Russian River Monitoring Program - FP-00351
Grant Number: P2281002
Sonoma County Water Agency
July 1, 2022 – June 30, 2023

California Coastal Salmonid Population Monitoring in the Russian River Watershed: 2022/2023

FRGP Grant #P2281002; Annual Report
Reporting Period: July 1, 2022 – June 30, 2023

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Overview

On July 1, 2022 Sonoma Water (SW) and California Sea Grant (CSG) began implementation of a new contract that continues work begun in 2013 to monitor anadromous CCC Coho Salmon, CCC steelhead, and, to a lesser extent, CC Chinook Salmon in the Russian River watershed. Work was implemented in accordance with California Department of Fish and Wildlife (CDFW) Fish Bulletin 180, the California Coastal Salmonid Population Monitoring Plan (CMP, Adams et al. 2011). The CMP uses the Viable Salmonid Population (VSP; McElhany et. al. 2000) concept to assess salmonid viability in terms of four key population characteristics: abundance, productivity, spatial structure, and diversity. To accomplish CMP goals, we performed basin-wide spawner surveys, basin-wide snorkel surveys, and operated life cycle monitoring stations (LCS) in four life cycle monitoring (LCM) streams to measure status and trends in anadromous Coho and steelhead populations in the Russian River basin. With data generated from these field efforts, we estimated basin-wide adult Coho and steelhead abundance, basin-wide spatial structure of juvenile Coho, freshwater survival of successive cohorts of Coho and steelhead in LCM streams, and marine survival of successive cohorts of Coho and steelhead in LCM streams within the Russian River watershed.

This annual report provides a summary of salmonid abundance at multiple life stages and at multiple spatial scales. We estimated Coho and steelhead smolt, adult and redd abundance in four streams (one LCS per stream) and basin-wide redd abundance using spawner survey data collected from a GRTS-ordered random sample of reaches throughout all reaches containing habitat for both Coho and steelhead. Sonoma Water also operated a LCS at the Mirabel dam site on the mainstem Russian River at rkm 39.67 aimed at assessing status and trends of Chinook Salmon smolt and adult abundance. For juvenile Coho, spatial structure in the Coho-steelhead sample stratum was estimated using snorkel counts from a GRTS-ordered random sample of reaches. Juvenile steelhead abundance was estimated using a modified basin-wide visual estimation technique (BVET) in the four LCM streams. The goal of this annual report is to keep CDFW and other interested parties informed of the tasks accomplished in accordance with the primary activities and deliverables outlined in FRGP Grant # P2281002. Related monitoring data conducted by CSG but funded by non-FRGP sources is reported in CSG (2004-2023).

Report Status

a) The funding agreement for this project was executed on June 21, 2022 and Amendment 1 was executed on July 21, 2023. The term of the grant is July 1, 2022 – June 30, 2025. The agreement between Sonoma Water and Regents of the University of California was executed on August 10, 2022.
b) This report covers: continuous PIT antenna monitoring, downstream migrant trapping conducted in spring 2022, snorkel surveys conducted in 2022, electrofishing surveys conducted in 2022, and spawner surveys conducted during the 2022/23 spawner season.
c) Issues or concerns affecting schedule and/or budget: None

d) Activities for next annual reporting period:
    a. Monitoring coordination and Planning
    b. Adult monitoring
    c. Juvenile and Smolt monitoring
e) Financial Reporting/Invoices:

An invoice for work through June 30, 2023 will be submitted in July 2023, in the amount of $200,145.35.

Task Updates

Task 1. Monitoring Coordination and Planning

This task includes:

- overall project coordination and oversight of field activities;
- QA/QC of data;
- spatial and tabular database management and data accessibility;
- refinement of the Russian River sample frame;
- responding to data requests, map preparation and reporting;
- coordination with existing monitoring efforts in the watershed;
- participation in technical advisory meetings.

General monitoring coordination and planning tasks were performed throughout the reporting period and included contacting landowners, scheduling field crews and coordination of field activities associated with spawner surveys, snorkel surveys and electrofishing surveys. Prior to each season of field work, educational materials were provided to crews and trainings were coordinated to train new technicians and familiarize existing field staff with updates to survey protocols. Fish identification, survey techniques, field safety, and a short course in tablet computing were also components these trainings. After the completion of each season of field work, monitoring data were error checked, uploaded to tabular and spatial databases, and final estimates of redd and adult abundance, smolt abundance, and juvenile spatial structure were calculated for LCM streams (Coho Salmon and steelhead) and mainstem Russian River (Chinook Salmon). Data were shared with local CDFW staff for purposes of fish rescue, Coho Salmon broodstock collection and drought stressor monitoring. Data were also shared with habitat restoration practitioners including local Resource Conservation Districts and Trout Unlimited. On May 23, 2023 a meeting of the Russian River CMP Technical Advisory Committee was convened so that SW and CSG could provide updates and receive technical advice and guidance about implementing CMP in the Russian River basin. The meeting was attended by over 20 participants from multiple agencies with interest in Russian River fish populations.

Because the Russian River watershed is over 90% privately owned, obtaining landowner access permission and tracking landowner communications is also an important component of project coordination. In total, over 480 contacts were made during the current reporting period by phone, email, and personal communication to gain access from 128 new and existing landowners for the 2022/23 spawner season. All landowner contact records, contact information, response information and details about landowner preferences are stored in a relational database designed for that purpose. During spawner, snorkel and electrofishing seasons, parking spots, entry points, details of landowner access, and other miscellaneous information were recorded and updated by crews using Survey 123 (Esri) forms and stored in a relational database ready access when planning field surveys.

Task 2. Life Cycle Monitoring

Introduction

This task and the associated data reported here includes:

- spawner surveys conducted during the 2022/23 spawner season in the four Coho-steelhead LCM streams (paid for by non-project funding sources through February 28);
- PIT antenna monitoring for adults and juveniles in the four Coho-steelhead LCM streams (paid for by non-project funding sources);
- downstream migrant trapping conducted in spring 2022 at five life cycle stations (LCSs) (paid for by non-project funding sources);
- basinwide visual estimation technique monitoring during late summer 2022 in the four Coho-steelhead LCM streams.

The objective of CMP life cycle monitoring is to detect trends in abundance of smolts and adults (Adams et al. 2011). The streams we selected for life cycle monitoring for Coho Salmon and steelhead are: Mill Creek (including Felta and Palmer Creeks), Green Valley Creek (including Purrington Creek), Dutch Bill Creek and Willow Creek (Figure 1). These sub-watersheds were chosen for Coho and steelhead LCM because of the substantial monitoring infrastructure already in place and because of long-term datasets for juvenile and adult Coho abundance collected by CSG as part of Russian River Coho Salmon Captive Broodstock Program monitoring. Life cycle monitoring for Chinook was conducted on the mainstem Russian River at Sonoma Water's Mirabel dam (Figure 1). This site also has long-term datasets for smolt and adult Chinook abundance from monitoring infrastructure already in place.

We conducted census spawner surveys in Green Valley, Dutch Bill, and Willow creeks and near-census spawner surveys in Mill creek to estimate Coho and steelhead redd abundance. We operated PIT antenna arrays on all four Coho and steelhead LCM streams to estimate adult Coho abundance.

We estimated Coho and Chinook smolt abundance using downstream migrant trapping methods similar to those described in FB 180. We operated downstream migrant traps (DSMT) on Mill Creek (rkm 2.00), Green Valley Creek (6.04 rkm), Dutch Bill Creek (rkm 0.28), and Willow Creek (rkm 3.69) for Coho smolts and at Sonoma Water's Mirabel dam site (rkm 39.67) on Russian River mainstem for Chinook smolts (Figure 1). Based on past experience, in most years it is possible to generate robust estimates of Coho and Chinook smolt abundance from DSMT alone because Coho and Chinook smolt migration typically occurs from March through June which coincides with a period when DSMTs can be successfully installed and operated.

A significant issue with relying on downstream migrant trapping for steelhead smolt abundance, however, is the fact that steelhead smolt migration occurs well before DSMTs can be safely installed and operated. If we were to rely on DSMTs alone, steelhead smolt abundance would be severely underestimated. To avoid this underestimation, we combined data from DSMTs with outputs from a pre-smolt steelhead abundance and survival model (SW and CSG 2015). This approach relies on steelhead smolt abundance estimates generated from late summer/early fall abundance estimates coupled with efficiency-adjusted detections of PIT-tagged steelhead at stationary PIT antenna arrays near the mouths of LCM streams throughout the ensuing winter. We began implementing this smolt model in Mill Creek in summer/fall 2018, and Green Valley, Dutch Bill and Willow Creeks in summer/fall 2019 and have been successful in detecting years with poor steelhead survival but producing quantitative estimates of steelhead smolt abundance has not always been possible.

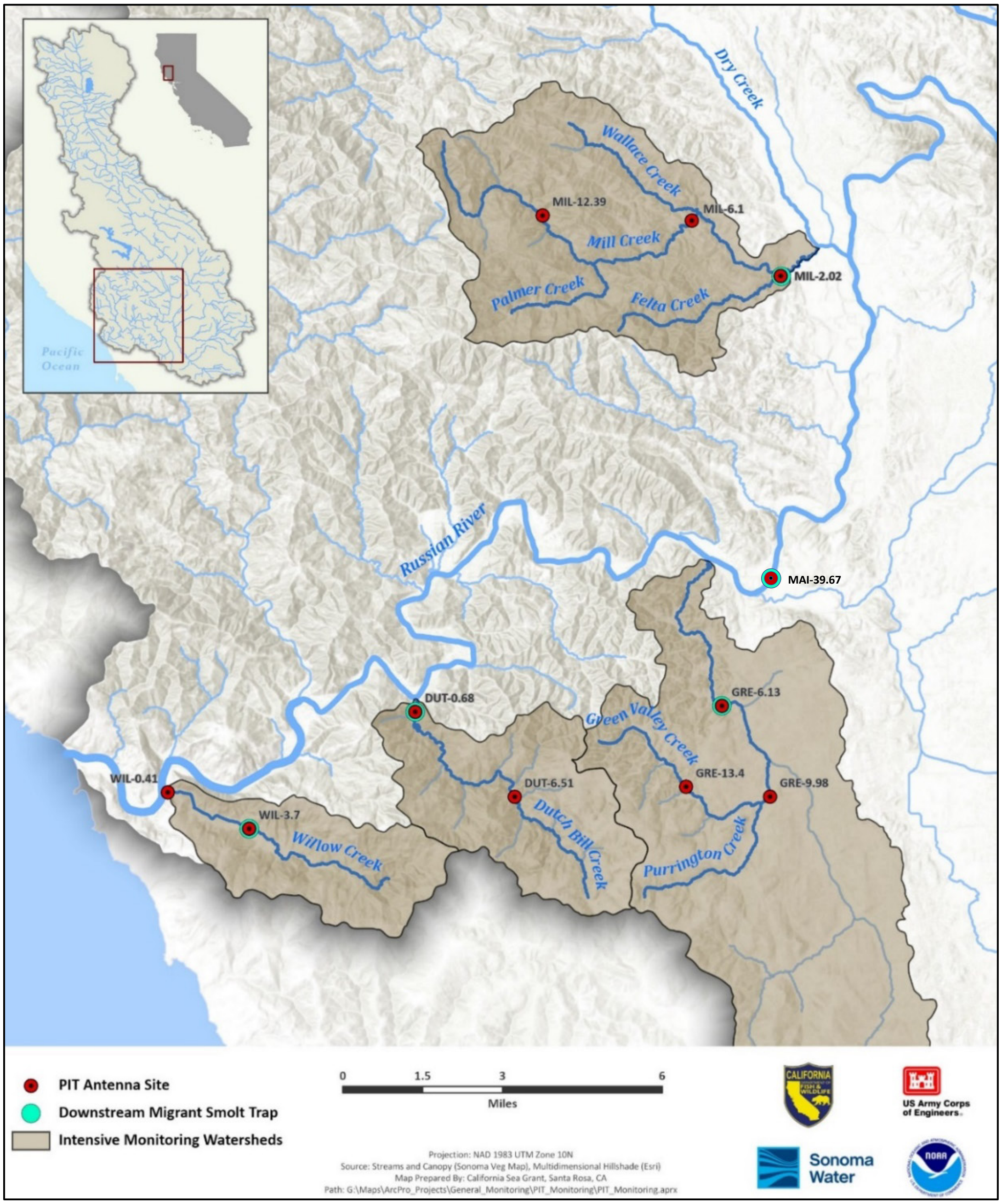


Figure 1. Coho Salmon and steelhead LCM watersheds (shaded polygons) and stationary PIT antennas. Blue line segments represent reaches containing habitat for one or more species

Methods

Redd abundance (Coho Salmon and steelhead)

We used protocols outlined in Adams et al. (2011) and Gallagher et al. (2007) to survey all LCM streams and recorded salmonid redds, live adult fish, and carcasses (excluding some reaches and portions of reaches in Mill Creek where we were unable to secure landowner access). We attempted to sample reaches every 10-14 days, though storms and heavy rains (and subsequent turbidity) prevented crews from surveying at times. Our survey start dates coincided with the first rains of winter sufficient to connect tributaries to the mainstem. The minimum visibility threshold for surveys was 0.5 m though some surveys were completed below this threshold depending on the size of the stream and if crews thought they could effectively identify redds and fish. Reaches were surveyed by two observers walking the reach from a downstream to upstream direction. When a redd was encountered it was measured (±0.1 m), marked with flagging, and a GPS location was recorded. Each redd was assigned a unique identification number. When live fish were encountered, species, length and condition were estimated. When carcasses were encountered, they were measured (±0.1 mm) and identified to species if possible. To avoid double-counting. carcasses were tagged with a metal hog tag on a piece of wire punched through the skin and around the spine just posterior of the dorsal fin. If possible, scale samples were collected and heads were removed for otolith collection. All carcasses, regardless of species, were scanned for PIT tags, coded wire tags (CWT), and examined for any fin clips or other markings that might indicate hatchery origin. GPS locations were collected for all live fish and carcass observations.

The species responsible for constructing a redd ("redd species") as well as the observer's confidence in that species assignment (redd "species certainty") was assigned to each redd observed in the field based on the presence of live fish associated with the redd, or observed field characteristics of the redd that were indicative of a certain species. We defined "association" between a fish and a redd strictly on the basis of whether the individual was exhibiting digging and/or guarding behavior adjacent to a redd. Redd species certainty was assigned as follows:

Certainty 1. Certain:

- one or more live adult(s) associated with the redd that the crew can positively identify to species.

Certainty 2. Somewhat certain:

- one or more live adult(s) associated with the redd but the crew could not positively identify to species;
- no live adults associated with the redd, but based on redd characteristics redd species can be inferred.

Certainty 3. Uncertain:

- no live adults associated with the redd and/or redd characteristics to indicate species were unclear.

Similarly, we assigned species certainty (1=certain; 2=somewhat certain; -9999=uncertain) to observed live adult salmonids and carcasses.

Upon classification of redd species in the field, we sought to make a final redd species assignment at the end of the season. First, we evaluated the method of redd species classification recommended by Adams et al. (2011) and described in Gallagher and Gallagher (2005) and Gough (2010). This method uses logistic regression models to classify unknown redds based on redd area and date of first observation. This method was generally useful in distinguishing Coho redds from steelhead redds, but it incorrectly classified 100% of known

Chinook redds as Coho redds. Consequently, this led to an inflated Coho redd abundance estimate. Because this and other redd species classification methods appeared biased for the Russian River, we decided to use a hybrid approach:

1. Observer redd species was assigned as the final redd species:
    a. for all observer certainty 1 redd species (i.e., species identification was possible and fish species certainty=1 for one or more fish associated with the redd);
    b. for any redd identified by the field crew as Chinook regardless of certainty level.
2. Estimated species from the Gallagher/Gough logistic regression equations was assigned as the final redd species for remaining redds where redd species certainty was 2 or -9999 and redd measurements were made.

If field crews never observed a certainty 1 fish species associated with a redd and if measurements were never taken, (which would make estimation with Gallagher/Gough logistic equations impossible), we used a method whereby fisheries biologists familiar with life-histories of salmonids in the watershed assigned redd species based on the closest certainty 1 fish in space and time. Since this situation only occurred when the crew could not get measurements on a redd (because fish were present), but also could not positively identify fish on a redd, this method was rarely used (the number of redds classified in this way never exceeded 2% in a season).

Once all redds were classified to species using the method described above, we estimated within-reach redd abundance following the methods of Ricker et al. (2014). These methods are based on the Jolly-Seber capture-mark-capture model to allow for the estimation of redd abundance by making assumptions about the recruitment process and mark-recapture survival estimates of redds between sampling occasions. Estimated redd survival is then used to account for redds that are constructed and obscured between survey occasions (meaning they were never actually observed). The estimation of total redds constructed within a survey reach can be described as a flag-based open population mark-recapture experiment in which redds are (1) individually identified and marked with unique redd IDs upon first observation; (2) recaptured (resighted) on subsequent survey occasions. The population of redds is considered open because new redds are recruited into the population when they are constructed, then removed from the population when they become obscured and therefore no longer visible. We estimated total abundance of redds in the four LCM tributaries using the simple random estimator described in Adams et al. (2011). Additional detail can be found in Ricker at al. (2014).

We attempted to survey all reaches in the four LCM tributaries containing habitat for Coho and steelhead. However, in Mill Creek and its tributaries (Felta, Wallace, and Palmer) there were three full reaches and sections of two other reaches that we could not survey due to lack of landowner access. Despite this they were included in the estimation of total redd abundance in Mill Creek as follows. For the two unsurveyed stream sections, redd density (redds$\cdot$km^{-1}) was calculated in the surveyed sections and the product of redd density and reach length (km) was used to estimate the number of redds in the unsurveyed sections. The estimated redd abundance for each unsurveyed stream section was then added to the estimate for the surveyed section in the reach to arrive at an adjusted redd abundance for each reach.

Estimates of total redds in these unsurveyed sections were calculated prior to calculation of total redd abundance. Within-reach variance could not be calculated for these unsurveyed reaches so they were not included in the calculation of total standard error of the total redd estimate for the Mill Creek watershed.

Adult abundance

Coho Salmon adults- PIT tagging of hatchery origin Coho smolts has occurred at the Don Claussen Fish Hatchery at Warm Springs Dam in some capacity since 2007. PIT-tagged fish are released into several Russian River tributaries, including the four LCM tributaries. In addition, we applied PIT tags to approximately 50% of all natural-origin Coho Salmon smolts captured in downstream migrant traps on LCM streams. PIT-tagged fish are subject to detection when they return as adults at stationary PIT tag detection systems at a network of PIT antenna arrays including near the mouths of the four LCM streams (Figure 1). Because these systems contain pairs (Mill, Green Valley, Dutch Bill creeks) or triplet (Willow Creek) antennas within an array that are oriented longitudinally along the stream channel, we can use detections on antennas within an array to estimate antenna efficiency. Antenna efficiency estimates are then used to expand the number of PIT antenna detections. Because we know the tagged to un-tagged ratio of juvenile/smolt Coho in the source population (i.e., at the hatchery or at downstream migrant traps), we can then use that ratio for a final expansion to arrive at an estimate for all adults returning to each LCM. We use a similar approach to estimate adult steelhead abundance in LCM streams, but this requires a significant juvenile steelhead PIT tagging effort in the fall (because of the lack of a large pool of PIT-tagged hatchery fish). A significant tagging effort was accomplished in Mill Creek in 2017 and 2018, but this effort was not begun until 2019 in other LCM tributaries.

Estimates of the number of adult Coho Salmon returning to LCM creeks were calculated by 1) counting the number of unique adult PIT tag detections on the lower antennas of each antenna array (minimum count), 2) dividing the minimum count for each stream by the proportion of PIT-tagged fish either released from the hatchery into each respective stream or tagged at the smolt trap (expanded count per stream), and 3) dividing the expanded count by the estimated efficiency of the lower antennas of each stream array (estimated count per stream). The efficiency of the lower antennas of each paired antenna array was estimated by dividing the number of detections on both upstream and downstream antennas by all detections on the upper antennas. Individual data recorded at the time of tagging was used to estimate the number of returns by release group (age and season of release). Spawner to redd ratios were calculated by dividing adult abundance estimates by redd abundance estimates for each creek.

Steelhead adults- Adult steelhead detections rely on steelhead that were tagged as juveniles surviving to the smolt stage, emigrating from their natal stream, surviving to enter the ocean, surviving the marine rearing phase, and returning to the system where PIT antennas can detect them. Given the greater variability in life history strategies (e.g., age at smolting, length of estuary and marine residence, etc.) as compared to Coho, the age at which steelhead smolt and return as adult is not predictable. We make use of PIT tag detection records to sort this out as follows. First, individuals are classified as potential smolts when they are detected traveling downstream during the smolt migration season (December-May). This comes mainly from antenna detections of PIT-tagged fish at locations downstream of their tagging site but could come from captures at downstream migrant traps. Individuals are classified as potential adult spawner migrants when they are detected traveling upstream during the spawning season (October-May) after having been absent from the PIT detection record (days at large) for 9 months or longer.

Chinook Salmon adults- The adult counting station for Chinook is located on the mainstem Russian River at Sonoma Water's inflatable dam in Forestville (river km 39.67). Instead of PIT tags and PIT antennas. we use a continuous underwater video monitoring system in the fish ladder to count Chinook adults returning to the Russian River basin as they pass upstream of the Mirabel dam through a fish ladder. This site is downstream of habitat that the vast majority of Chinook spawners use (Chase et al. 2007) and, in most years, the system is operated late enough into the season to encompass the majority of fish migrating past the dam. The monitoring system consists of an underwater video camera at the upstream end of a fish ladder located on the west side of the inflatable dam (prior to 2020, there were two fish ladders – one on each side of the inflatable dam site). The video system operated continuously throughout the majority of the adult Chinook migration period except for brief periods (seconds to minutes) when the camera was inoperable (e.g., due to power outages). All data were reviewed by technicians and counts of fish moving upstream trough the ladder were recorded in a database. Installation of the video system occurred in early September prior to the onset of adult migration and removal occurred when Sonoma Water's inflatable dam was lowered for the season.

Smolt abundance

Coho Salmon smolts- Downstream migrant traps (funnel and/or pipe) were operated on Mill, Green Valley, Dutch Bill, and Willow Creeks and a rotary screw trap was operated on mainstem Russian River during the spring when the majority of the Coho and Chinook Salmon smolt outmigration occurs and when the flows are conducive to safe trap operation. Traps were tended daily with additional checks during peak outmigration and when flow and/or debris load was high. PIT tags were applied to individuals and data were collected in order to assess smolt abundance at LCM stations, population diversity, and to facilitate future estimation of marine survival and adult abundance. Specific protocols for fish handling, work-up, and PIT-tagging for Mill, Green Valley, Dutch Bill, and Willow Creeks can be found in CSG (2021a).

A two-trap mark-recapture design and analytical methodology was used to estimate the total number of Coho Salmon smolts emigrating from each creek during the trapping season during the time when traps were in (Bjorkstedt 2010). An antenna array located immediately upstream of each smolt trap acted as an upstream "trap" where fish were "marked" (marked fish=all PIT-tag detections on antenna array), and the smolt trap served as a downstream trap where fish were recaptured. PIT-tagged fish detected at both the antenna array and captured in the trap were considered recaptures, and non-PIT-tagged fish and PIT-tagged fish only detected in the trap (but not the antenna) were considered unmarked fish.

Steelhead smolts- For steelhead smolt estimation each year in LCM streams, we attempt to employ a smolt abundance model that is founded on abundance estimates of juvenile steelhead in a given LCM stream in late summer/fall prior to a given steelhead smolt emigration season. Estimates are from two-stage sampling following a modified basin-wide visual estimation technique (BVET) of Hankin and Reeves (1988). The first stage is visual sampling (snorkeling) in every other pool (i.e., every 2^{nd} pool) of a given CMP reach just prior to electrofishing (second stage sampling) in every n^{th} pool in that same reach. On a given day when second stage sampling (backpack electrofishing) is set to occur, a pool is randomly selected as a “calibration” pool which is first snorkeled (single pass) to obtain a minimum count followed immediately by removal sampling (using backpack electrofishing) to obtain an abundance estimate in that same pool. The ratio of these two values is then used as a “calibration ratio” to expand snorkel counts in other pools where only snorkel counts are obtained. For each stream, the expanded snorkel counts from each pool are summed and then doubled to account for the fact that only every other pool was snorkeled. This final number is then used as the estimated abundance of late summer/fall juveniles in a given LCM stream. The final steps to arrive at smolt abundance come from a combination of efficiency-expanded detection counts at stationary PIT antennas located at the mouth of each stream and operated year-round, which are, in turn, used to estimate survival from the juvenile to smolt stage. Detailed steps are described in SW and CSG (2020).

Unlike previous years, snorkel counts in 2021 and 2022 could not be calibrated with backpack electrofishing surveys. Instead, a single pass snorkel survey was conducted in every other pool for all accessible wetted reaches. A single diver recorded the number of salmonids observed in pools by species and age class. Water quality measurements (dissolved oxygen and water temperature) were taken concurrent to snorkel surveys in order to evaluate the stream conditions and suitability for subsequent backpack electrofishing. Calibration ratios calculated during the 2019 season were applied to snorkel counts for the 2022 season. Pools were divided into two strata: pools with 10 or fewer steelhead (≤10) and pools with more than 10 steelhead (>10). The stratum specific calibration ratio was then applied to each pool count and the adjusted snorkel counts were summed for each stream and then doubled to account for pools that were not sampled to provide the abundance estimates. Steelhead abundance in riffle habitat was not included in the estimate for the 2022 season.

Because of poor water quality conditions due to drought conditions in 2021, only first stage sampling (single pass snorkeling) was conducted. This meant that no PIT tagging of juvenile steelhead in LCM streams could occur and without PIT-tagged individuals we were unable to estimate the survival of late-summer juveniles to the smolt stage and calculate an expanded smolt count for the 2022 emigration season.

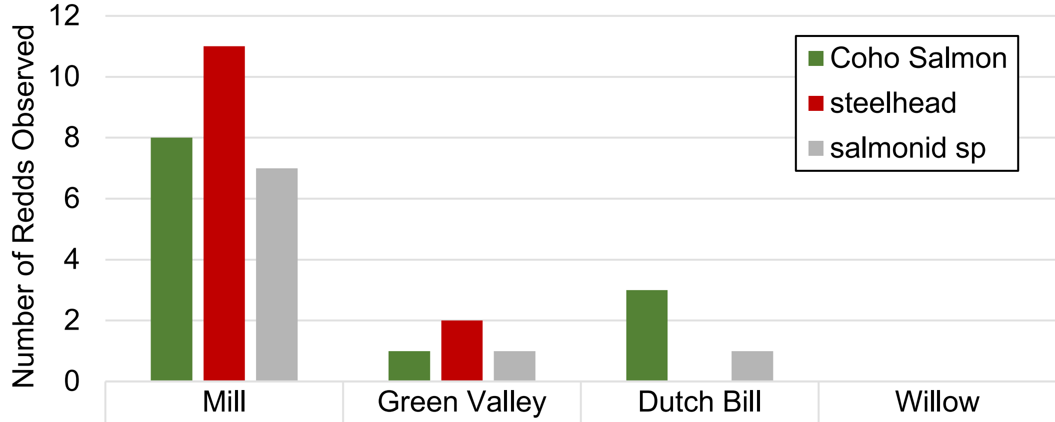
Chinook Salmon smolts- At the mainstem Russian River trap site, we operated one rotary screw trap (1.5 m diameter cone) immediately downstream of the downstream opening of the fish ladder on the west side of the river. All fish captured in the trap were identified to species and enumerated. All Coho Salmon and steelhead ≥55 mm were scanned for a PIT tag and all Coho were scanned for CWTs. A subsample of each species was anesthetized using Alka Seltzer and measured for fork length (±1 mm) and mass (±0.1 g). A subsample of Chinook Salmon smolts was fin-clipped and released upstream of the trap to facilitate abundance estimates. Other species, including recaptured Chinook, were released downstream of the first riffle downstream of the trap. All anesthetized fish were allowed to recover fully in aerated buckets prior to release.

We employed a one-trap mark-recapture design (Bjorkstedt 2010) to estimate Chinook smolt abundance. In this design, a sample of fish that were captured in the Mirabel trap each day were marked with a fin clip and subject to recapture in the trap by releasing them upstream of the trap.

Results

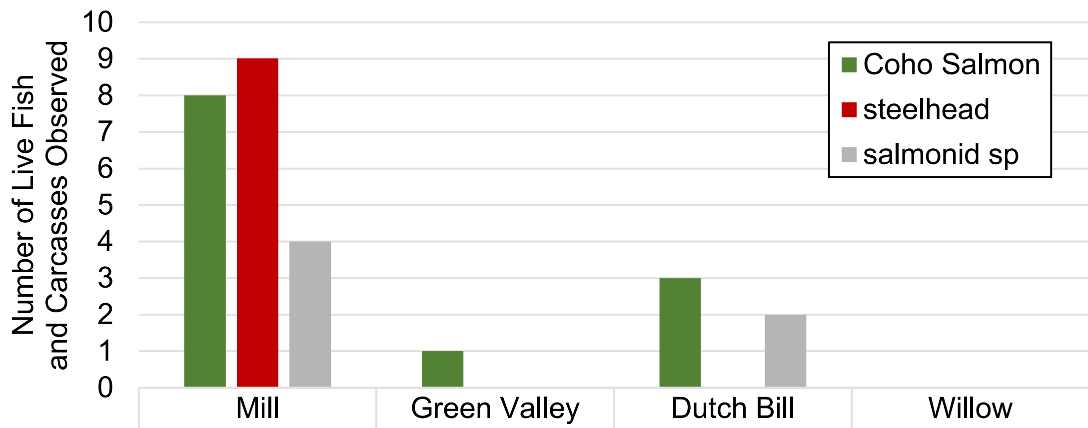
Redd abundance (Coho Salmon and steelhead)

Surveys began December 12, 2022 and were completed April 27, 2023. Surveys in past years have continued only until mid-April, but it was generally recognized that this was not sufficient to capture the extent of the steelhead spawning season. During the time that surveys were conducted, we completed 102 surveys in LCM tributary reaches. The number of trips was reduced this season because of large and frequent storms. For the 2022/23 season, we observed Coho redds in 4 reaches and steelhead redds in 5 reaches out of the 17 LCM reaches surveyed. We observed the largest number of Coho and steelhead redds in the Mill Creek watershed, but most of these were observed in the first 2.5 km of Mill Creek. Overall, Mill Creek had the highest number of observed redds for both Coho and steelhead(Figure 2). We observed 3 Coho individuals (live fish and carcasses) in both Mill and Dutch Bill creeks tying them for the largest number of individual Coho sightings (Figure 3). The largest number of steelhead individuals were also observed in the Mill watershed (Figure 3). Estimates of Coho redd abundance in LCM tributaries were 24 (±95% CI: 21) in the Mill watershed, 1 in the Green Valley watershed, 3 in Dutch Bill Creek, and 0 in Willow Creek. Mill watershed and Green Valley watershed generally have the highest numbers of Coho redds compared to the other LCM tributaries. Mill had a slightly higher than average redd total, but Green Valley was considerably lower than in most other years (Figure 4). Estimates of steelhead redd abundance in LCM tributaries (±95% CI) were 20 (±95% CI: 13) in the Mill watershed, 3 in the Green Valley watershed, 1 in Dutch Bill Creek, and 0 in Willow Creek. Similar to Coho, steelhead redd numbers tend to be higher in Mill and Green Valley watersheds as compared to other LCM streams, but steelhead redd numbers in Mill were lower than most of the past seasons (though much higher than other LCM tributaries). Steelhead redd numbers in Green Valley and all other LCM tributaries were much lower than previous seasons (Figure 5). Confidence intervals were not calculated for Willow, Dutch Bill, and Green Valley Creeks because all habitat was surveyed, so tributary estimates did not need to be expanded to unsurveyed reaches.



	Mill	Green Valley	Dutch Bill	Willow
Coho Salmon	8	1	3	0
steelhead	11	2	0	0
salmonid sp	7	1	1	0

Figure 2. New redds counted in LCM tributaries for all three levels of redd species certainty during the 2022/23 spawner season. Mill watershed totals include all tributaries (Felta, Wallace, and Palmer Creeks) and Green Valley watershed totals include Purrington Creek.



	Mill	Green Valley	Dutch Bill	Willow
Coho Salmon	8	1	3	0
steelhead	9	0	0	0
salmonid sp	4	0	2	0

Figure 3. Live fish and carcasses counted in LCM tributaries for all three levels of species certainty during the 2022/23 spawner season. Mill watershed totals include all tributaries (Felta, Wallace, and Palmer Creeks) and Green Valley watershed totals include Purrington Creek.

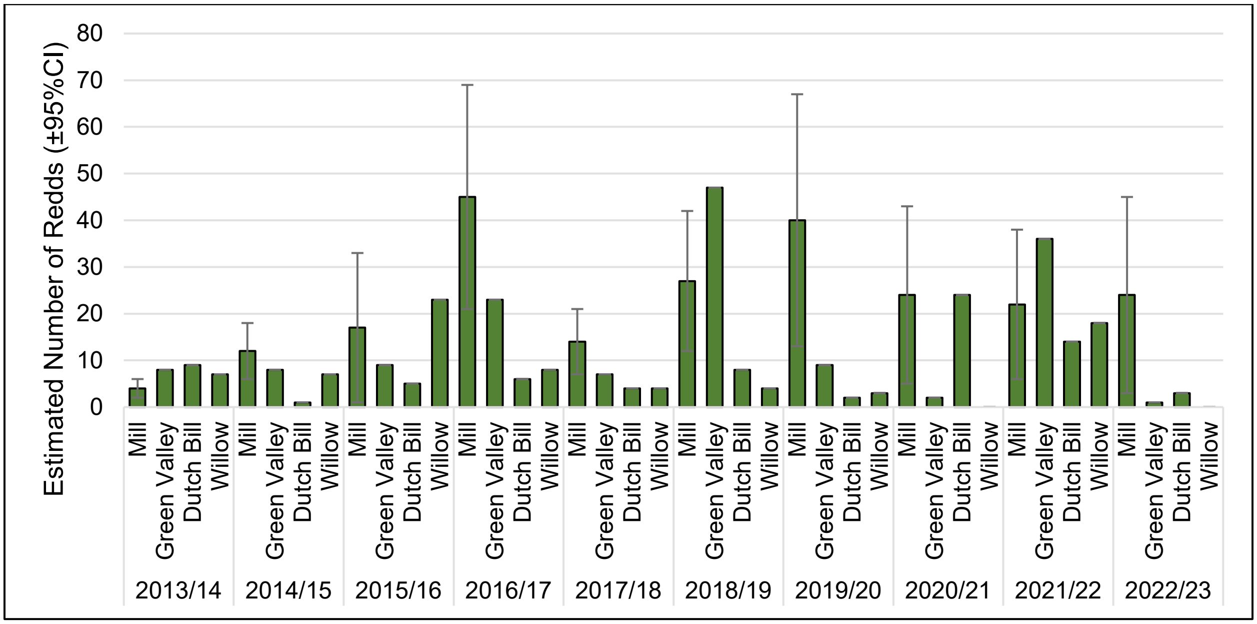


Figure 4. Estimated Coho redd abundance in LCM tributaries by spawner season. Estimates for previous seasons are shown in order to display trends. Because Mill Creek is the only creek where census spawner surveys could not be performed (due to landowner access), it is the only creek where an expansion was calculated and is therefore the only one with confidence intervals.

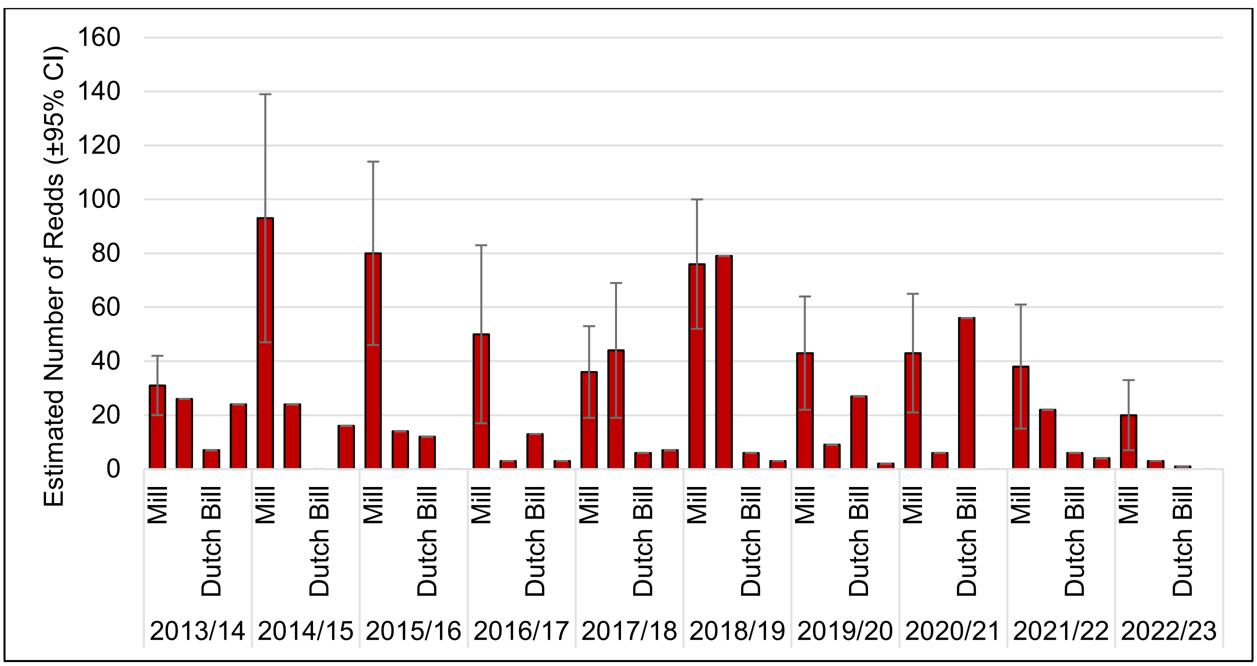


Figure 5. Estimated steelhead redd abundance in LCM tributaries by spawner season. Estimates for previous seasons are shown in order to display trends. Because Mill Creek is the only creek where census spawner surveys could not be performed (due to landowner access), it is the only creek where an expansion was calculated and is therefore the only one with confidence intervals.

Adult abundance

Coho Salmon adults- Dutch Bill creek had the highest adult Coho estimates in the 2022/23 return year (Figure 6). Overall, the total adult Coho estimate for all LCM streams combined was one of the lowest in a decade (Figure 7). Spawner to redd ratios varied considerably (from 0.58 to 9) among LCM streams. A ratio for Willow creek could not be calculated because neither adult returns nor redds were documented there during the 2022/23 season (Table 1).

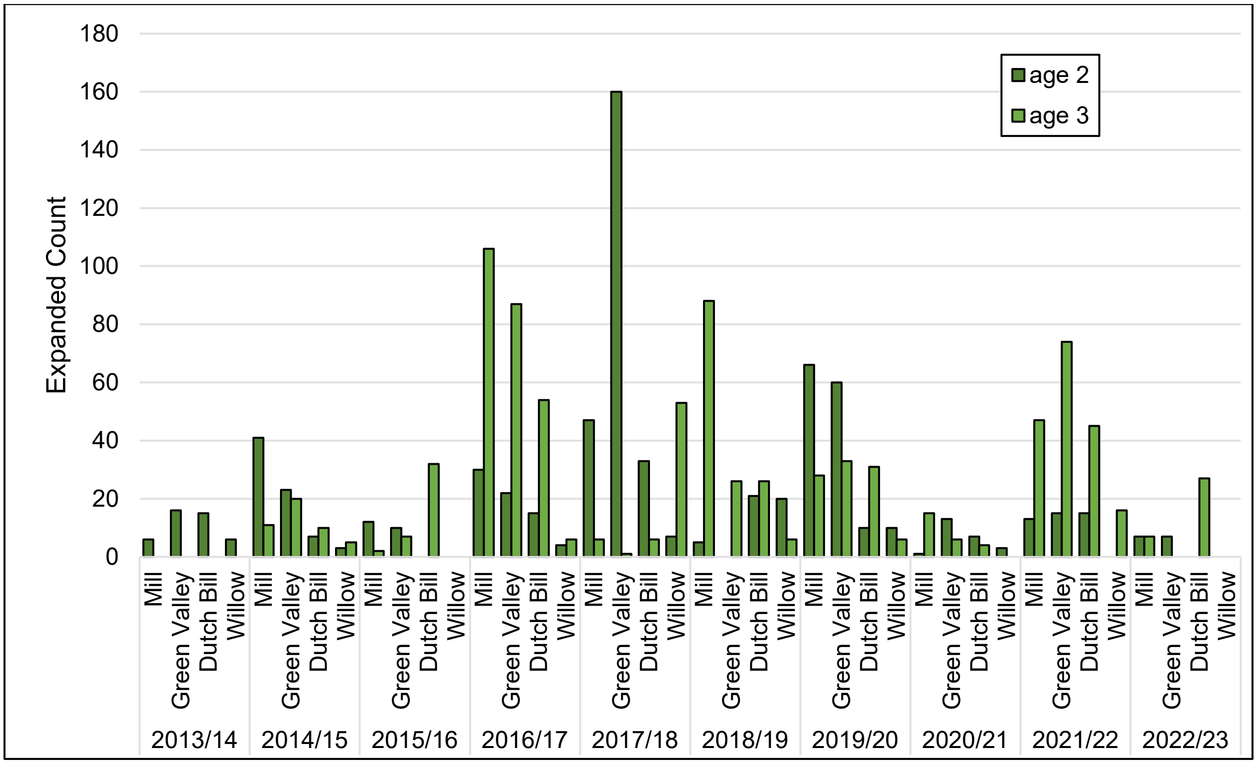


Figure 6. Adult Coho abundance in LCM tributaries by spawner season. Total adult estimates are broken out by age class. Estimates include both natural- and hatchery-origin fish.

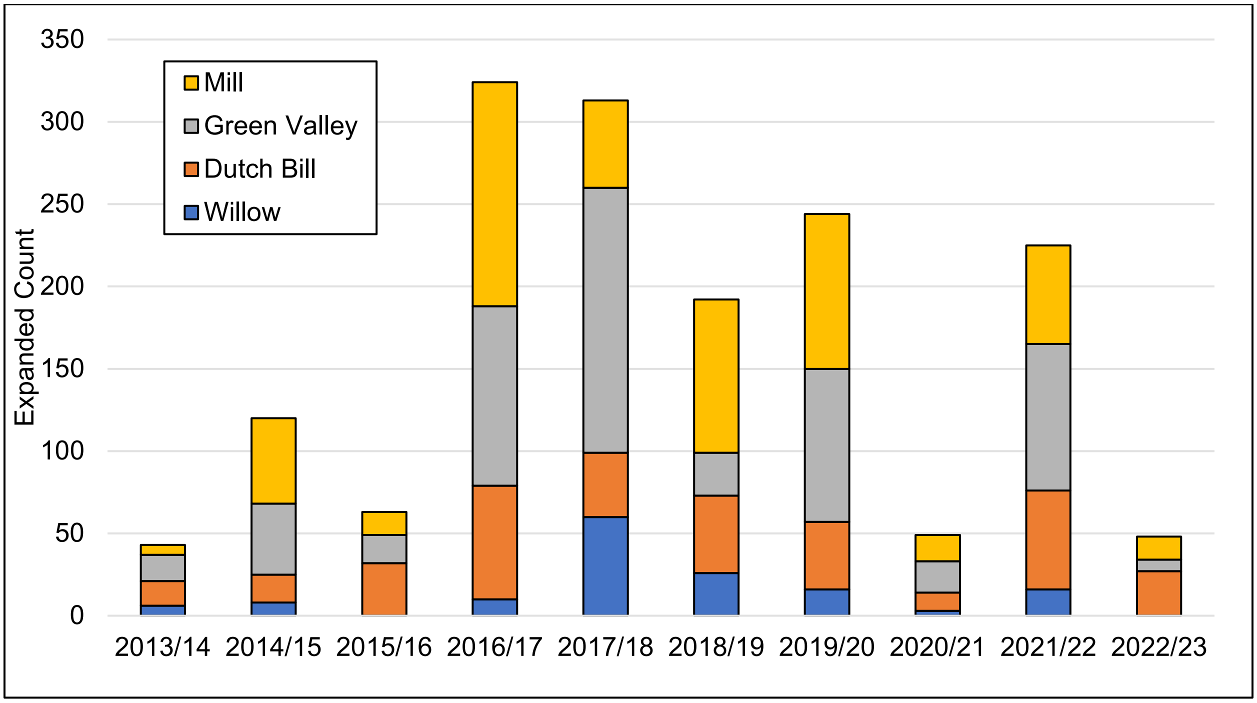


Figure 7. Trends in estimated adult Coho Salmon abundance in LCM tributaries. Estimates include both 2 year olds and 3 year olds and both natural- and hatchery-origin fish.

Table 1. Estimated spawner to redd ratios in LCM tributaries.

Sub-watershed	Adult Estimate	Redd Estimate	Spawner to Redd Ratio
Mill	14	24	0.58
Green Valley	7	1	7
Dutch Bill	27	3	9
Willow	0	0	N/A

Steelhead adults- Because of the very low numbers of adult steelhead PIT detections that meet the criteria for a returning adult, we were not able to calculate an adult steelhead abundance estimate for the 2022/23 season. This also prevented us from calculating a spawner to redd ratio for adult steelhead. We detected 10 individuals that, based on their PIT detection history, were possible steelhead adult returnees (Table 2).

Table 2. PIT antenna detections during the reporting period that could potentially be returning adult steelhead. Steelhead are classified as adult spawning migrants when they are detected traveling upstream during the spawning season (October-May) after they have reached a minimum assumed age and have experienced a potential time at sea (days at large) of 9 months or longer.

Tag stream	Size at tagging	Year tagged	Smolt date	Brood year	Adult detect
Mill Creek	60	2017	3/22/2018	2016	2021
Dry Creek	92	2017		2016	2021
Dry Creek	83	2017		2016	2021/22
Mill Creek	69	2017		2016	2021/22
Mill Creek	81	2017	1/15/2019	2016	2021/22
Dry Creek	77	2019	5/17/2020	2018	2022/22
Purrington Creek	75	2019	4/4/2020	2018	2021/22
Mill Creek	61	2019		2018	2021/22
Willow Creek	68	2019		2018	2021/22
Palmer Creek	74	2019		2018	2020/22

Chinook Salmon adults- With the exception of two years when new fish screens and fish ladder were being installed (2014, 2015) and a year when an early storm led to dam deflation prior to the onset of the adult Chinook migration (2021), an underwater video system has facilitated counts of adult Chinook Salmon swimming past the Mirabel dam since 2000 (Figure 8). In 2022, the video system was operated from 9/1 until 12/9 when the dam was lowered due to high flows that are typical in late at that time of year (Figure 9). Although the count of 1,180 was slightly higher than recent years, but below the long-term median (2,057) and average (2,641) for the data set (Figure 10).

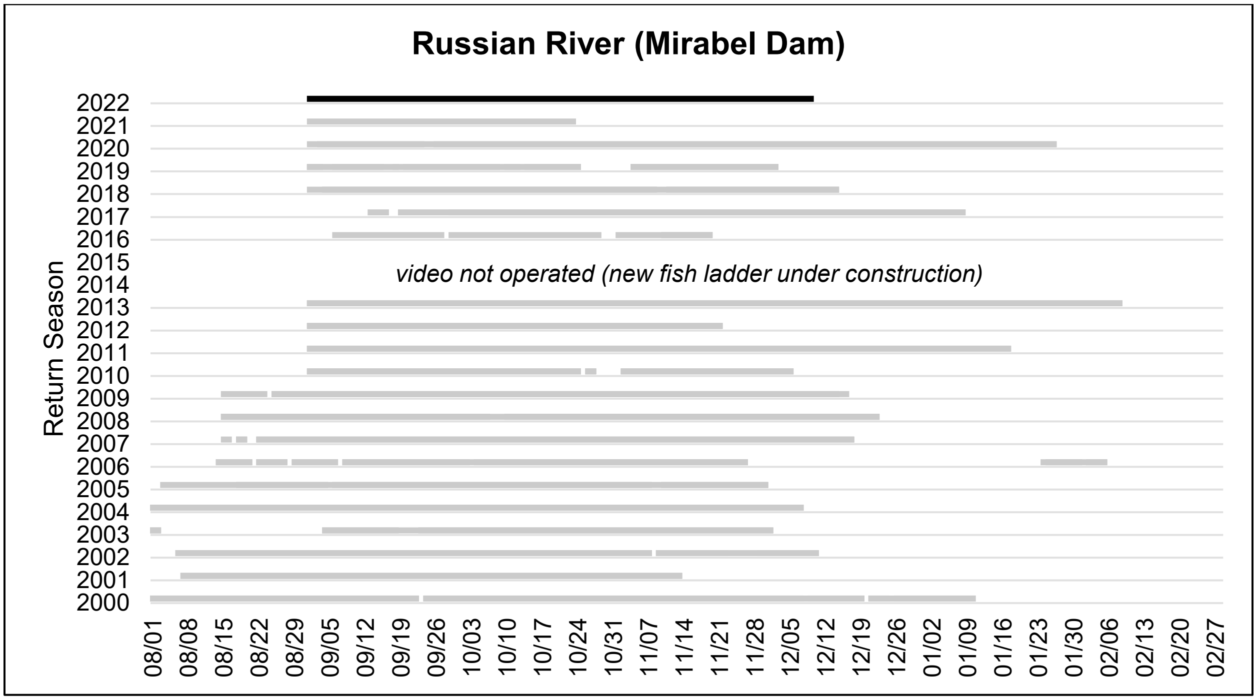


Figure 8. Period of operation by year of underwater video system at the mainstem Russian River Chinook Salmon LCS, 2000-2022.

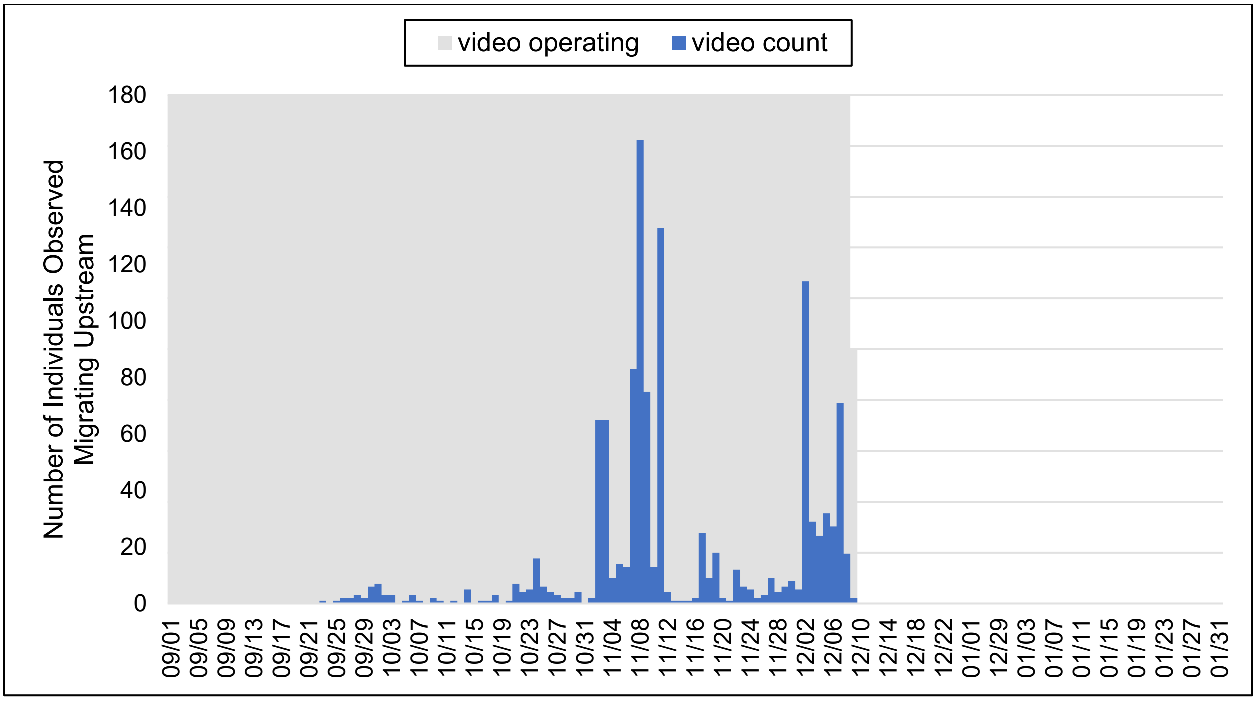


Figure 9. Chinook Salmon adult movement upstream past the mainstem Russian River Chinook Salmon LCS by date and dates video system was operating, 2022.

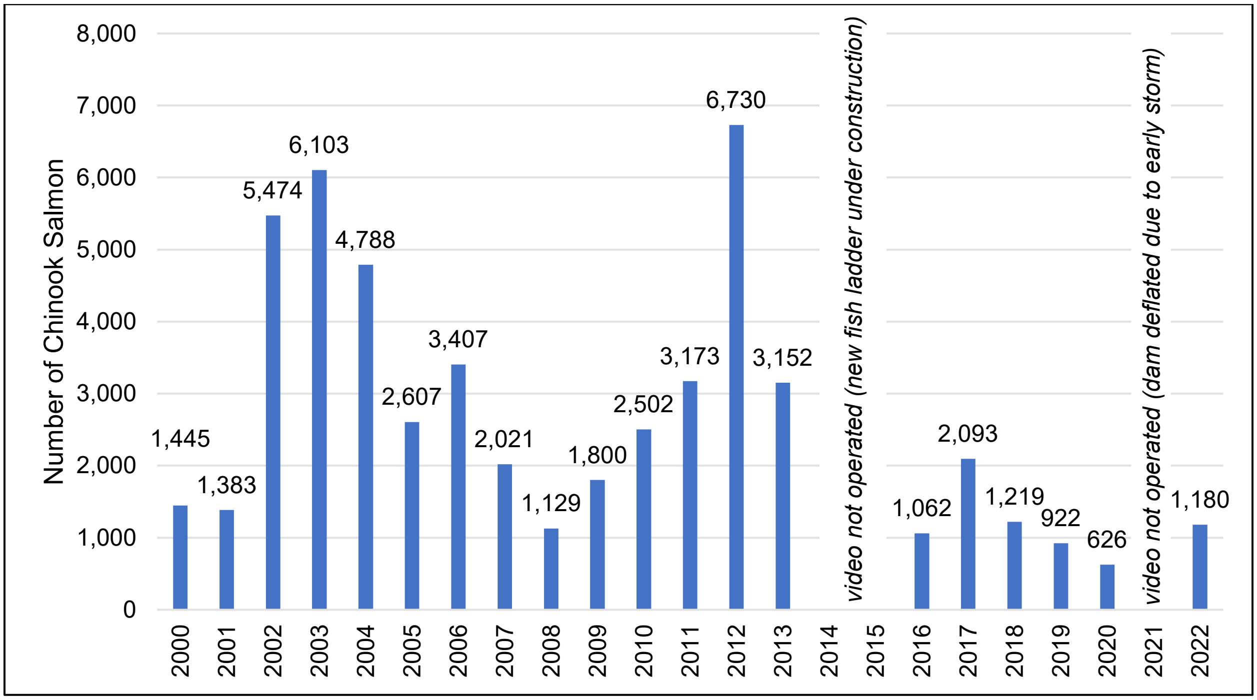


Figure 10. Adult Chinook video counts at the mainstem Russian River Chinook Salmon LCS, 2000-2022.

Smolt abundance

Detailed information on trap operation can be found in CSG (2021a) and SW Biological Opinion data reports (2009-2020).

In 2022, downstream migrant traps in Coho-steelhead LCM streams were installed in early to mid-March and operated into late May/early June. Traps were operated until stream flow in the vicinity of traps became disconnected in the vicinity of the trap and/or daily catches of Coho and steelhead dropped to near zero for several consecutive days (Figure 11, Figure 12, Figure 13). PIT antennas were operated throughout the period in LCM streams.

The downstream migrant trap at the mainstem Russian River Chinook Salmon LCS was installed on 4/7 which was relatively earlier than the past several years (Figure 14). Trap operation was ceased on 7/7 when daily catches of Chinook Salmon smolts dropped to near zero for several consecutive days (**Figure 15**). Because of low water conditions, we were able to operate the trap during the entire period without interruption.

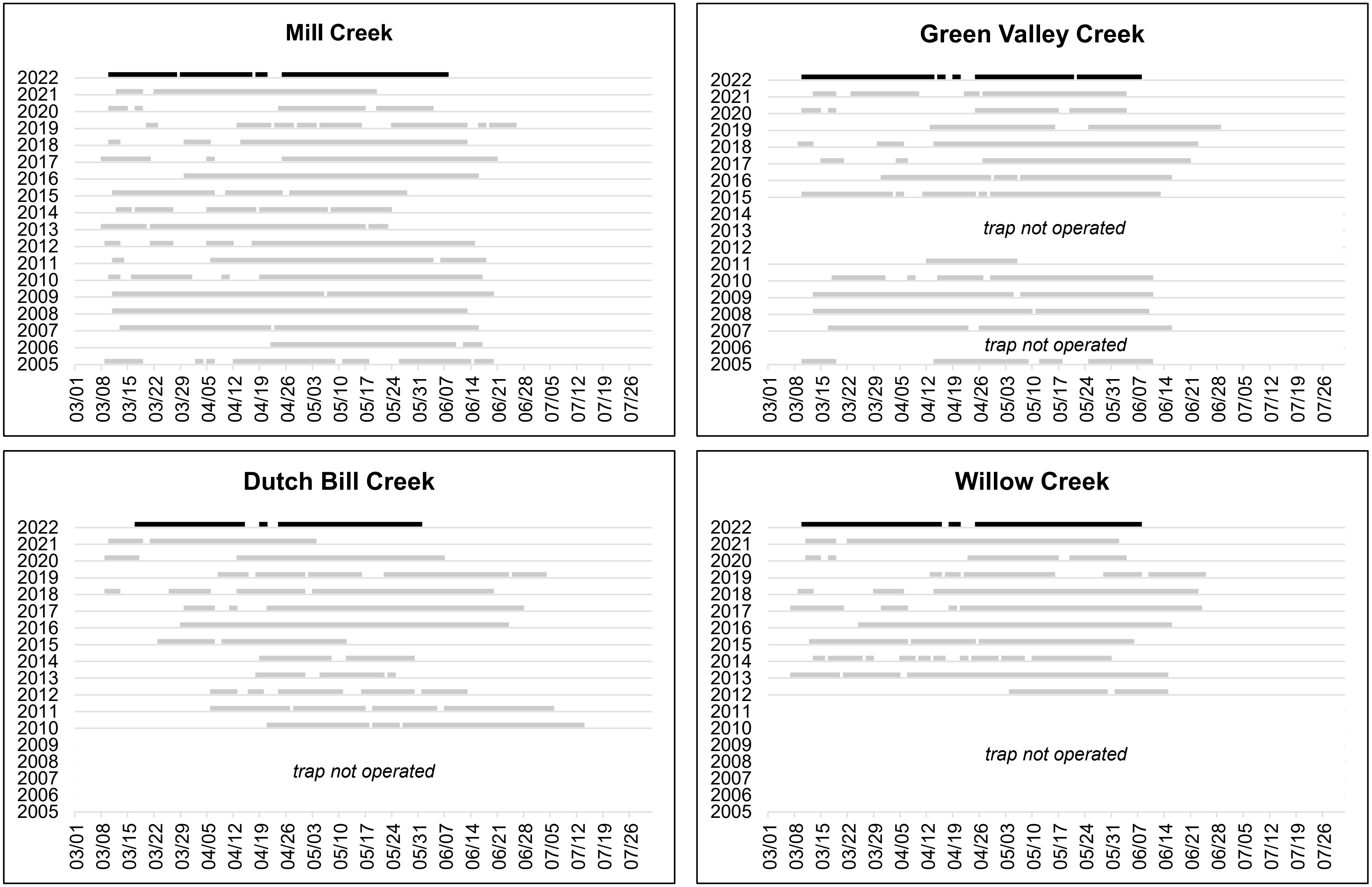


Figure 11. Period of operation by year of downstream migrant traps in Coho-steelhead life cycle monitoring streams by year, 2005-2022.

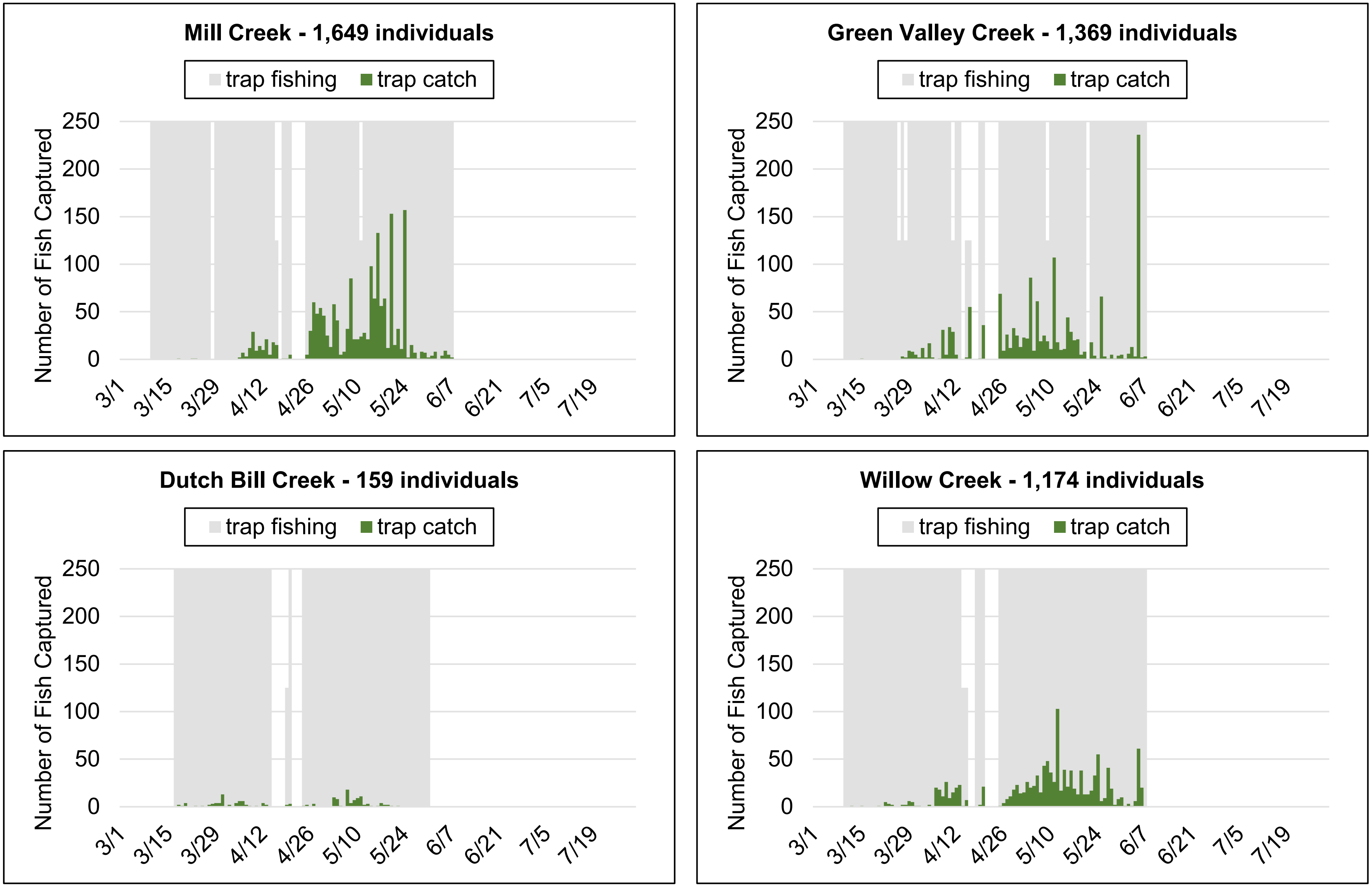


Figure 12. Coho Salmon smolt capture by date and dates downstream migrant traps were operating in Coho-steelhead life cycle monitoring streams, 2022.

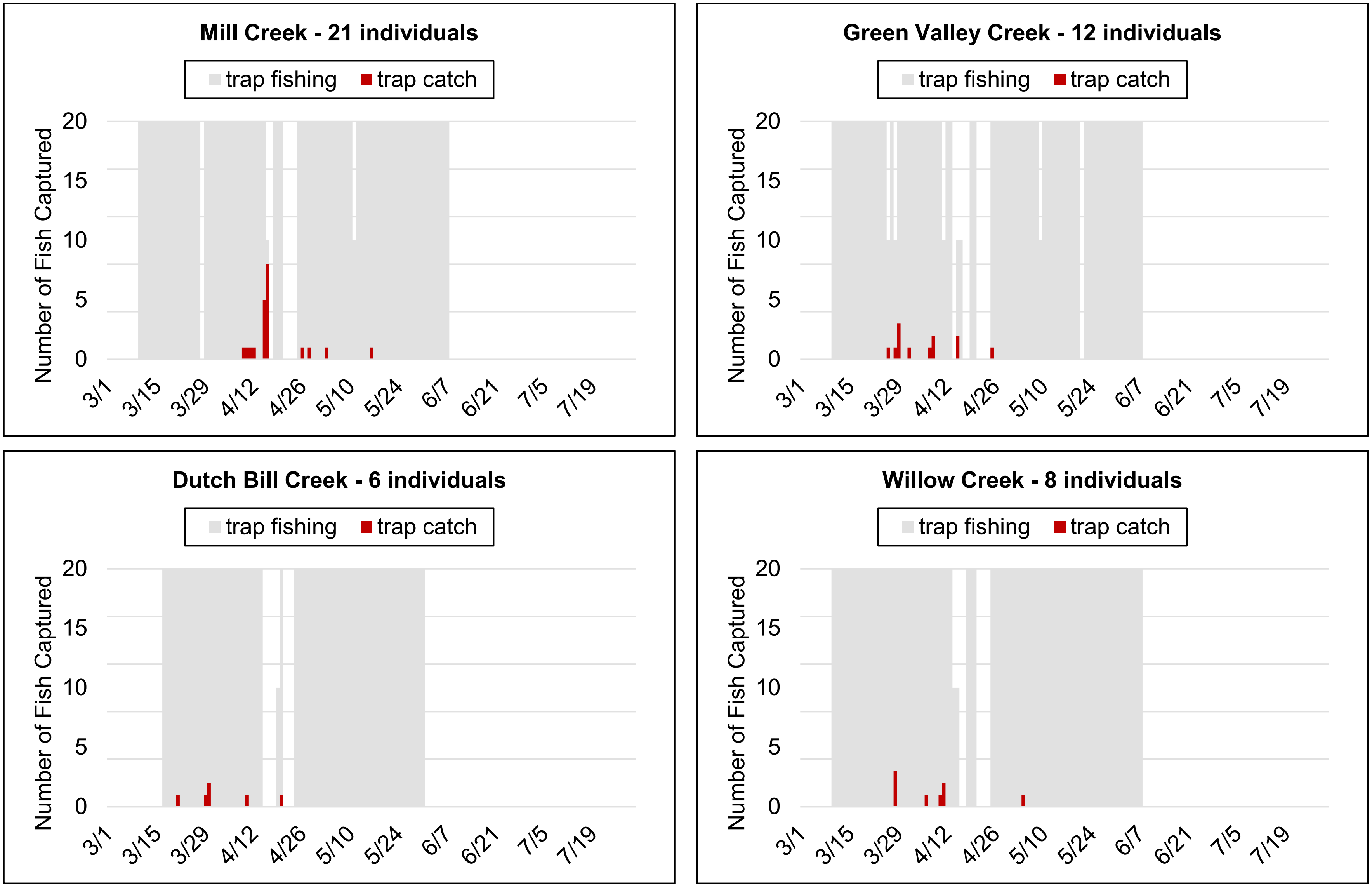


Figure 13. Steelhead smolt capture by date and dates downstream migrant traps were operating in Coho-steelhead life cycle monitoring streams, 2022.

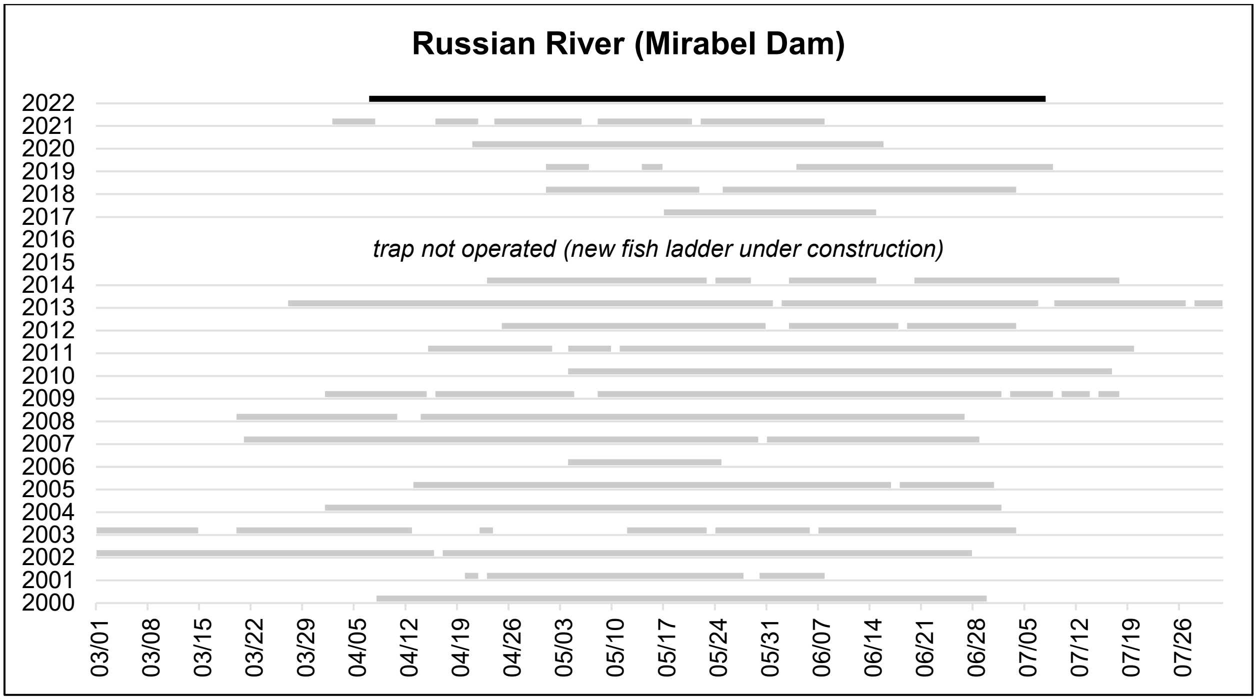


Figure 14. Period of operation by year of the downstream migrant trap at the mainstem Russian River Chinook Salmon LCS, 2000-2022.

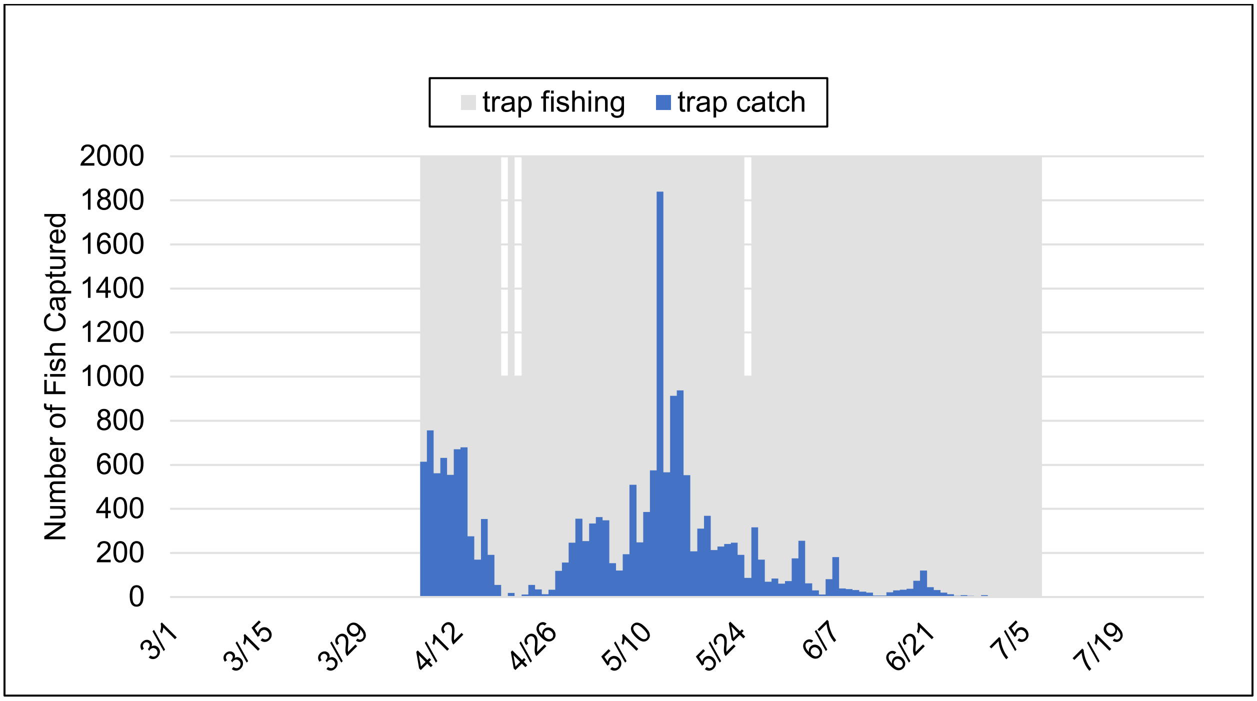
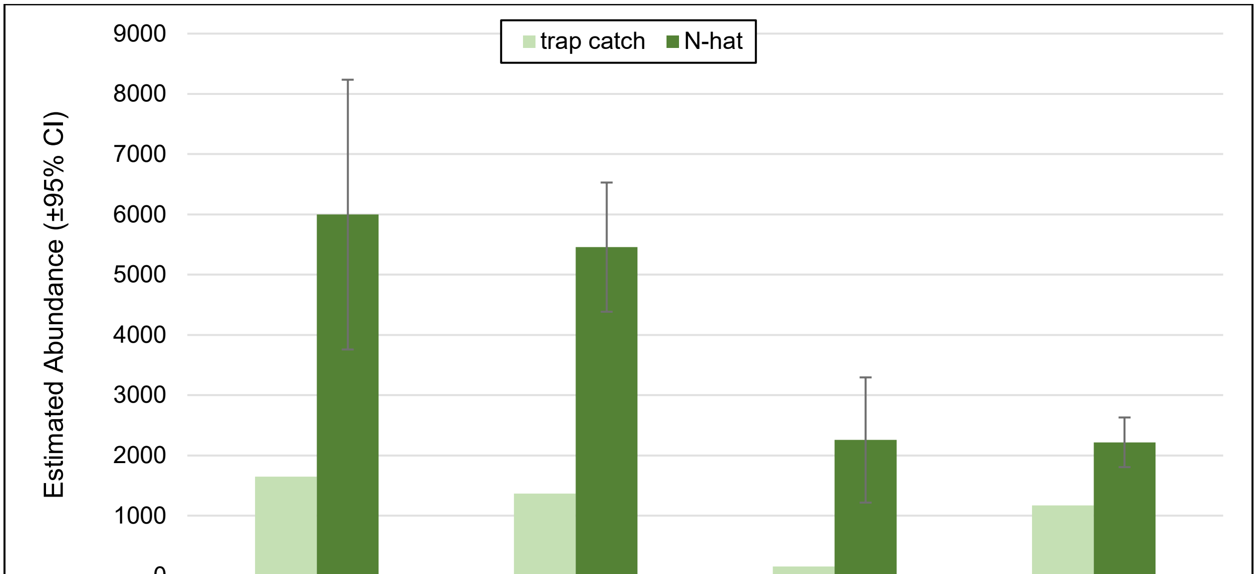


Figure 15. Chinook Salmon smolt capture by date and dates downstream migrant trap was operating at the mainstem Russian River Chinook Salmon LCS, 2022.

Coho Salmon smolts- Abundance estimates in 2002 were highest in Mill and Green Valley creeks while abundance was lowest in Dutch Bill and Willow creeks (Figure 16). Abundance estimates were significantly higher in Mill Creek as compared to estimates in 2021. For the other three LCM streams, estimates were similar to 2021; however, Green Valley Creek has shown a steady decline in smolt abundance since the high of over 23,000 in 2017 (Figure 17).



	Mill Creek	Green Valley Creek	Dutch Bill Creek	Willow Creek
trap catch	1649	1369	159	1174
N-hat	5997	5457	2257	2219

Figure 16. Coho Salmon smolt abundance estimates (±95% confidence intervals) for Mill, Green Valley, Dutch Bill, and Willow Creeks in 2019 and 2020.

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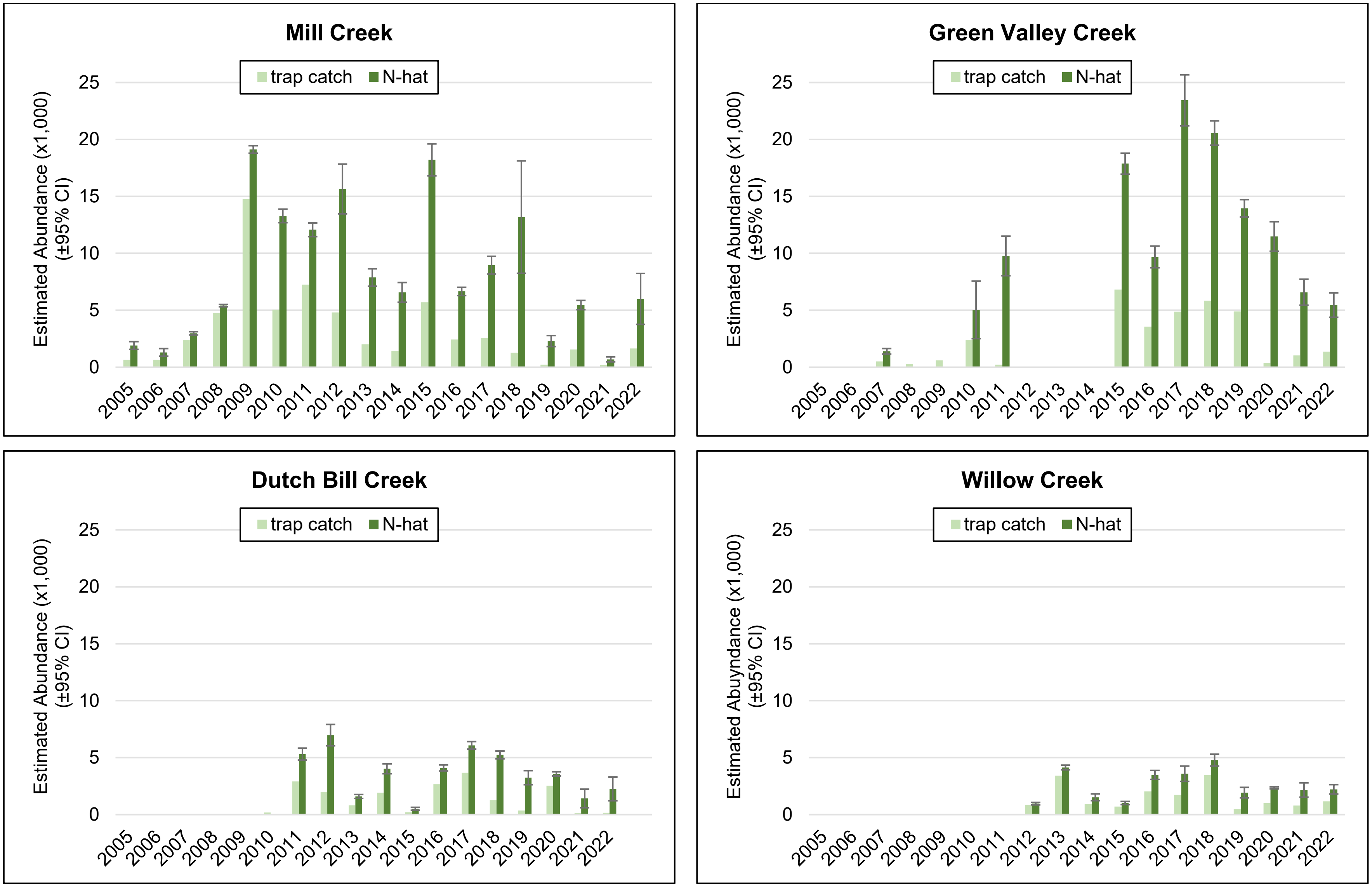

Figure 17. Estimated abundance of Coho Salmon smolts in Coho-steelhead life cycle monitoring streams, 2005-2022.

Steelhead smolts- Due to poor habitat conditions in 2021, electrofishing surveys were not conducted in the life cycle monitoring streams. Without PIT-tagged individuals, we were unable to estimate the survival of juveniles to the smolt stage and therefore unable to calculate a smolt estimate for the 2022 emigration season (Figure 18).

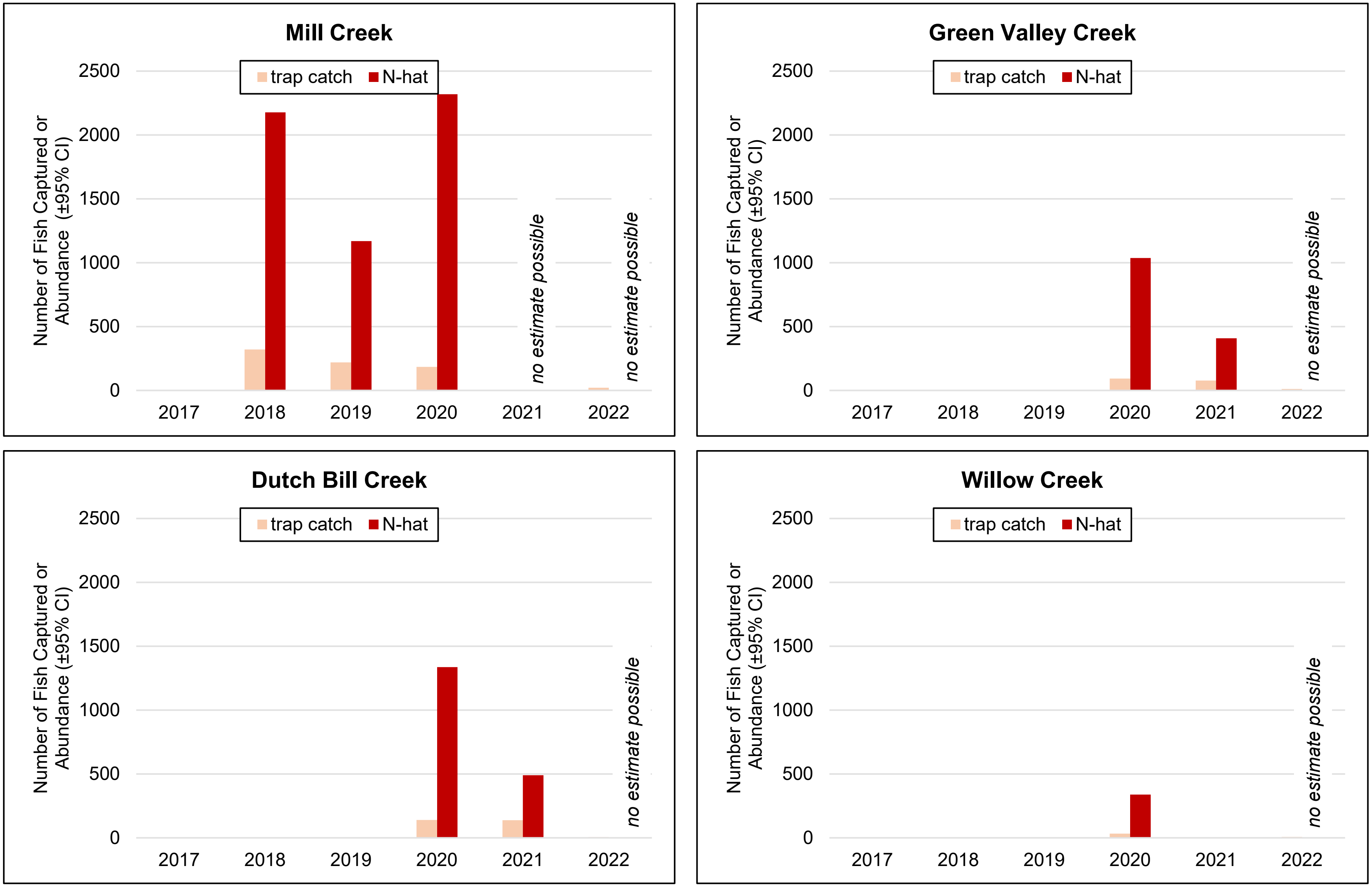

Figure 18. Estimated abundance of steelhead smolts in Coho-steelhead life cycle monitoring streams, 2017-2022. Note that estimates were not possible in 2021 in Mill or 2022 in any LCM stream because, due to water quality conditions, no juveniles could be PIT-tagged.

Steelhead pre-smolts- The 2022 season had improved stream conditions compared to the previous season and, overall, more habitat was available for juvenile steelhead. Late summer visual (snorkel) surveys were conducted in all four of the LCM streams and steelhead counts from these surveys are the basis for our juvenile steelhead estimate. Electrofishing surveys occurred from mid-September to mid-October in streams with adequate water quality (Mill, Palmer, Purrington, Dutch Bill, and Willow Creeks). Due to the low number of juvenile steelhead encountered during snorkel surveys, electrofishing surveys conducted in 2022 were not used to calibrate the snorkel counts. However, we did conduct single pass electrofishing surveys for the sole purpose of PIT-tagging juveniles for future detection as they emigrate from their natal streams. These detections will be used to calculate a survival index to the smolt stage and generate a smolt estimate when possible. We PIT-tagged 625 steelhead and 524 Coho, combined, in all LCM watersheds.

A late summer population estimate for juvenile steelhead was calculated based on snorkel counts using the calibration ratios calculated in the 2019 season. Table 3 provides the number of fish counted in pools sampled for steelhead smolt population estimation in 2022/23 smolt migration season. As with juvenile abundance estimates in 2021, estimates in 2022 were also low when compared to 2019 (Figure 19).

Table 3. Number of juvenile salmonids counted in pool habitat during 2022 late summer snorkel surveys in the four life cycle monitoring streams. Note that parr are distinguished based on their estimated size (parr ≥ age-1+ or older and young-of-the-year (YOY) = age-0+).

Watershed	Tributary	Life stage	Steelhead	Coho Salmon
	Mill Creek	parr	53	3
		YOY	111	73
	Felta Creek	parr	10	3
		YOY	21	158
	Palmer Creek	parr	18	5
		YOY	75	94
Mill Watershed Total			***288***	***336***
	Green Valley Creek	parr	36	16
		YOY	132	1395
	Purrngton Creek	parr	24	18
		YOY	120	1404
Green Valley Watershed Total			***312***	***2833***
	Dutch Bill Creek	parr	56	12
		YOY	142	2632
	Perenne Creek	parr	1	1
		YOY	5	76
Dutch Bill Watershed Total			***204***	***2721***
	Willow Creek	parr	5	69
		YOY	25	1855
Willow Watershed Total			***30***	***1924***

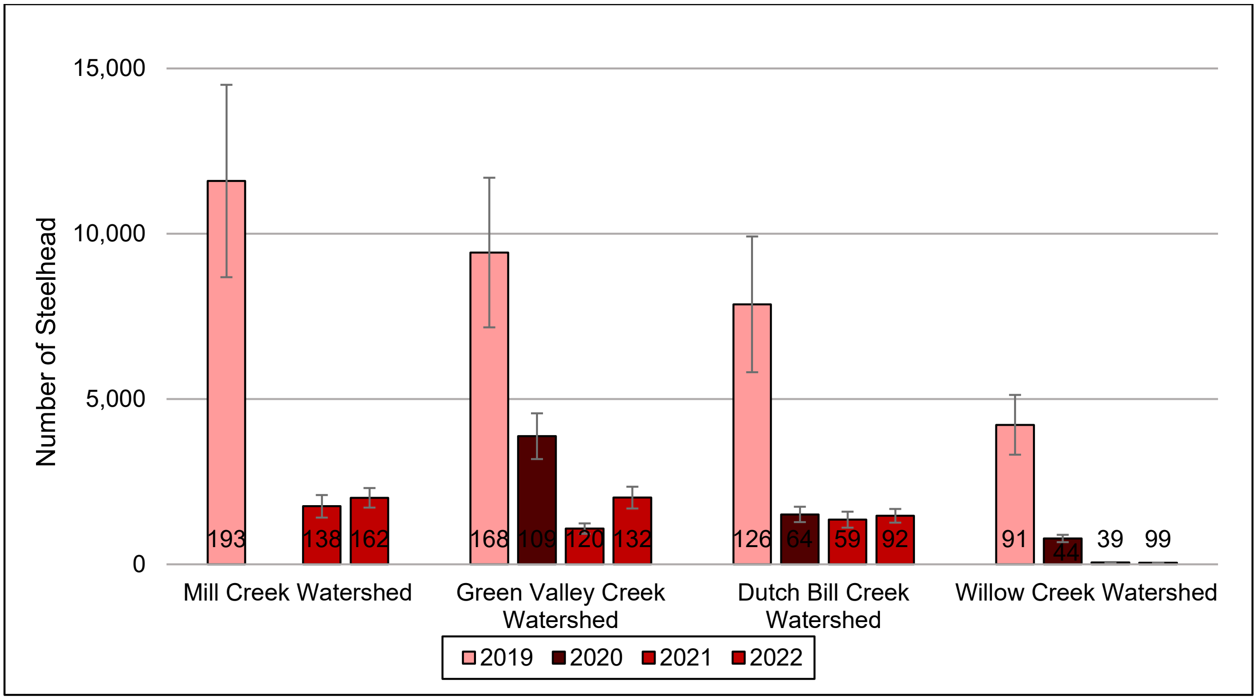

Figure 19. Estimated abundance of steelhead juveniles in four life cycle monitoring streams based on expanded counts from snorkel surveys. The number at the base of each bar indicates the number of pools snorkeled in each watershed. The 2020 Mill Creek watershed estimate was not calculated because poor habitat conditions after the Walbridge fire precluded snorkel surveys.

A total of 496 pools were snorkeled in 2022, representing approximately 50% of accessible pool habitat in the LCM watersheds of Mill, Green Valley, Dutch Bill, and Willow creeks. End-of-summer steelhead population estimates for pool habitat in the LCM watersheds ranged from over 2,000 in Mill and Green Valley Creek watersheds to approximately 40 in Willow Creek watershed.

Juvenile steelhead abundance in 2022 was similar to the previous year's low abundance. The total estimated abundance of pre-smolt steelhead from the LCM watersheds that were sampled was 5,542 (±837.8 95% CI) for pool habitat (**Table 4**).

Table 4. Juvenile steelhead population estimates and sampling effort in LCM watersheds during end-of-summer 2022. Sample size (n) is based on number of pools with at least one steelhead observed.

LCM watershed	Stream	Sample size (n)	Juvenile steelhead estimate (pools only)	±95% CI
	Mill Creek	86	1137.04	168.8
	Felta Creek	40	231.26	31
	Palmer Creek	36	643.38	95.8
Mill Creek watershed		***162***	***2011.68***	***295.6***
	Green Valley Creek	63	1094.88	176.8
	Purrington Creek	68	923.04	152.4
	Harrison Creek	Not sampled		
	Little Green Valley Creek	1	0	0
	Nutty Valley Creek	Not sampled		
Green Valley Creek watershed		***132***	***2017.92***	***329.2***
	Dutch Bill Creek	82	1423.08	201
	Grub Creek	3	0	0
	Perenne Creek	7	44.76	6
Dutch Bill Creek watershed		***92***	***1467.84***	***207***
	Willow Creek	99	44.76	6
Willow Creek watershed		***99***	***44.76***	***6***

Chinook Salmon smolts- In 2022, the estimated abundance was the second highest on record since SW began downstream migrant trapping at this site in 2000 (Figure 20).

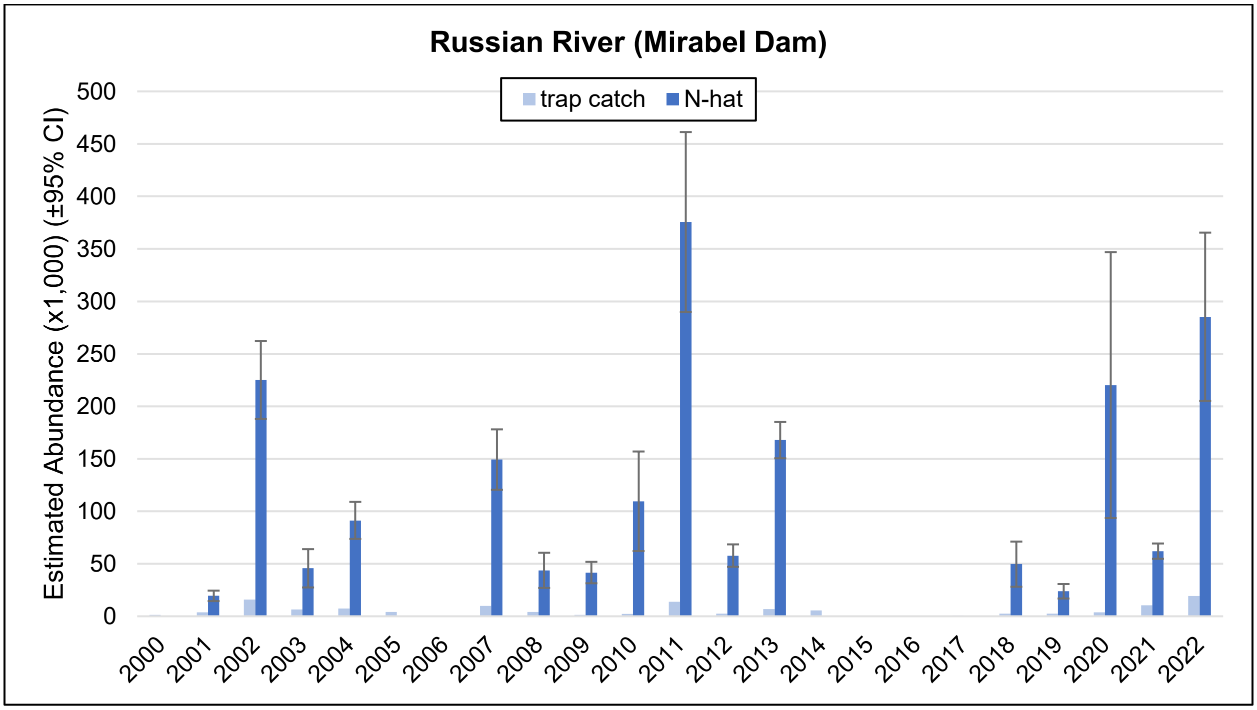

Figure 20. Estimated abundance of Chinook Salmon smolts in the mainstem Russian River Chinook Salmon LCS, 2000-2022. Note that in some years, trap efficiency resulted in too few fish captured to estimate abundance.

Discussion

Coho redd abundance was low in LCM tributaries during the 2022/23 return season and was tied with 2013/14 and 2014/15 as the lowest Coho redd numbers we have seen in the last decade of LCM monitoring. There were heavy storms associated with an atmospheric river during the usual peak in Coho spawning activity, and while this may have had an effect on redd numbers, it probably was not the only reason for the low number of redds observed (see Basin-wide discussion below). Mill creek had the highest number of redds counted this season, and therefore the highest redd abundance estimate, but the live fish and carcasses seen in Mill creek were essentially equal to the number found in Dutch Bill creek. This could indicate that, because of differences in stream gradient and composition redds are more likely to persist in Mill than in Green Valley, but more likely it is an artifact of the sampling methods we use. Redd surveys as an index for adult returns rely on visually inspecting the creek bed. A difficult task when large storms create turbid conditions and high flows. This shows the utility of combining spawner surveys with adult return estimates generated from PIT antenna detections and associated data. In this case, the PIT estimate for returning adult Coho was larger in Dutch Bill than in Mill, so it seems likely that there was spawning activity in Dutch Bill than we were unable to detect with spawner surveys alone. We recommend continuing to utilize PIT antenna technology to estimate adult Coho returns. Despite small sample sizes that can cause estimates to fluctuate considerably with the addition or subtraction of a single fish (CSG 2022), this seems to be the most accurate way to generate adult estimates for Coho. For steelhead, the task is more complicated. Studies of Coho in the Russian River are fortunate to have large pools of PIT-tagged hatchery fish for use in population studies, but PIT-tagged steelhead must be physically captured in the wild (either in DSMT traps, or by electrofishing), tagged, and released. So far our attempts to PIT tag enough fish while electrofishing in LCM tributaries to get enough returns to have a usable estimate of adult returns have been hampered by late-summer water quality conditions that prevent us from electrofishing large portions of streams. For the upcoming 2023 season we anticipate the opportunity to safely sample fish populations with backpack electrofishing. Unfortunately, our preliminary summer snorkel surveys are showing low numbers of steelhead present, so that even if we could electrofish all LCM habitats, we probably still will not have a large enough pool of tagged fish to work with. Despite the ability to implement full quantitative sampling for steelhead in the way we originally envisioned, we recommend continuing to refine this technique because, in our estimation, the pre-smolt steelhead abundance and survival model remains as the only practical approach to meeting CMP objectives related to steelhead in the Russian River watershed and, perhaps, elsewhere. Furthermore, ancillary data on stream drying and associated water quality conditions are giving us a very good qualitative indication that juvenile steelhead and Coho survival in many tributaries during recent drought years has been poor to zero. At the same time, we are also informing knowledge gaps regarding variation in steelhead life history strategies (e.g., age at smoltification, age at adult return), straying, and the timing of smolting and spawning.

Task 3. Basin-wide Monitoring

Introduction

This task and the associated data reported here covers:

- annual adult spawner surveys to generate estimates of Coho Salmon and steelhead redds in the Coho-steelhead stratum;
- annual juvenile snorkel surveys to evaluate the spatial structure of juvenile Coho Salmon in the Coho-steelhead stratum.

Basin-wide sampling using a GRTS framework is designed to work in concert with life cycle monitoring to provide information on population status and trends at the watershed scale. These data can be combined with CMP data from other coastal systems to measure progress toward population recovery at the ESU scale (Adams et al. 2011). Here we provide results of basin-wide adult redd abundance sampling (from spawner surveys) and juvenile spatial structure sampling (from snorkel surveys) aimed at accomplishing basin-wide CMP objectives.

Methods

Redd abundance

Field methods for basin-wide spawner surveys were almost identical to those described above for spawner surveys in the four LCM watersheds. The difference was that while a near-census of reaches was conducted in all the LCMs, a subsample of reaches for basin-wide surveys were chosen based on the GRTS ordering and placed into rotating panels. During the 2022/23 spawner season, we employed the methods recommended by Adams et al. (2011) and outlined in Gallagher et al. (2007) to survey for redds, live fish, and carcasses in the Coho-steelhead sample stratum only, whereas in previous years we had been funded to sample in the steelhead-only sample stratum as well. Reaches where landowner access could not be secured for at least 75% of the reach length were skipped and the next reach in the GRTS draw was substituted.

We estimated basin-wide redd abundance in the Coho-steelhead sample stratum (79 reaches) for the 2022/23 spawner season using survey methods identical to the methods described for deriving total redd estimates from spawner surveys in LCM streams (Ricker et al. 2014; Adams et al. 2011). Like LCM surveys, the estimation approach employed both a within-reach and among-reach expansion each season and variance associated with each was combined into an overall variance estimate.

Juvenile Coho Salmon occupancy

Sampling to estimate juvenile Coho occupancy was based on modifications of protocols in Garwood and Ricker (2014). In each survey reach, two independent snorkel passes were completed. On the first pass, juvenile Coho Salmon and steelhead were counted in every other pool within the reach, with the first pool sampled (pool 1 or pool 2) determined randomly. Pools were defined as habitat units with a depth of greater than 0.3 m in an area at least as long as the maximum wetted width and a surface area of greater than 3 m^2. A second pass was completed the following day in which every other pool that was snorkeled during the first pass was snorkeled a second time (i.e., every fourth pool). These data were then used in an occupancy model to estimate occupancy at the reach scale and occupancy at the pool scale for Coho Salmon only. A GPS point was collected at the downstream end of each pool snorkeled during the pass 1 survey.

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. In larger pools requiring two snorkelers, two lanes were agreed upon and each snorkeler moved upstream through their designated lane at a similar rate. Final counts for the pool were the sum of both lane counts. All observed salmonids were identified to species and size and physical characteristics (YOY or parr (≥ age-1)). Presence of non-salmonid species was documented at the reach scale. Field computers with Survey 123 (Esri) were used for data entry and, upon returning from the field, data files were downloaded, QA/QC'd, and transferred to a SQL database. Spatial data were downloaded, QA/QC'd, and stored in an ArcGIS geodatabase for map production.

A multiscale occupancy model was used to estimate the probability of juvenile Coho occupancy at the reach scale ($\hat{\psi}$) and conditional occupancy at the pool scale ($\hat{\theta}$), given presence in the reach (Nichols et al. 2008; Garwood and Larson 2014). Detection probability (p) at the pool scale was accounted for using the data from repeat dives. The proportion of area occupied (PAO) for the sample frame was then estimated as the product of the reach and pool scale occupancy parameter estimates ($\hat{\psi} * \hat{\theta}$). All models were run in Program MARK (White and Burnham 1999). Snorkel surveys were carried out prior to release of hatchery juveniles to ensure that occupancy estimates reflected natural-origin fish only. Additional reaches outside of those needed for GRTS estimates were surveyed to contribute to long-term datasets or inform specific studies, but results from those reaches were not included in the occupancy estimates. For example, Yellowjacket Creek and the upper extent of Redwood Creek were surveyed to monitor Coho adjacent to a remote site incubator (RSI) study conducted in partnership with NMFS, CDFW, and USACE.

Results

Redd abundance

The start date for basin-wide spawner surveys was December 12, 2022, concurrent with the start of spawner surveys in the four LCMs as well as the date rain reconnected tributaries (thus allowing fish access). Surveys were completed April 27, 2023. Over the course of the season we completed 316 surveys in 54 reaches (excluding sub-reaches) in the Coho-steelhead sample stratum. We used 38 reaches (roughly 48% of the stratum) to calculate total redd abundance for the stratum. The average time between surveys was 19.5 days (±95% CI: 1.13) with a maximum time between repeated surveys on any reach of 55 days. The average and maximum days between surveys are much higher than in previous years because of the frequency of large storms in early 2023. We observed the largest numbers of Coho and steelhead redds in Pena and Mill creeks, though counts in both were far lower than in years past (Figure 21). We also observed the largest number of individuals (live fish and carcasses) in Pena and Mill creeks, though Pena had almost twice as many individual observations as Mill. Pena was the only creek where Chinook individuals were observed (Figure 22) and Coho and steelhead spawning was fairly narrowly distributed (Figure 23 and Figure 24). We found only 11 Coho carcasses this season, and of these only 5 were in suitable condition for otolith extraction. One of the 2 Coho carcasses we found had a CWT tag which indicates hatchery origin. The estimate of Coho redd abundance in the Russian River basin was 74 (±95% CI: 50) for the 2022/23 spawner season. The estimate of steelhead redd abundance in the Coho-steelhead stratum (the portion of steelhead habitat in the basin overlapping with Coho habitat) was 86 (±95% CI: 57) for the 2022/23 spawner season. The Coho redd estimate is below the 10-year average of 119 and the steelhead estimate is well below the 10-year average of 389 (Figure 25).

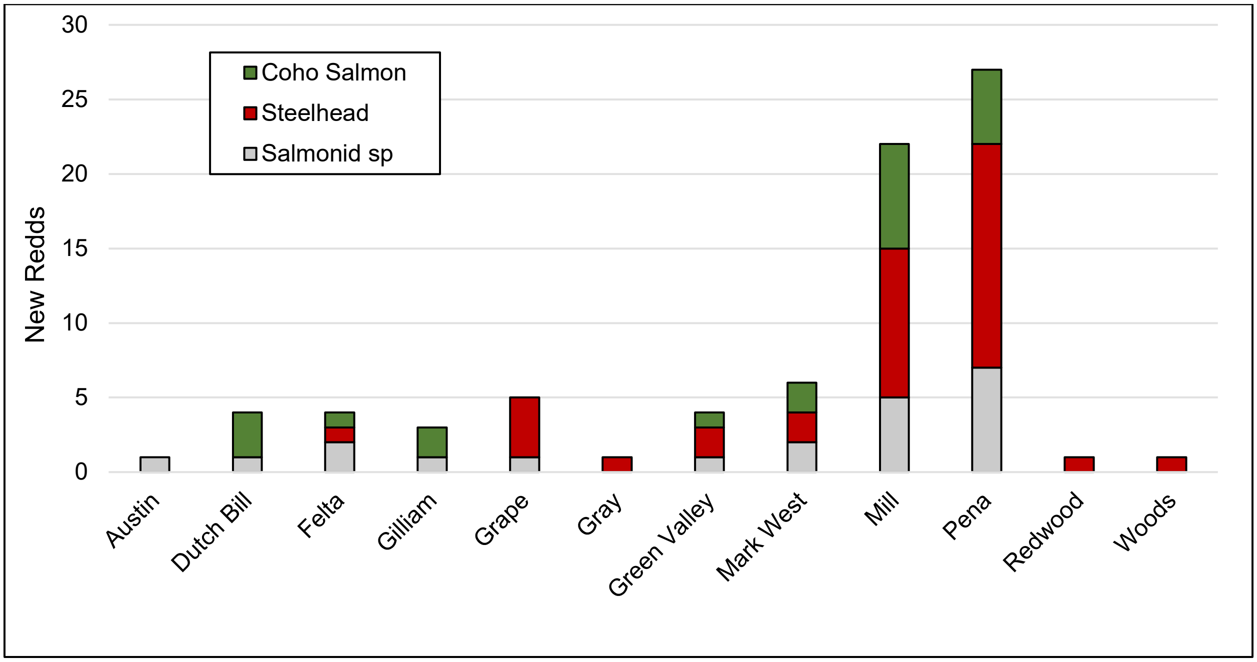

Figure 21. New redds counted in basin-wide spawner surveys by tributary for all three levels of redd species certainty. Only tributaries where redds were found are included. Note that not all habitat within each creek may have been surveyed in a given year (i.e., only reaches included in the rotating panel for a given season were surveyed).

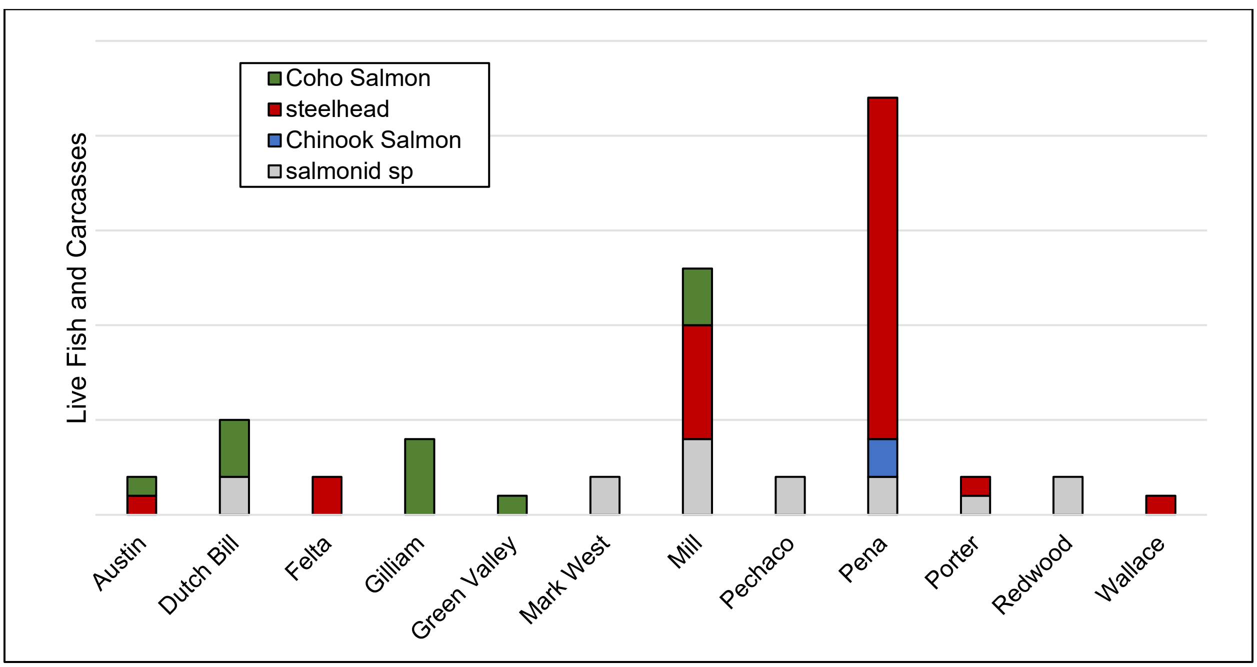

Figure 22. Live adult salmonids and carcasses counted in basin-wide spawner surveys by tributary for all three levels of fish species certainty. Only tributaries where live fish and carcasses

were found are included. It is possible that some fish could have been counted more than once. Note that not all habitat within each creek may have been surveyed in a given year (i.e., only reaches included in the rotating panel for a given season were surveyed).

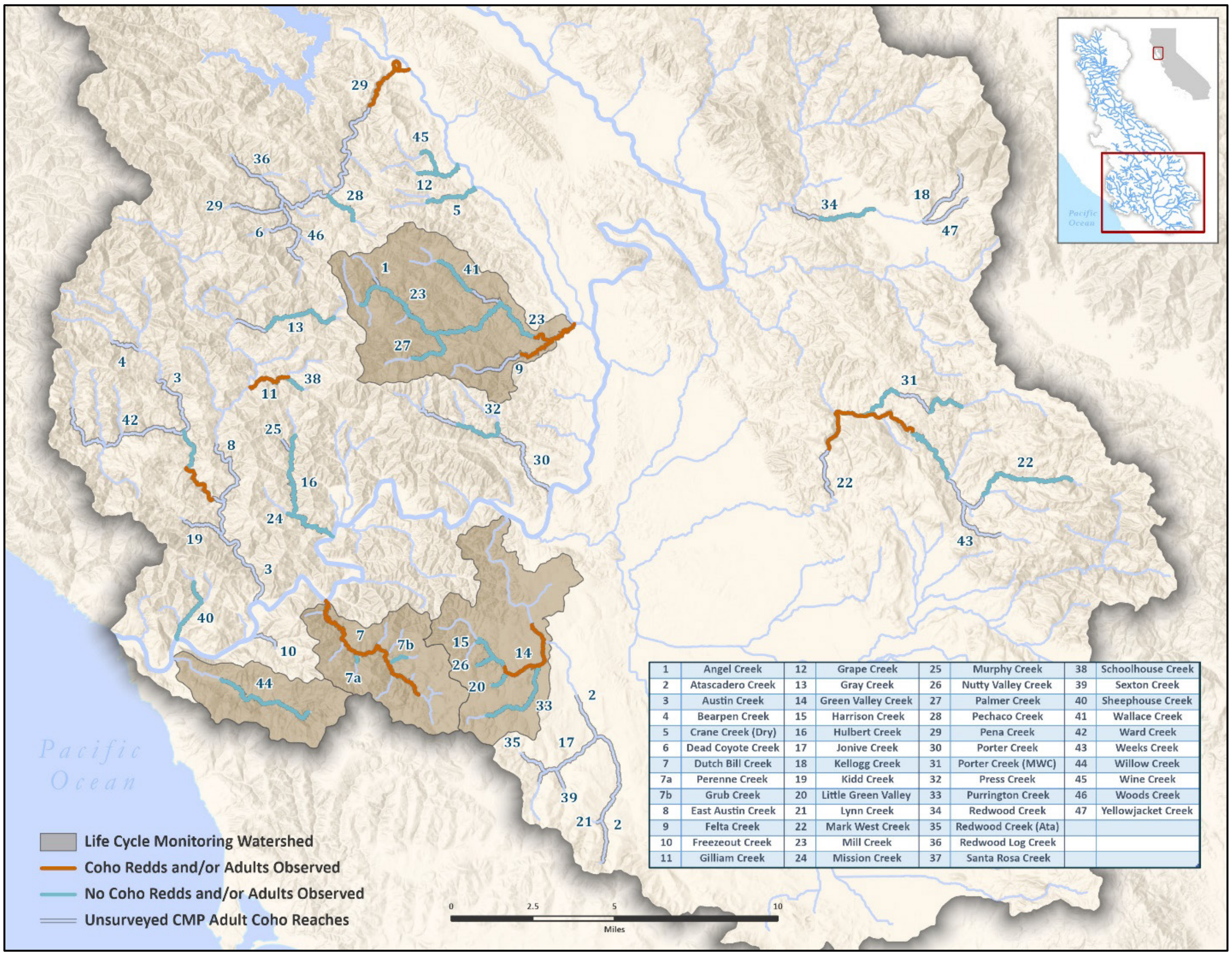

Figure 23. Coho-steelhead stratum reaches where Coho Salmon redds and/or Coho Salmon adults were observed. Sampled reaches where the presence of Coho was not documented appear in light blue.

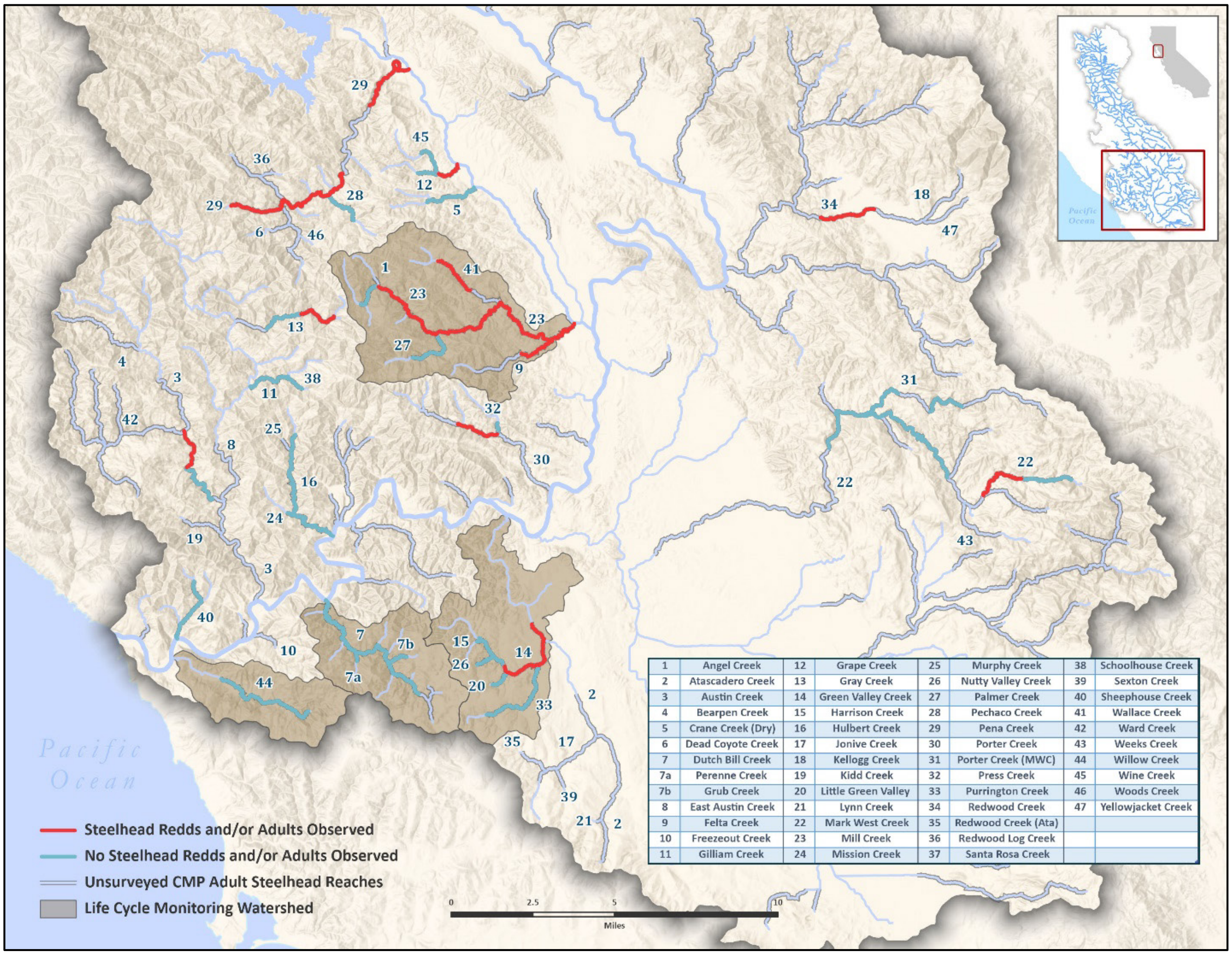

Figure 24. Coho-steelhead stratum reaches where steelhead redds and/or steelhead adults were counted. Sampled reaches where the presence of steelhead was not documented appear in light blue.

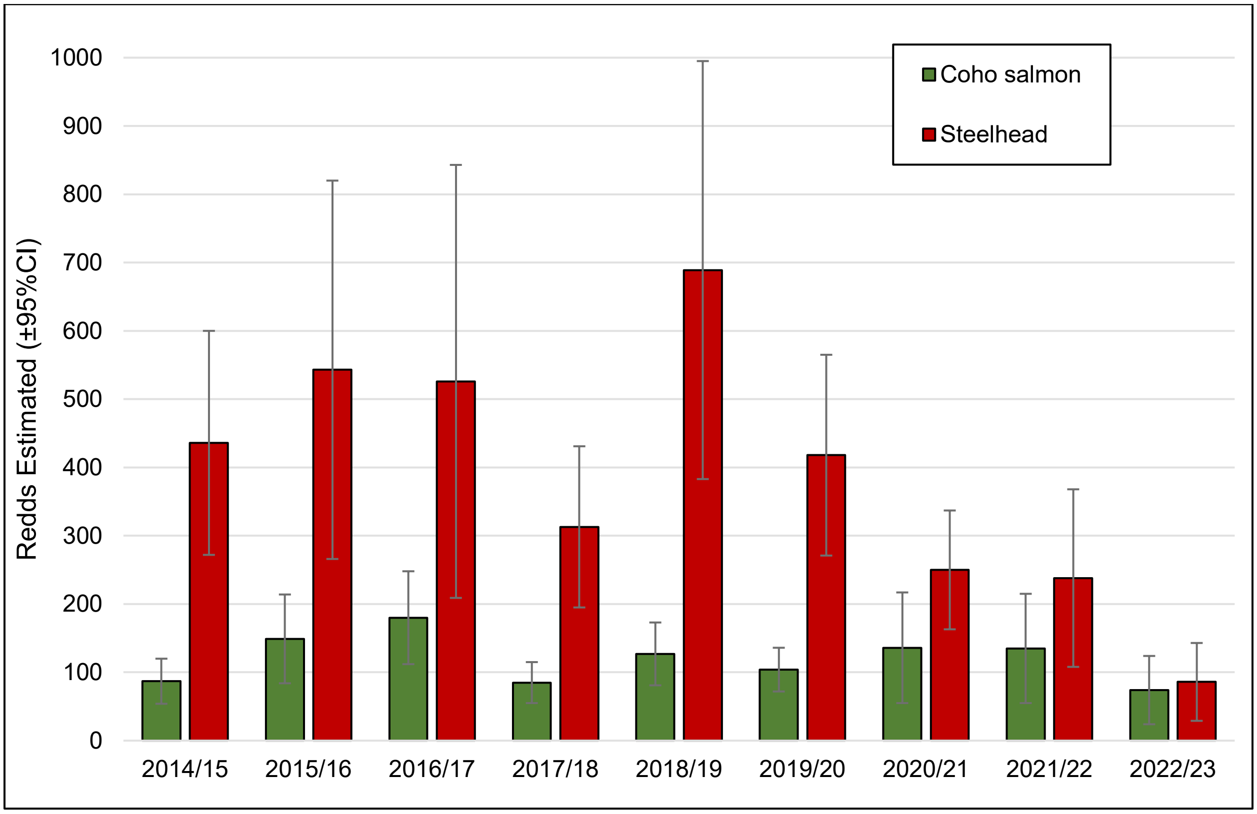

Figure 25. Trend in basin-wide estimates of Coho and steelhead redd abundance by season for the Coho-steelhead sample stratum. Steelhead estimates do not include the entirety of the range of steelhead in the Russian River, just the portion that overlaps with Coho habitat.

Juvenile Coho Salmon occupancy

Between May 16 and August 24, 2022, we snorkeled 75 reaches encompassing 214 km (133 mi) of stream length and 42 tributaries (Figure 26). All juvenile Coho Salmon rearing reaches of Willow, Dutch Bill, Green Valley, and Mill creeks were surveyed, and 69 reaches within the Russian River sample frame that were considered to contain juvenile Coho habitat (66% of Coho reaches) were included in the basin-wide occupancy estimate. We excluded counts from Yellowjacket Creek when calculating basin-wide occupancy because hatchery fry were released from an RSI prior to snorkel surveys, and we had no way of visually distinguishing them from natural-origin fish. Six other reaches were not included in the occupancy estimate because either 1) they did not contain juvenile Coho habitat, 2) they were not part of the GRTS draw for 2022, or 3) only a single pass was completed.

We observed 26,565 Coho Salmon YOY and 4,990 steelhead YOY. All Coho YOY were presumed to be of natural-origin, except in Yellowjacket and Redwood creeks because of hatchery-origin fish released from an RSI in Yellowjacket Creek. Natural-origin Coho YOY were observed in 58 of the 75 juvenile Coho reaches surveyed and in 33 of the 42 juvenile Coho streams snorkeled (77% and 79%, respectively). Steelhead YOY were observed in 66 of the 76 steelhead reaches and 31 of the 42 steelhead streams surveyed (87% and 74%, respectively).

Natural-origin Coho counts were highest in Green Valley Creek, with the second highest counts in Willow and Dutch Bill creeks.

Based on results of the multiscale occupancy model, we estimate that the probability of Coho Salmon YOY occupying a given reach within the basin-wide Russian River Coho-steelhead stratum (ψ) in 2022 was 0.73 (95% CI : 0.61 - 0.82), and the conditional probability of Coho YOY occupying a pool within a reach, given that the reach was occupied (θ), was 0.62 (95% CI: 0.59-0.65). The proportion of the Coho-steelhead stratum occupied (PAO) was 0.45. This was the highest PAO observed of the eight years sampled (Figure 27).

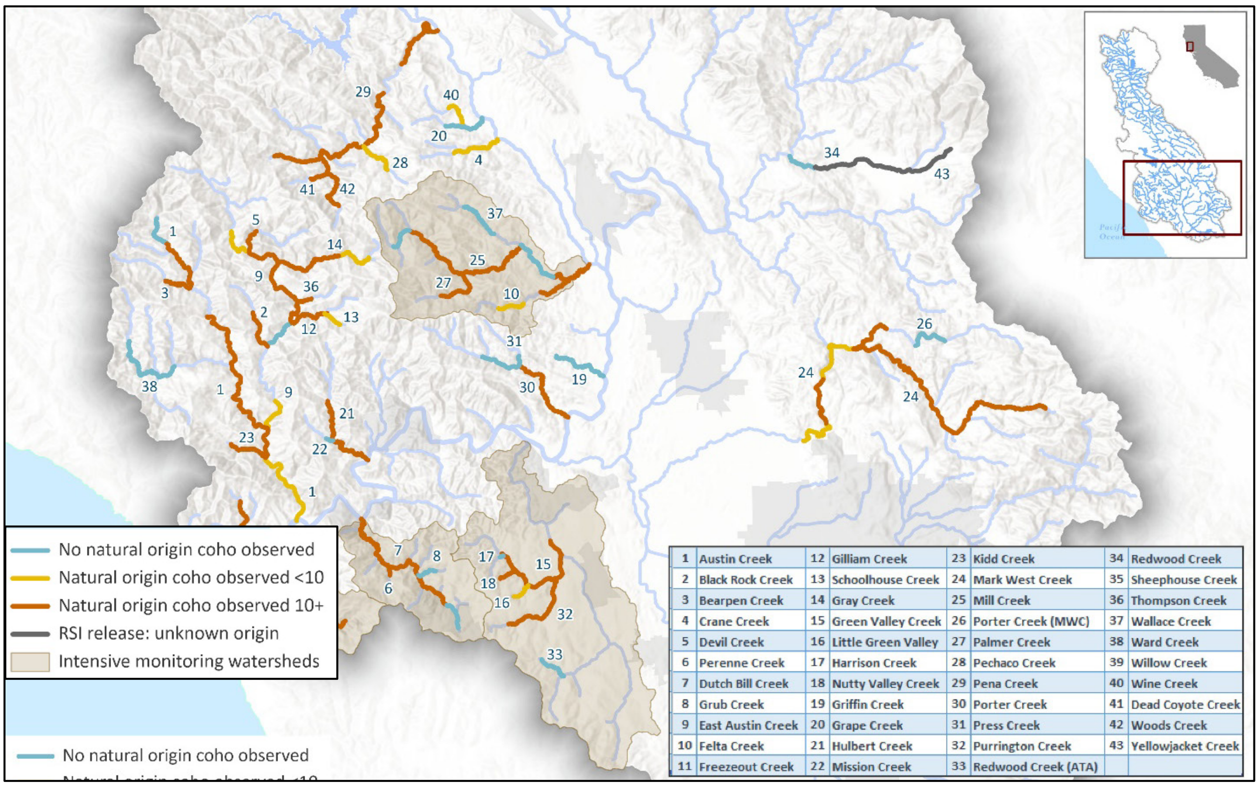

Figure 26. Natural-origin juvenile Coho Salmon distribution from snorkel surveys in the Russian River basin, 2022

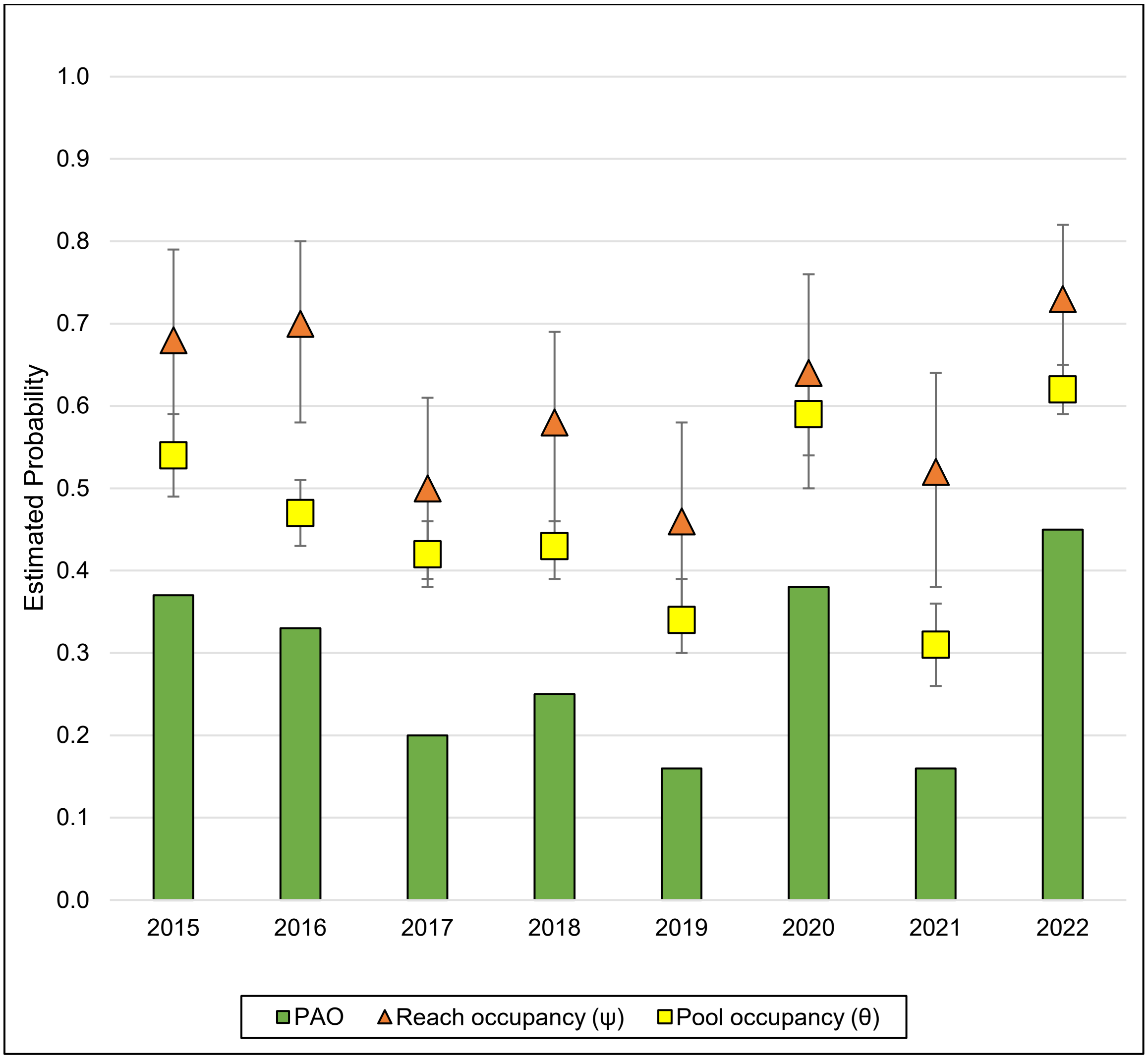

Figure 27. Trend in reach occupancy (*ψ*), conditional pool occupancy (*ϑ*), and PAO for juvenile Coho Salmon in the Coho-steelhead sample stratum.

Discussion

Redd abundance

Estimates of both Coho and steelhead redd abundance in the Coho-steelhead stratum were the lowest during the 2022/23 spawning season than any season since we began basin-wide spawner surveys in 2014. This is consistent with comparatively low redd abundance estimates and PIT antenna estimates of adult Coho returning to LCM streams. Though rainfall for the season was not far above average, an atmospheric river at the end of December brought several high-intensity rainfall events to the basin that created unsuitable conditions for conducting spawner surveys. For nearly a month long period starting the last week of December and continuing till the third week of January we were prevented from doing spawner surveys by high flows and turbidity (Figure 28). Creeks were checked periodically during this time to confirm that unsuitable survey conditions persisted. Overall, repeated atmospheric river events throughout the season led to the lowest number of successful trips this season (316 excluding sub-reaches), than we have completed during a spawner season since 2014/15. The period of time when this first atmospheric river hit corresponds with the usual peak in Coho spawning activity from mid-December to mid-January (Figure 29). Likely, our inability to survey during this time contributed to the low Coho estimates, but the corresponding low PIT antenna estimates indicate Coho adult returns were low despite our inability to document them with spawner surveys. We are without corroborating evidence to indicate steelhead adult returns were low, as we were unable to produce a steelhead adult estimate from PIT antenna detections, but there is less evidence that an inability to survey contributed to the low steelhead redd estimates. The usual peak in spawning for steelhead is a much longer period than for Coho. It generally extends from early-February to late-March (Figure 30). While there were some periods in March when atmospheric river events prevented us from surveying, the majority of the month of February we were able to get out for surveys (Figure 28).

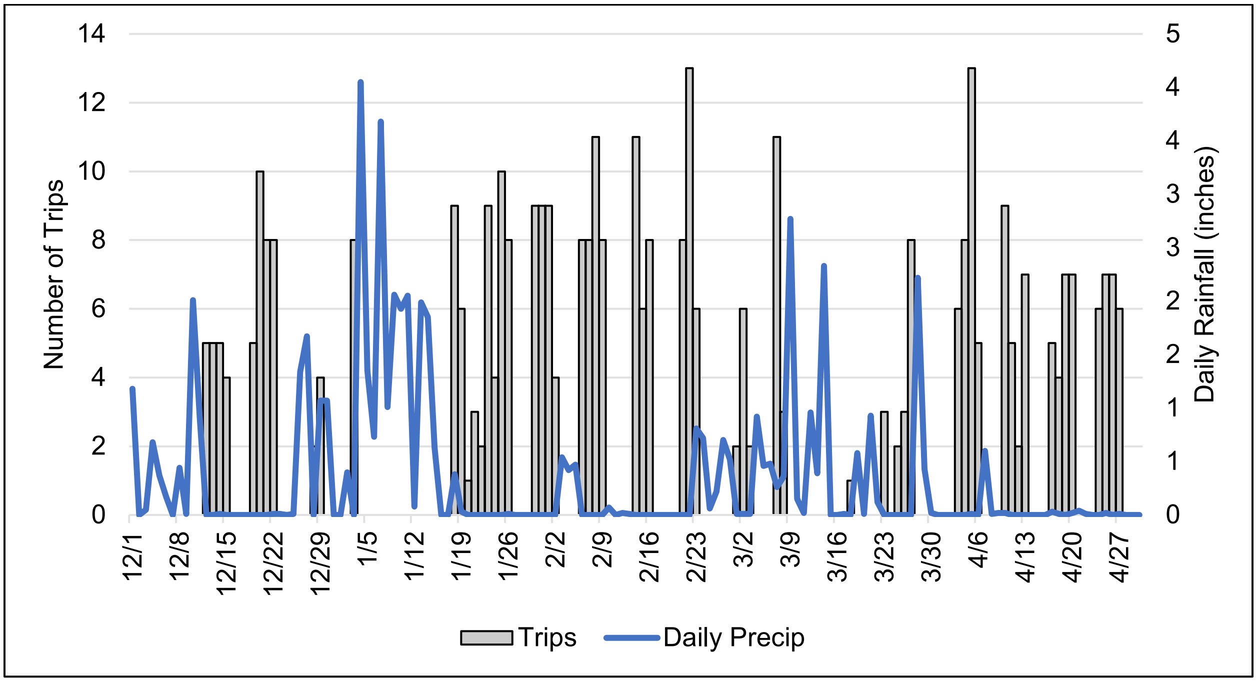

Figure 28. Daily rainfall totals measured at Warm Springs Hatchery during the 2022/23 spawning season and number of daily successful spawner survey trips during the 2022/23 spawning season (gray bars).

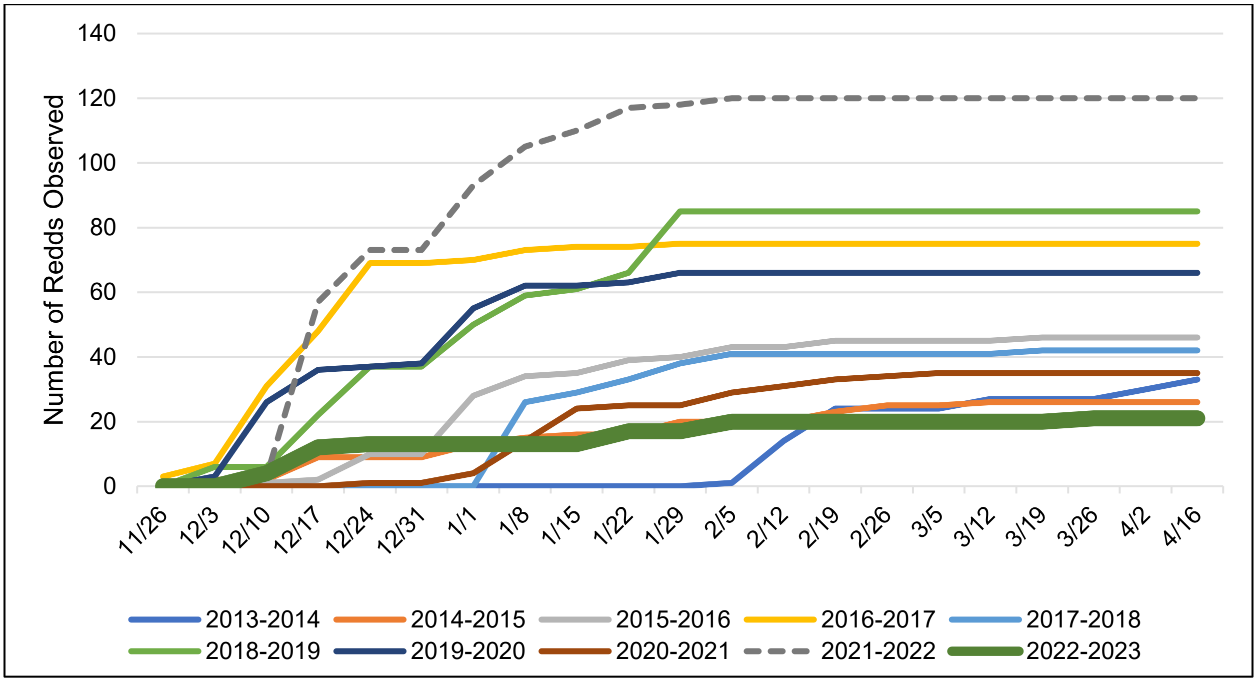

Figure 29. Cumulative Coho redd counts by survey date from the last decade of CMP spawner surveys. The thickest, red line is the most recent spawning season (2022/23) and the dashed line is the previous spawner season (2021/22).

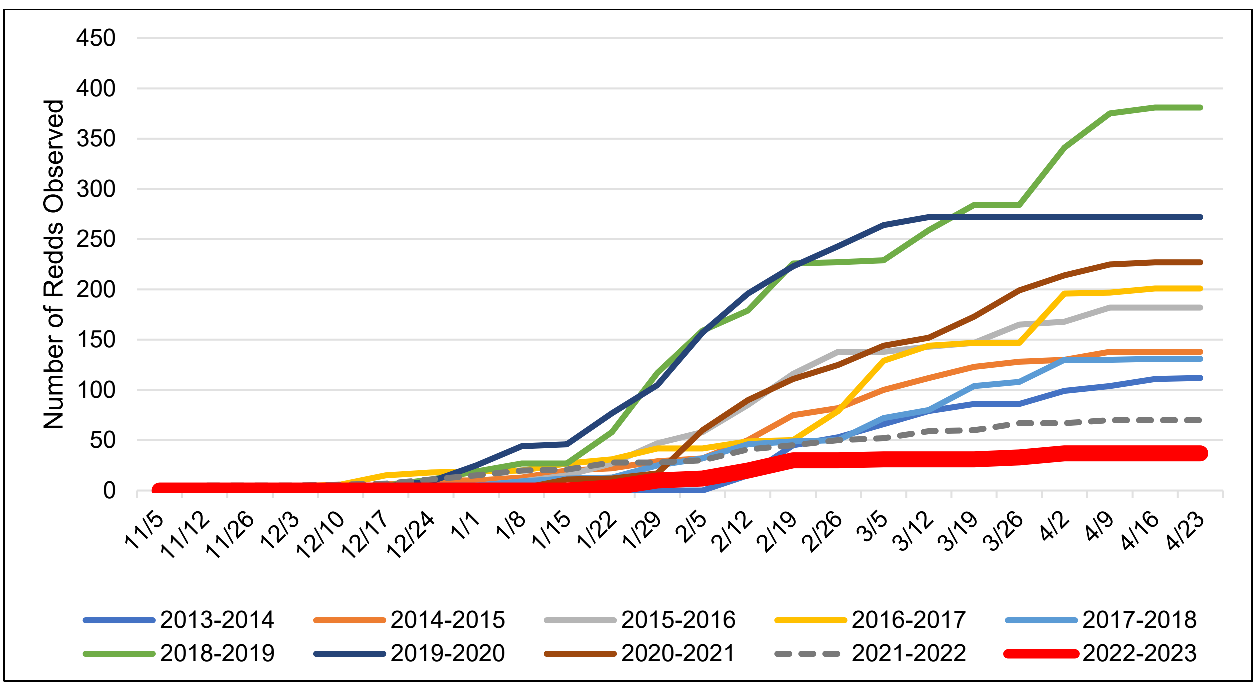

Figure 30. Cumulative steelhead redd counts by survey date from the last decade of CMP spawner surveys. The thickest, red line is the most recent spawning season (2022/23) and the dashed line is the previous spawner season (2021/22).

It is likely the low returns we documented this season were the result of poor summer water quality conditions and drying/disconnecting streams when the returning 2022/23 cohort was rearing and smolting. Juvenile Coho PAO estimates were deceptively high in 2020, but these were based on snorkel surveys occurring from June to early-August before severe drought conditions set in and water quality deteriorated in many streams. California Sea Grant documented these habitat conditions and estimated that in some LCM streams as much as 90% of the habitat dried out or became otherwise uninhabitable due to a combination of high temperatures, low dissolved oxygen and stream drying (CSG 2021b).

Juvenile Coho Salmon occupancy

In 2022 Coho PAO was the highest it has been since we began conducting basin-wide snorkel surveys to estimate spatial structure in 2015, indicating that Coho were using more of the watershed for rearing than we have ever observed. Estimated Coho redd abundance and adult Coho returns were slightly higher than the five-year average in the winter of 2021/2022, but the number of Coho redds counted was the highest it has been in a decade. The slightly higher than average estimate was due to the high Coho redd counts in streams that were not included in the random sample draw, indicating that the high numbers were localized to a small number of streams. It is notable then that the high counts seem to have led to a greater distribution of Coho juveniles across the available habitat. There is evidence that early summer snorkel surveys, while efficient at documenting juvenile presence, do not paint a complete picture of juvenile population health since they do not take into account survival during the late summer when water quality conditions can be dire as streams disconnect (CSG 2021b). This highlights a potential challenge for the Russian River Coho Salmon population in which low water years allow broad spawning success yet result in summer conditions across much of the basin being unsuitable for juvenile survival during the summer.

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