Army Corps of Engineers (USACE) Don Clausen Fish Hatchery into tributaries of the Russian River with the goal of reestablishing populations that were on the brink of extirpation from the watershed. California Sea Grant at University of California (CSG) 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, CSG has been closely monitoring smolt abundance, adult returns, survival, and spatial distribution of coho salmon populations in four intensive monitoring watersheds: Willow, Dutch Bill, Green Valley, and Mill creeks. Data collected from this effort are provided to the Broodstock Program for use in evaluating the success of hatchery releases and informing future releases.

Over the last decade, CSG has developed many partnerships in salmon and steelhead (*O. mykiss)* 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 streamflow and juvenile coho salmon survival as part of the Russian River Coho Water Resources Partnership (Coho Partnership), an effort to improve streamflow and water supply reliability to water users in five flow-impaired Russian River tributaries. In 2013, we partnered with Sonoma Water (SW) 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. We have conducted wet/dry mapping in partnership with Wildlife Conservation Board (WCB), Trout Unlimited (TU), Gold Ridge Resource Conservation District (GRRCD), and Sonoma Resource Conservation District (SRCD) during summer and fall to document sections of stream as wet, intermittent, or dry based on surface flow. These projects, along with others, have led to the expansion of our program, which now includes over 50 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 and non-profit organizations, along with hundreds of private landowners who have granted us access to the streams that flow through their properties.

In this annual report, we provide results from drought monitoring in support of salmonid recovery actions in the Russian River watershed across five subtasks, including snorkel surveys, wet/dry mapping, flow monitoring training, fish rescue support, and participation in CDFW's Salmonid Habitat Restoration Priorities (SHaRP) meetings. Results from additional studies are included in this report, including snorkel surveys in the four Broodstock Program watersheds (funded by USACE), snorkel surveys in Yellowjacket Creek (funded by National Marine Fisheries Service (NMFS)), and wet/dry mapping in Green Valley, Mark West, Pena, and Mill creeks (funded by WCB). Additional information and previous reports can be found on our website.

2. Subtask 1: Snorkel surveys

2.1. Goals and objectives

Summer snorkel surveys were conducted in Russian River tributaries to document the relative abundance and spatial distribution of juvenile coho salmon and steelhead during the summer of 2022. These data were used to determine whether successful spawning occurred the previous winter and to track spatiotemporal trends in relative abundance and occupancy.

2.2. Methods

2.2.1. Sampling reaches

For drought monitoring, CMP methods were applied using an established spatially-balanced random sample of reaches in the Russian River sample frame (a sample frame of stream reaches identified by the Russian River CMP Technical Advisory Committee[1] as having coho salmon, steelhead, and/or Chinook salmon habitat). A reach is described as a 2-3 km section of stream, and is the same as the reach designations used for CMP monitoring activities. Reaches were selected using a generalized random tessellation stratified (GRTS) approach as outlined in Fish Bulletin 180 (Adams et al. 2011). Prior to the start of the season, we contacted landowners to confirm and attempt to expand established access for selected reaches. If landowner access could not be achieved for at least three quarters of a selected reach, it was excluded from sampling. Additionally, as surveys were scheduled, communication with landowners along each reach occurred to inform them when survey efforts were taking place.

2.2.2. Field methods

Sampling was based on modifications of protocols in Garwood and Ricker (2014). On each snorkel survey, salmonids were counted in every other pool within the reach, with the first pool (one or two) determined randomly. Pools were defined as habitat units with a depth of greater than one foot in an area at least as long as the maximum wetted width and a surface area of greater than three square meters. A GPS point was collected at the downstream end of each pool snorkeled.

For reaches that were included in the occupancy estimate, a second snorkeling pass was completed in which every other pool that was snorkeled during the first pass (e.g., every fourth pool) was snorkeled a second time in order to account for detection efficiency. In general, a second pass did not occur on the same day as a first pass given low streamflow and suspended sediment from the snorkeler's movements limiting visibility for a second pass. However, in cases in which both first and second passes did occur on the same day, second pass snorkelers ensured adequate visibility for detection of fish was present in pools before sampling. For reaches that were not included in the occupancy estimate, only a single pass was completed. In Yellowjacket Creek, a census survey was performed and every pool was sampled during a single pass.

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[1] A body of fisheries experts, including members of the Statewide CMP Technical Team, tasked with providing guidance and technical advice related to CMP implementation in the Russian River.

During each survey, snorkeler(s) moved from the downstream end of each pool (pool tail crest) to the upstream end, surveying as much of the pool as water depth allowed. Dive lights were used to inspect shaded and covered areas. In order to minimize disturbance of fish and sediment, snorkelers avoided sudden or loud movements. Double counting was minimized by only counting fish once they were downstream of the observer. Snorkelers recorded a rating that described the certainty of their count in each pool. In larger pools requiring two snorkelers, two lanes were agreed upon and each snorkeler moved upstream through the lane at the same rate. Final counts for the pool were the sum of both lane counts. All observed salmonids were identified to species (coho salmon, Chinook salmon, steelhead) and age class (young-of-year (yoy) or parr (≥ age-1)), based on size and physical characteristics. Presence of non-salmonid species was documented at the reach scale. Trimble TDC600 tablets were used for data entry, upon returning from the field, data files were downloaded, error checked, and transferred into a SQL database. Spatial data were downloaded, error checked, and stored in an ArcGIS geodatabase for map production.

Snorkel data were used to generate maps of juvenile salmonid distribution that could be viewed by CDFW biologists and other partnering organizations through a web-based mapping tool. In-season data were updated weekly to aid CDFW and other resource agencies in real-time decisions about broodstock collection, fish rescue and drought-related management actions throughout the season.

2.2.3. Metrics

2.2.3.1. Relative abundance

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

2.2.3.2. Spatial distribution

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

2.3. Results

Between May 16 and August 24, 2022, CSG and SW biologists snorkeled 74 reaches representing 209 km (130.1 mi) of stream and 42 tributaries (Figure 1). All 16 juvenile coho salmon rearing reaches of Willow, Dutch Bill, Green Valley, and Mill creeks were surveyed for Broodstock Program monitoring, and an additional 53 reaches within the Russian River sample frame that were considered to contain juvenile coho salmon habitat (69 total reaches representing 72% of coho reaches) were included in the occupancy estimate for drought monitoring. Results from additional efforts were not included in the occupancy estimates. These efforts included Yellowjacket Creek, which was surveyed to monitor coho salmon adjacent to a remote site incubator (RSI) study conducted in partnership with NMFS, CDFW, and USACE. RSI coho salmon releases occurred prior to snorkel surveys, and we had no way of visually distinguishing hatchery (RSI)- and natural-origin juvenile coho salmon. An additional three reaches were surveyed to maintain long-term relative abundance data sets on specific streams and two of these reaches, one in upper Dutch Bill Creek and one in Mark West Creek, were classified as steelhead only rearing reaches.

We observed 25,800 coho salmon yoy during the summer of 2022, with an expanded minimum count of 50,779 (Table 1), and we observed 4,987 steelhead yoy, with an expanded minimum count of 9,965 (Table 2). Our web-mapping viewer of in-season fish distribution was continuously updated and maintained throughout the season. In streams where snorkel surveys were conducted before fish releases from RSI and CDFW relocation efforts, all coho salmon yoy were presumed to be of natural origin. Coho salmon yoy were observed in 58 of the 72 juvenile coho salmon *reaches* surveyed and in 34 of the 42 juvenile coho salmon *streams* snorkeled (81% and 81%, respectively) (Table 1, Figure 2). Steelhead yoy were observed in 61 of the 77 steelhead reaches and 31 of the 44 steelhead streams surveyed (79% and 74%, respectively) (Table 2). Natural-origin coho salmon counts were highest in Green Valley Creek, with the second highest counts in Dutch Bill Creek (Table 1). Higher numbers of coho salmon were also observed in Kidd Creek (Austin Creek watershed), Willow Creek, Woods Creek (Pena Creek watershed) and Purrington Creek (Green Valley Creek watershed) (Table 1).

Based on results of the multiscale occupancy model, we estimate that the probability of coho salmon yoy occupying a given reach within the basinwide Russian River coho salmon stratum (ψ) in 2022 was 0.73 (0.61 - 0.82, 95% CI), and the conditional probability of coho salmon yoy occupying a pool within a reach, given that the reach was occupied (θ), was 0.62 (0.59 – 0.65, 95% CI). The proportion of the coho salmon stratum occupied (PAO) was 0.45. This was the highest PAO observed over the last eight years (Table 3).

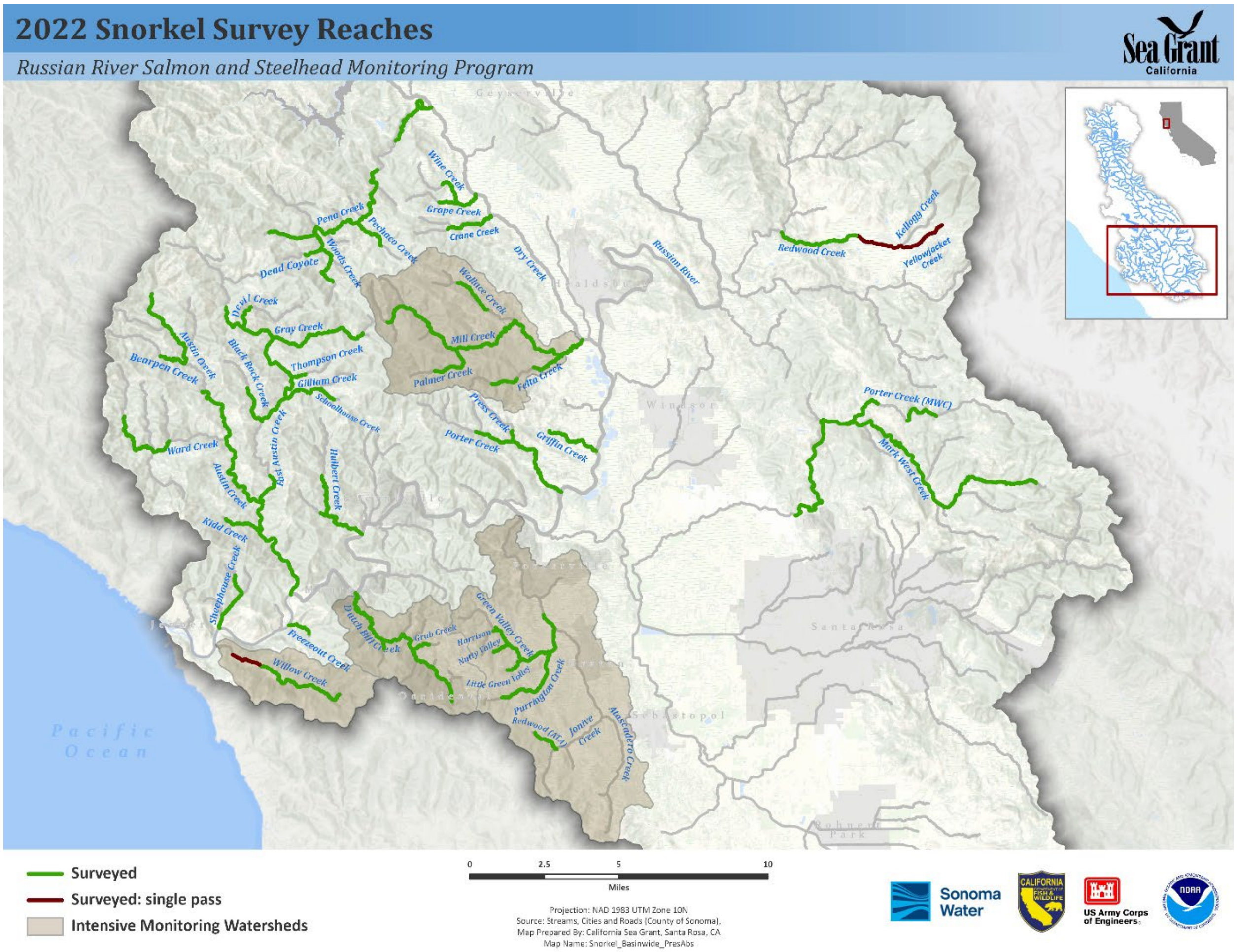

Figure 1. Reaches surveyed during 2022 summer juvenile snorkel surveys, with the four Broodstock Program intensive monitoring watersheds of Mill, Green Valley, Dutch Bill, and Willow creeks highlighted. Reaches in brown were sampled with only a single pass.

Table 1. Number of observed and expanded coho salmon yoy and parr observed in Russian River tributaries, summer 2022.

Tributary	Pools snorkeled (n)	Stream length snorkeled (km)	Yoy	Expanded Yoy[1]	Parr	Expanded Parr[1]
Austin Creek	147	22.0	515	1,030	3	6
Bearpen Creek	13	1.9	182	364	0	0
Black Rock Creek	20	2.5	247	494	1	2
Crane Creek (Dry)	8	3.2	0	0	0	0
Dead Coyote Creek	11	1.1	204	408	0	0
Devil Creek	13	1.5	117	234	0	0
Dutch Bill Creek	108	9.7	3521	7,042	28	56
East Austin Creek	118	13.1	61	122	0	0
Felta Creek	61	3.7	306	612	3	6
Freezeout Creek	20	1.5	3	6	1	2
Gilliam Creek	24	2.6	107	214	0	0
Grape Creek	25	2.6	0	0	2	4
Gray Creek	130	6.3	780	1,560	0	0
Green Valley Creek	92	7.0	5697	11,394	50	100
Griffin Creek	10	3.6	0	0	0	0
Grub Creek	6	1.1	0	0	0	0
Harrison Creek	2	0.2	0	0	0	0
Hulbert Creek	34	6.1	154	308	0	0
Kidd Creek	35	2.5	1359	2,718	3	6
Little Green Valley Creek	10	1.2	6	12	4	8
Mark West Creek	230	25.0	1156	2,312	1	2
Mill Creek	137	16.6	258	516	7	14
Nutty Valley Creek	2	1.2	47	94	1	2
Palmer Creek	44	2.9	97	194	4	8
Pechaco Creek	21	2.3	3	6	0	0
Pena Creek	110	15.1	645	1,290	2	4
Perenne Creek	12	0.5	111	222	1	2
Porter Creek	77	7.4	1050	2,100	11	22
Porter Creek (MWC)	30	5.1	59	118	0	0
Press Creek	7	0.6	0	0	0	0
Purrington Creek	81	4.8	2194	4,388	1	2
Redwood Creek	38	4.8	9	18	1	2
Redwood Creek (Atascadero)	24	1.9	0	0	12	24
Schoolhouse Creek	3	1.1	1	2	0	0
Sheephouse Creek	61	3.7	384	768	50	100
Thompson Creek	13	0.9	12	24	0	0
Wallace Creek	25	2.5	0	0	0	0
Ward Creek	63	5.0	0	0	0	0
Willow Creek	112	6.0	3011	6,022	38	76
Wine Creek	1	1.8	1	2	0	0
Woods Creek	71	4.1	2682	5,364	3	6
Yellowjacket Creek[2]	145	2.8	821	821	0	0
Total	**2,194**	**209.5**	**25,800**	**50,779**	**227**	**454**

[1] Expanded count is the observed count multiplied by a factor of 2.
[2] Snorkel counts include coho salmon yoy released from RSI. Every pool was snorkeled to evaluate RSI releases.

Table 2. Number of observed and expanded steelhead yoy and parr observed in Russian River tributaries, summer 2022.

Tributary	Pools snorkeled (n)	Stream length snorkeled (km)	Yoy	Expanded Yoy[1]	Parr	Expanded Parr[1]
Austin Creek	147	22.0	564	1128	141	282
Bearpen Creek	13	1.9	0	0	3	6
Black Rock Creek	20	2.5	7	14	7	14
Crane Creek (Dry)	8	3.2	0	0	0	0
Dead Coyote Creek	11	1.1	0	0	4	8
Devil Creek	13	1.5	119	238	11	22
Dutch Bill Creek	108	9.7	248	496	34	68
East Austin Creek	118	13.1	611	1,222	315	630
Felta Creek	61	3.7	21	42	9	18
Freezeout Creek	20	1.5	3	6	20	40
Gilliam Creek	24	2.6	84	168	13	26
Grape Creek	25	2.6	0	0	3	6
Gray Creek	130	6.3	333	666	74	148
Green Valley Creek	92	7.0	499	998	16	32
Griffin Creek	10	3.6	0	0	0	0
Grub Creek	6	1.1	0	0	0	0
Harrison Creek	2	0.2	5	10	0	0
Hulbert Creek	34	6.1	3	6	11	22
Kidd Creek	35	2.5	37	74	29	58
Little Green Valley Creek	10	1.2	0	0	0	0
Mark West Creek	230	25	277	554	202	404
Mill Creek	137	16.6	415	830	84	168
Nutty Valley Creek	2	1.2	0	0	0	0
Palmer Creek	44	2.9	136	272	20	40
Pechaco Creek	21	2.3	35	70	25	50
Pena Creek	110	15.1	680	1,360	89	178
Perenne Creek	12	0.5	2	4	1	2
Porter Creek	77	7.4	272	544	79	158
Porter Creek (MWC)	30	5.1	27	54	19	38
Press Creek	7	0.6	0	0	0	0
Purrington Creek	81	4.8	269	538	56	112
Redwood Creek	38	4.8	99	198	127	254
Redwood Creek (Atascadero)	24	1.9	6	12	14	28
Schoolhouse Creek	3	1.1	0	0	2	4
Sheephouse Creek	61	3.7	22	44	27	54
Thompson Creek	13	0.9	40	80	8	16
Wallace Creek	25	2.5	0	0	1	2
Ward Creek	63	5	29	58	27	54
Willow Creek	112	6	21	42	3	6
Wine Creek	1	1.8	0	0	1	2
Woods Creek	71	4.1	114	228	34	68
Yellowjacket Creek[2]	145	2.8	9	9	27	27
Total	**2,194**	**209.5**	**4,987**	**9,965**	**1,536**	**3,045**

[1] Expanded count is the observed count multiplied by a factor of 2.
[2] Every pool was snorkeled to evaluate RSI releases.

Table 3. Percent of area occupied by coho salmon yoy within juvenile coho reaches of the Russian River sample frame, 2015-2022.

Year	Reaches Sampled	Stream length surveyed (km)	PAO
2015	58	167	0.37
2016	72	206	0.33
2017	73	214	0.20
2018	69	205	0.25
2019	70	211	0.15
2020	51	139	0.37
2021	63	178	0.16
2022	69	199	0.45

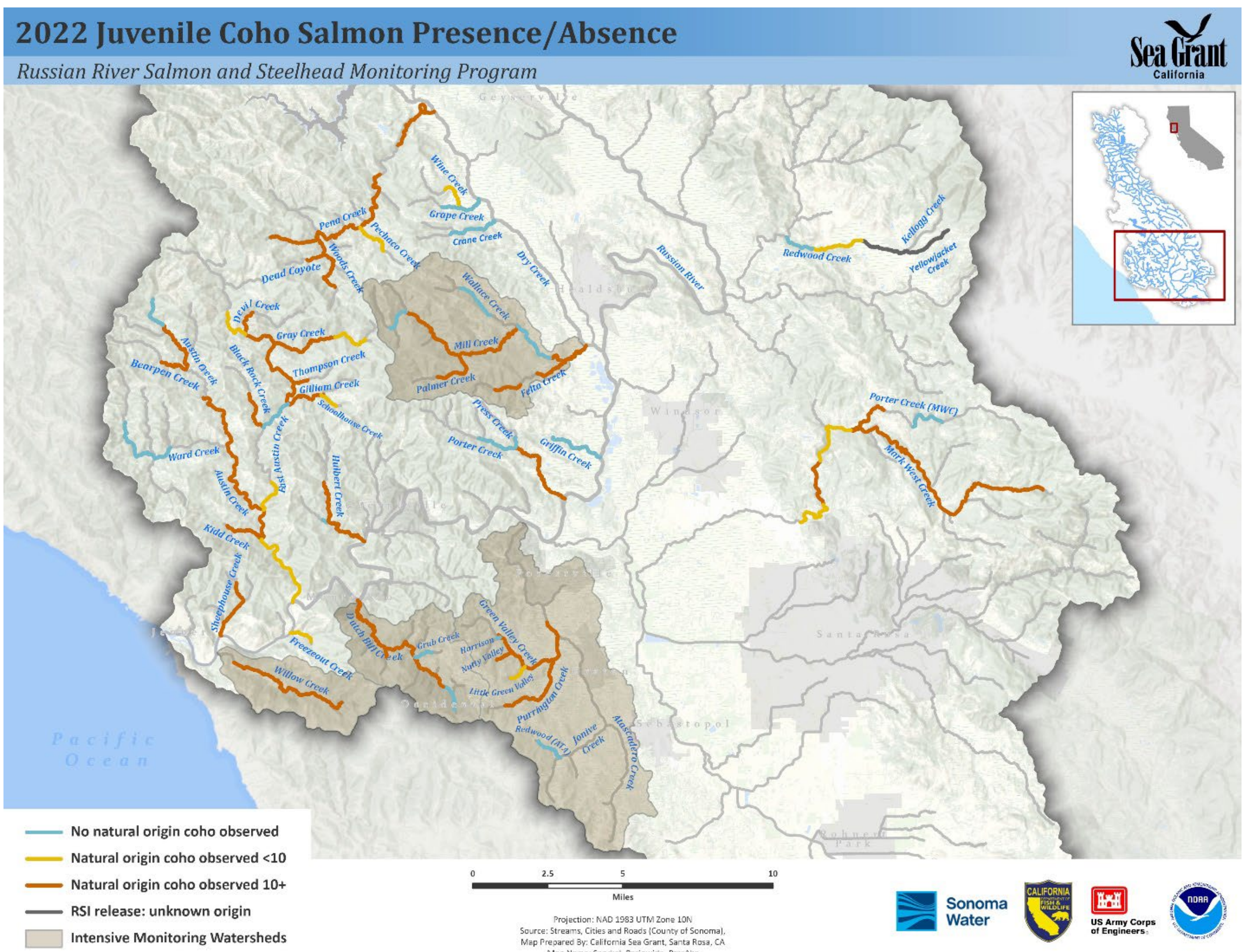

Figure 2. Natural-origin coho salmon presence by reach in surveyed Russian River tributaries, summer 2022.

2.4. Discussion

Due to low streamflow conditions across the Russian River watershed during the spring of 2022, no spring, pre-smolt or smolt releases of hatchery coho salmon took place in Broodstock Program watersheds. Precipitation totals in the 2021-2022 water year (October 2021-September 2022) were 76% of the previous 20-year average in the Russian River basin (based on precipitation at the Venado rainfall gage; California Data Exchange Center, https://cdec.water.ca.gov/queryTools.html). However, the timing of the precipitation was unusual as much of the water year's total precipitation (47") occurred during an atmospheric river event in October 2021 (18") (Figure 3). Additional rainfall occurred in November (4") and was steady during December (12"), but slowed during the late winter months of January through March (totaling 4"). The low water input from late winter rains and the ongoing impact of dry conditions over multiple preceding drought years (see www.drought.gov/states/california) resulted in low water levels in the late winter and early spring months. During spawner surveys in February and March, CSG staff observed disconnections at the mouths of tributaries across the Russian River watershed, including Porter, Felta, Mission, Little Green Valley, Nutty Valley, Kidd, Pena, and Hulbert creeks. During trap season in early April, CSG staff observed disconnections in Willow, Green Valley, and Mill creeks, but several spring rain events beginning in mid-April (totaling 5") reconnected these streams, which remained connected into June. Additionally, rain in the first week of June (less than 1") elevated observed streamflows. The spring and early summer rainfall had a positive impact on spring instream conditions and improved smolt emigration success (California Sea Grant 2022). During summer 2022 snorkel surveys, we observed low numbers of coho salmon parr (age 0+) in tributaries, and we interpret this as an indication that streamflows were high enough for smolts to successfully emigrate (i.e., fewer smolts remained within tributaries and less residualization occurred relative to summer 2021). For the remainder of the water year, rainfall occurred on September 18 and 19 (totaling 3"), and there was minimal precipitation in October (0.03").

The improvement in estimated occupancy from summer 2021 (0.16) to summer 2022 (0.45) is encouraging. Although early summer occupancy estimates are an indicator of the extent of successful spawning, in years with widespread stream drying, they do not fully capture how much of the basin successfully supported rearing juveniles. Utilizing results of late season wet/dry mapping, we estimated a late-season occupancy (see wet/dry mapping section).

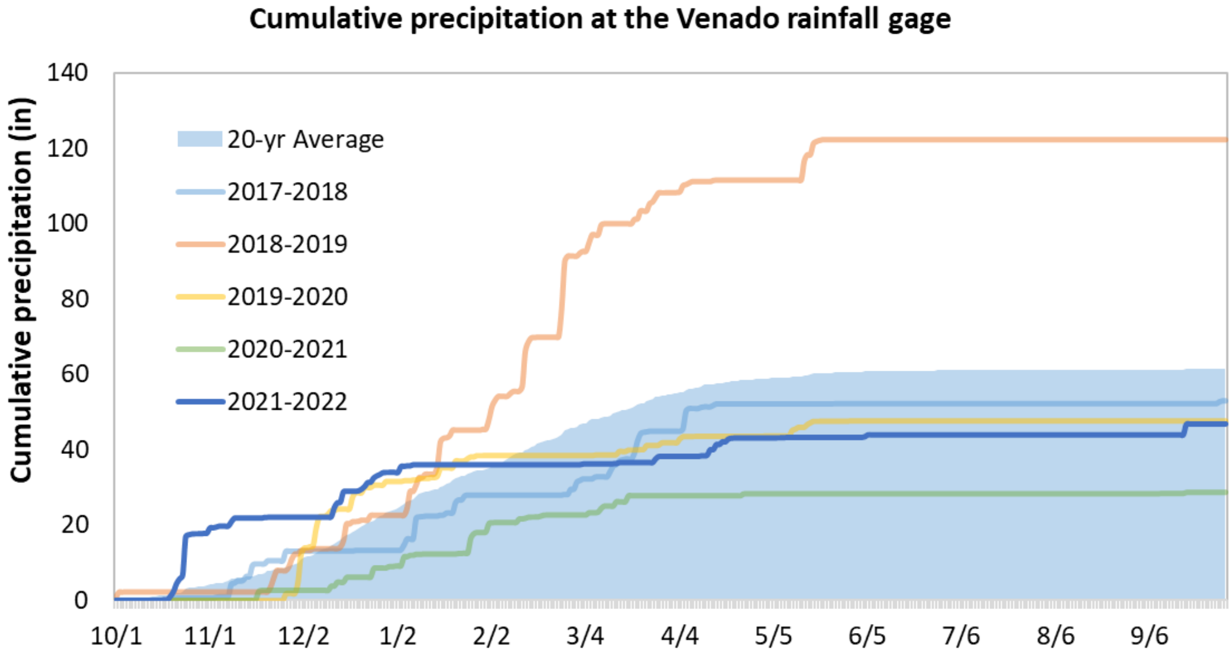

Figure 3. Cumulative precipitation at the Venado rainfall gage by water year over the past five years. The average annual accumulated precipitation over the previous 20 years is shown in shaded blue. Data obtained from the California Data Exchange Center (https://cdec.water.ca.gov).

3. Subtask 2: Wet/dry mapping

3.1. Goals and objectives

Wet/dry mapping, also referred to as wetted habitat surveys, were conducted in Russian River tributaries where snorkeling surveys were conducted. The goal of these surveys was to document wetted habitat available to rearing juvenile salmonids during the dry season and to quantify the proportion of stream length that remained wet or dried during the fall at different spatial scales (e.g., the stream or watershed scale).

3.2. Methods

To document base flow conditions, or when the instream flow is at its lowest, surveys were conducted in the fall, between mid-August and October. CSG staff planned the survey schedule to include reaches that were snorkeled during the summer and coordinated landowner access. In instances for which we included results from surveys conducted for projects funded by Wildlife Conservation Board (WCB) grants, we selected the survey that represented base flow conditions. For many of these WCB studies, surveys were performed throughout the dry season to document changes occurring in habitat available to juvenile salmonids.

Wet/dry surveys were performed by walking the stream channel and recording wet and dry segments of stream, based on presence or absence of surface flow, as line features on a GPS-enabled data collection device. Spatial data were collected on ESRI's FieldMap application as a team of two walked the reach in an upstream direction. Water temperature and dissolved oxygen (DO) measurements were collected in 5-minute intervals using a handheld YSI Pro20 meter. GPS points corresponding to the sampled pools were also collected and recorded in a customized Survey123 data collection form. After survey completion, tabular data were checked for errors and uploaded to a SQL database. Spatial data were processed using geospatial tools in ArcGIS software, where the condition of "intermittent" was assigned to sections of stream with alternating short lengths (<50 feet) of wet and dry lines. The full field protocol is available online (California Sea Grant 2021) and the data processing procedures are described in the WCB contract report *Flow and survival studies to support endangered coho recovery in flow-impaired tributaries of the Russian River Basin* (California Sea Grant 2019).

Spatial data were processed weekly and made available via the online web viewer (https://russianrivercoho.maps.arcgis.com/apps/dashboards/06582b2b564442f18cae7de71e576c54) to agency partners, along with associated water quality data. Data were provided in real time to help inform decisions about broodstock collection, fish rescue, and drought-related management actions, such as flow releases, throughout the season. We overlaid fish distribution and abundance data obtained during snorkel surveys in early summer with wet/dry results to estimate a late-season occupancy that reflects expected impacts of stream drying on salmonids. For this late-season occupancy (defined as 'end-of-season PAO'), the spatial overlay of early season snorkel pools with late-season wetted habitat conditions was used, with snorkel pools that fell in stretches of stream that were dry in the late season treated as not occupied regardless of whether coho were present in the early season snorkel survey, while the occupancy status of pools that fell in sections that were either wet or intermittent was unchanged for the estimate. Only reaches within the basinwide Russian River coho salmon stratum (ψ) in 2022 and for which both snorkel and wetted habitat data were available were included in this estimate.

3.3. Results

Between August 23 and October 27, 2022, CSG, SW, and CDFW biologists surveyed 85 reaches, covering 194 km of stream length in the lower Russian River basin (Figure 4, Table 4). All of the reaches that were snorkeled during summer were surveyed for wetted habitat mapping, except for Black Rock Creek, where were unable to establish landowner access for this survey. Across surveyed streams, 66% of stream length remained wet while 24% were dry and 10% were intermittent. Stream drying occurred across the surveyed extent of the lower Russian River basin and occurred most frequently within the lower reaches of tributary watersheds (e.g., Dutch Bill, Porter, Mill, and Pena creeks). Some tributary watersheds remained predominantly wet, including East Austin and Mark West creeks. Many of the smaller tributaries feeding into the Russian River main stem and Dry Creek, including Hulbert, Griffin, Crane, Grape, and Wine creeks were, as we have come to expect during drought years, predominantly dry in the fall.

Based on spatial overlay of fish abundance and distribution data from early summer snorkel surveys over the wetted habitat maps to estimate impacts of stream drying on salmonids, some of the fish observed during snorkel surveys would have been exposed to dry or intermittent conditions in the fall (shown at the watershed scale for a subset of surveyed watersheds, Figure 5 - Figure 10). Preliminary analysis for an 'end-of-season PAO' was 0.38.

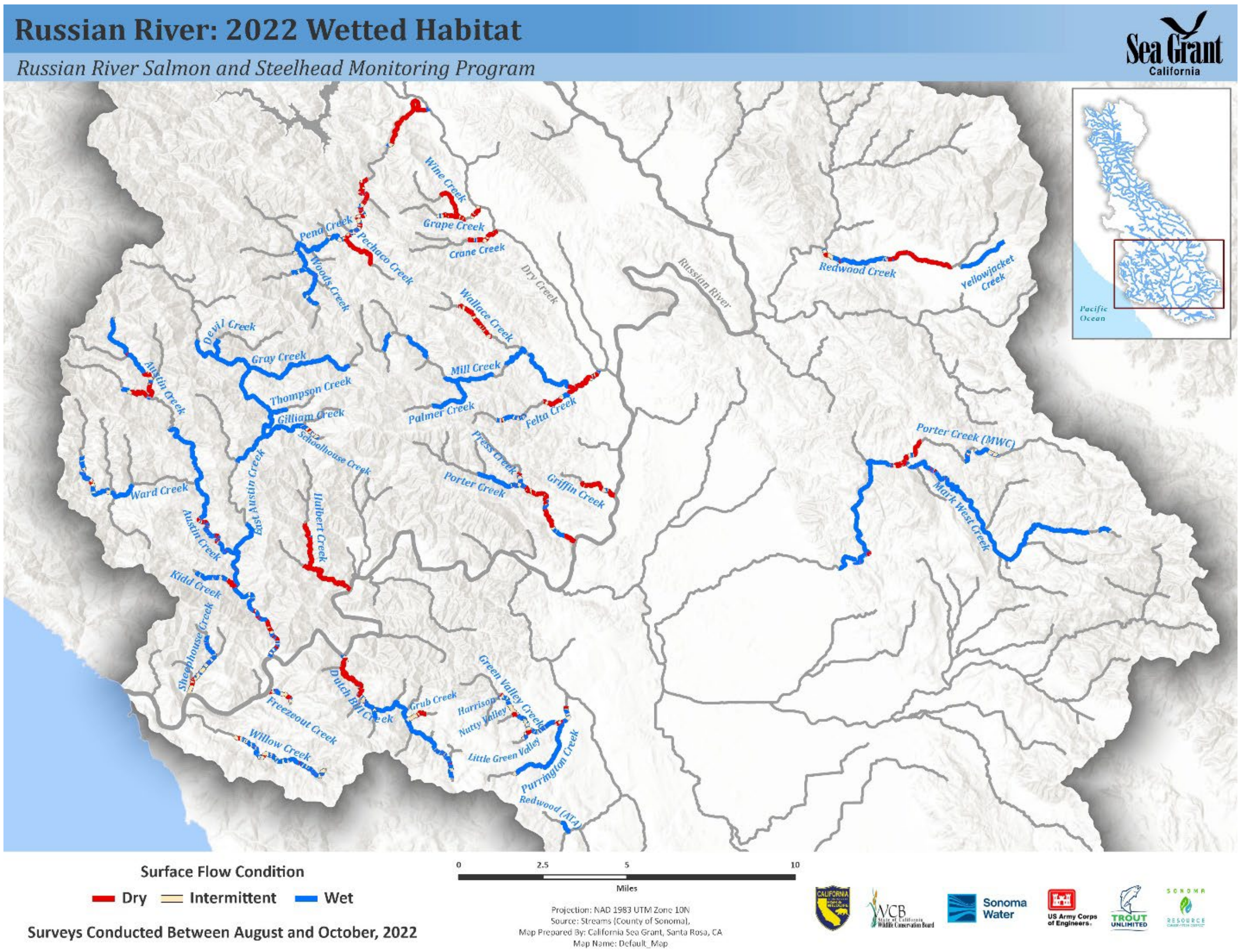

Figure 4. Wetted habitat conditions during fall 2022 across the Russian River watershed, showing observed surface flow as wet, intermittent, or dry.

Table 4. Stream length surveyed for wetted habitat, dates surveyed, and proportion of stream length with observed surface flow as wet, intermittent, or dry during fall 2022.

Tributary	Stream length surveyed (km)	Dates surveyed	Length wet (%)	Length intermittent (%)	Length dry (%)
Austin Creek	21.9	Aug 23-25	82%	5%	13%
Bearpen Creek	1.9	Aug 25	24%	15%	61%
Crane Creek (Dry)	1.9	Oct 27	7%	26%	67%
Dead Coyote Creek	0.7	Sep 7	84%	14%	2%
Devil Creek	1.1	Aug 31	100%	0%	0%
Dutch Bill Creek	11.3	Oct 12-13	66%	6%	28%
East Austin Creek	12.7	Sep 29, Oct 24-25	100%	0%	0%
Felta Creek	3.7	Sep 27-29	43%	20%	37%
Freezeout Creek	1.5	Sep 1	29%	42%	28%
Gilliam Creek	2.6	Sep 26	100%	0%	0%
Grape Creek	2.3	Sep 20	5%	34%	61%
Gray Creek	6.2	Aug 31	100%	0%	0%
Green Valley Creek	5.4	Aug 22	53%	40%	8%
Griffin Creek	2.3	Oct 27	5%	13%	82%
Grub Creek	1.1	Oct 13	1%	61%	38%
Harrison Creek	0.2	Oct 11	29%	71%	0%
Hulbert Creek	6.1	Sep 21	1%	1%	98%
Kidd Creek	2.5	Sep 1	66%	9%	26%
Little Green Valley Creek	0.7	Oct 11	39%	25%	36%
Mark West Creek	24.4	Sep 13-15	95%	2%	3%
Mill Creek	12.7	Sep 27-28	82%	3%	15%
Mission Creek	0.4	Sep 21	0%	0%	100%
Nutty Valley Creek	0.3	Oct 11	0%	0%	100%
Palmer Creek	2.9	Sep 28	100%	0%	0%
Pechaco Creek	2.3	Sep 13	0%	0%	100%
Pena Creek	12.6	Sep 7-12	35%	16%	49%
Perenne Creek	0.5	Oct 13	85%	15%	0%
Porter Creek	7.4	Sep 22	47%	9%	44%
Porter Creek (MWC)	4.1	Sep 21	38%	20%	41%
Press Creek	0.6	Sep 22	46%	39%	15%
Purrington Creek	4.5	Oct 7-11	97%	3%	0%
Redwood Creek	7.2	Aug 30	42%	8%	51%
Redwood Creek (Atascadero)	0.8	Sep 20	100%	0%	0%
Schoolhouse Creek	1.1	Sep 26	42%	50%	8%
Sheephouse Creek	3.7	Sep 1	49%	41%	10%
Thompson Creek	0.9	Sep 26	100%	0%	0%
Wallace Creek	2.5	Sep 28	1%	25%	74%
Ward Creek	5.0	Oct 11	81%	18%	1%
Willow Creek	6.1	Oct 3	67%	30%	3%
Wine Creek	1.8	Sep 20	0%	0%	100%
Woods Creek	4.1	Sep 12	97%	2%	1%
Yellowjacket Creek	2.6	Aug 29	100%	0%	0%
Total	**194.4**		**24%**	**10%**	**66%**

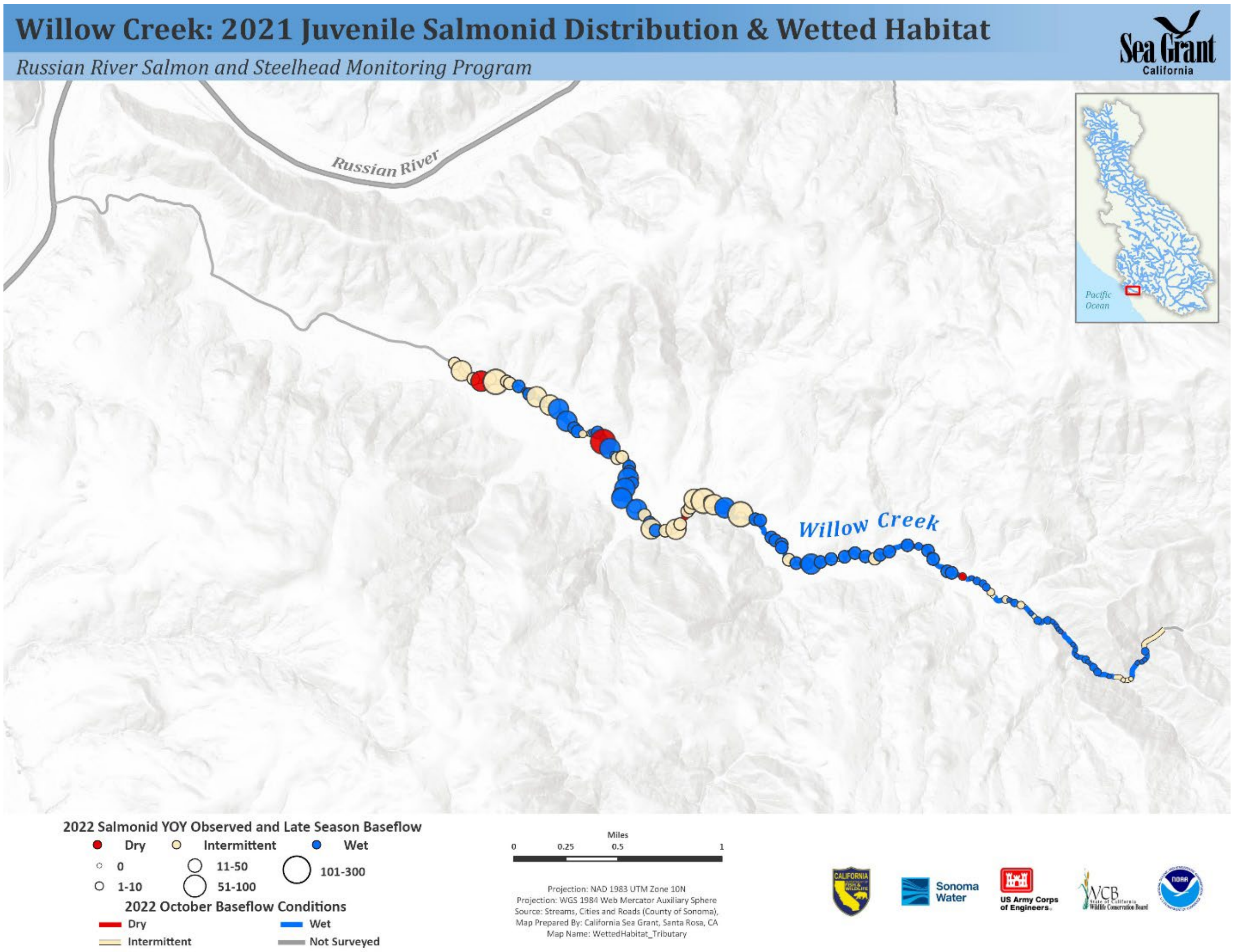

Figure 5. Density and distribution of juvenile coho salmon yoy observed in Willow Creek from summer 2022 overlaid with fall 2022 wetted habitat conditions. Note that the smallest circle indicates no coho observations in the associated pool.

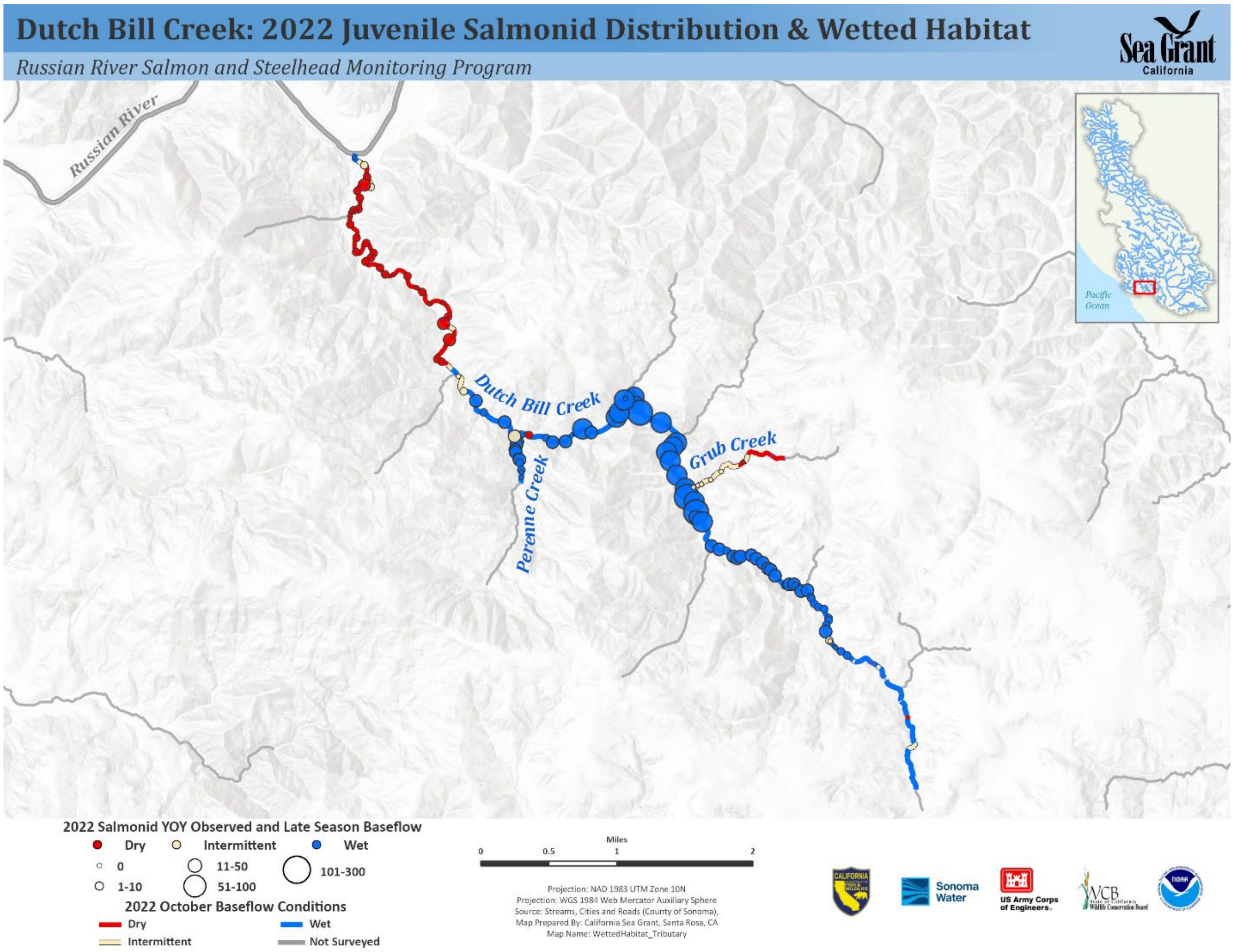

Figure 6. Density and distribution of juvenile coho salmon yoy observed in Dutch Bill Creek from summer 2022 overlaid with fall 2022 wetted habitat conditions. Note that the smallest circle indicates no coho observations in the associated pool.

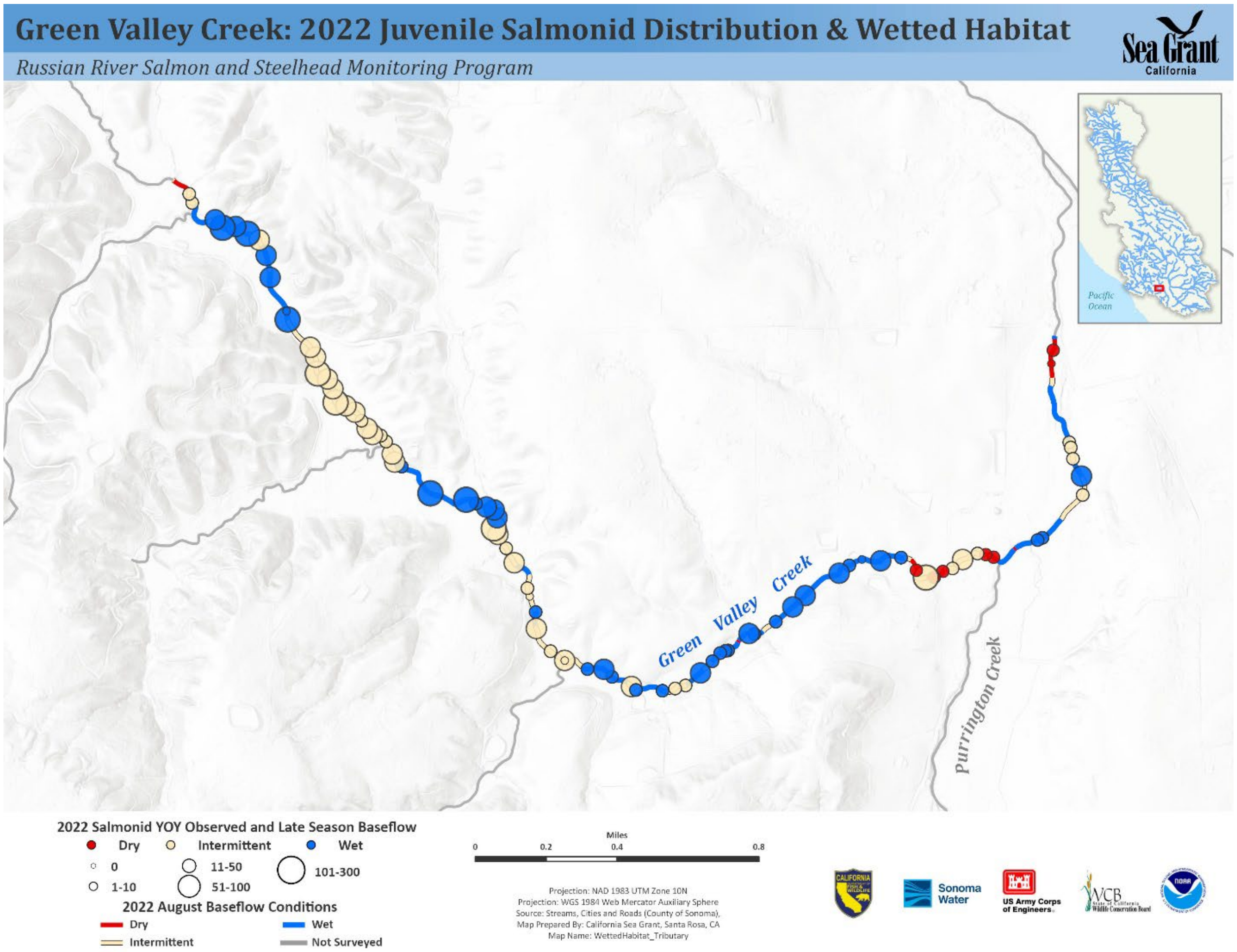

Figure 7. Density and distribution of juvenile coho salmon yoy observed in Green Valley Creek from summer 2022 overlaid with fall 2022 wetted habitat conditions. Note that the smallest circle indicates no coho observations in the associated pool.

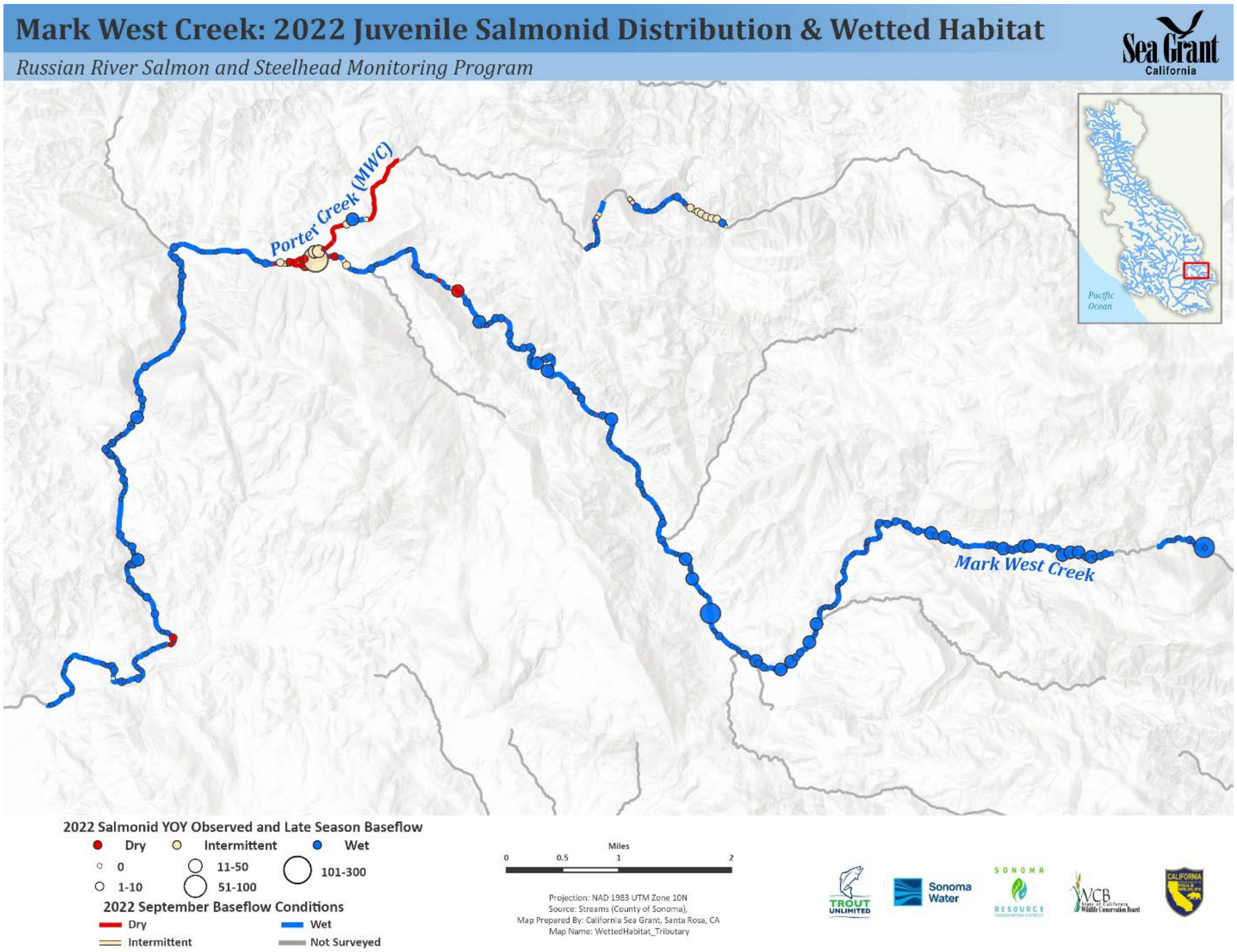

Figure 8. Density and distribution of juvenile coho salmon yoy observed in the Mark West Creek watershed from summer 2022 overlaid with fall 2022 wetted habitat conditions. Note that the smallest circle indicates no coho observations in the associated pool.

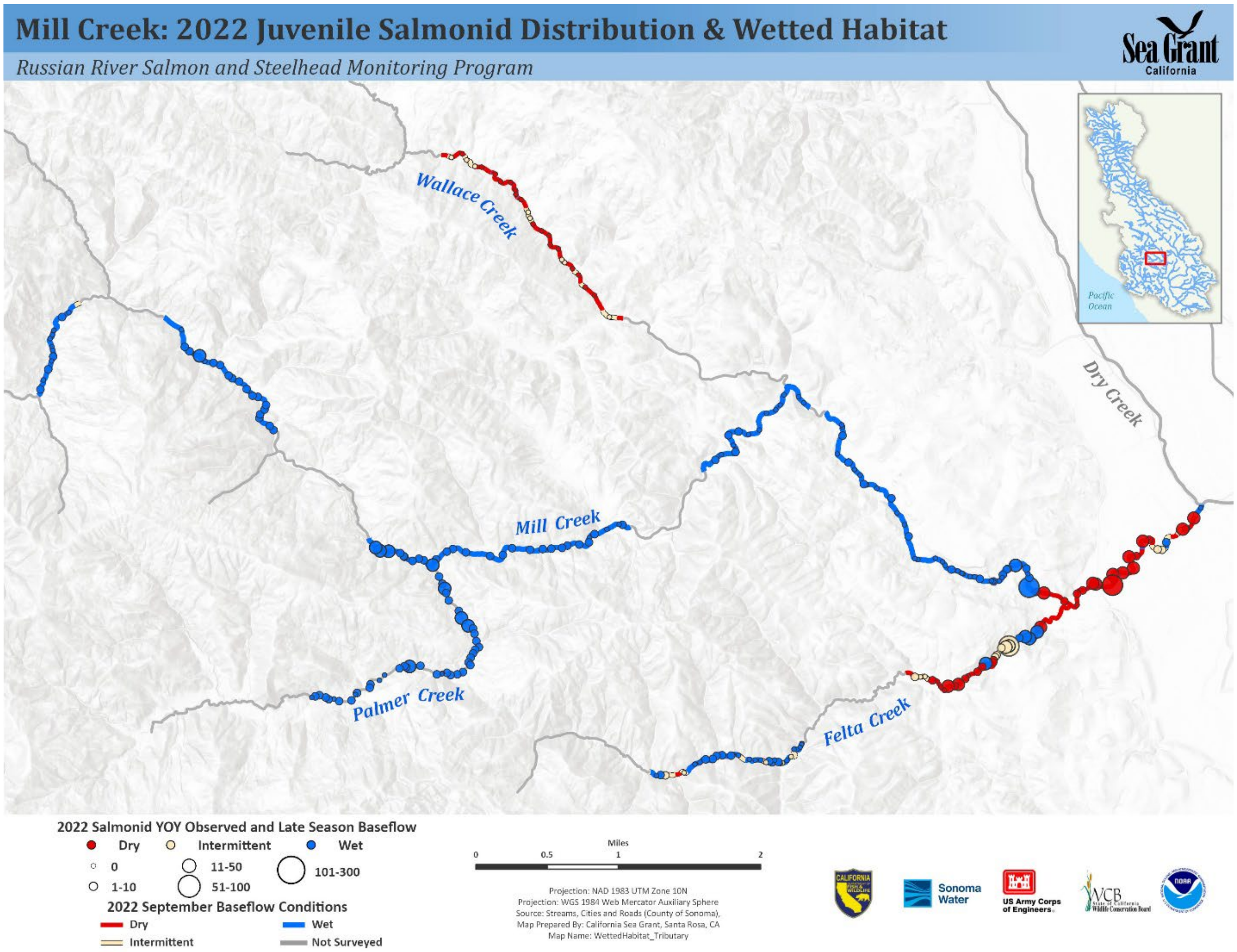

Figure 9. Density and distribution of juvenile coho salmon yoy observed in the Mill Creek watershed from summer 2022 overlaid with fall 2022 wetted habitat conditions. Note that the smallest circle indicates no coho observations in the associated pool.

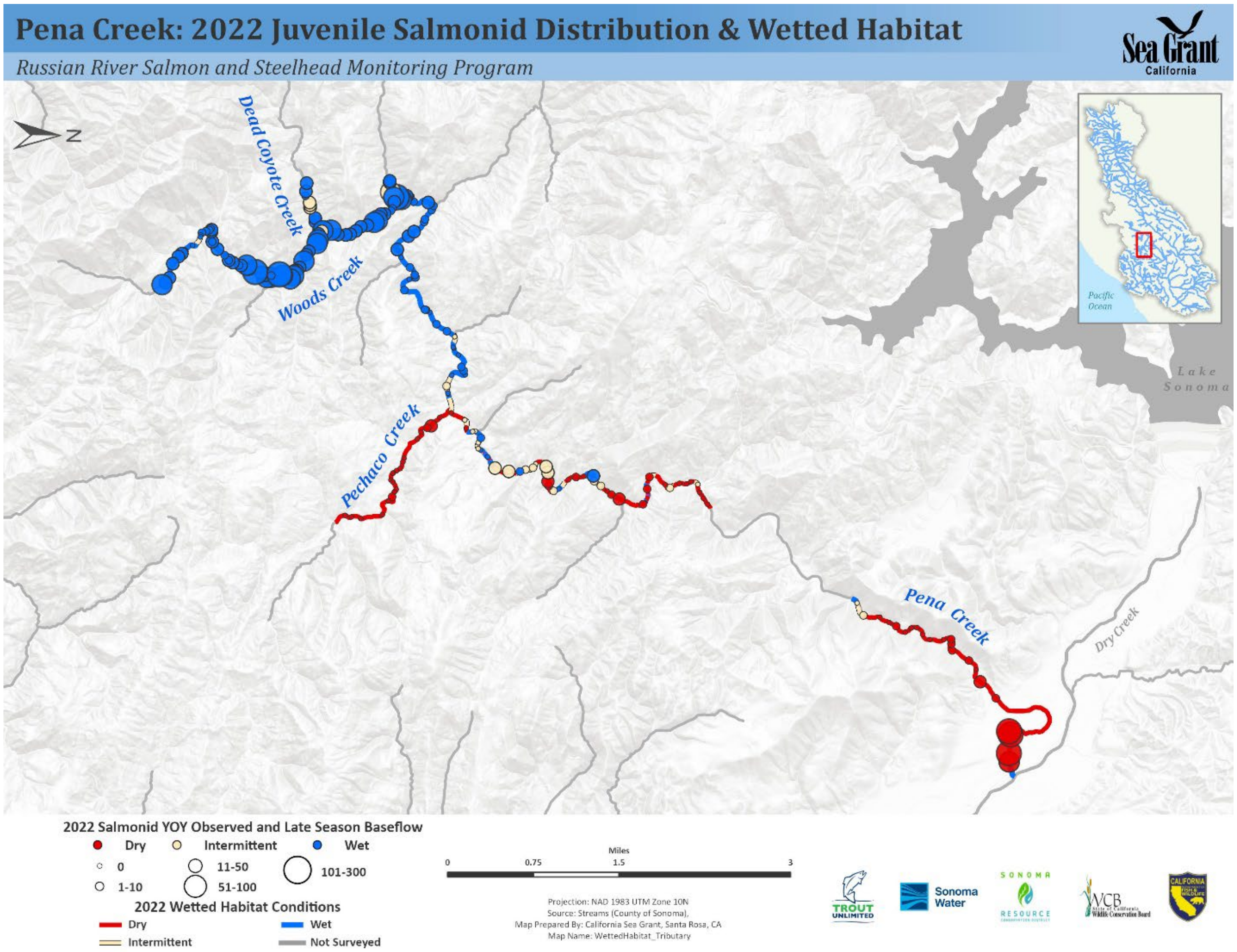

Figure 10. Density and distribution of juvenile coho salmon yoy observed in the Pena Creek watershed from summer 2022 overlaid with fall 2022 wetted habitat conditions. Note that the smallest circle indicates no coho observations in the associated pool.

3.4. Discussion

While we anticipated the fall timing of wetted habitat surveys to capture the driest extent of the year, 3” of rain occurred in mid-September. This rain may have briefly rewetted streams, so locations surveyed soon after the rain (i.e., Grape, Redwood (Atascadero), Hulbert, Porter (Mark West), and Porter creeks; Table 4) may have had increased observations of wet conditions when at other times in the fall they would have been dry. This mid-September rain did improve water quality conditions for fish present in wetter tributaries as observed by cooler water temperatures.

During 2022, we observed only a moderate reduction in occupancy from 0.45 during snorkel season to 0.38 during the late season. This was an improvement to the occupancy estimates from 2021, which revealed a drastic reduction in occupancy from 0.16 during snorkel season to 0.09 during the late season. Fish distribution minimized the impact of drying that occurred in some watersheds. As a separate note, fish rescue efforts by CDFW altered the fate of fish present in locations that later became dry. These rescue efforts were targeted in locations that would have had the largest impact on juvenile coho salmon.

4. Subtask 3: Flow release training

In the summer of 2015, the Camp Meeker Recreation and Parks District began releasing cold water from their municipal tanks (sourced from Russian River wells downstream) into Dutch Bill Creek in order to help rearing, juvenile salmon and steelhead to survive the dry summer months. Annual flow releases, conducted in partnership with the Camp Meeker community, the Russian River Coho Water Resources Partnership, CA Department of Fish and Wildlife, and the State Water Board, have been taking place in Dutch Bill Creek since that time and have resulted in improved streamflow and water quality during the critical summer months. CSG has been monitoring summer wetted habitat and water quality conditions in Dutch Bill Creek in order to document instream changes related to these flow releases, as well as to inform decisions for the timing, duration, and flow rates for releases. From 2015-2021, this monitoring was funded by the National Fish and Wildlife Foundation (NFWF) and Wildlife Conservation Board (WCB). Funding for those projects has concluded and CSG is no longer able to implement the monitoring program; however, CDFW recognized the importance and positive impacts resulting from these efforts and has agreed to continue the monitoring and coordination effort for the Camp Meeker release, as well as an additional release from St. Dorothy's Rest, which began in 2022.

CSG staff worked with CDFW biologists to transfer knowledge, technical skills, and resources developed during previous monitoring efforts. We provided context related to partner agency coordination, attended two flow release monitoring meetings hosted by CDFW, and met with project leadership to support development of an annual monitoring plan for the 2022 season. Prior to the field season, CSG shared monitoring protocols, including documentation related to wet/dry mapping and water quality logger calibration. CSG staff developed and shared resources related to landowner communication and best practices for landowner relationship-building, as well as encouraged partner agencies to coordinate landowner requests to reduce the number of requests they receive.

CSG purchased replacement sensor caps and other materials needed for the installation of dissolved oxygen (DO) loggers in Dutch Bill Creek. CSG provided hands-on training for CDFW staff on the preparation of loggers for field installation, including calibration and launching. Location data for logger sites from previous flow release monitoring seasons were shared, and a CSG biologist accompanied the CDFW field team to help with installation of five DO loggers on May 26.

On May 31, CSG conducted a pre-release wet/dry mapping survey that doubled as a field training for a CDFW biologist and CDFW database manager. CSG trained these individuals in both spatial and tabular data collection and described underlying data structures. We provided advice and our data collection forms using survey123 as templates to CDFW in case they elect to implement similar data collection and management structures in the future. For this season, CDFW utilized CSG's geospatial data infrastructure, such as the offline map available on the data collection application, and quality control and processing measures for collected data. The GIS specialist at CSG worked closely with the CDFW team to establish credentials needed to access data hosted through CSG ArcGIS Online geodatabases, as well as data collection forms and customized geospatial processing tools.

On June 4, a CSG biologist assisted project partners with installing insulation on the flow release pipe as a way to mitigate high water temperatures experienced in previous release years. Adhesive foam insulation was installed along the length of the above-ground pipe, and appeared to be successful in maintaining cooler water temperatures.

In mid-October, CSG performed an additional wet/dry mapping survey to capture annual baseflow conditions and shared resulting data with CDFW partners. Towards the end of the monitoring season, CSG trained CDFW biologists on the adjustment of continuous DO data using the field calibration values collected on wet/dry mapping surveys. CSG provided the protocol, demonstrated the process step-by-step, and compiled field calibration values. Once CDFW retrieved the loggers and began adjusting the data, CSG provided technical support as needed. CDFW is now in the final stages of processing these data, and the CSG project lead has remained in contact with the CDFW team to review the status of, and next steps for, the flow release monitoring activities. CSG also provided reports and presentations documenting outcomes from flow release monitoring in Dutch Bill Creek and other streams in previous years to help guide CDFW's reporting efforts. Overall, it was a successful transition of knowledge and skills. The documentation, protocols, and recommendations provided by CSG will be useful in future flow release monitoring activities.

5. Subtask 4: Fish rescue support

CSG staff supported CDFW biologists in fish rescue efforts by providing coho salmon density and spatial distribution data from snorkel surveys. These data were made accessible through an online ArcGIS dashboard and mobile field map. The addition of a field map in 2022 enabled CDFW biologists to access data while in the field, which allowed a more targeted approach. The snorkel survey schedule was communicated with fish rescue crews and adjusted when possible in response to identified data needs and rescue plans. CSG staff developed and shared resources related to landowner communication and best practices for landowner relationship-building, as well as encouraged partner agencies to coordinate landowner requests to reduce the number of requests they receive.

An informational need was identified for evaluating the relative urgency of fish rescue efforts across the Russian River watershed. In response, CSG staff developed a prioritization spreadsheet to help inform fish rescue needs based on tributary, stream reach, coho salmon redd observations, and observed or anticipated drying or extreme temperature conditions. As data related to stream condition (stream connectivity, temperature, dissolved oxygen) were collected during snorkel surveys, it was relayed to CDFW biologists to help with their prioritization and consideration of the best timing for rescue efforts. Research geneticists from the Southwest Fisheries Science Center in Santa Cruz have stated that incorporating natural origin juvenile coho salmon into the captive Broodstock Program at Warm Springs has helped increase genetic diversity in the broodstock population. To assist with captive broodstock collection, CSG provided recommendations for collection locations based on observed coho salmon redds during the spawner season, especially in streams where fish collection had not occurred in recent years. Broodstock collection locations were not limited to streams that necessitated rescues.

CSG staff also developed an ArcGIS survey123 form for fish rescue documentation which was integrated into CSG's database. This form recorded the number of fish removed by species and life stage, PIT tag numbers, locations of fish removals, and locations of where fish were released. Documenting these numbers, individual fish, and relocations was imperative to avoid complications with ongoing monitoring efforts, including the summer snorkel surveys that were occurring simultaneously with fish rescue efforts and PIT tag antenna arrays capturing fish movement data across the watershed. A subset of the collected coho salmon from each rescue effort were taken to Warm Springs hatchery to be incorporated into the captive Broodstock Program. Remaining fish were relocated back into sections of creek that provided better rearing conditions. CSG staff provided support for determining ideal release locations for rescued fish. To avoid overcrowding in relocation streams, density maps were used to identify release locations with adequate conditions and lower densities of fish.

6. Subtask 5: Present drought-related impacts at Salmonid Habitat Restoration Priorities meetings

CSG staff provided support to CDFW biologists regarding drought-related impacts on Russian River North Coast Salmon Project streams. We met with CDFW Salmonid Habitat Restoration Priorities (SHaRP) program staff to plan contributions. We suggested additional invitees, provided summaries of fish distribution, wetted habitat, water quality and over-season survival data, and consulted on data interpretation. For the SHaRP meetings for Dutch Bill, Willow, and Mill creeks, we evaluated and summarized long-term fish distribution and wetted habitat data and prepared presentations customized to address specific SHaRP attributes and restoration needs in order to aid participants in voting from a more educated standpoint even if they had limited knowledge of the watershed prior to the meeting. We reviewed draft presentation materials with CDFW staff prior to each meeting. We attended the Dutch Bill and Willow creeks SHaRP meetings on June 1 and 2 and the Mill Creek SHaRP meetings on November 8 and 9 and shared our presentations for each watershed with the goal of informing SHaRP voting and prioritization of needs. We contributed to discussions, including observed trends, limiting factors, and reach- and parcel-specific recommendations for restoration action planning. We also answered many questions and provided insight on landowner communications and opportunities. We submitted our presentation materials to CDFW staff.

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