Monitoring to Support Central California Coast Coho Salmon Recovery

Annual Report for National Marine Fisheries Service

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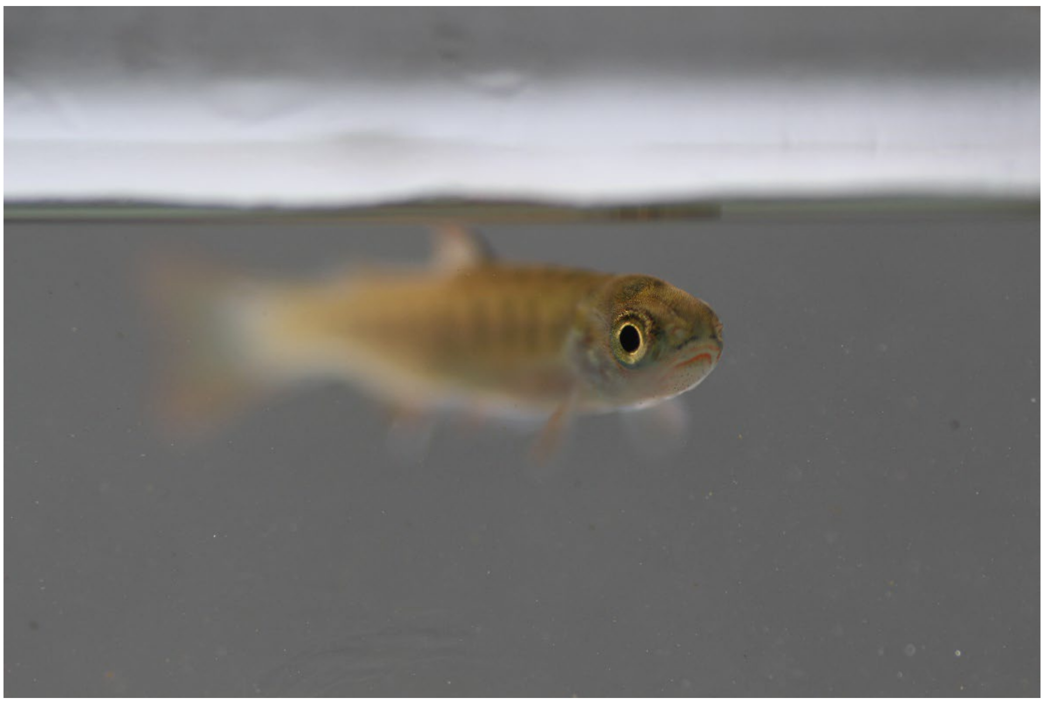

Prepared by:

Will Boucher, Laura Slater, Elizabeth Ruiz, Andrew Bartshire, Andrew McClary, and Mariska Obedzinski

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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 prevent extirpation by supplementing streams with hatchery fish until habitat is restored to a point that it can support self-sustaining runs once again. The US Army Corps of Engineers (USACE) 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 may 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 a remote site incubator (RSI). While raising juvenile coho salmon in the hatchery environment for up to a year bypasses some of the mortality experienced in streams at early life stages, this approach comes at the cost of limited hatchery resources and the potential for increased artificial selection. 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 trout 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), USACE, 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's Russian River watershed. 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, 2021, and 2022, RSI operations and follow-up monitoring surveys were conducted on Yellowjacket Creek, a tributary to Redwood Creek. It should be noted that the RSI on Yellowjacket Creek was located upstream of a 0.22 km restoration project reach, in which a series of step pools were created for the benefit of salmon. This report summarizes the results of the fourth year of RSI evaluation efforts, conducted in 2022.

2. Methods

2.1. RSI operation

During the spring of 2022, with guidance from NMFS, CSG operated an RSI on Yellowjacket Creek, a tributary to Redwood Creek in the Maacama Creek watershed. An estimated 10,083 fertilized eggs were delivered from Don Clausen Fish Hatchery a few days before their anticipated hatch date and placed in a single RSI unit (Figure 1) alongside Yellowjacket Creek on February 28, 2022. The RSI was checked every 2-3 days during operation. The number of dead eggs and 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.

In 2022, two modifications were made to the configuration of the RSI to prevent alevins from flushing out of the incubation tank prematurely. A flow diffuser was added to the inflow pipe of the incubation tank to reduce turbulence within the tank by redirecting incoming flow from a vertical to horizontal orientation as well as dispersing pressure through dozens of smaller holes rather than two larger inputs. The second modification was the addition of a filter to the outflow pipe in the incubation tank. The filter consisted of a PVC extension loop with hundreds of small holes drilled into it (Figure 2), replicating a design developed by Jim Rzegocki (Rzegocki 2010). The high number of holes and increased surface area provided by the extension allowed for reduced suction pressure through each hole. We installed the filter after a majority of the eggs hatched and egg shells had flushed out of the system (around day 10). This filter helped retain alevins within the incubation tank, eliminating the need of transferring them from the live cart tank back to the incubation tank which was required in previous years. The modifications were successful in reducing handling during a sensitive state of development.

When fry were ready for release, they were loaded into aerated backpacks and released at a single location at river km 0.91, which was 0.18 river kms downstream of the RSI (river km 1.09). The release site offered better habitat for fry than the location of the RSI.

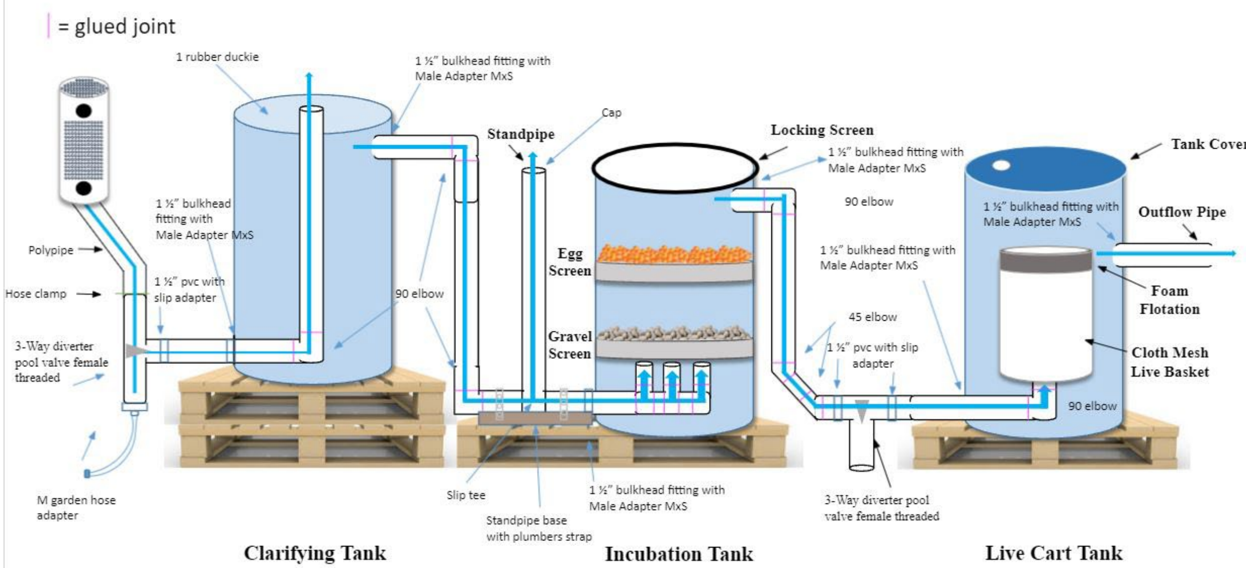

Figure 1. RSI configuration and design. Credit: NOAA


Figure 2. The RSI unit was modified with the installation of a filter on the outflow pipe of the incubation tank around day 10 to prevent the movement of alevin from the incubation tank to the live cart tank.

2.2. Snorkel surveys

During the summer of 2022, snorkel surveys were conducted to document the number and spatial distribution of juvenile salmonids present in the vicinity of the RSI. These surveys were completed after the release of RSI fish in the early spring. Snorkel surveys were conducted in Yellowjacket Creek from river km 0.3 to the upstream extent of anadromy, as limited by a barrier to fish passage. We could not survey the lowest extent of Yellowjacket Creek, from river km 0.3 to the confluence with Redwood Creek due to lack of landowner permission. Because Yellowjacket Creek flows into Redwood Creek and RSI-released fish potentially dispersed there, CSG also conducted snorkel surveys in Redwood Creek from its confluence with Maacama Creek up to its confluence with Yellowjacket Creek at river km 7.15. Lower Redwood Creek (river km 0 – 4.77) was surveyed as part of the California Coastal Monitoring Program (CMP) in the Russian River, funded by CDFW. As per CMP snorkeling protocols, every second pool was snorkeled in that reach. In Yellowjacket Creek and the upper reach of Redwood Creek (river km 4.77 – 7.15), every pool was snorkeled.

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. Divers sampled from the downstream end of each pool (pool tail crest) to the upstream end, surveying as much of the pool as water depth allowed, counting and recording the number of juvenile coho salmon and steelhead present in each pool. All observed salmonids were identified to species and age class based on size and morphological characteristics. In general, salmonids > 100 mm in fork length were considered parr (≥ age-1) and those ≤ 100 mm fork length were considered young-of-year (yoy). Dive lights were used to illuminate dim areas such as undercut banks and under woody debris. Data were recorded in an ArcGIS Survey123 form on a Trimble TDC600 device. A GPS point was collected at the downstream end of each pool snorkeled. Upon return from the field, data were downloaded and error-checked; tabular data were uploaded to CSG's SQL database and spatial data were uploaded to an enterprise geodatabase. Expanded count estimates for the lower reach of Redwood Creek (river km 0 – 4.77) were made by multiplying the minimum observed count by a factor of two because every other pool was sampled. This adjustment was not made for Yellowjacket Creek and the upper reach in Redwood Creek in which every pool was sampled.

2.3. Electrofishing surveys

Electrofishing surveys were conducted in Yellowjacket Creek to capture juvenile coho salmon and collect genetic samples for use in determining whether the fish originated from the RSI release. These surveys were conducted in the late summer after snorkel surveys were complete. Our objective was to obtain a minimum of 100 genetic samples, dispersed according to the distribution of coho salmon observed during snorkeling surveys in Yellowjacket Creek. We used the estimates of fish abundance determined during snorkel surveys to assign proportional genetic sample targets to each pool. If genetic sample targets were not met in a given pool, then electrofishing was conducted in the next upstream pool until the target was met.

Electrofishing surveys were conducted using NMFS' Backpack Electrofishing Guidelines (National Marine Fisheries Service 2000) by crews 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. The condition of captured fish was closely monitored to minimize stress and 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 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 habitat unit number, fish number, species, length, and weight 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 ArcGIS Survey123 form on a Gentac field computer. Upon return from the field, data were error-checked and uploaded to a SQL database.

3. Results

3.1. RSI operation

Of the 10,083 eggs placed into the RSI, 291 eggs were not viable, resulting in a 97% hatch rate (Table 1). After hatching, 387 alevin died, resulting in a 96% alevin survival rate. None of the deaths appeared to be caused by the filter added to the outflow pipe of the incubation tank. Because the live cart tank was left intact, we had the ability to monitor how many alevin left the incubation tank prior to installation of the filter. During that timeframe (day 0-10), only nine alevin left the incubation tank to the live cart tank. These fish were transferred back to the incubation tank.

A total of 9,405 juvenile coho salmon survived, resulting in an overall 93% egg to fry survival rate. Fish were released as unfed fry into Yellowjacket Creek at a single location at river km 0.91 (Figure 3) on

March 29, which was 29 days after the eggs were placed into the RSI. This release date was delayed one day from when fry were deemed ready due to a rain event.

3.2. Snorkel surveys

On May 16 and 17, each of the 145 pools in Yellowjacket Creek were surveyed, and 821 coho salmon yoy, nine steelhead yoy, and 27 steelhead parr were observed.

On May 6, each of the 23 pools in upper Redwood Creek (river km 4.77 – 7.15) were surveyed, and 151 coho salmon yoy and no steelhead were observed.

On July 13 and 14, every other pool in lower Redwood Creek (river km 0 – 4.77) was surveyed. In 28 pools surveyed, 9 coho salmon yoy, 1 coho parr, 99 steelhead yoy, and 127 steelhead parr were observed.

3.2.1. Coho salmon

Coho salmon were present in 50 of the 145 pools sampled in Yellowjacket Creek, averaging 16 coho yoy/pool in the pools where they were present. Most of these observations (49) occurred in the 52 pools located downstream of the RSI release location (Figure 3). A majority of the coho salmon (487/821, 59%) were observed in pools located downstream of the restoration project. Only six coho salmon yoy were observed in a single pool upstream of the RSI release location, with the furthest upstream movement of 0.02 km.

In Redwood Creek, a total of 160 coho salmon yoy were observed, with an expanded estimate of 169 fish (Figure 4). No coho salmon yoy were observed in the lower third of Redwood Creek.

3.2.2. Steelhead

Steelhead were present in 28 of the 145 pools sampled in Yellowjacket Creek, though densities were low (Figure 5). In Redwood Creek, a total of 99 steelhead yoy and 127 steelhead parr were observed, for an expanded estimate of 198 steelhead yoy and 254 steelhead parr. All steelhead were present in the lower two reaches of Redwood Creek.

3.3. Electrofishing surveys

Electrofishing surveys were conducted on August 29 and 30 in Yellowjacket Creek. A total of 42 pools were sampled (Figure 6). Capture totals consisted of 217 coho salmon yoy, 8 steelhead yoy and 5 steelhead parr. No tags (CWT or PIT) were detected in any of the captured fish from Yellowjacket Creek.

The average fork length of coho salmon was 64 mm and average weight was 3.8 g. Coho salmon captured in Yellowjacket in 2022 were on average larger than those captured in 2021 but smaller than the average size observed in 2020 (Table 2).

Genetic samples were collected from 120 coho salmon yoy. All genetic samples were cataloged and delivered to NOAA’s Southwest Fisheries Science Center.

Table 1. Summary of coho salmon survival during rearing in a RSI adjacent to Yellowjacket Creek, 2020-2022.

	2020	2021	2022
Eggs loaded (n)	10,205	20,004	10,083
Dead eggs (n)	101	697	291
Hatch rate (%)	99%	97%	97%
Dead alevin (n)	157	1,150	387
Egg to fry survival (%)	98%	91%	93%
Released fry (n)	9,947	18,157	9,405

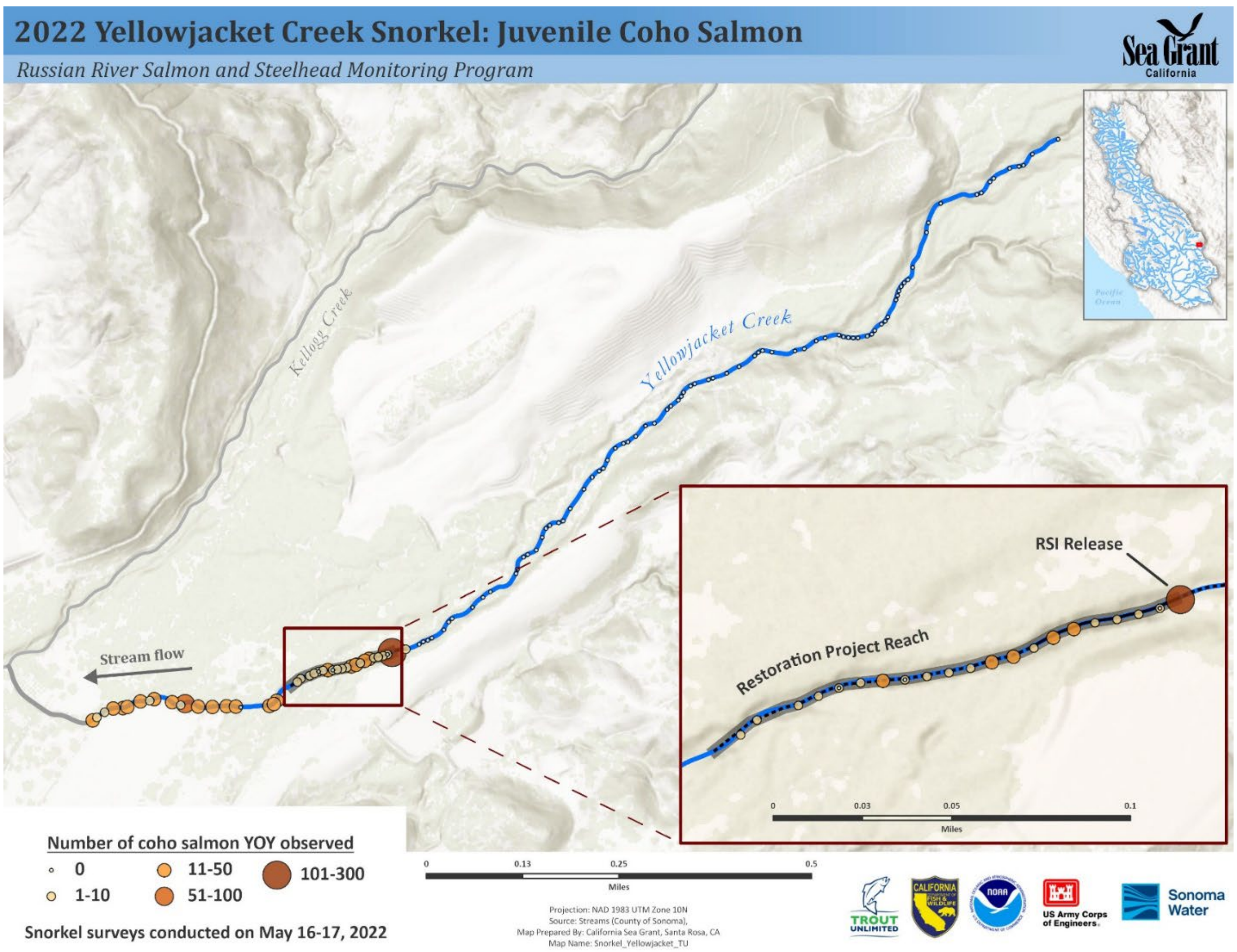

Figure 3. Juvenile coho salmon density and distribution in relation to RSI release location in Yellowjacket Creek, 2022.

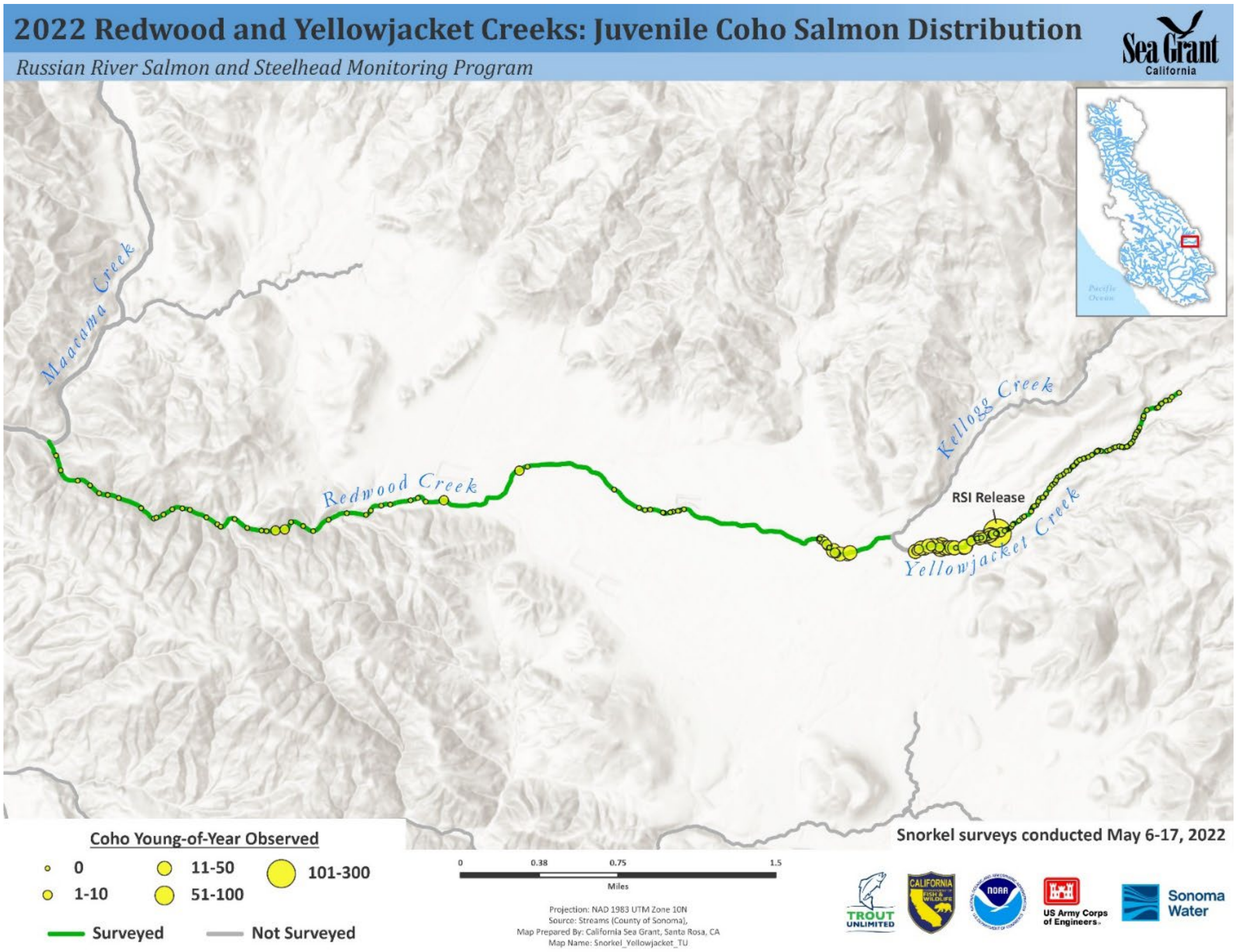

Figure 4. Juvenile coho salmon density and distribution in Yellowjacket and Redwood creeks, summer 2022.

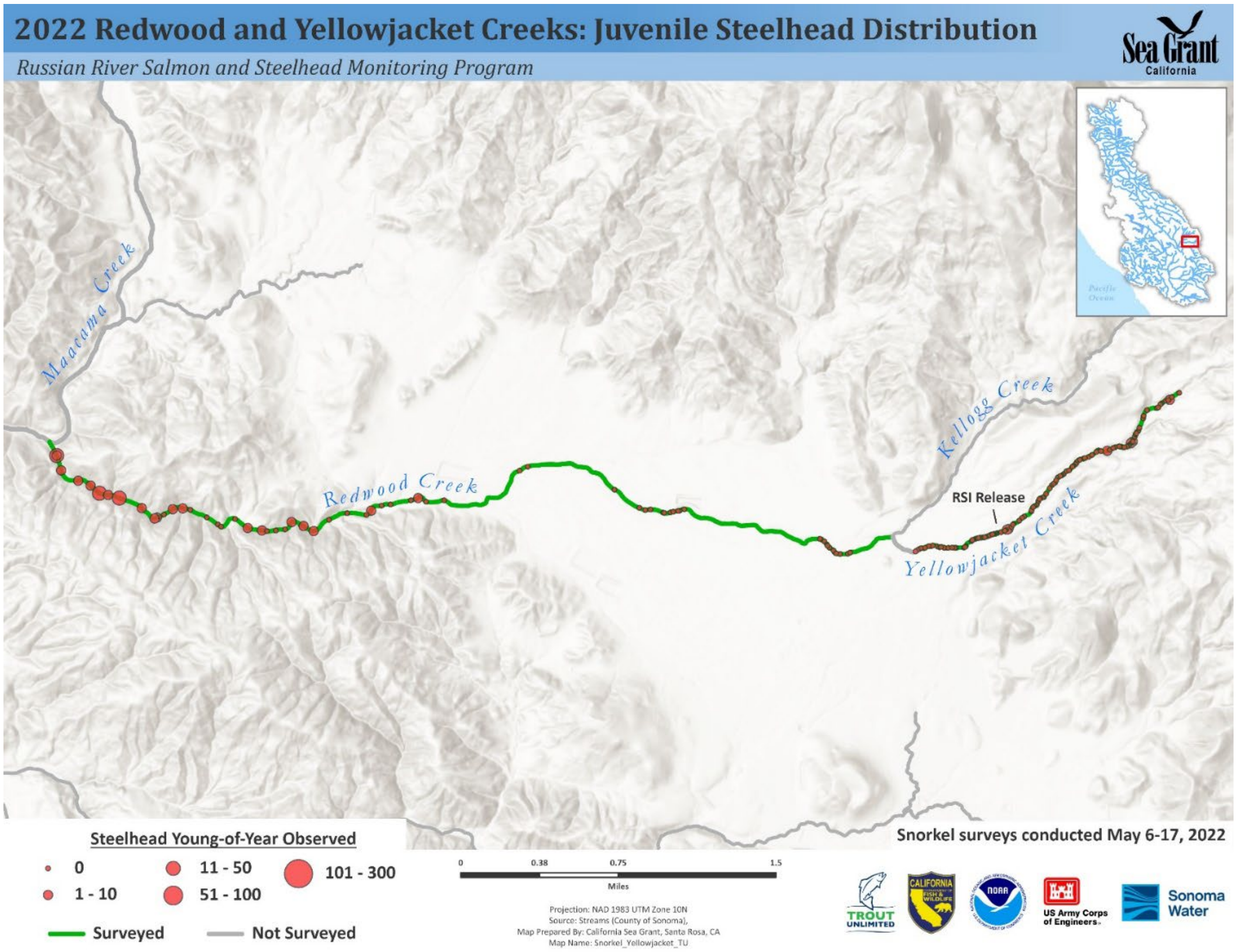

Figure 5. Juvenile steelhead density and distribution in Yellowjacket and Redwood creeks, summer 2022.

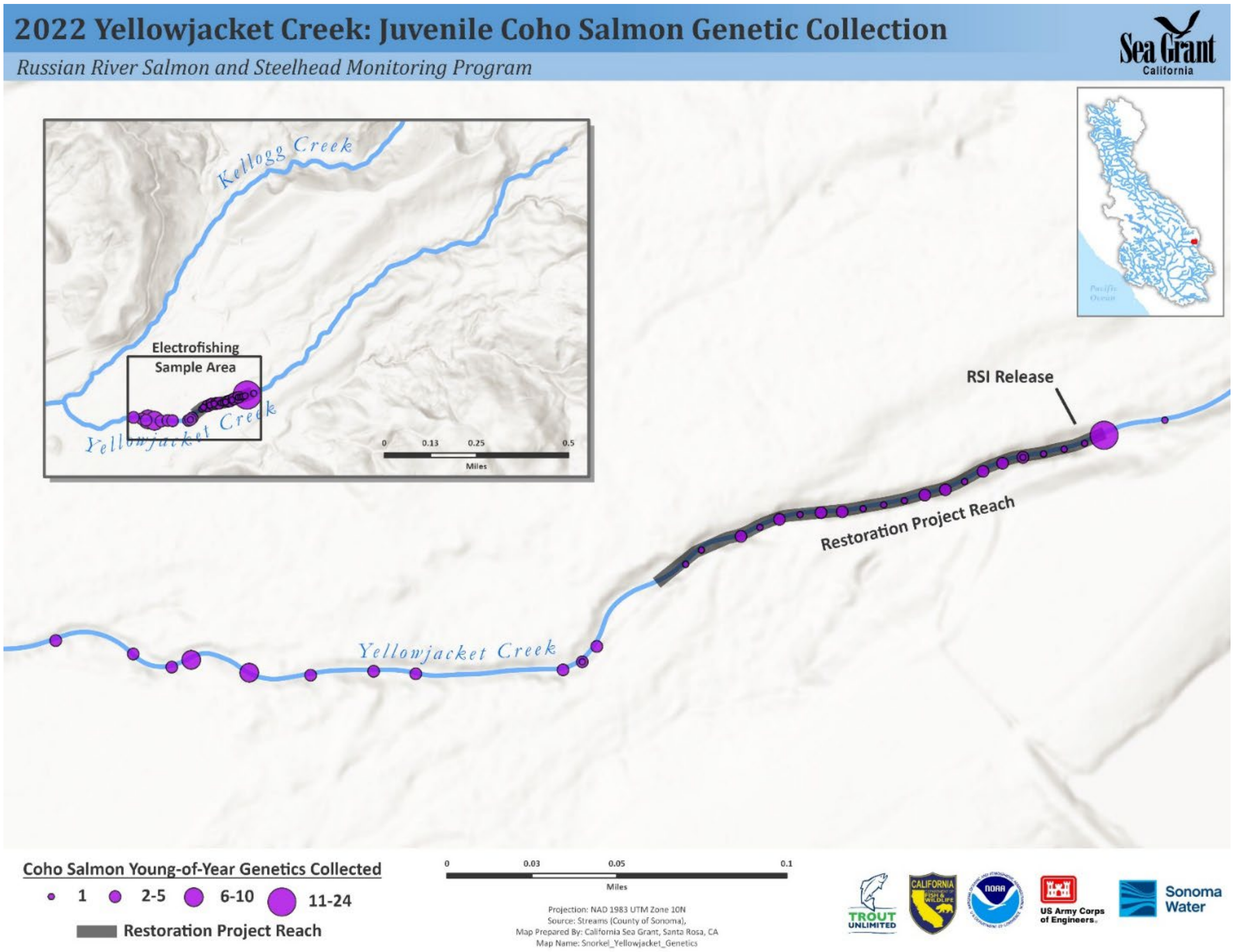

Figure 6. Density and distribution of coho salmon genetic sample collection in Yellowjacket Creek, 2022

Table 2. Average fork length and weight of unmarked juvenile coho salmon yoy captured during electrofishing surveys in Yellowjacket Creek, 2020-2022.

Year	Sampling Dates	Coho salmon captured (n)	Average fork length (mm)	Average weight (g)
2020	9/14 - 9/16	127	71	4.3
2021	9/27 - 9/29	147	62	2.9
2022	8/29 - 8/30	217	64	3.8

4. Discussion

4.1. RSI operation

Modifications to the configuration of the RSI in 2022 appeared to have positive impacts on operations. The addition of the flow diffuser distributed incoming flow through dozens of small holes rather than two large inputs and also redirected flow from a vertical to horizontal orientation. Flow through the system (gallons per minute) remained the same, but ambient conditions appeared to be less turbulent. The filter added to the outflow pipe of the incubation tank adequately resolved an undesirable occurrence documented in prior years of RSI operation, namely alevin leaving the incubation tank prematurely (California Sea Grant 2022b). Premature departure was defined as fish with intact yolk sacs (alevin) that could not swim freely in the water column leaving the incubation tank. These fish were not ready for release, and the live cart tank was not suitable for long-term retention of fish, so in prior years these fish were moved by hand back to the incubation tank. Adding the filter reduced handling of fish and efficiency of RSI operation (through reduced time spent by field crews on RSI operation). Another critical component of the filter use is the timing of installation. The size of hole needed to retain alevin within the incubation tank is too small for passage of egg shells. We recommend installing the filter after the hatch is complete and a majority of the egg shells have flushed out of the system. Installing the filter too early could result in a clogging of the outflow pipe and possible overflowing of the incubation tank. Although a few alevin left the incubation tank prior to installing the filter, we believe this to be a minimal loss compared to the risk of the filter clogging during this time because alevin at this lifestage tend to stay near the gravel at the bottom of the incubation tank.

PIT-tag detection systems in other Russian River tributaries have shown that hatchery fish may move downstream quickly after release, and sometimes these downstream migrations have coincided with high flows surrounding a rainfall event (California Sea Grant 2021a). For those reasons, the RSI release in 2022 was delayed one day due to a 1” rain event that occurred during the planned time of release. Lower Yellowjacket Creek and sections of upper Redwood Creek have a tendency to dry during summer months, and we wanted to discourage a potential downstream migration to those less desirable sections of creek. Similar to 2021, RSI fish were loaded into an aerated backpack and released at a single site downstream that offered a long, shallow pool with slower stream velocities and backwater habitat. We recommend during future RSI site selection considerations, release location is selected with the option for fish release to occur on site, either volitionally from the RSI or by hand, to eliminate the need to move fish in aerated backpacks.

Due to reduced hatchery production, the number of eggs loaded in the RSI in 2022 was reduced by nearly a half relative to 2021 but were similar to numbers in 2020 (Figure 7). During each year of RSI operation in Yellowjacket Creek, hatch rate has been at least 97%. Egg to fry survival in Yellowjacket Creek has exceeded 90% over three years of RSI operations. Survival was lowest in 2021 due to an equipment malfunction resulting in the fatality of approximately 1,000 fry. Egg to fry survival of natural-origin coho salmon in the Russian River watershed is unknown, but in years of low precipitation and streamflow, redds have been observed drying during the timeframe of expected egg development (California Sea Grant 2022a). Use of RSIs can provide additional capacity for providing hatchery fish to systems with low or variable survival of natural-origin fish during early life stages.

4.2. Post-release monitoring

The presence of coho salmon in Yellowjacket Creek suggests 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 821 coho salmon yoy were observed in Yellowjacket Creek. 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 coho salmon yoy observed during snorkel surveys were from the RSI. In Redwood Creek, an estimated 169 coho salmon yoy were observed, with fish predominately distributed in the upper extent of the creek (Figure 4). No genetic samples were collected from Redwood Creek in 2022. However, if genetic results from Yellowjacket Creek confirm RSI origin, it is likely some or all fish in Redwood were also of RSI origin.

A release of 18,157 coho salmon fry from the RSI in 2021 resulted in 896 coho salmon yoy observed in Yellowjacket Creek during summer snorkel surveys (California Sea Grant 2022b). Interestingly, a release of nearly half the number of fry (n = 9,405 fry) from the RSI in 2022 resulted in a similar number of yoy (n = 821 yoy) observed in Yellowjacket Creek during summer snorkel surveys. However, this is in contrast with lower number of yoy (n = 166 yoy) observed in Yellowjacket Creek in 2020, even though release numbers were similar to those in 2022 (n = 9,947 fry) (California Sea Grant 2021b) (Figure 7). With similar egg to fry survival across the three years of operation in Yellowjacket Creek (Table 1), the differences in summer yoy counts are likely driven by post-release factors. We suspect that the lower survival of coho in 2020 as compared to 2022 was due to a less-suitable release location in 2020. Higher stocking densities may explain the lower survival in 2021. It is possible that releasing 18,157 coho salmon fry in 2021 at single location resulted in increased competition, decreased fitness, and decreased in-stream survival. Future studies evaluating the association between release numbers and summer yoy counts may improve understanding of factors influencing survival.

Results from the RSI study in Yellowjacket Creek are encouraging and demonstrate that the RSI release strategy can contribute towards coho production. Care should be taken in selecting RSI sites that have high-quality rearing habitat to ensure high oversummer survival. This is particularly important in drought years, where many Russian River tributaries lack suitable rearing conditions. Although releasing fish into the streams at an earlier life stage is bound to result in higher juvenile mortality than fish held in the hatchery to the smolt stage, it does have the benefit of exposing fish to a longer period of natural selection. For the Russian River Broodstock Program, we recommend use of the RSI release strategy when the number of eggs available at the hatchery exceeds the capacity of fish that can be raised to fall and smolt life stages. Continued evaluation of the operation, release strategies, and follow-up monitoring of RSIs in the Russian River would enhance our understanding of these potential tradeoffs of the RSI strategy.

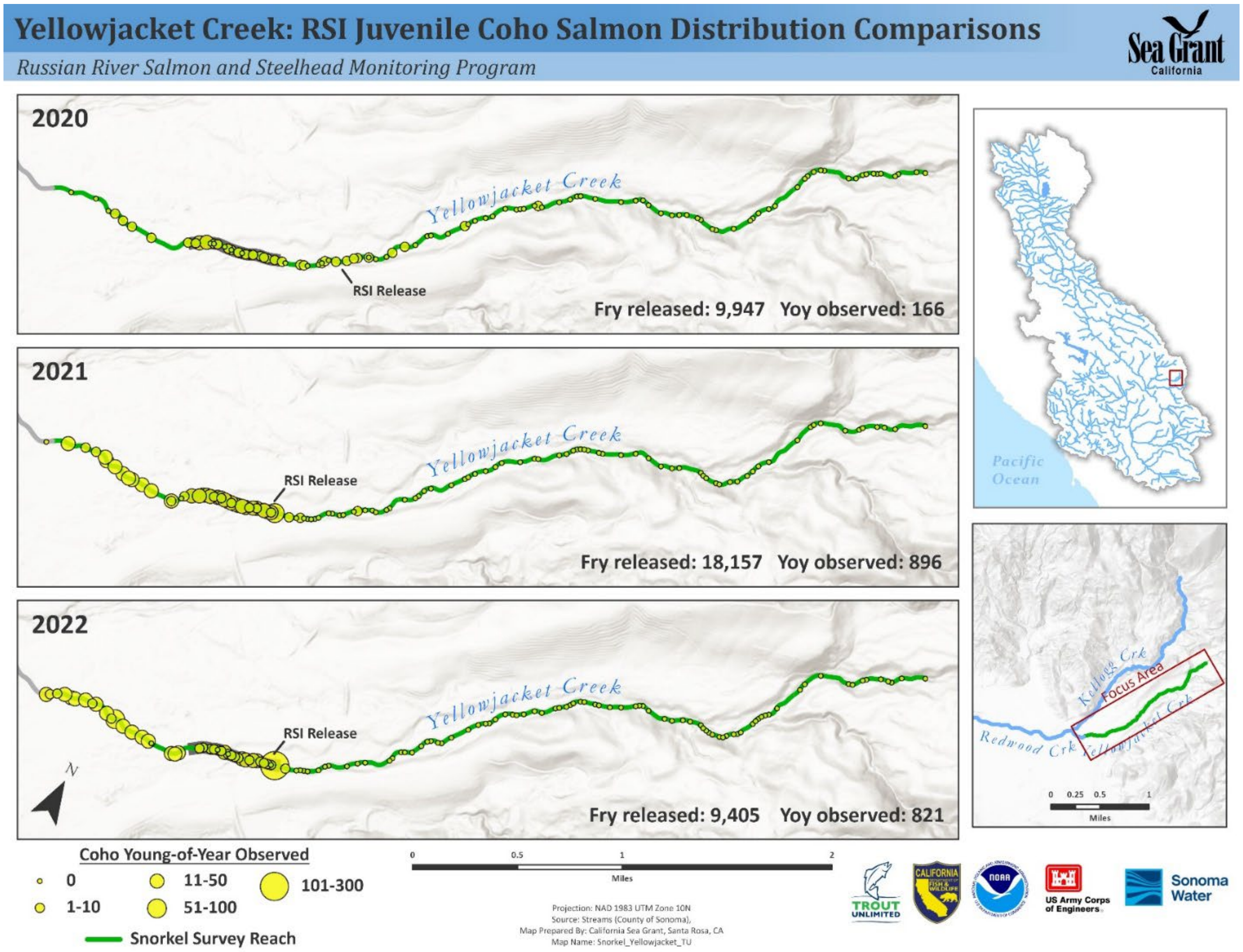

Figure 7. Comparison of coho salmon yoy density and distribution in Yellowjacket Creek from 2020 through 2022.

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