Monitoring to Support Central California Coast Coho Salmon Recovery in Tributaries of the Lower Russian River Basin

Annual Report for National Marine Fisheries Service

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Prepared by:

Will Boucher, Laura Slater, Mariska Obedzinski, Andrew Bartshire, Zac Reinstein and Andrew McClary

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1. Remote-Site Incubator pilot study monitoring

1.1. Introduction

As endangered coho salmon populations continue to decline in many central California coast streams, there is an increasing interest in captive broodstock programs. Such efforts can help preserve remaining genetic diversity of local populations and supplement streams with hatchery fish until long-term recovery and self-sustaining populations can be achieved. The US Army Corps of Engineers (ACOE) currently hosts the Russian River Coho Salmon Captive Broodstock Program (Broodstock Program) at the Don Clausen Fish Hatchery at Warm Springs Dam. This multi-partner conservation hatchery program cultures natural-origin juvenile coho salmon from Russian River tributaries, raises them to the adult stage, and spawns them according to a genetic matrix to maximize genetic diversity. Progeny of these broodstock are then released into 15-20 Russian River tributaries each year as fed fry (approximately 3-9 months old) and as one-year old pre-smolts and smolts. Based on the initial success of this program, there is interest in expanding the releases to include additional streams within and beyond the Russian River watershed. The Don Clausen Fish Hatchery has a limited capacity to rear fish and is unable to rear enough juveniles to stock all streams that would benefit from hatchery support.

Remote-site incubation is a rearing and release technique in which fertilized eggs are placed in a streamside holding barrel where fish emerge and either volitionally swim through pipes into the stream or are manually released into the stream. Broodstock are raised and spawned in existing hatchery infrastructure to produce eggs that are then placed in remote-site incubators (RSI). While raising juvenile coho salmon in the hatchery environment for up to a year leads to larger size at release, this approach comes at the cost of limited rearing space. If fish can be released at an earlier life stage, less tank space and upkeep is required. Previous work has shown that RSIs can be an effective tool for incubation of Atlantic Salmon, Arctic Grayling and Westslope Cutthroat embryos (Andrews et al. 2016; Donaghy and Verspoor 2000; Kaeding and Boltz 2004). RSI use, alongside traditional hatchery rearing, ultimately expands the capacity for Broodstock Program fish to be released into selected streams.

The National Marine Fisheries Service (NMFS), in partnership with the California Department of Fish and Wildlife (CDFW), ACOE, and California Sea Grant (CSG), initiated a study in 2019 to evaluate the use of RSIs as a recovery tool for endangered coho salmon in California. In 2019, following release of RSI fry into Gray Creek, CSG conducted snorkel and electrofishing surveys to estimate abundance and spatial distribution of juvenile coho salmon that may have resulted from RSI releases (California Sea Grant 2020). Genetic samples collected in 2019 revealed that 96% of fish sampled in Gray Creek were of RSI origin (Gilbert-Horvath 2019). In 2020 and 2021, RSI operations and follow-up monitoring surveys were conducted on Yellowjacket Creek, a tributary to Redwood Creek. It should be noted that the RSI in Yellowjacket Creek was located upstream of a 0.22 km restoration project reach, in which a fish passage barrier was remediated and a series of step pools was created for the benefit of salmon. This report summarizes the results of the third year of RSI evaluation efforts, conducted in 2021.

1.2. Methods

1.2.1. RSI operation

During the spring of 2021, CSG operated an RSI on Yellowjacket Creek, a tributary to Redwood Creek in the Maacama Creek watershed. An estimated 20,004 fertilized eggs were delivered from Warm Springs Hatchery and placed in a single RSI unit (Figure 1) in Yellowjacket Creek on February 26, 2021. The RSI was checked every 2-3 days during operation. The number of dead eggs and or alevin were documented and discarded on each visit. Routine system maintenance included cleaning out egg shells of recently hatched alevin, checking flow rates, and cleaning debris accumulation on system intake hardware. Since fry could travel via pipes to the live basket in the live cart tank after emergence, the live basket was also checked. Fry that were not ready for release into the stream were moved back into the incubation tank where there was more available space for the fry. The fry were released into Yellowjacket Creek across four days (March 28-31); this release occurred 30-33 days after the eggs were placed into the RSI. All fry were loaded into aerated backpacks and released at a single location at rkm 0.91, which was downstream of the RSI (rkm 1.09) where the stream offered better habitat for fry.

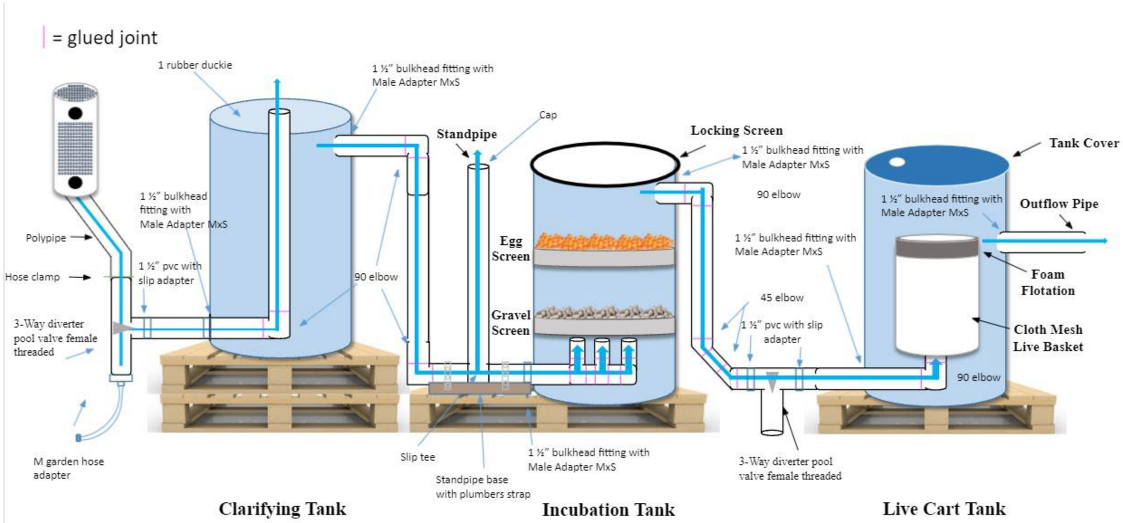

Figure 1. RSI configuration and design. Credit: NOAA

1.2.2. Snorkeling surveys

During the summer of 2021, snorkel surveys were conducted to document the number and spatial distribution of juvenile coho salmon present following the release of RSI fish in the early spring. Snorkel surveys in Yellowjacket Creek were conducted on May 17-18 from rkm 0.3 to the upstream extent of anadromy. In addition, as a part of an additional monitoring effort (through the CDFW-funded Coastal Monitoring Program), two survey reaches in Redwood Creek were surveyed on May 11-12 from the confluence of Maacama Creek (rkm 0) to rkm 4.77 in Redwood Creek.

In Yellowjacket Creek, all pools were snorkeled, while in Redwood Creek, every other pool was snorkeled. Pool habitat was defined as stream sections that met the following criteria:

- surface area > 3 m^2
- pool depth > 1 ft.
- pool length ≥ maximum wetted width

Divers sampled in a downstream to upstream direction, counting and recording the number of juvenile coho salmon and steelhead in each pool. All observed salmonids were identified to species and grouped into age classes based on size. Salmonids > 100 mm in fork length were documented as parr and those ≤ 100 fork length were considered yoy. Dive lights were used to illuminate dim areas such as undercut banks and under woody debris. In addition to salmonid counts, large woody debris counts were performed at the pool scale. Large wood was defined as logs greater than 30 cm in diameter and 2 m in length. Data from each pool were recorded in an Allegro field computer, and GPS coordinates were recorded to document spatial distribution of juvenile salmonid distribution in relation to the release site. Data were downloaded, error-checked and then uploaded to CSG's SQL database. In Redwood Creek, expanded count estimates were made by multiplying the minimum observed count by a factor of 2.

1.2.3. Electrofishing surveys

Following snorkeling surveys, electrofishing was conducted to capture juvenile coho salmon and collect genetic samples for use in determining whether the fish originated from the RSI release. Our objective was to obtain a minimum of 100 genetic samples, dispersed according to the distribution of coho salmon observed throughout the stream. We used the fish density data collected during our snorkeling surveys to assign proportional genetic sample targets to each electrofishing pool so that samples would be representative of the distribution observed during snorkeling surveys. If genetic sample targets were not met after electrofishing in each pool, then additional shocking was conducted immediately upstream until the target was met.

Electrofishing surveys were conducted using NMFS' Backpack Electrofishing Guidelines (National Marine Fisheries Service 2000) by a crew of 4-5 people. Prior to electrofishing, temperature, dissolved oxygen, and conductivity measurements were taken to confirm that values fell within the acceptable thresholds of < 18°C, > 6.0 mg/l for dissolved oxygen and < 350 µS/cm for conductivity, and the condition of captured fish was constantly monitored to avoid mortalities.

Captured salmonids were anesthetized, measured for length and weight, and scanned for coded wire tags (CWT) and passive integrated transponder (PIT) tags. Genetic samples were collected from all unmarked coho salmon yoy by clipping a small (<1 mm^2) piece of fin tissue from the tip of the lower caudal fin. Fin tissue was placed on blotting paper inside an envelope marked with fish number, species, length, weight and origin for subsequent cross-reference. Samples were then transferred to the Southwest Fisheries Science Center in Santa Cruz for analysis to determine whether the observed fish were of the same family groups as the eggs placed in the RSI. All data were recorded in an Allegro field computer, error-checked, and uploaded to CSG's SQL database.

1.3. Results

1.3.1. RSI operation

Of the 20,004 eggs that were placed into the RSI, 697 eggs were not viable (96.52% hatch rate). After hatch, 1,150 Alevin died (94.04% Alevin survival rate). A total of 18,157 juvenile coho salmon (90.77% egg to fry survival) were released from the RSI into Yellowjacket Creek at a single location at rkm 0.91 (Figure 2) between March 28-31, 2021.

1.3.2. Snorkeling surveys

On May 17 and 18, 2021, field crews snorkeled 124 pools throughout Yellowjacket Creek. In total, 896 coho salmon yoy, 15 coho salmon parr, 5 steelhead yoy, and 47 steelhead parr were observed. Coho salmon and steelhead were present in 48 and 37 of the 124 surveyed pools, respectively.

1.3.2.1. Coho salmon

Coho salmon were present in 45 of 47 pools located downstream of the RSI release location. The majority of the coho salmon (624/986, 69.6%) that were observed were found in pools located within the restoration project reach boundaries (rkm 0.69-0.91) with an average density of 20.8 coho salmon/pool (Figure 2). Only three coho salmon yoy were observed upstream of the RSI release location with the furthest upstream movement of 0.18 rkm.

In Redwood Creek, a total of 46 coho yoy were observed, for an expanded count of 92 fish (Figure 3).

1.3.2.2. Steelhead

Steelhead were documented in 26 of the 124 pools sampled in Yellowjacket Creek. Distribution of steelhead was spread throughout the entire area surveyed (Figure 4). Average densities within the habitat enhancement reach were 0.5 fish/pool and 0.4 fish/pool outside of the project reach.

1.3.3. Electrofishing surveys

Electrofishing surveys were conducted between September 27 and 29 in Yellowjacket Creek. A total of 40 pools were sampled (Figure 5). Capture totals consisted of 324 coho salmon yoy, 7 coho salmon parr and 39 steelhead parr. Neither tag type (CWT or PIT) was detected in any of the captured fish from Yellowjacket Creek.

Genetic samples were collected from 120 coho salmon yoy. The average fork length of coho salmon was 62 mm and average weight was 3.1 g. Coho salmon captured in Yellowjacket in 2021 were on average smaller than those captured in 2020 but similar to the size seen in Gray Creek in 2019 (Table 1). All genetic samples were cataloged and delivered to NOAA's Southwest Fisheries Science Center.

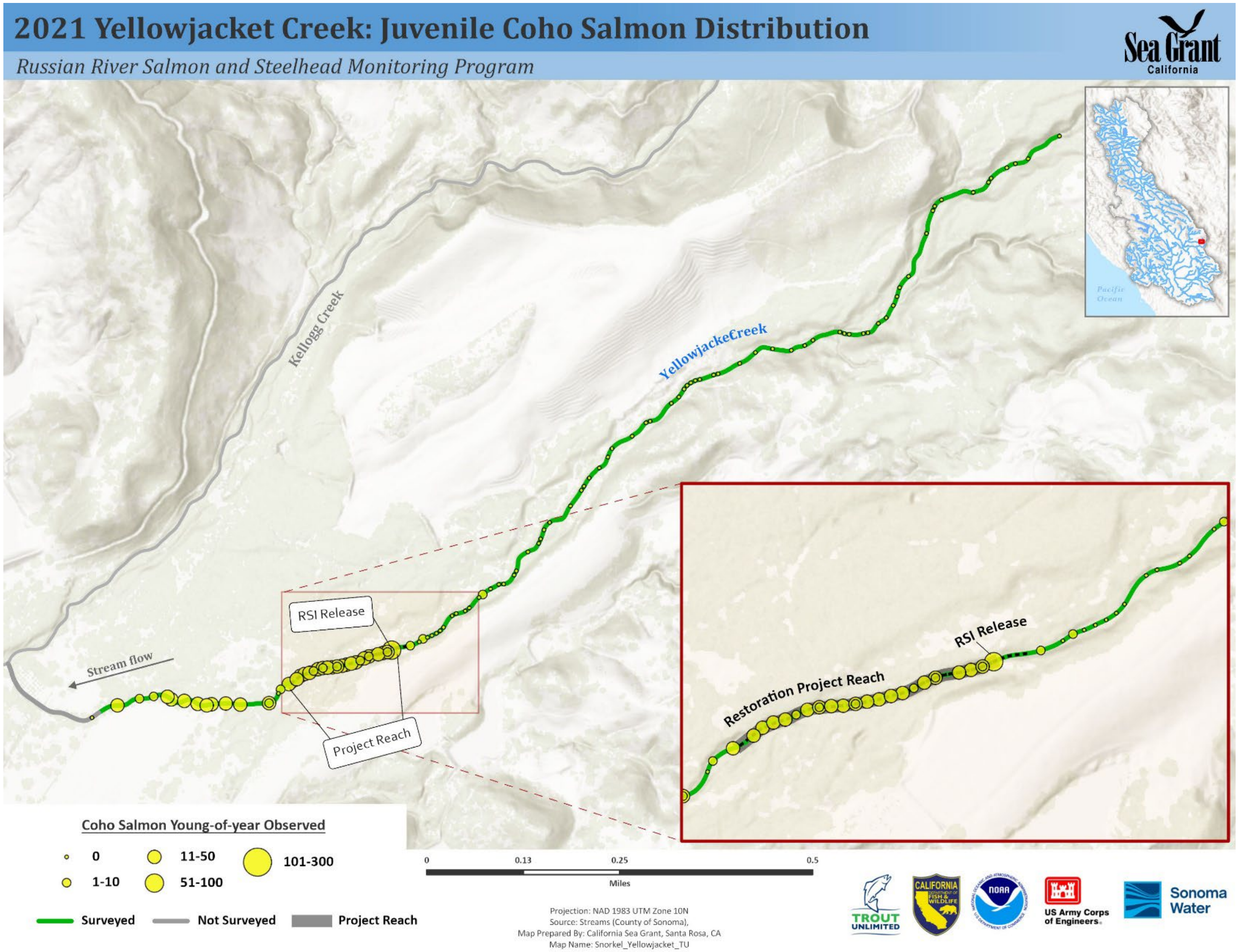

Figure 2. Juvenile coho salmon density and distribution in relation to RSI release location in Yellowjacket Creek, 2021.

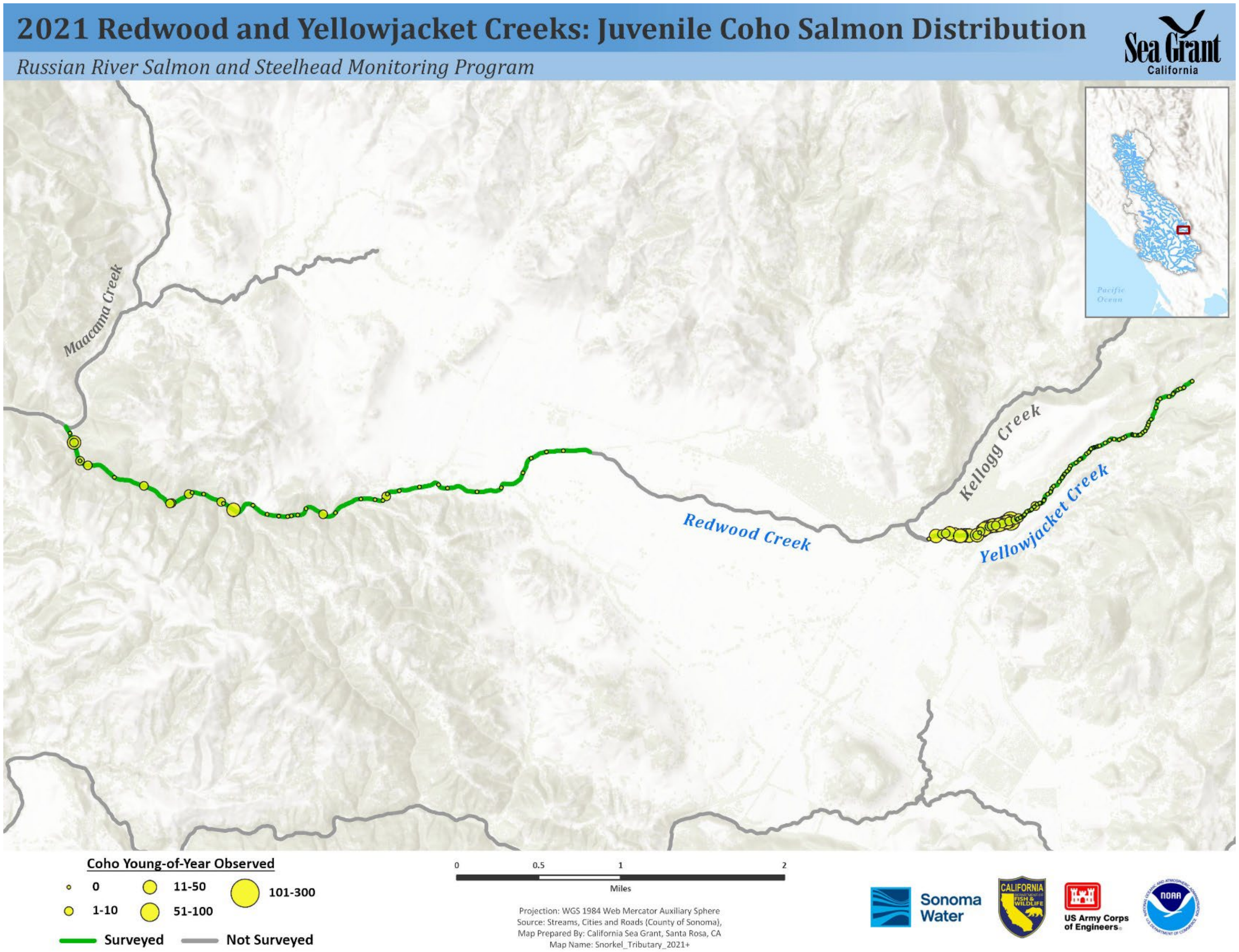

Figure 3. Juvenile coho salmon density and distribution in Yellowjacket and Redwood creeks, summer 2021.

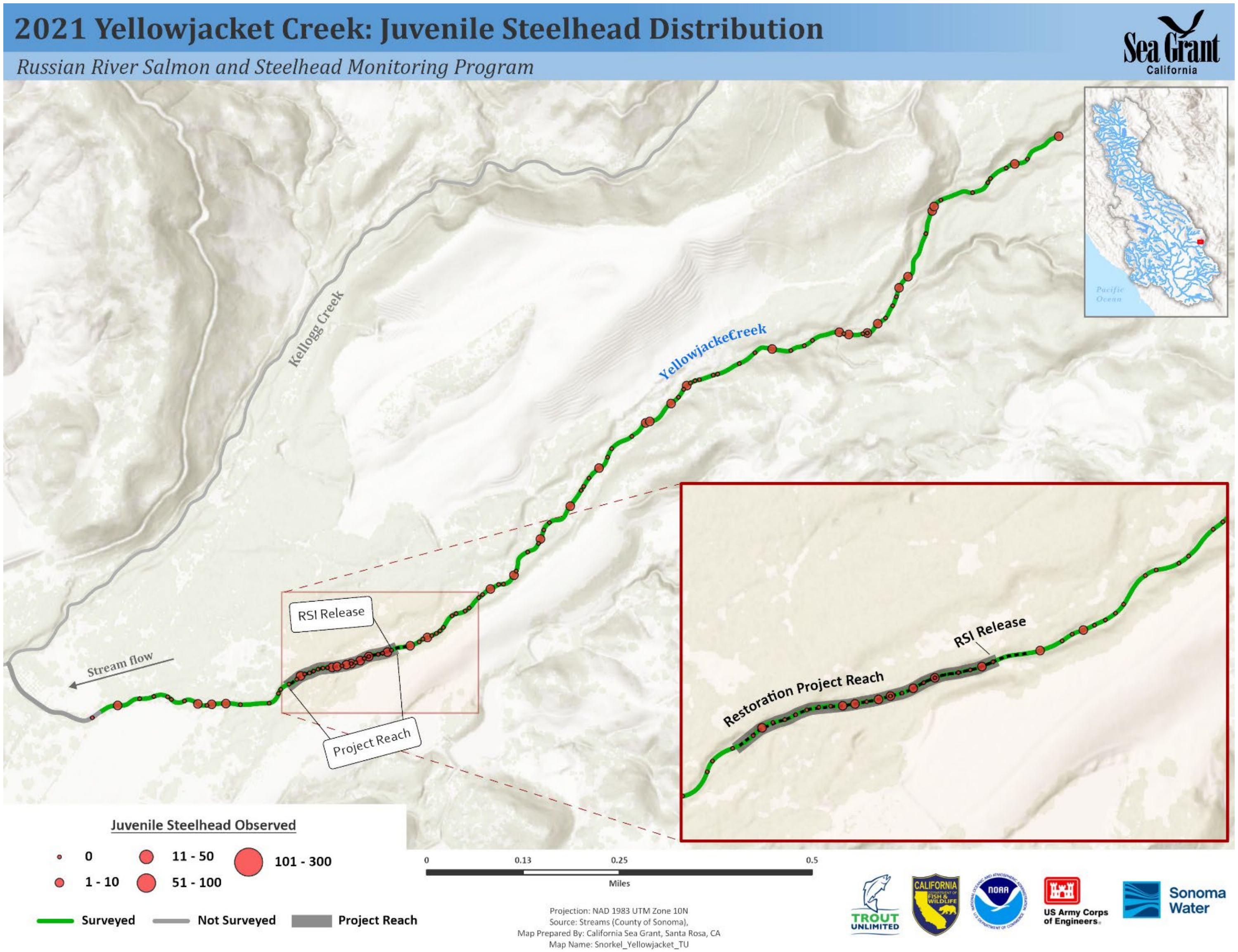

Figure 4. Juvenile steelhead density and distribution in Yellowjacket Creek, summer 2021.

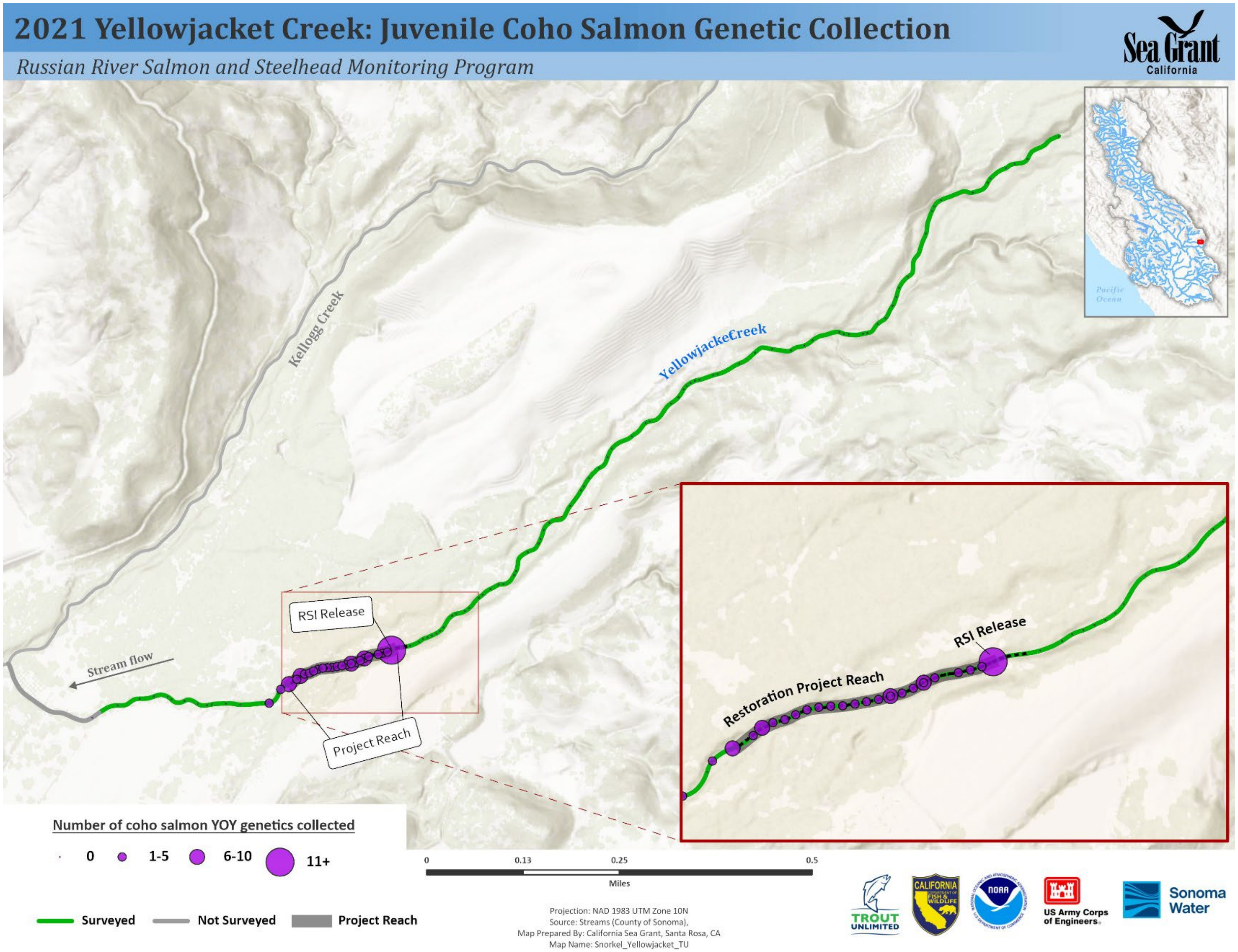

Figure 5. Density and distribution of genetic sample collection in Yellowjacket Creek, 2021

Table 1. Average length and weight of unmarked juvenile coho salmon captured during electrofishing in Gray Creek (2019), Yellowjacket and Redwood Creeks (2020) and Yellowjacket Creek (2021).

Year	Survey Dates	Tributary	# Individuals	Average Fork Length (mm)	Average Weight (g)
2019	9/10 - 9/12	Gray Creek	156	62.5	2.9
2020	9/14 - 9/16	Yellowjacket Creek	127	71	4.3
2020	9/15	Redwood Creek	4	75	4.4
2021	9/27 - 9/29	Yellowjacket Creek	120	62	3.1

1.4. Discussion

1.4.1. RSI operation

The number of eggs placed in the RSI operation was nearly doubled from 10,205 in 2020 to 20,004 in 2021. NOAA documented a hatch success during RSI operations in 2020 of 99.01% (NOAA, unpublished data). In 2021, CSG documented a hatch success of 96.52%. Hatch success results seen in Yellowjacket Creek in 2020 & 2021 parallel those seen in the Yankee Fork Stream Side Incubator Program in Idaho between 1995 and 2010 (Denny and Evans 2012). Egg to fry survival in Yellowjacket Creek was documented at 97.47% in 2020 and 90.77% in 2021. Increasing the number of eggs in the RSI did not have a large impact on the egg to fry survival. It should be noted that during the 2021 operations, there was an equipment malfunction that resulted in the fatality of approximately 1,000 fry. A small gap between the gravel screen and edge of the incubation tank barrel formed, through which fish passed into a compartment below the gravel screen, an area that was not intended to be occupied and that was not safe for fry. If this malfunction had not occurred, egg to fry survival would have been closer to results seen in 2020.

Another challenge that CSG observed during RSI operations in 2021 was the amount of fish handling needed once fish started to become mobile and swim, which was around day 17. Once fish became mobile, they often swam from the incubation tank to the live cart tank (Figure 1). During the RSI checks in 2021, CSG repeatedly moved these fish from the live cart tank to the incubation tank because there was insufficient space in the live cart tank to support fish for an extended period of time. A modification of the RSI to either more effectively retain fry in the incubation tank or create more available space in the live cart tank would improve the efficiency of RSI checks and, more importantly, allow for reduced handling of fish.

The release strategy was modified in 2021. The section of stream immediately surrounding the RSI is characterized by a moderately high gradient with few pools or off channel habitat directly downstream. In 2020, fry volitionally swam through pipes connecting the RSI to an adjacent section of stream. In 2021, fry were loaded into aerated backpacks and released 0.18 rkm downstream at a location that offered a long, shallow pool with slower stream velocities and backwater habitat. A study in coastal Oregon streams showed that in spring months, coho salmon fry occupied backwater habitat, with characteristics similar to the 2021 Yellowjacket release site, more than twice that of any other habitat type (Nickelson et al. 1992).

As mentioned above, increasing the number of eggs in the RSI did not seem to have a large impact on egg to fry survival. A consideration for further efforts would be to study the effects of increased fry releases once they are in the stream environment. It has been documented that RSI fish distribute themselves in a predominately downstream direction from the release location, with movement seen as far as 5.06 rkm away in Gray Creek. However, overcrowding the stream, especially in a small tributary, could result in increased competition, decreased fitness, and decreased in-stream survival.

1.4.2. Post-release monitoring

The presence of coho salmon in Yellowjacket Creek suggests a high likelihood that some of the RSI-release fish survived and remained in Yellowjacket Creek. However, analysis of genetic samples is necessary to confirm that the fish observed in Yellowjacket Creek originated from the RSI releases. During snorkel surveys, a total of 896 coho yoy and 15 coho parr were observed. Given our stratified approach to genetic sampling, if genetic analysis confirms that all sampled fish are of RSI origin, it is likely that all of the observed coho yoy (896) were from the RSI. These counts were notably higher than 2020 counts (166 coho yoy) and even when factoring the increase of starting egg count, 2021 results showed higher instream success within Yellowjacket Creek. With egg to fry survival fairly consistent across all years of operation, the difference in results was likely driven by post release variables such as release strategy, release location and instream conditions. Counts of steelhead in Yellowjacket Creek were also lower in 2021. A total of 259 steelhead were counted in 2020 and only 52 were counted in 2021. This likely reduced the amount of instream predation on coho salmon fry. The presence of coho parr in 2021, though we are unable to confirm if they are of RSI origin, suggests that some fish are surviving to the smolt life stage. Ideally these fish would have left Yellowjacket Creek by the time we snorkeled in May, but during extreme drought years with low spring flows, we have observed higher numbers of holdover smolts throughout the basin (California Sea Grant 2022).

In-stream dispersal of coho fry after release was consistent with previous results seen in both Gray Creek in 2019 and Yellowjacket in 2020. Upstream movement was minimal with downstream dispersal being the dominant direction. The confluence of Kellogg Creek and Redwood Creek are 0.91rkm downstream of the RSI release site. In both 2020 and 2021, Kellogg Creek, a tributary to Redwood Creek, was not surveyed due to landowner access restrictions. It is possible that some RSI origin fish could have moved into Kellogg Creek. Another uncertainty in monitoring the Yellowjacket Creek RSI site is accounting for fish that could have moved downstream into Redwood Creek. The upper section of Redwood Creek as it runs across Knights Valley is highly alluvial and completely dries out in the early summer. CSG attempted to snorkel the upper section of Redwood Creek up to the confluence with Yellowjacket Creek in early May, but that entire section of creek was dry at that time. Snorkeling upper Redwood Creek at an earlier date may provide some clarity to downstream movement of Yellowjacket fish. The lower section of Redwood Creek was surveyed in early May, where an expanded count of 92 coho yoy were observed. It is possible that these fish could have originated from the RSI, but genetic samples were not collected from Redwood Creek in 2021 so we are unable to confirm this downstream movement.

Results seen from the RSI efforts in 2021 are encouraging and have shown that a RSI can contribute a meaningful number of coho yoy to a single tributary in the Russian River. The coho yoy observed in

Yellowjacket Creek represent 17% of all coho yoy observed during Russian River monitoring in early summer 2021 (California Sea Grant 2022). Many of the other streams where coho yoy were observed subsequently went dry. Placing RSIs, which lead to high egg to fry survival, in creeks with favorable characteristics could ensure that those fry, once released, are located in sections of streams that have better summer rearing conditions. This is particularly important in drought years, such as 2021, when many tributaries lacked suitable rearing conditions. Additionally, RSI-released fish have the possible advantages of imprinting, self-reliance for provisioning food, and relying on natural instincts for survival. Continued evaluation of the operation, release strategies, and follow-up monitoring of RSIs in the Russian River would enhance our understanding of these potential benefits.

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