California Coastal Salmonid Population Monitoring in the Russian River Watershed: 2023/2024

FRGP Grant # P2281002; Annual Report
Reporting Period: July 1, 2023 – June 30, 2024

Suggested citation:
Sonoma Water and California Sea Grant. 2023. California Coastal Salmonid Population Monitoring in the Russian River Watershed: 2023/2024. Santa Rosa, CA. 59 pp.

Contributors:
Sonoma Water: Aaron Johnson, Gregg Horton, Andrea Pecharich
California Sea Grant: Mariska Obedzinski, Andrew Bartshire

Contents

Executive Summary

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 (LCSs) in four life cycle monitoring subwatersheds (LCMs) to measure status and trends in anadromous Coho Salmon and steelhead populations in the Russian River basin. With data generated from these field efforts, we estimated basin-wide adult Coho and steelhead redd abundance, basin-wide spatial structure of juvenile Coho, freshwater survival of successive cohorts of Coho and steelhead in LCMs, and marine survival of successive cohorts of Coho and steelhead in LCMs 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 subwatersheds (one LCS per subwatershed) and basin-wide redd abundance using spawner survey data collected from a GRTS-ordered random sample of reaches in the watershed containing habitat for both Coho and steelhead (Coho-steelhead stratum). 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 in the mainstem Russian and tributaries upstream of the dam. The spatial structure of juvenile Coho populations in the Coho-steelhead sample stratum was estimated using snorkel counts from a GRTS-ordered random sample of reaches. We also attempted to estimate juvenile steelhead abundance using a modified basin-wide visual estimation technique (BVET) in the four LCMs. 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 conducted by CSG but funded by non-FRGP sources is reported in CSG (2004-2024).

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 2023, snorkel surveys conducted in 2023, electrofishing surveys conducted in 2023, and spawner surveys conducted during the 2023/24 spawner season.

c) Issues or concerns affecting schedule and/or budget: None
d) Activities for next reporting period:
    a. Monitoring coordination and planning
    b. Adult monitoring
    c. Juvenile and smolt monitoring
e) Financial Reporting/Invoices:

An invoice for work through 06/30/24 was submitted on 8/8/24 in the amount of $185,475.61.

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, training new field personnel, preparation of reports, and coordination of field activities associated with spawner surveys, snorkel surveys and electrofishing surveys. Prior to each season of field work, training was provided to crews to inform new staff and reacquaint existing field staff with data collection protocols. Fish identification, survey techniques, field safety, and a short course in tablet computing were components of training. 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, adult, and smolt abundance were calculated for LCM subwatersheds (Coho Salmon and steelhead) and smolt and adult abundance at the Russian River LCS (Chinook Salmon). Estimates of redd abundance were also calculated for the Russian River basin (Coho Salmon and steelhead), as well as estimates of juvenile spatial structure (Coho Salmon only). Data were shared with local CDFW and Army Corps 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. A meeting of the Russian River CMP Technical Advisory Committee is planned early in the next reporting period to update stakeholders on progress and allow feedback from members of the statewide CMP team and other CMP practitioners.

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 520 contacts were made during the current reporting period by phone, email, and personal communication to gain access from 174 new and existing landowners and property representatives. These contacts were made for securing temporary access for Sonoma Water field crews during the 2023 snorkel season, 2023 BVET survey season, and the 2023/24 spawner season. Contacts were also made to secure temporary access for partners including CDFW, local Resource Conservation Districts, and Trout Unlimited. 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 field crews using Survey 123 (Esri) forms and stored in a relational database for 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 2023/24 spawner season in the four Coho-steelhead LCM subwatersheds (paid for by non-project funding sources through February 28);
- PIT antenna monitoring for adults and juveniles in the four Coho-steelhead LCM subwatersheds (paid for by non-project funding sources);
- downstream migrant trapping conducted in spring 2023 at five life cycle stations (LCSs) (paid for by non-project funding sources);
- basin-wide visual estimation technique monitoring during late summer 2023 in the four Coho-steelhead LCM subwatersheds.

The objective of CMP life cycle monitoring is to detect trends in abundance of smolts and adults (Adams et al. 2011). The subwatersheds we selected for life cycle monitoring for Coho Salmon and steelhead are: Mill, Green Valley, Dutch Bill and Willow (Figure 1). These subwatersheds were chosen partly 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 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 experience, in most years it is possible to generate robust estimates of Coho and Chinook smolt abundance from DSMTs 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 pre-smolt model in Mill in summer/fall 2018, and Green Valley, Dutch Bill and Willow in summer/fall 2019. Although we have been successful in detecting years with poor steelhead survival, producing quantitative estimates of steelhead smolt abundance has not always been possible.

We conducted census spawner surveys in Green Valley, Dutch Bill, and Willow and near-census spawner surveys in Mill to estimate Coho and steelhead redd abundance (some reaches in Mill were excluded because landowners adjacent to the creek prevented access). We operated PIT antenna arrays at the mouths of all four Coho and steelhead LCM streams to estimate adult Coho abundance.

Figure 1. Coho Salmon and steelhead LCMs (shaded polygons) and downstream migrant traps coupled with stationary PIT antennas for each LCS. Blue line segments represent reaches containing habitat for one or more species.

Methods

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 to assess smolt abundance at LCSs, 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 subwatershed during the trapping season (Bjorkstedt 2010) while the traps were operating. 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 the four LCMs, we attempt to employ a smolt abundance model that is founded on abundance estimates of juvenile steelhead in each LCM in late summer/fall prior to a given steelhead smolt emigration season. Juvenile abundance 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 2nd 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 conducted during the first stage sampling. 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 each LCM. 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 LCM and operated year-round, which are, in turn, used to estimate survival from the juvenile to smolt stage (survival index). The survival index for each LCM stream is then applied to the respective juvenile abundance estimate, yielding an estimate of smolts emigrating from each LCM stream. Detailed steps are described in SW and CSG (2020).

Chinook Salmon smolts At the mainstem Russian River trap site, we operated one rotary screw trap (1.5 m diameter cone) downstream of the dam before the dam was inflated then immediately downstream of the downstream opening of the fish ladder on the west side of the river after the dam was inflated. 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 and measured for fork length (±1 mm) and mass (±0.1 g). A subsample of Chinook Salmon smolts was also 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.

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 subwatersheds. In addition, we applied PIT tags to approximately 50% of all natural-origin Coho Salmon smolts captured in downstream migrant traps on LCMs. 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 LCMs (Figure 1). Because these systems contain pairs (Mill, Green Valley, Dutch Bill) or triplet (Willow) 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 LCMs, 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 as is the case with Coho). A significant tagging effort was accomplished in Mill in 2017 and 2018, but this effort was not begun until 2019 in other LCM subwatersheds.

Estimates of the number of adult Coho Salmon returning to LCM subwatersheds 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 adults 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.

Generating an estimate for adult steelhead abundance in LCM streams using the same method we use for Coho 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 LCMs. Poor stream conditions and low steelhead juvenile abundance in recent years has limited our ability to PIT tag the quantity of fish in each LCM that would be required to generate an estimate

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. 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 through 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.

Redd abundance (Coho Salmon and steelhead)

We used protocols outlined in Adams et al. (2011) and Gallagher et al. (2007) to survey all LCMs and recorded salmonid redds, live adult fish, and carcasses (excluding some reaches and portions of reaches in Mill subwatershed 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 tributary streams 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 recorded. 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 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; 3=uncertain) to observed live adult salmonids and carcasses.

Certainty 1. Certain:

- two or more physical/behavioral characteristics unique to the species were observed by the crew.

Certainty 2. Somewhat certain:

- only one physical/behavioral characteristics unique to the species was observed by the crew;
- timing of the encounter was short enough that characteristics could not be confirmed.

Certainty 3. Uncertain:

- no physical/behavioral characteristics were observed to indicate species.

Upon classification of redd species in the field, we sought to make a final redd species assignment at the end of the season. 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 unspecified 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 subwatersheds using the simple random estimator described in Adams et al. (2011). Additional details can be found in Ricker at al. (2014).

We attempted to survey all reaches in the four LCM subwatersheds containing habitat for Coho and steelhead. However, in the Mill subwatershed 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·km^{-1}) was calculated in the surveyed sections and the product of redd density and each section 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 subwatershed.

Results

Smolt abundance

Detailed information on trap operation can be found in CSG data reports (CSG and SW 2004-2024) and SW Biological Opinion data reports (Martini-Lamb and Manning et al. 2009-2022).

Because of late rains in spring 2023, downstream migrant traps at the four Coho-steelhead LCSs could not be installed until mid-April but all four were operated until mid-June. We ceased operating traps when stream flow in the vicinity of traps became disconnected and/or daily catches of Coho and steelhead dropped to near zero for several consecutive days (Figure 2, Figure 3, Figure 4). PIT antennas were operated throughout the period in LCMs which facilitated smolt abundance estimation.

As with the Coho-steelhead LCMs, late spring rain delayed installation of the downstream migrant trap at the Russian River Chinook Salmon LCS until May 5 which was relatively later than the past several years (Figure 5). Trap operation ceased on July 5 when daily catches of Chinook Salmon smolts dropped to near zero for several consecutive days (Figure 6). Trap operation was interrupted for 8 days between June 13 while the Mirabel dam was inflated.

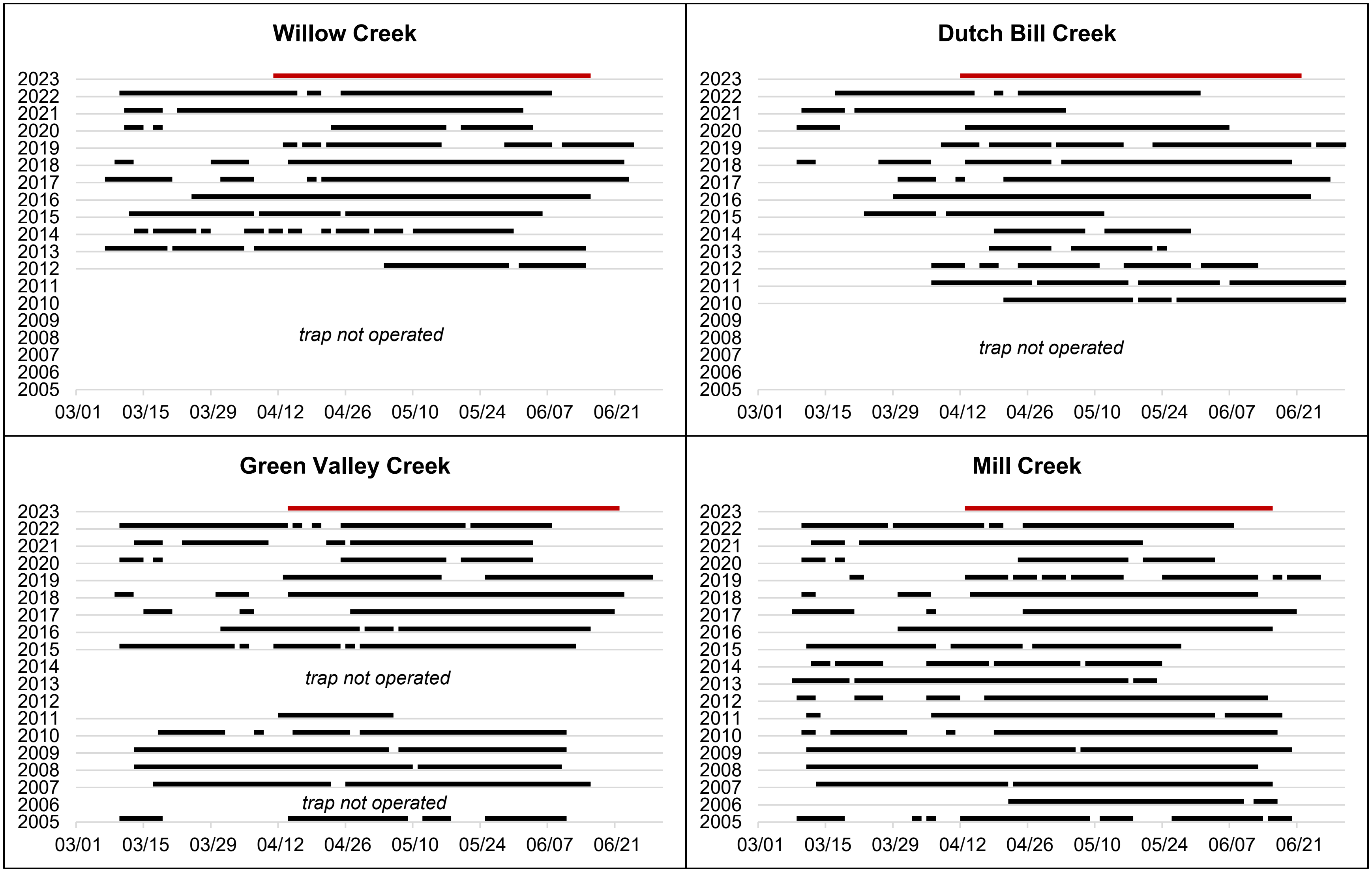


Figure 2. Period of operation by year of downstream migrant traps in Coho-steelhead life cycle monitoring streams by year, 2005-2023.

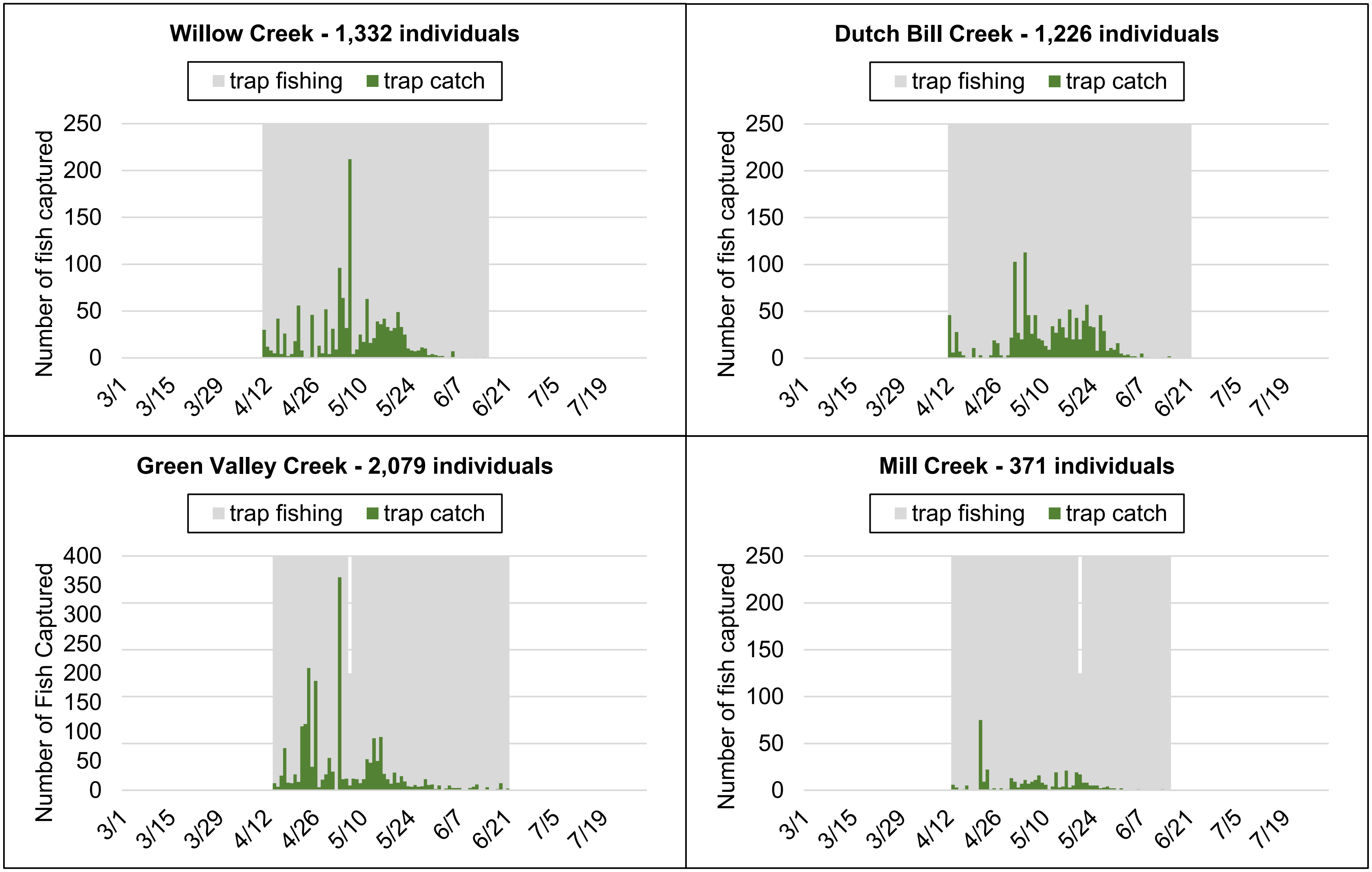


Figure 3. Coho Salmon smolt capture by date and dates downstream migrant traps were operating in Coho-steelhead life cycle monitoring streams, 2023.

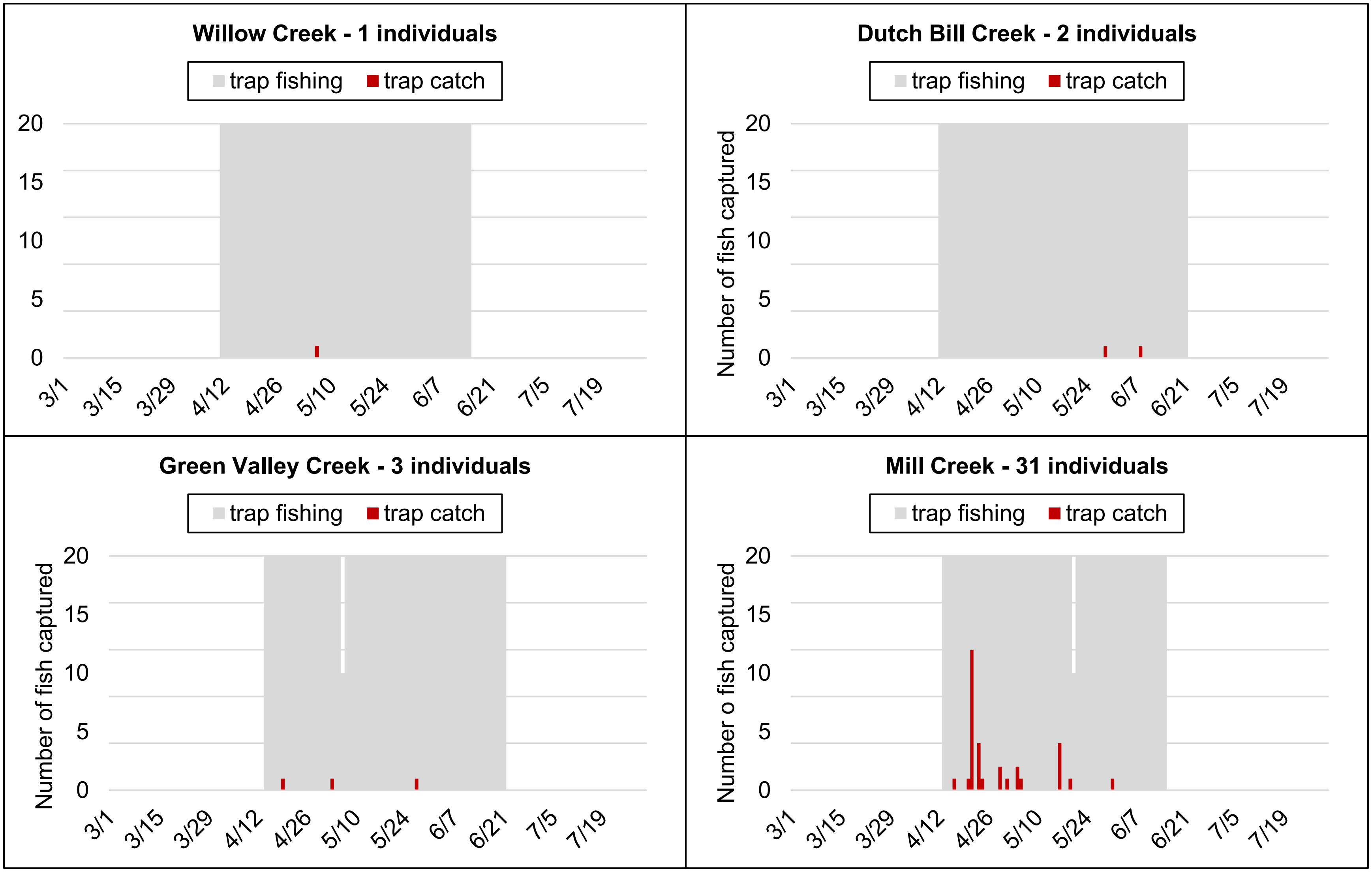


Figure 4. Steelhead smolt capture by date and dates downstream migrant traps were operating in Coho-steelhead life cycle monitoring streams, 2023.

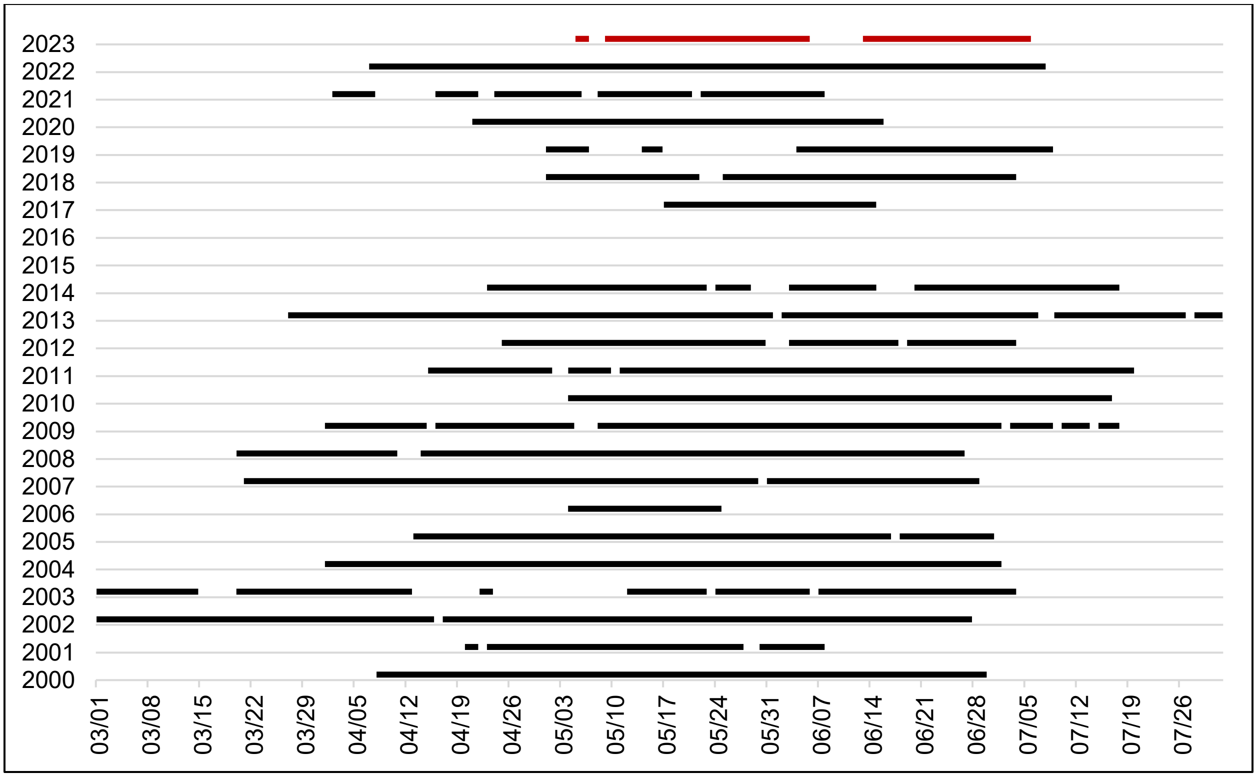


Figure 5. Period of operation by year of the downstream migrant trap at the mainstem Russian River Chinook Salmon LCS, 2000-2023.

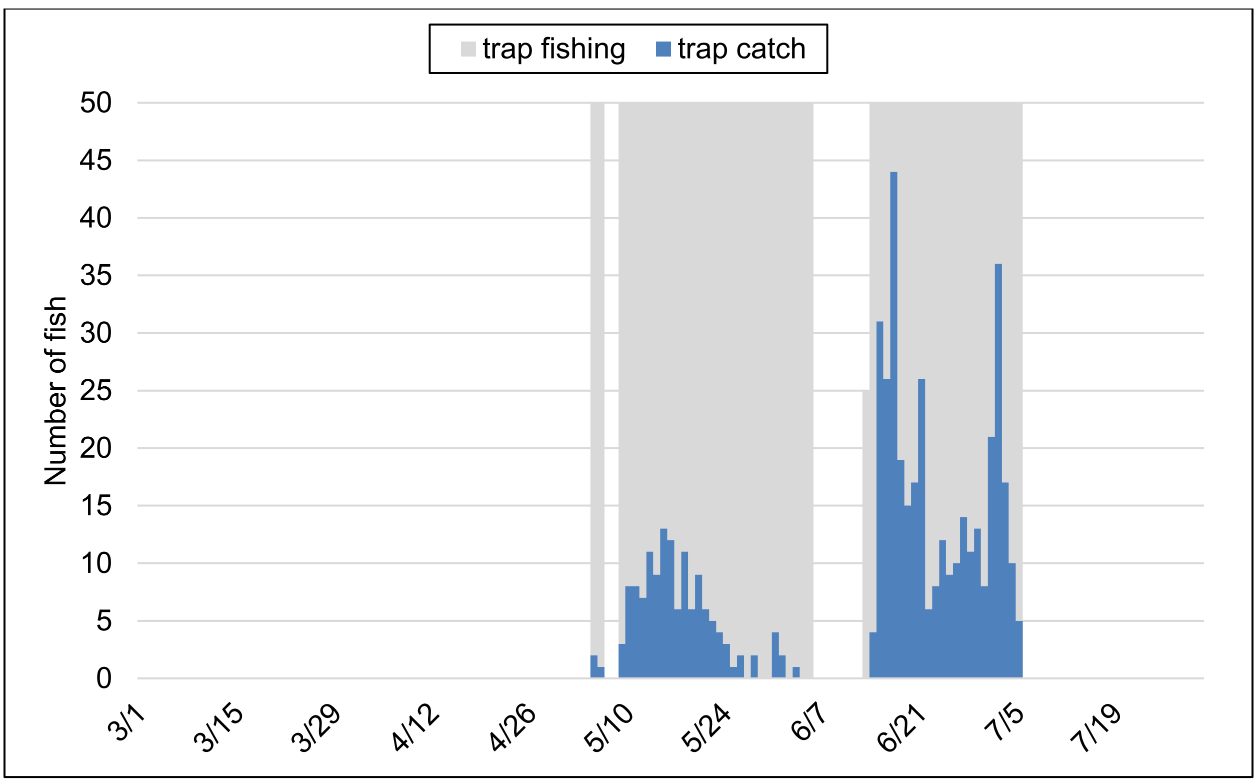
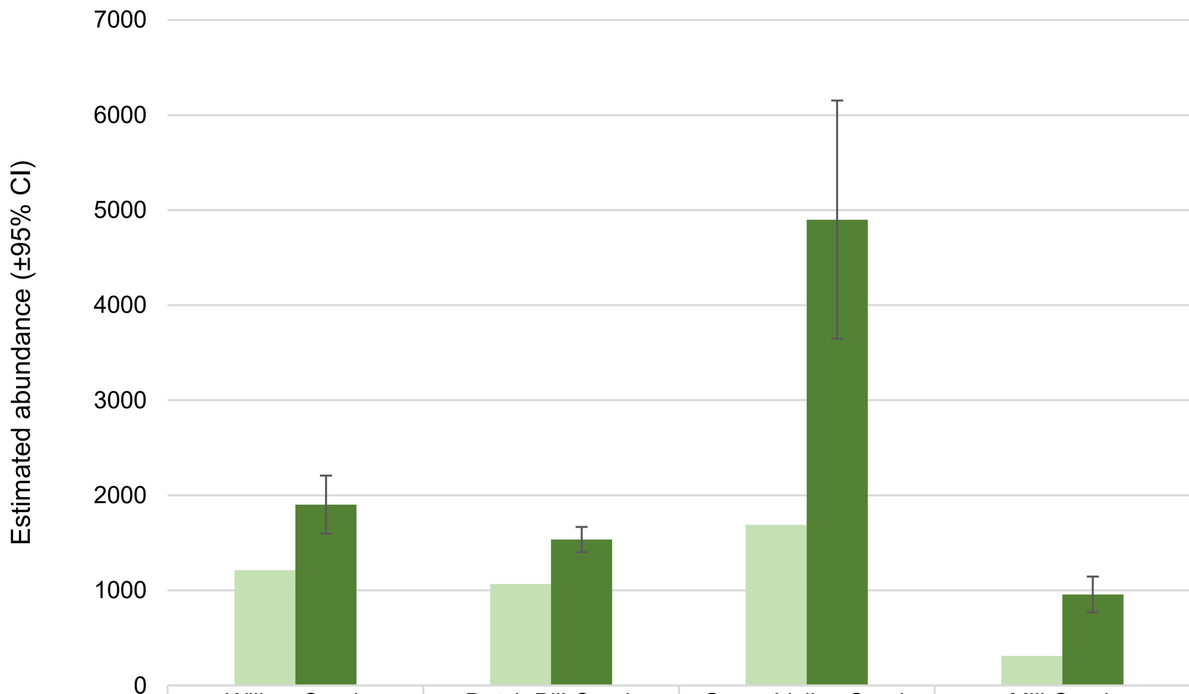


Figure 6. Chinook Salmon smolt capture by date and dates downstream migrant trap was operated at the mainstem Russian River Chinook Salmon LCS, 2023.

<u>Coho Salmon smolts</u> Among the four LCMs, the 2023 abundance estimate was by far the highest in Green Valley (Figure 7); however, abundance estimates in all streams were below estimates in 2022 and generally lower than recent years (Figure 8). Green Valley continued to show a steady decline in smolt abundance since a high of over 23,000 in 2017.



	Willow Creek	Dutch Bill Creek	Green Valley Creek	Mill Creek
Trap Catch	1212	1067	1691	310
N-hat	1902	1534	4900	957

Figure 7. Coho Salmon smolt abundance estimates for the LCMs.

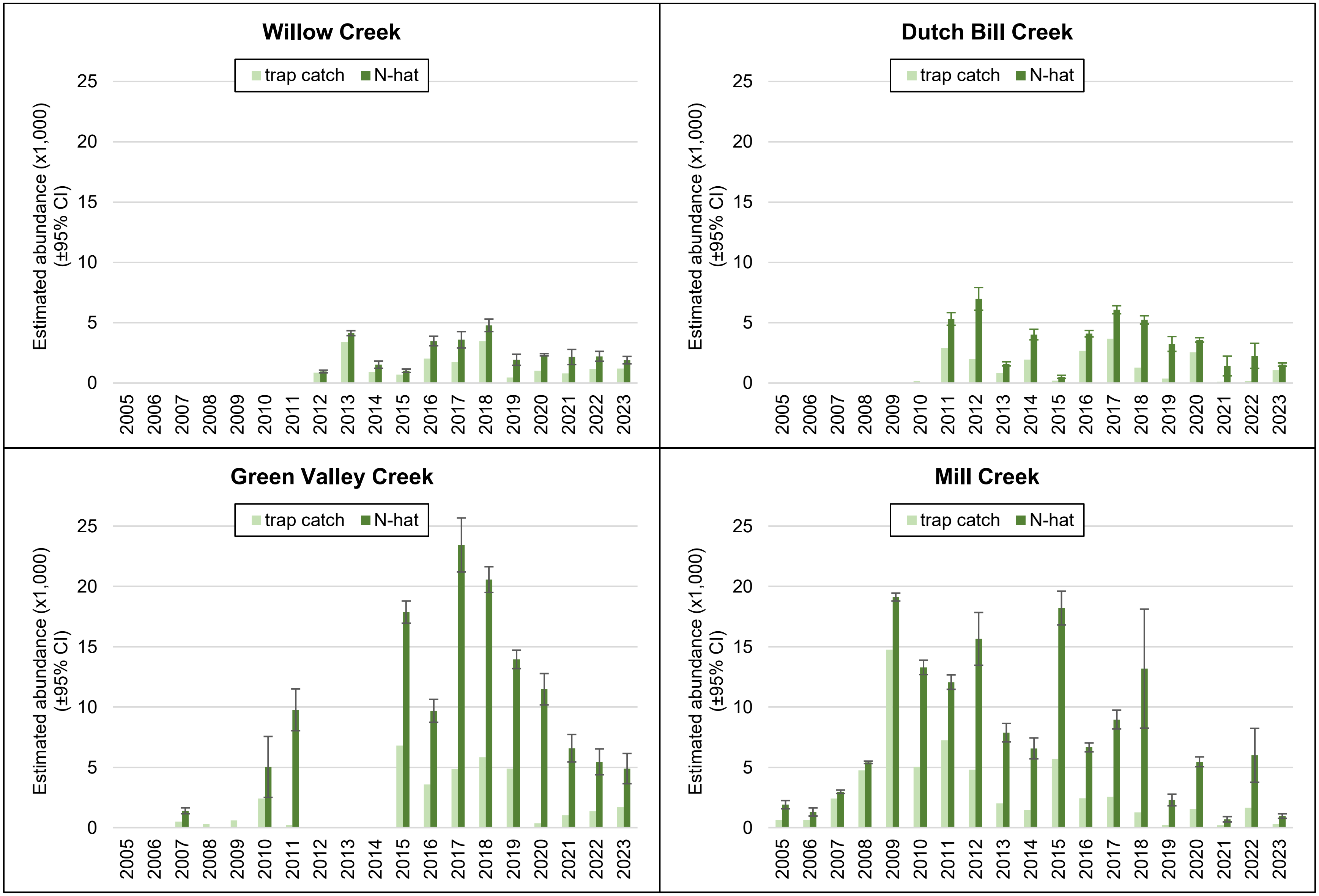


Figure 8. Estimated abundance of Coho Salmon smolts in Coho-steelhead life cycle monitoring streams, 2005-2023.

Steelhead smolts The estimate for steelhead smolts (2022-2023) is based on antenna detections of steelhead juveniles that were pit-tagged during the late summer of 2022. Improved stream conditions were observed in 2022 compared to the previous season, and overall, more habitat was available for juvenile steelhead because of higher stream flows. Late summer visual (snorkel) surveys were conducted in all four of the LCMs and steelhead counts from these surveys are the basis for our juvenile steelhead estimate. Electrofishing surveys occurred from mid-September to mid-October in selected streams (Mill, Palmer, Purrington, Dutch Bill, and Willow creeks). Due to the low number of juvenile steelhead encountered during snorkel surveys (first stage sampling), electrofishing surveys were not used to calibrate the snorkel counts (second stage sampling), but rather for the sole purpose of PIT tagging juveniles for future detection as they emigrate from their natal streams. These detections were used to calculate a survival index to the smolt stage and generate a smolt estimate when possible. During the sampling period between September 12 and October 15, 2022, we PIT-tagged 625 steelhead and 524 Coho in all LCMs combined.

A late summer (pre-smolt) population estimate for steelhead was calculated based on snorkel counts using the correction factor calculated during the 2019 season (Table 1). Detections of PIT-tagged individuals from late summer sampling in 2022 at downstream antennas during the steelhead emigration period (Nov 1, 2022-June 30, 2023) were used to estimate survival of juveniles to the smolt stage and calculate a smolt estimate for the 2022-2023 emigration season. These survival indexes were quite low for Willow, Dutch Bill and Green Valley but in Mill the survival index was similar to previous years (Table 2). PIT antenna-based steelhead estimates were at least one order of magnitude higher than raw trap catches (Figure 9). This is consistent with our findings in past years when smolt abundance estimates could be calculated.

Table 1. Calibration ratio (R-hat) applied to snorkel counts based on number of steelhead observed in pool habitat only, calculated in 2019 and applied to snorkel counts in 2022.

Group	R-hat	SE	95% LCI	95% UCI	n
≤ 10 sthd	3.73	0.25	3.23	4.22	109
> 10 sthd	2.94	0.03	1.33	2.53	74

Table 2. Steelhead pre-smolt abundance estimates, number of pools sampled, survival indexes and smolt estimates in the four LCMs, 2017-2023.

Season	LCM	pre-Smolt N-hat	Number of pools snorkeled[1]	Survival index[2]	Smolt N-hat (±95% CI)
2017-2018	Mill	8300	175	0.26	2158 (229)
2018-2019	Mill	4645	191	0.24	1115 (220)
2019-2020	Willow	4220	91	0.08	338 (72)
2019-2020	Dutch Bill	7864	126	0.17	1337 (349)
2019-2020	Green Valley	9431	168	0.11	1037 (249)
2019-2020	Mill	11596	193	0.20	2319 (582)
2020-2021	Willow	781	44	NA	NA
2020-2021	Dutch Bill	1509	64	0.17	251 (39)
2020-2021	Green Valley	3876	109	0.06	251 (45)
2020-2021	Mill	NA	NA	0.10	NA
2021-2022	Willow	60	39	NA	NA
2021-2022	Dutch Bill	1351	59	NA	NA
2021-2022	Green Valley	1080	120	NA	NA
2021-2022	Mill	1755	138	NA	NA
2022-2023	Willow	45	99	0.07	3 (0.4)
2022-2023	Dutch Bill	1468	92	0.06	90 (13)
2022-2023	Green Valley	2018	132	0.05	95 (15)
2022-2023	Mill	2012	162	0.16	326 (48)

[1] Approximately 50% of all pools in each LCM were snorkeled each summer and provide the basis for the pre-smolt estimate, except for Mill in 2020 due to impacts from the Walbridge Fire

[2] Survival index and smolt estimate could not be calculated when electrofishing and pit-tagging did not occur due to poor water quality.

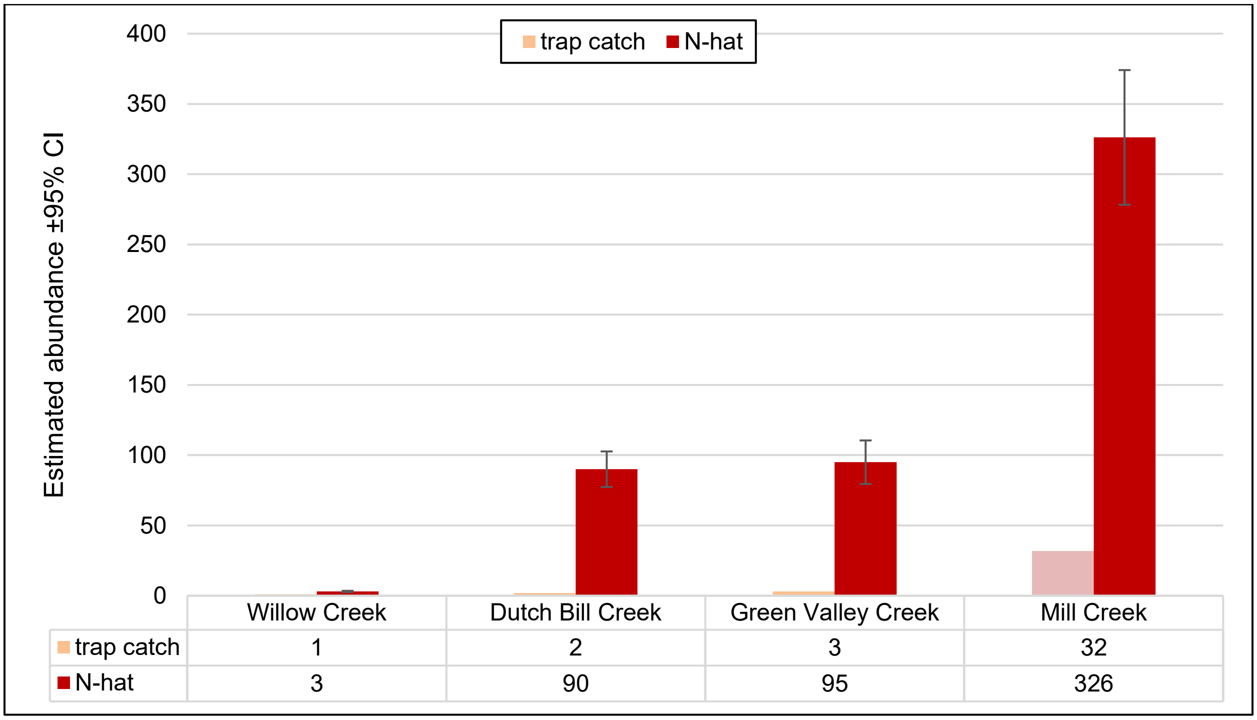


Figure 9. Steelhead smolt abundance estimates for the LCM subwatersheds, 2023. Note that because of early steelhead smolt migration relative to safe trap installation, the abundance estimates are based on a pre-smolt steelhead abundance and survival model and not trap catch.

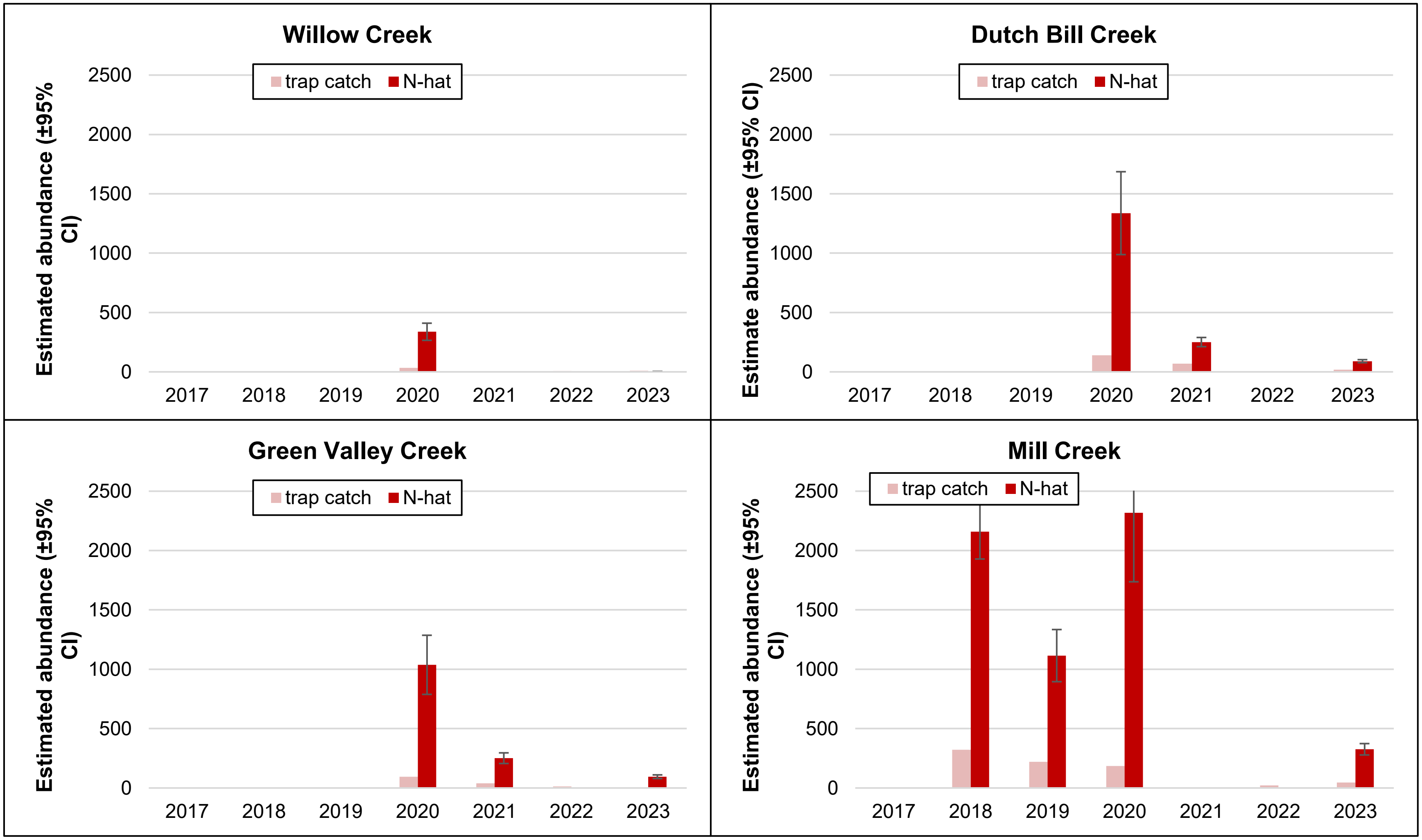


Figure 10. Estimated abundance of steelhead smolts in Coho-steelhead life cycle monitoring streams, 2017-2023. Note that estimates were not possible in 2021 in Mill or 2022 in any LCM because no juveniles could be PIT-tagged due to poor water quality conditions.

Chinook Salmon smolts Due to the late installation of the Mirabel downstream migrant trap and low trap catch and efficiency (465 fish and 18 recaptures), we captured very few Chinook smolts and were unable to estimate Chinook Salmon smolt abundance for 2023 (Figure 11).

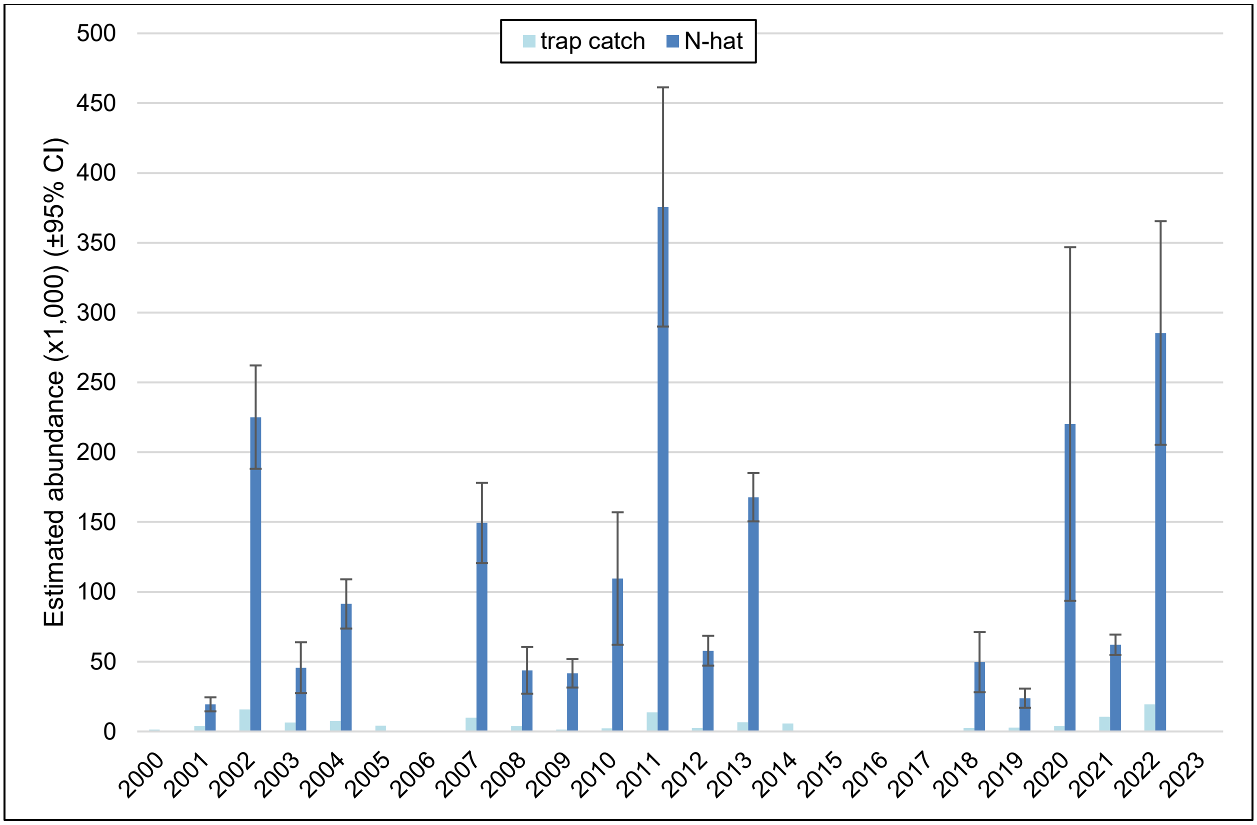


Figure 11. Estimated annual abundance of Chinook Salmon smolts at the mainstem Russian River Chinook Salmon LCS for the years abundance estimates were possible.

Adult abundance

Coho Salmon adults Adult Coho estimates from PIT tag detections in the LCMs were considerably higher than the previous season (2022/23), and almost double the ten-year average. Dutch Bill had the highest adult Coho estimates for the 2023/24 return year (Figure 12, Figure 13). Spawner to redd ratios varied considerably (from 4.7 to 26) among LCMs, but were also considerably higher than the previous season, and some of the highest we have seen in the last decade. A ratio for Willow could not be calculated because while there were adult returns estimated, there were no Coho redds estimated this season (Table 3). More detailed results and analysis can be found in CSG and SW 2024 (Winter).

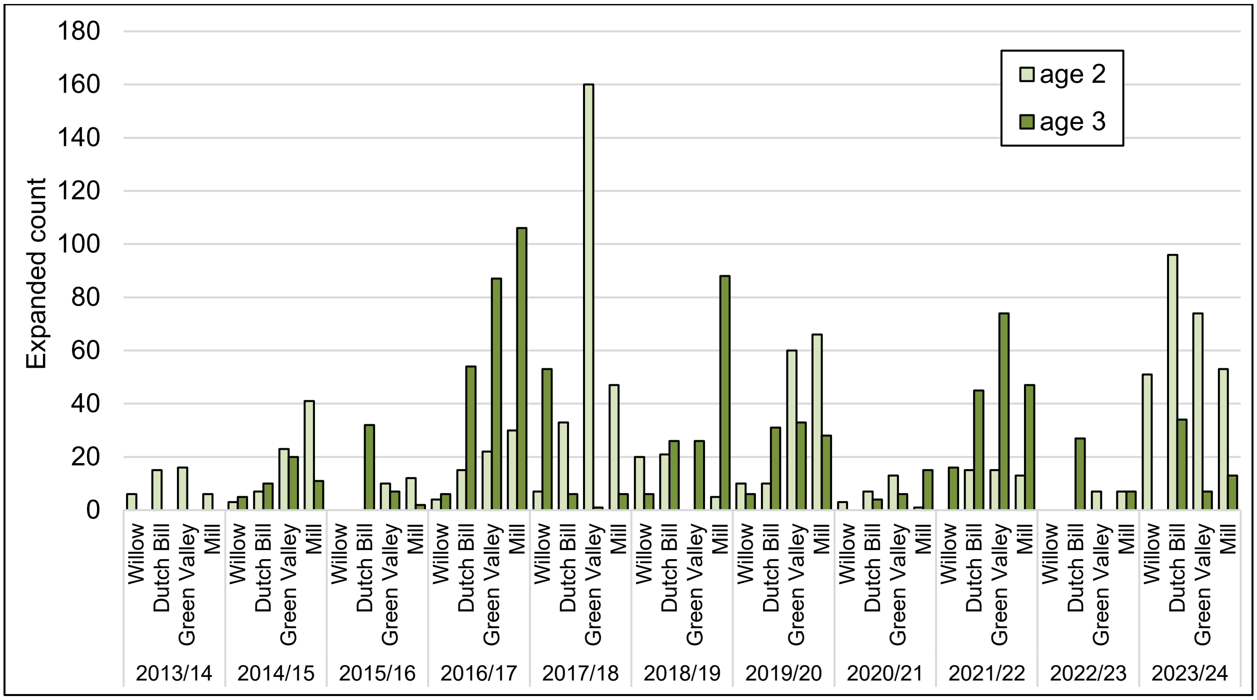


Figure 12. Estimates of adult Coho Salmon abundance in LCM subwatersheds, return winters 2013/14 through 2023/24. Total adult estimates are broken out by age class and include both natural- and hatchery-origin fish.

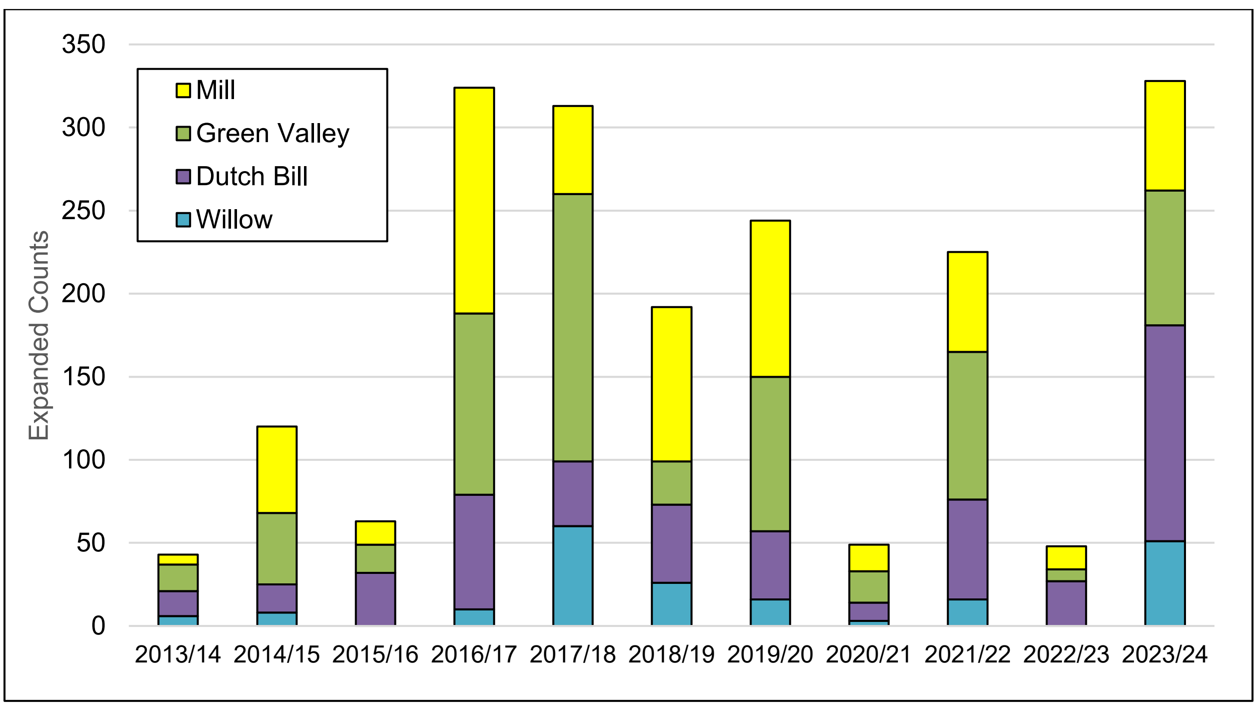


Figure 13. Trends in estimated adult Coho Salmon abundance in LCM subwatersheds, return winters 2013/14 through 2023/24. Estimates include both 2-year-olds and 3-year-olds and both natural- and hatchery-origin fish.

Table 3. Estimated spawner to redd ratios in LCM subwatersheds for return winter 2023/24.

Subwatershed	Adult Estimate	Redd Estimate	Spawner to Redd Ratio
Mill	66	14	4.7
Green Valley	81	6	13.5
Dutch Bill	130	5	26.0
Willow	51	0	NA

Steelhead adults Similar to the 2022/23 season, and 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 2023/24 season. This also prevented us from calculating a spawner to redd ratio for adult steelhead. However, we observed 17 steelhead that we assumed were adults based on having reached a minimum assumed age and potential time at sea (days at large) of at least 9 months (Table 4). A greater confidence is assumed for individuals that also have a downstream detection of emigration during the smolt season and subsequent upstream migration at a stream mouth during the spawning season. It should be noted that not all 17 individuals were tagged during CMP lifecycle monitoring tagging efforts. Fish from Austin and Dry Creeks were tagged during sampling compelled by the Russian River Biological opinion.

Table 4. Encounter information from steelhead tagged during late summer sampling as juveniles detected as likely adults during the 2023-2024 adult spawning migration season. Note that some fish were tagged during non-CMP tagging efforts.

Tag stream	Size at tagging	Year tagged	Smolt date	Brood year	Adult detects	Comments
Felta	78	2019		2018	2024	No smolt detection
Green Valley	83	2019		2018	2024	No smolt detection
Purrington	80	2019		2018	2024	No smolt detection
Austin	66	2020		2019	2024	No smolt detection
Dry	105	2021	10/4/2021	2019	2024	
Dry	105	2021		2019	2024	No smolt detection
Purrington	95	2020	11/18/2020	2019	2024	
Purrington	65	2020	2/6/2022	2019	2023, 2024	Detected returning two consecutive years
Dry	85	2021		2020	2024	No smolt detection
Austin	67	2022		2021	2024	No smolt detection
Austin	62	2022		2021	2024	No smolt detection
Dry	87	2022	5/14/2023	2021	2024	
Dutch Bill	66	2022	4/22/2023	2021	2024	
Mill	67	2022		2021	2024	No smolt detection
Palmer	70	2022		2021	2024	No smolt detection

Palmer	64	2022	12/28/2022	2021	2024	
Palmer	65	2022	3/18/2023	2021	2024	

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 14). In 2023, the video system was operated from 9/2 until 12/18 when the dam was lowered due to high flows that are typical that time of year (Figure 15). The pro-rated count of 1,997 was higher than recent years, approximating the long-term median (2,057) and average (2,610) for the data set (Figure 16).

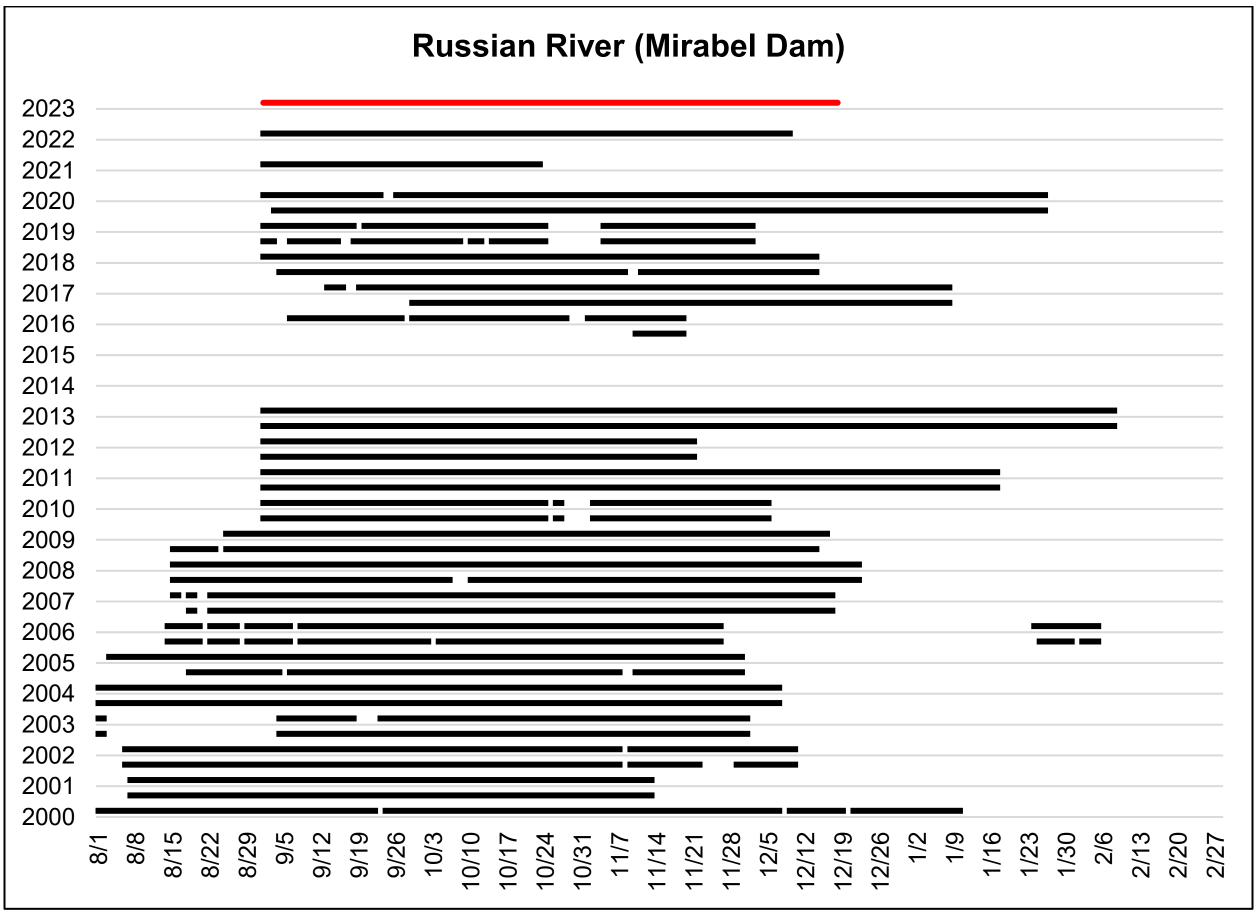


Figure 14. Period of operation by year of underwater video system at the mainstem Russian River Chinook Salmon LCS, 2000-2023.

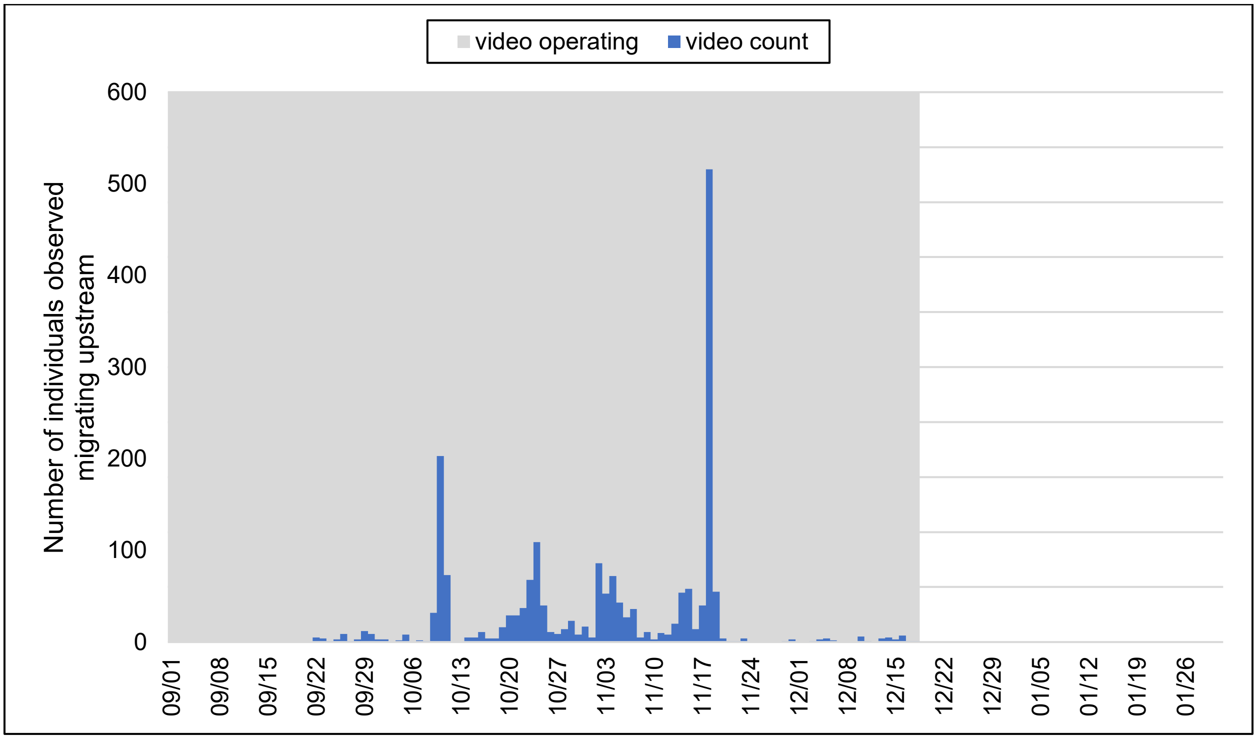


Figure 15. Chinook Salmon adult movement upstream past the mainstem Russian River Chinook Salmon LCS by date and dates video system was operating, 2023.

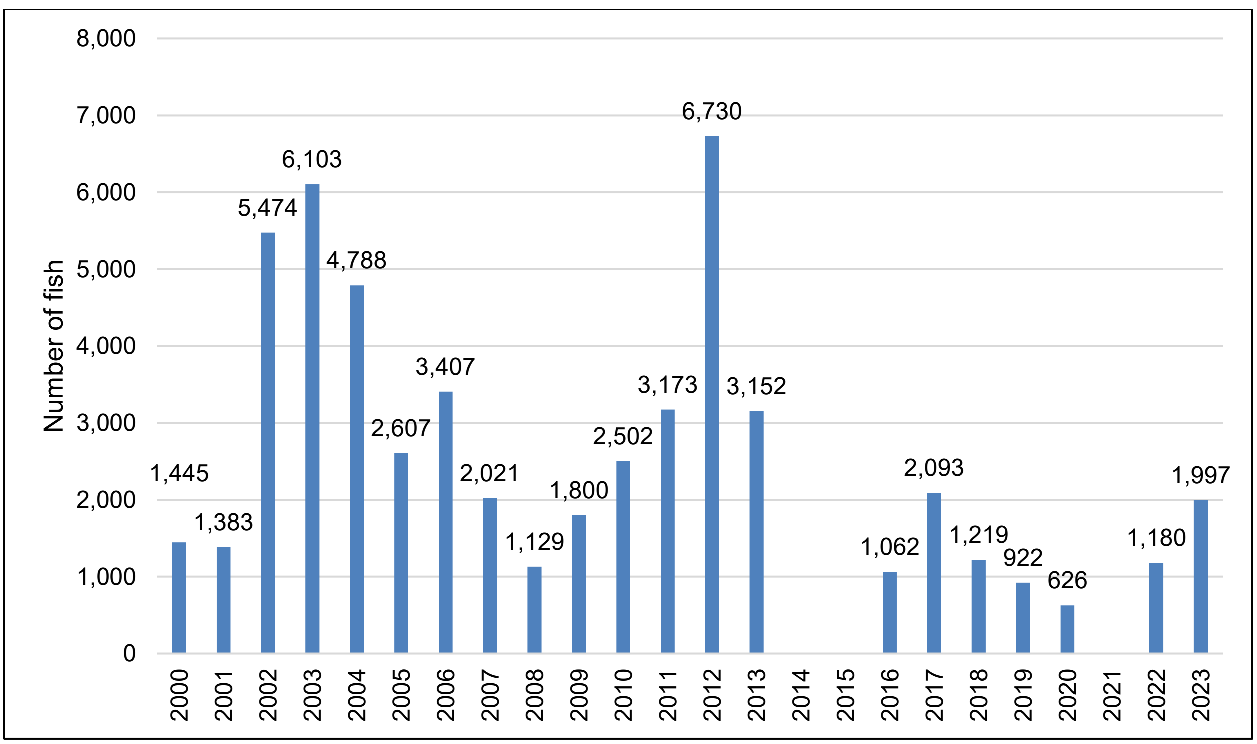


Figure 16. Adult Chinook pro-rated video counts at the mainstem Russian River Chinook Salmon LCS, 2000-2023.

Redd abundance (Coho Salmon and steelhead)

Surveys began December 11, 2023, and were completed April 29, 2024. During that period, we attempted to repeat samples at a 10–14-day interval, but this was often impossible. The winter of 2023/24 was characterized by several large storms that brought heavy rains, high flows and turbidity to the Russian River basin (Figure 17). We completed only 101 surveys in LCM reaches during the 2023/24 season. Of the 14 parent reaches surveyed in the LCMs, Coho redds or individuals were recorded in 10 (71%) and steelhead redds or individuals were recorded in 8 (57%). We observed the largest number of both Coho and steelhead redds in Mill (Figure 18). Mill also had the largest total number of individuals (live fish and carcasses) observed, and the largest number of steelhead individuals observed, but Green Valley had the largest number of Coho individuals observed (Figure 19). Estimates of Coho redd abundance in LCMs were 14 (±95% CI: 10) in Mill watershed, 6 in Green Valley, 5 in Dutch Bill and 0 in Willow. For the last two consecutive seasons, Mill had the largest number of estimated Coho redds by far. The last time any of the other three subwatersheds had comparable numbers of Coho redds was during the 2021/22 spawner season when Coho counts throughout the basin were the highest we have seen in the last decade (Figure 20). Estimates of steelhead redd abundance in LCMs were 49 (±95% CI: 21) in Mill, 8 in Green Valley, 1 in Dutch Bill, and 0 in Willow. Similar to Coho, steelhead redd abundance was highest in Mill. In previous seasons, steelhead redd numbers were generally higher in Mill and Green Valley as compared to other LCMs, though during the past few seasons steelhead have been rare in all LCMs except Mill. During the 2020/21 spawner season, steelhead redd estimates were higher in Dutch Bill than in Mill, and during the 2017/18 and 2018/19 seasons, estimates were higher in Green Valley, but those are the only seasons where Mill has not had the highest steelhead redd abundance estimate. Despite being generally higher than other LCMs, steelhead redd estimates in Mill have been on a general downward trend in the last decade though this season’s estimate was a bit higher than last season’s (Figure 21). Confidence intervals were not calculated for Willow, Dutch Bill, and Green Valley because all habitat was surveyed, so subwatershed estimates did not need to be expanded to unsurveyed reaches.

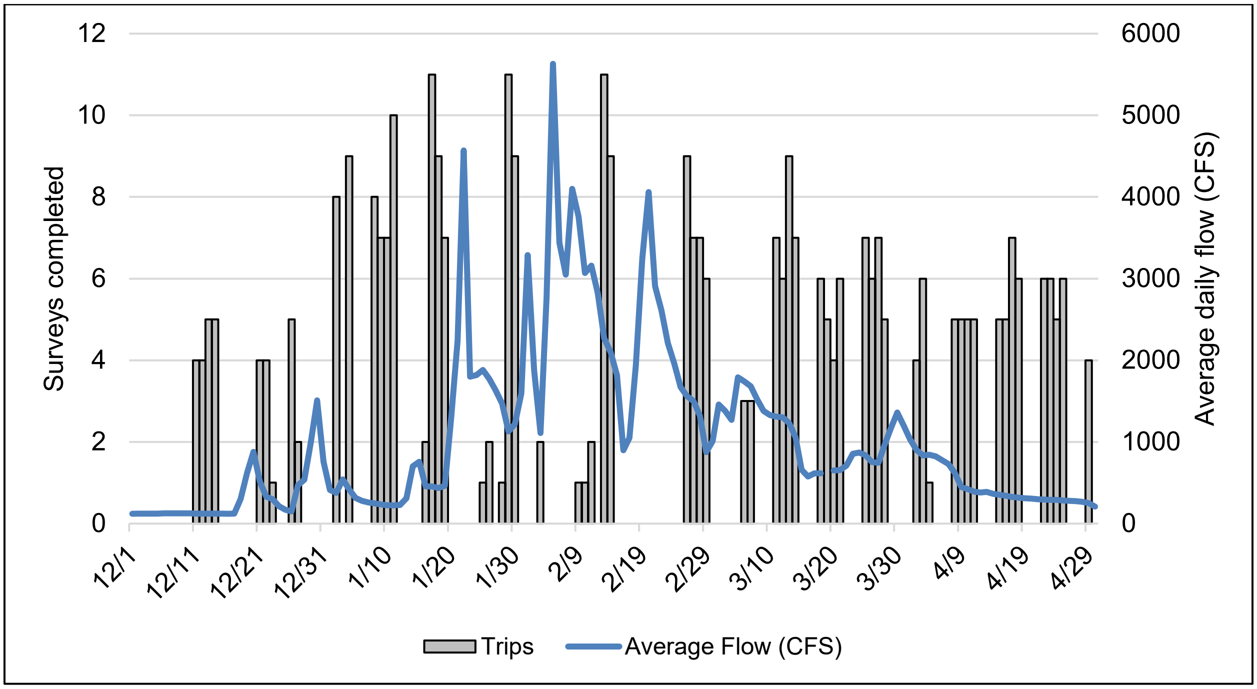
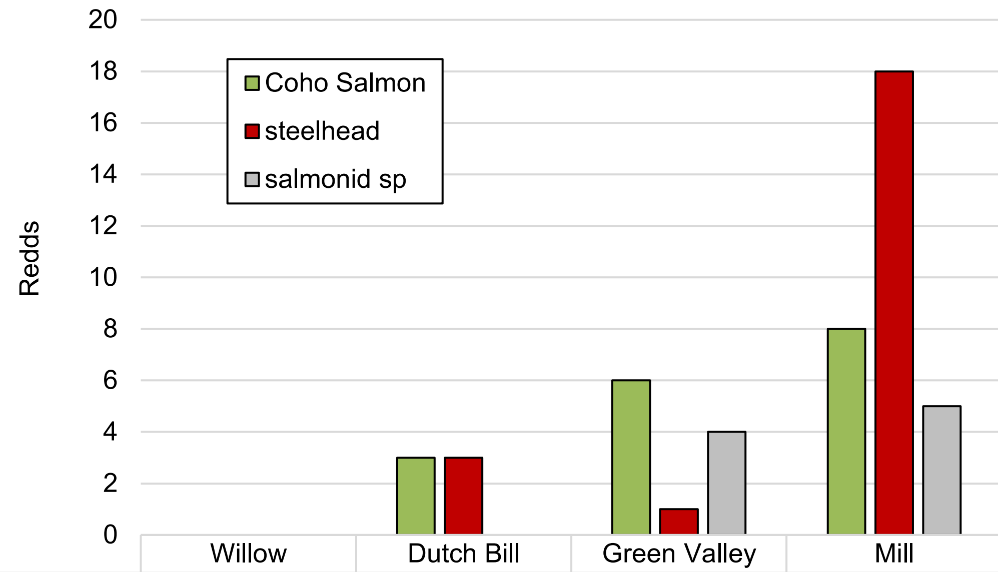
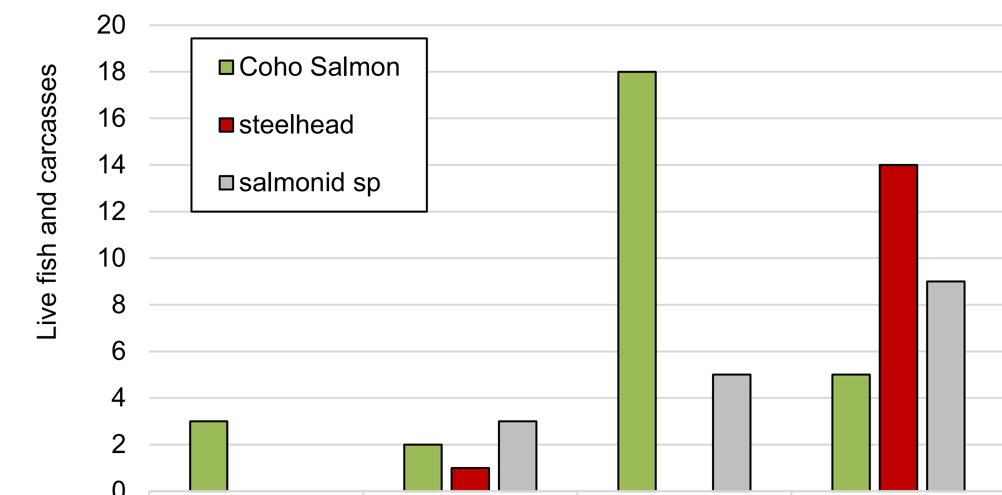


Figure 17. Daily rainfall totals measured near the mouth of Dry Creek during the 2023/24 spawning season (blue line) and number of successful spawner survey trips during the 2023/24 spawning season (gray bars).



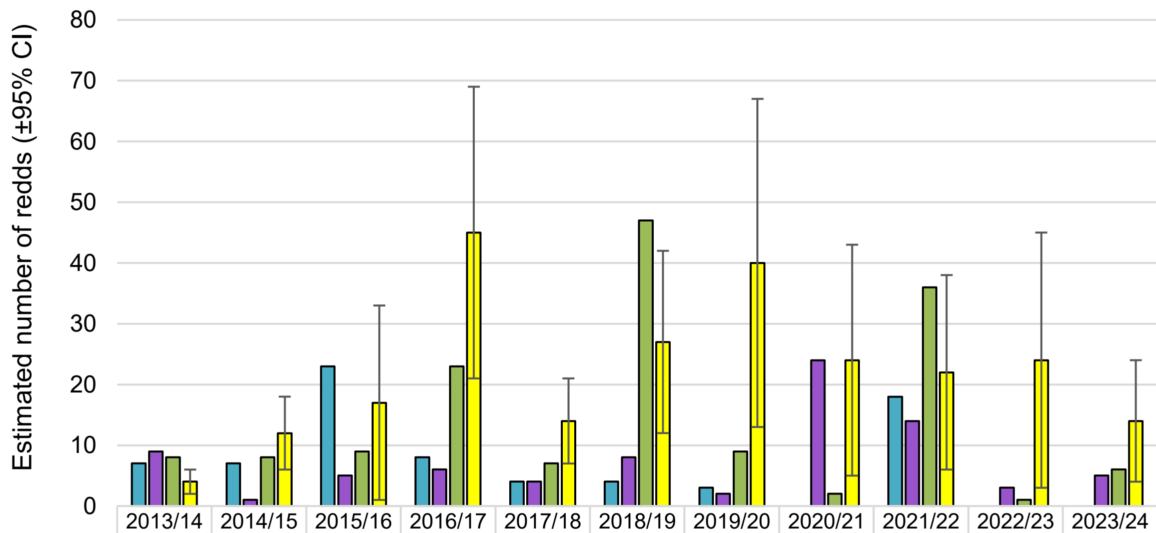
	Willow	Dutch Bill	Green Valley	Mill
Coho Salmon	0	3	6	8
steelhead	0	3	1	18
salmonid sp	0	0	4	5

Figure 18. New redds counted in LCMs for all three levels of redd species certainty during the 2023/24 spawner season. Mill totals include all tributaries (Felta, Wallace, and Palmer Creeks) and Green Valley totals include Purrington Creek.



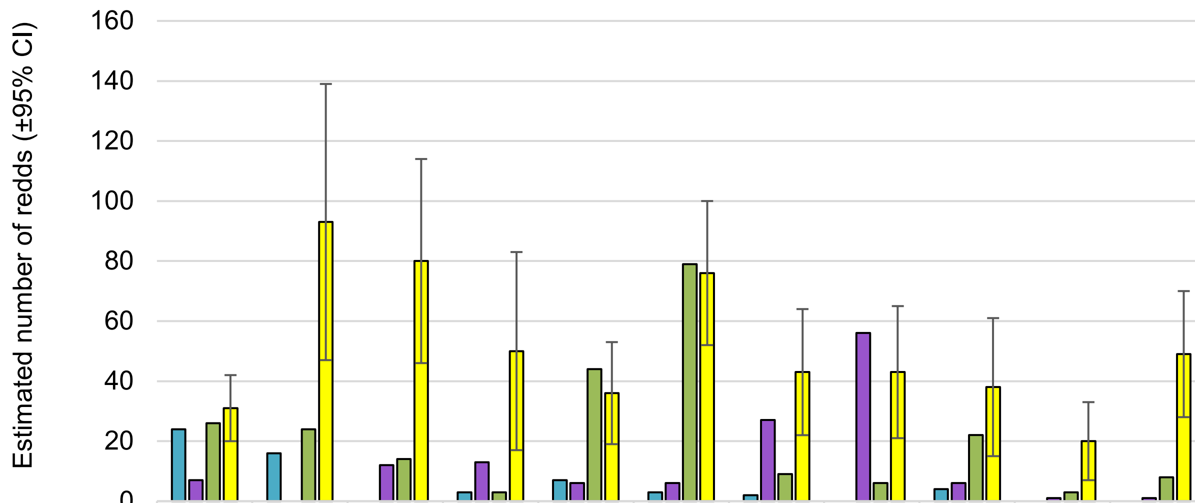
	Willow	Dutch Bill	Green Valley	Mill
Coho Salmon	3	2	18	5
steelhead	0	1	0	14
salmonid sp	0	3	5	9

Figure 19. Live fish and carcasses counted in LCMs for all three levels of species certainty during the 2023/24 spawner season. Mill watershed totals include all tributaries (Felta, Wallace, and Palmer Creeks) and Green Valley watershed totals include Purrington Creek.



	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24
Willow	7	7	23	8	4	4	3	0	18	0	0
Dutch Bill	9	1	5	6	4	8	2	24	14	3	5
Green Valley	8	8	9	23	7	47	9	2	36	1	6
Mill	4	12	17	45	14	27	40	24	22	24	14

Figure 20. Estimated number of Coho Salmon redds in LCMs, return winters 2013/14 through 2023/24. Because Mill is the only LCM where census spawner surveys could not be performed (due to landowner access), it is the only LCM where an expansion was calculated and is therefore the only one with confidence intervals.



	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24
Willow	24	16	0	3	7	3	2	0	4	0	0
Dutch Bill	7	0	12	13	6	6	27	56	6	1	1
Green Valley	26	24	14	3	44	79	9	6	22	3	8
Mill	31	93	80	50	36	76	43	43	38	20	49

Figure 21. Estimated number of steelhead redds in LCMs, return winters 2013/14 through 2023/24. 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.

Discussion

Smolt abundance

Coho redd and adult estimates in 2021/22 (the parental cohort for the 2023 smolts) were generally high, with some of the highest Coho redd counts in the last decade. Consequently, we expected smolt estimates to also be high. However, 2023 Coho smolt abundance estimates were generally low in LCM subwatersheds. We attribute these low smolt estimates to the later trapping season necessitated by high spring flows. Generally, DSMTs are installed in mid-March, but in 2023 high flows delayed installation until mid-April (Figure 2). However, it is likely that higher spring flows may have led to higher summertime flows which could be beneficial to migrating Coho smolts and oversummer survival of juveniles.

Steelhead smolt estimates for 2022/23 remained low, which is not surprising given the low number of steelhead juveniles observed during the late summer and the low survival indices in recent years (Table 2). It is worth noting that the survival index in the Mill Creek watershed had increased since the last calculated values from 2020 (0.16 compared to 0.10).

We were unfortunately unable to calculate accurate Chinook smolt estimates this season because of the late installation of the trap, low catch, and low numbers of recaptured fish (making calculation of capture efficiency impossible). The Mirabel dam was inflated much later in the season than in previous years (because of higher spring flows in the Russian River), forcing us to trap in the middle of the stream instead of near the downstream exit of the fish ladder where trapping is more efficient and catches are significantly higher. DSMT trapping in Dry Creek compelled by non-CMP objectives was unaffected by these difficulties and showed that there likely was an average number of out-migrating Chinook smolts in 2023.

An important factor that is not currently being captured by CMP monitoring in the Russian River watershed is riverine migration mortality. Horton (et al. 2021; SW unpublished data) have shown that survival of smolts as they migrate through the mainstem Russian River can be extremely low and is positively related to mainstem discharge. We strongly recommend continuing to monitor mainstem smolt migration survival so that we can better account for and potentially mitigate freshwater survival impacts.

Adult and redd abundance

With the exception of Mill, Coho Salmon and steelhead redd abundances in LCMs were generally low during the winter of 2023/24, although Coho abundances in Green Valley and Dutch Bill were a bit higher than 2022/23. Even in Mill, however, there seemed to be downward trends in both Coho Salmon and steelhead redd production (since the 2016/17 season for Coho and since the 2014/15 season for steelhead). In the Russian River watershed, recent drought and wildfire impacts could certainly play a role in the recent downward trends observed for both species. However, similar downward trends have been observed in other coastal systems as well. It will be important to continue life cycle monitoring so that we can tease apart within-subwatershed survival from riverine and marine survival. Ideally, we would couple stream flow and habitat characterization with life cycle data to understand causal factors so that steps can be taken to mitigate impacts.

The low Coho redd estimates are somewhat unexpected when compared to the relatively high numbers of adult Coho returns we estimated with PIT antennas. We suggest two possible reasons for this discrepancy. First, spawner surveys are impossible during periods of heavy rainfall and resulting high flows and turbidity. During the 2023/24 season, it was especially difficult to survey because of the many frequent and heavy rains (Figure 17). Many of these systems hit during mid-December to mid-January when we generally see the majority of Coho Salmon redds. Our inability to consistently survey reaches at 10–14-day intervals likely led to newly constructed redds becoming obscured during the long stretches of time between repeated surveys. This would lead to an underestimation of Coho redd abundance. Although there were several storms large enough to prevent spawner surveys this winter, rainfall and subsequent flows were likely not high enough to scour redds and lead to high egg and early fry mortality. Second, PIT antenna-based estimates of 2-year-old adults (predominantly males) were much higher than estimates of 3-year-olds. These returning jacks would not contribute to redd production, so it follows that during years of higher jack returns and lower 3-year-old returns, we would see lower redd production. Indeed if we examine the 10-year record, we can see that both the 2017/18 spawner season and the 2013/14 spawner seasons were characterized by much higher estimates of 2-year old adults returning than 3-year olds in LCM subwatersheds (Figure 12), but low estimates of Coho redds (Figure 20).

We were once again unable to calculate an adult steelhead estimate from PIT tagging juvenile steelhead in LCM subwatersheds and detection on PIT antennas as adult returns. The detections we have seen illustrate some of the inherent difficulties with studying steelhead that have such a varied life history. A consistent and predictable source of pit-tagged steelhead juveniles, from hatchery stock for example, would help improve our ability to generate an adult steelhead estimate.

The 2023 adult Chinook return count was close to the long-term average. There were no unexpected problems with video monitoring in 2023 meaning that the resultant count accurately represents the number of adult Chinook returning upstream of the Mirabel dam. The higher number in 2023 as compared to recent years (Figure 16) could mean that the recent downward trend is beginning to reverse.

This 2023/24 adult return season showed that methods of evaluating adult returns are not equally useful in all years. Environmental factors can affect some adult counting methods more than others. However, this reveals the utility of having multiple methods of quantifying adult abundance (PIT antennas, video counts) and indicators of abundance (redd estimates). While methods may be differentially affected by environmental factors, the long-term trend data provided by a lengthy and complete dataset can still be useful for evaluating population fluctuations over time. Therefore, we recommend continuation of both LCM redd, PIT antenna, and video monitoring in the future.

Task 3. Basin-wide Monitoring

Introduction

This task and the associated data reported here includes:

- 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

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. To minimize disturbance of fish and sediment, snorkelers avoided sudden or loud movements. Double counting was minimized by only counting fish as they moved 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 of double-diver pools were the sum of both lane counts. All observed salmonids were identified to species based on physical characteristics and assigned life stage based solely on estimated length (young-of-the-year [YOY] if less than 100mm or parr [≥ age-1] if greater than 100mm). The presence of non-salmonid species was recorded at the pool scale, but actual counts were not recorded. 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.

Redd abundance

Field methods for basin-wide spawner surveys were almost identical to those described above for spawner surveys in the four LCMs. 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 each spawner season, reaches from two panels are surveyed. One panel of reaches is surveyed every season, and one panel is on a three-year cycle. During the 2023/24 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 2023/24 spawner season using survey methods identical to the methods described for deriving total redd estimates from spawner surveys in LCMs (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.

Results

Juvenile Coho Salmon occupancy

Between June 5 and September 13, 2023, we snorkeled 69 reaches in 41 streams encompassing 200 km (124 mi) of stream length (Figure 22). All accessible juvenile Coho Salmon rearing reaches of Willow, Dutch Bill, Green Valley, and Mill subwatersheds were surveyed, and 67 reaches within the Russian River sample frame that were considered to contain juvenile Coho Salmon habitat (85% of Coho Salmon reaches) were included in the basin-wide occupancy estimate. Two reaches of East Austin Creek (EAU6 and EAU8) were not included in the occupancy estimate because data from one of the two passes was lost due to the malfunction of data collection device.

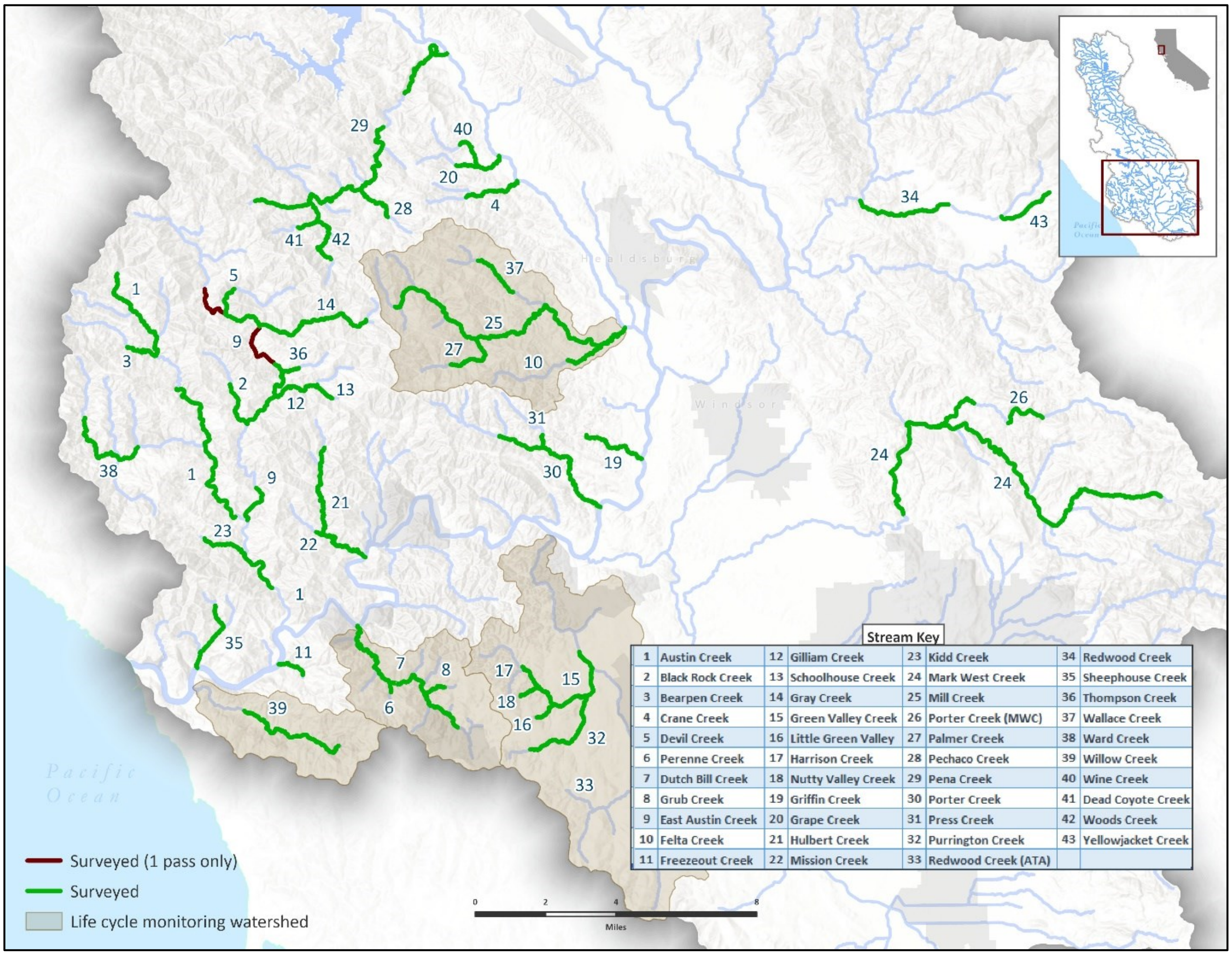


Figure 22. Map of reaches snorkeled during the 2023 snorkel season. Two reaches in East Austin Creek had only one pass of data recorded because the second pass data was lost due to field computer malfunction.

We observed 375 Coho Salmon YOY and 12,768 steelhead YOY during snorkel surveys. All YOY were presumed to be of natural origin. Though hatchery origin steelhead are adipose clipped, we recognize that marks indicating hatchery origin are nearly impossible to distinguish while snorkeling; however, because hatchery steelhead are released as smolts that would be much larger in size than natural-origin age-0+ or age-1+ fish, we are confident that we could readily distinguish them and therefore not include them in counts. Coho Salmon YOY were observed in 24 of the 69 juvenile Coho Salmon reaches surveyed and in 19 of the 41 juvenile Coho Salmon streams snorkeled (35% and 46%, respectively) (Figure 23). Steelhead YOY were observed in 62 of the 69 steelhead reaches and 35 of the 41 steelhead streams surveyed (90% and 85%, respectively). In seven of the 19 streams where Coho YOY were found, fewer than 10 Coho were observed. Coho YOY counts were highest in Green Valley, Grape, and Dutch Bill creeks, though even in those streams numbers were low. Counts of steelhead YOY were highest in Pena, Mill, and Felta creeks which are all streams within the Dry Creek subwatershed (Figure 24, Figure 25).

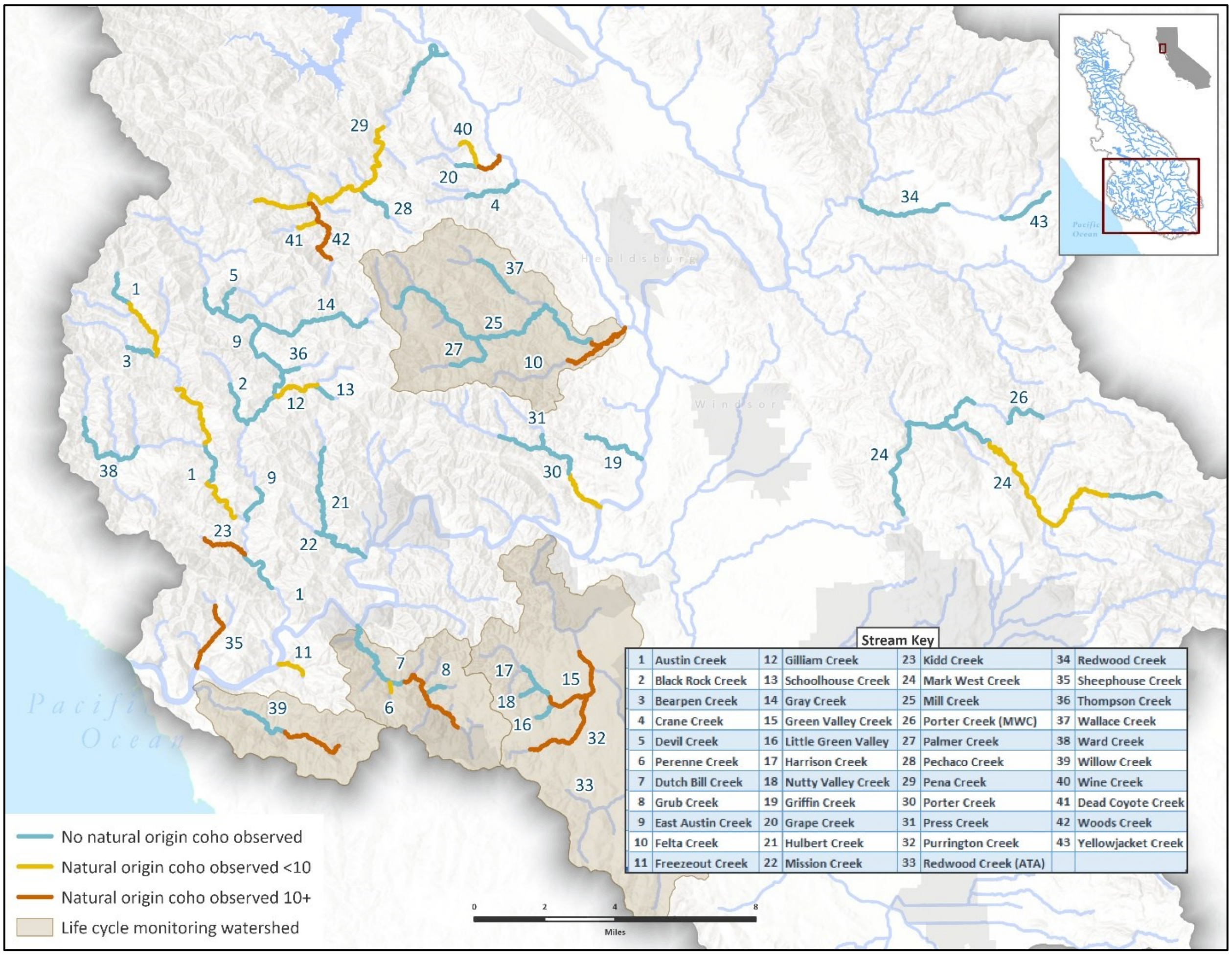


Figure 23. Natural origin Coho Salmon presence by reach in Russian River streams surveyed in summer 2023.

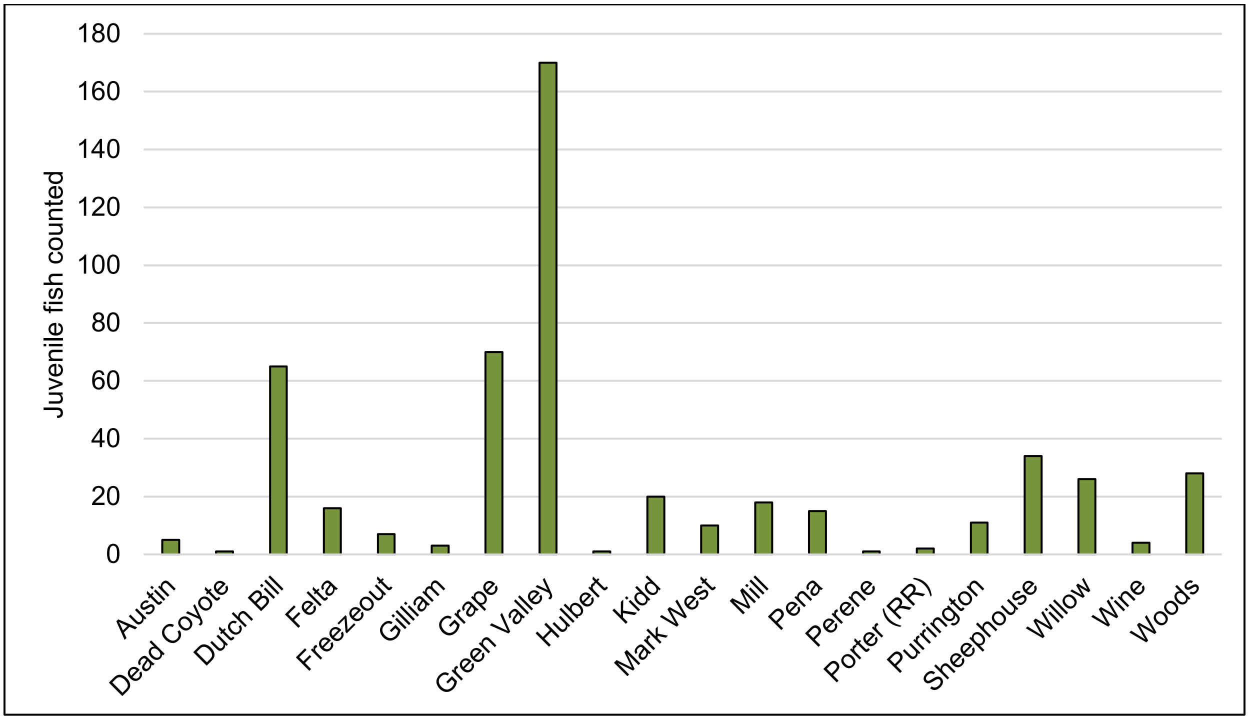


Figure 24. First pass counts of juvenile Coho Salmon (YOY and parr) in streams surveyed during the 2023 snorkel season. Only streams where juvenile Coho were found are included. Note that not all habitat within each creek was necessarily surveyed.

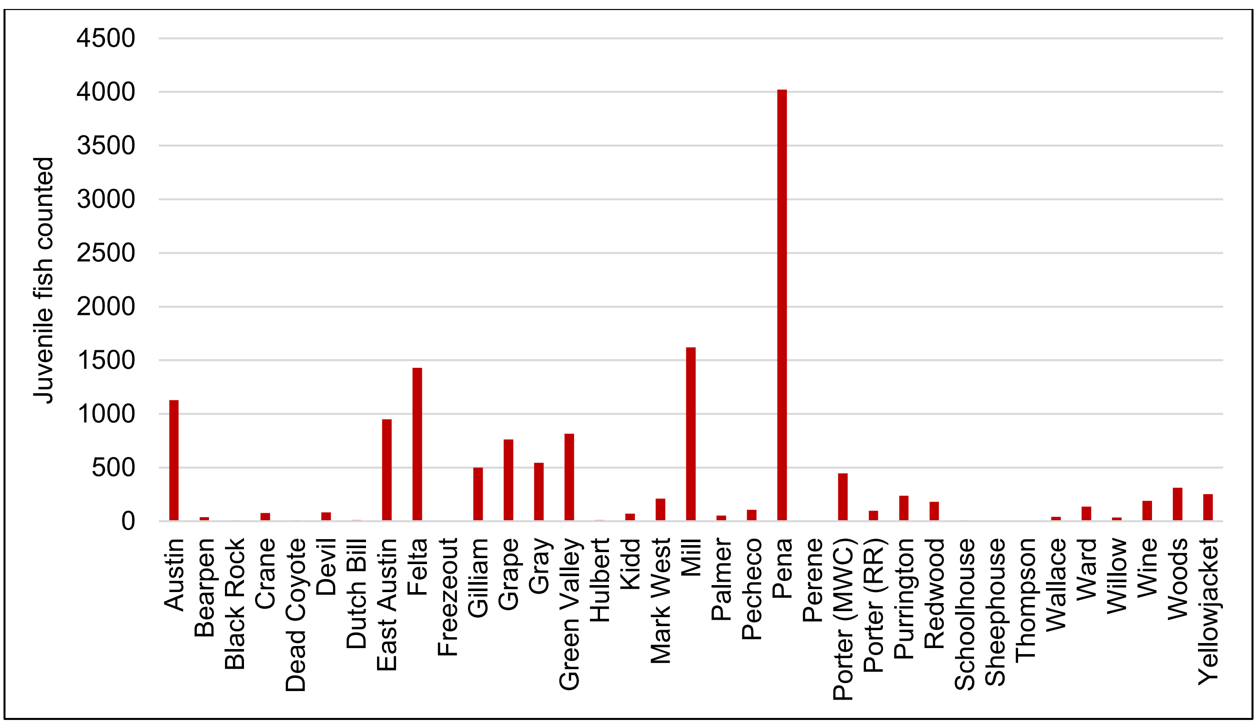


Figure 25. First pass counts of juvenile steelhead (YOY and parr) in streams surveyed during the 2023 snorkel season. Only streams where juvenile steelhead were found are included. Note that not all habitat within each creek may have been surveyed in a given year.

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 Salmon stratum in 2023 was 0.38 (95% CI: 0.27-0.52,), and the conditional probability of Coho Salmon YOY occupying a pool within a reach, given that the reach was occupied, was 0.21 (95% CI: 0.16-0.27,). The proportion of the Coho Salmon stratum occupied (PAO) was 0.08, lower than any previous years in our survey record and approximately 30% of the 9-year average (Figure 26).

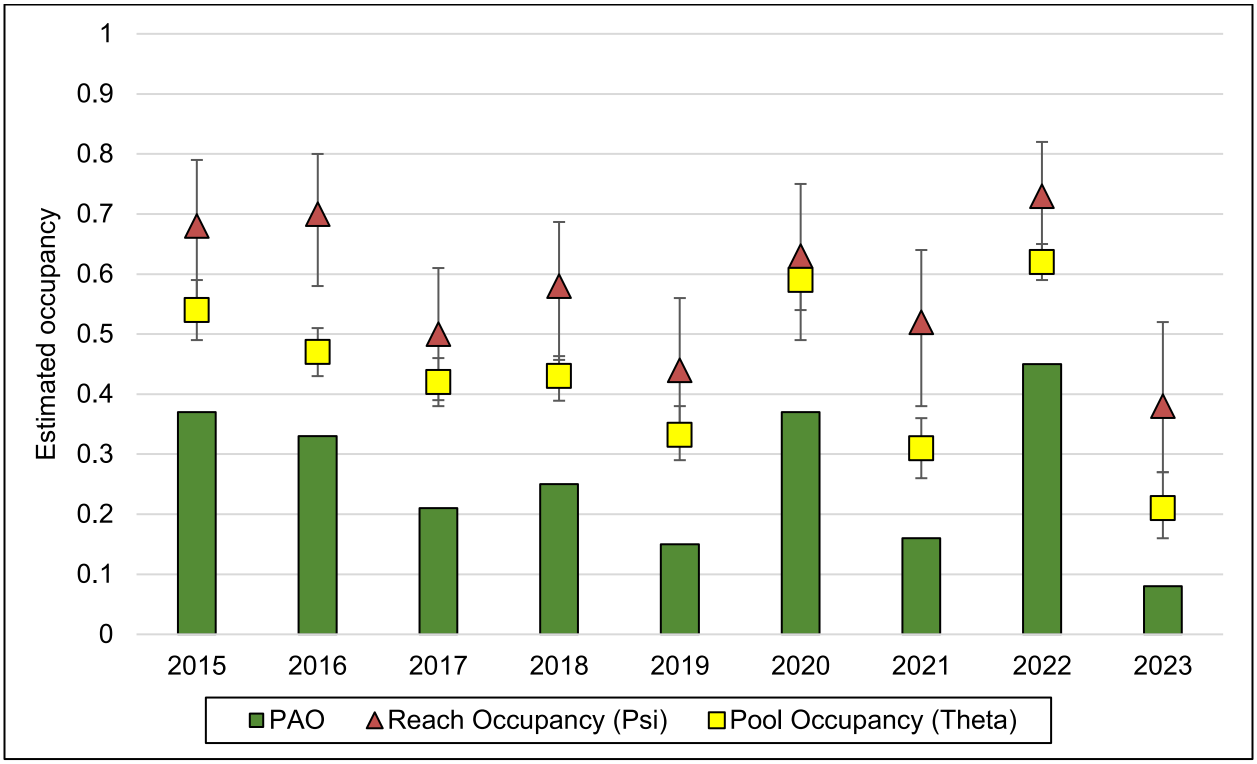


Figure 26. Estimated reach occupancy, conditional pool occupancy, and PAO for juvenile Coho Salmon in the Coho-steelhead sample stratum, summer 2015 through 2023.

Redd abundance

We began surveys on December 11, 2023, following the first rain event of the season, and continued surveying through April 29, 2024. Due to persistently high and turbid flow conditions during the winter of 2023/24 (Figure 17), we were unable to consistently maintain our goal of conducting surveys within each reach on a 10-14 day cycle, and this resulted in fewer surveys than in previous years (64 survey days as compared to the 10-year average of 76 survey days since 2014/15 (Figure 27). The median time between surveys was 19 days with a maximum time between repeated surveys on any reach of 58 days. Overall, we conducted a total of 337 surveys on 49 reaches in 30 streams within the Russian River basin (Figure 28). A total of 138 salmonid redds were observed: 28 Coho Salmon redds, 81 steelhead redds, 2 Chinook Salmon redds, and 27 redds of unknown salmonid species origin (Table 5). Coho Salmon redds were observed in 15 of the 30 streams surveyed (50%), and steelhead redds were observed in 15 of the 30 streams surveyed (50%) (Table 5). Pena was the only creek where Chinook redds or Chinook individuals were observed (Figure 29, Figure 30). Of the 28 Coho redds observed, 46% were observed in Mill (8) and Pena (5) subwatersheds, and of the 81 steelhead redds observed, 64% were observed in Mill (18) and Pena (33) subwatersheds. In addition to redd presence, there were 5 streams where adult Coho were observed but no Coho redds and 1 stream where adult steelhead were observed but no steelhead redds. Overall, adult Coho and/or Coho redds were observed in a total of 20 streams (Figure 31) and adult steelhead and/or steelhead redds were observed in a total of 16 streams (Figure 32).

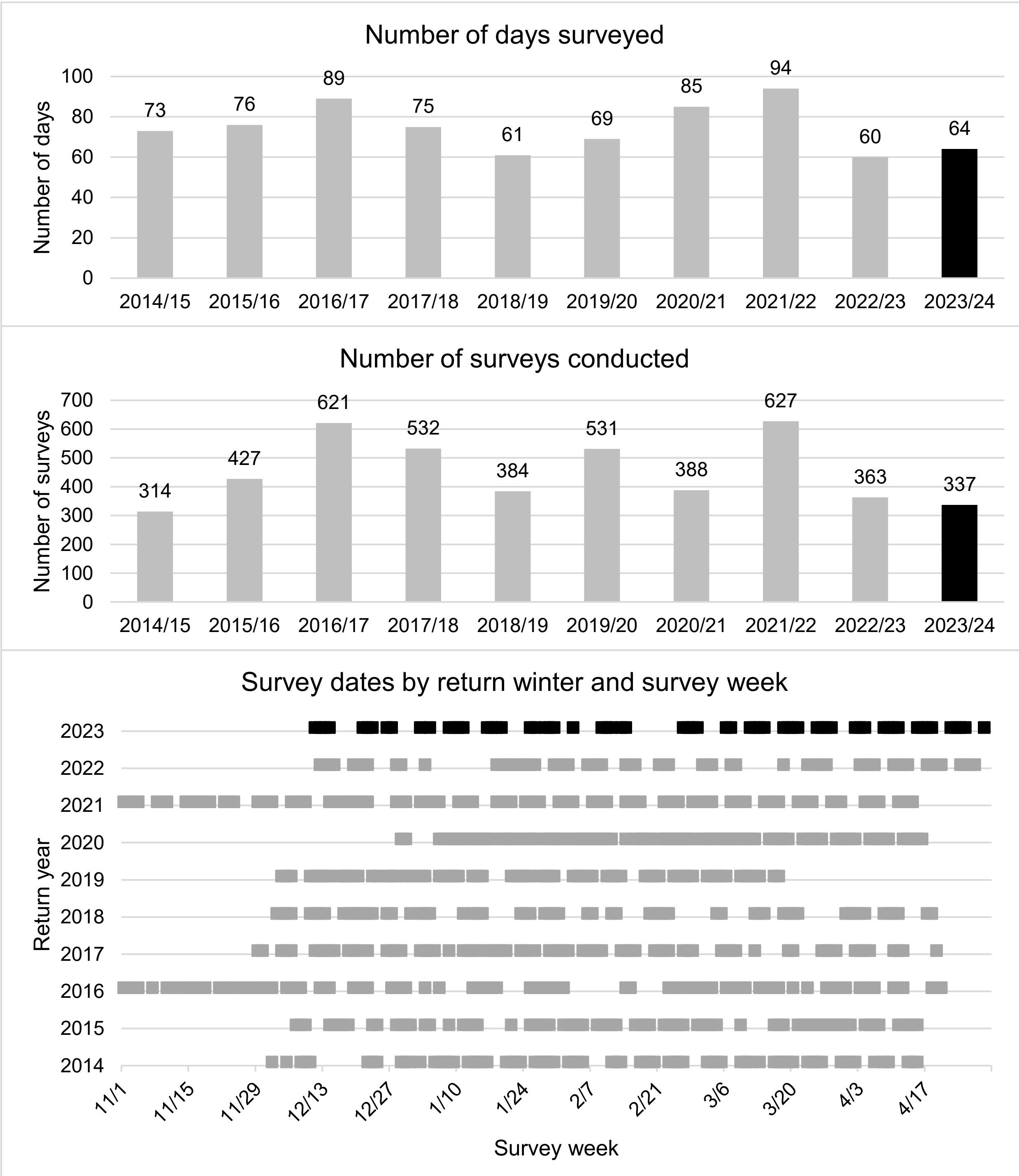


Figure 27. Historical spawner survey effort. Note this does not include surveys that were conducted in steelhead-only reaches.

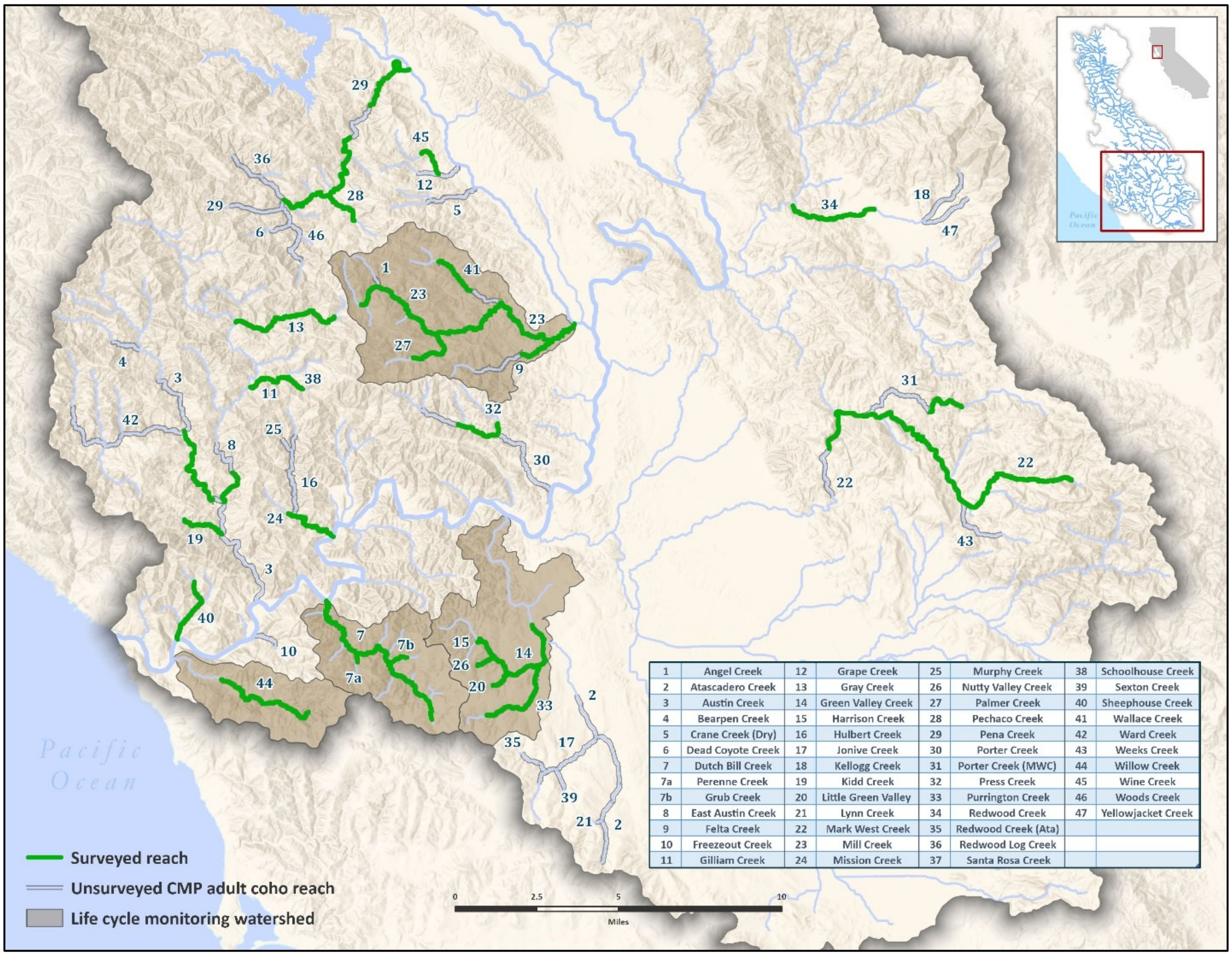


Figure 28. Spawner survey reaches sampled within the Coho-steelhead stratum.

Table 5. Number of salmonid redds (and percentages) observed by species during winter 2023/24 in Russian River streams.

Tributary	Length surveyed (km)	Coho Salmon	Steelhead	Chinook Salmon	Salmonid sp	Total
Austin Creek	5.0	1 (3.6%)	0 (0%)	0 (0%)	0 (0%)	1 (0.7%)
Dutch Bill Creek	9.7	2 (7.1%)	3 (3.7%)	0 (0%)	0 (0%)	5 (3.6%)
East Austin Creek	2.1	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Felta Creek	2.0	2 (7.1%)	1 (1.2%)	0 (0%)	1 (3.7%)	4 (2.9%)
Gilliam Creek	2.6	1 (3.6%)	3 (3.7%)	0 (0%)	1 (3.7%)	5 (3.6%)
Gray Creek	6.3	1 (3.6%)	3 (3.7%)	0 (0%)	1 (3.7%)	5 (3.6%)
Green Valley Creek	7.0	3 (10.7%)	0 (0%)	0 (0%)	3 (11.1%)	6 (4.3%)
Grub Creek	1.1	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Harrison Creek	0.2	1 (3.6%)	1 (1.2%)	0 (0%)	1 (3.7%)	3 (2.2%)
Hulbert Creek	3.2	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Kidd Creek	2.5	0 (0%)	2 (2.5%)	0 (0%)	0 (0%)	2 (1.4%)
Little Green Valley Creek	1.2	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Mark West Creek	19.2	1 (3.6%)	9 (11.1%)	0 (0%)	3 (11.1%)	13 (9.4%)
Mill Creek	16.6	5 (17.9%)	14 (17.3%)	0 (0%)	3 (11.1%)	22 (15.9%)
Mission Creek	0.4	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Nutty Valley Creek	1.2	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Palmer Creek	2.9	1 (3.6%)	2 (2.5%)	0 (0%)	1 (3.7%)	4 (2.9%)
Pechaco Creek	2.3	1 (3.6%)	2 (2.5%)	0 (0%)	0 (0%)	3 (2.2%)
Pena Creek	11.8	4 (14.3%)	31 (38.3%)	2 (100%)	10 (37.0%)	47 (34.1%)
Perenne Creek	0.5	1 (3.6%)	0 (0%)	0 (0%)	0 (0%)	1 (0.7%)
Porter Creek	2.3	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Porter Creek (MWC)	2.4	0 (0%)	1 (1.2%)	0 (0%)	0 (0%)	1 (0.7%)
Press Creek	0.6	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Purrington Creek	4.8	2 (7.1%)	0 (0%)	0 (0%)	0 (0%)	2 (1.4%)
Redwood Creek	4.8	2 (7.1%)	7 (8.6%)	0 (0%)	1 (3.7%)	10 (7.2%)
Schoolhouse Creek	1.1	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Sheephouse Creek	3.7	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Wallace Creek	2.5	0 (0%)	1 (1.2%)	0 (0%)	0 (0%)	1 (0.7%)
Willow Creek	6.0	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Wine Creek	1.8	0 (0%)	1 (1.2%)	0 (0%)	2 (7.4%)	3 (2.2%)
Total	**127.6**	**28 (100%)**	**81 (100%)**	**2 (100%)**	**27 (100%)**	**138 (100%)**

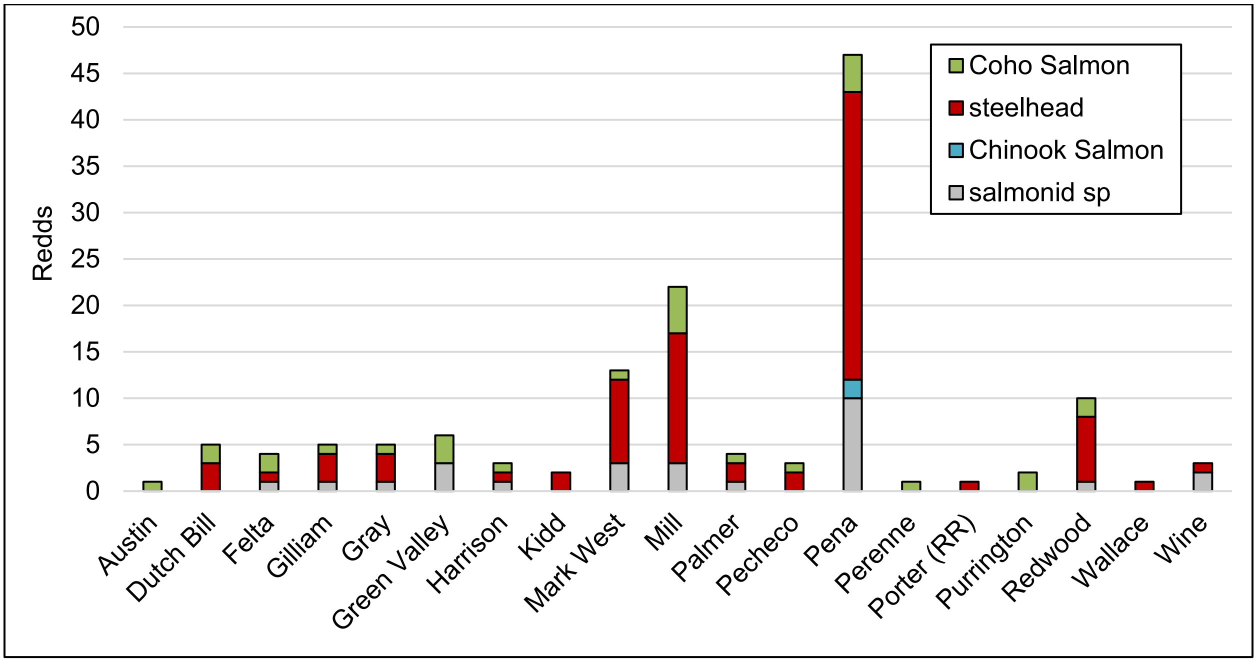


Figure 29. New redds counted during spawner surveys by tributary for all three levels of redd species certainty. Only Streams where redds were found are included. Note that not all habitat within each creek may have been surveyed in a given year (i.e., only reaches included in the rotating panel for a given season were surveyed).

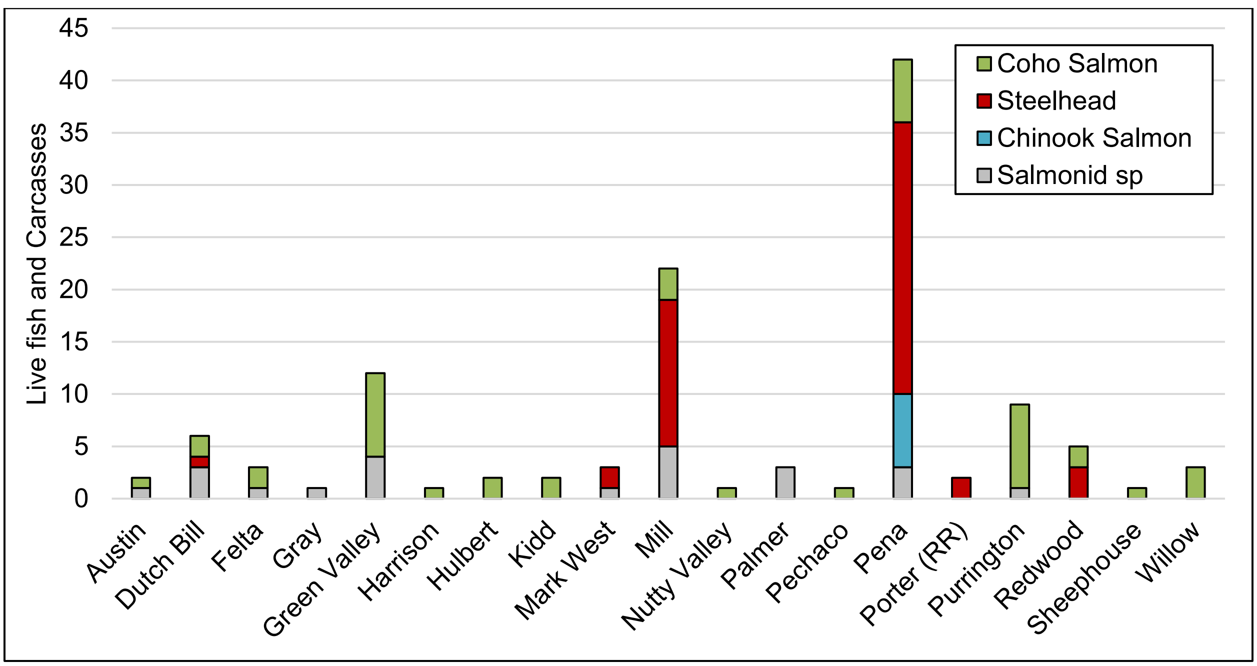


Figure 30. Live adult salmonids and carcasses counted during spawner surveys by tributary for all three levels of redd species certainty. Only streams where redds were found are included. Note that not all habitat within each creek may have been surveyed in a given year (i.e., only reaches included in the rotating panel for a given season were surveyed).

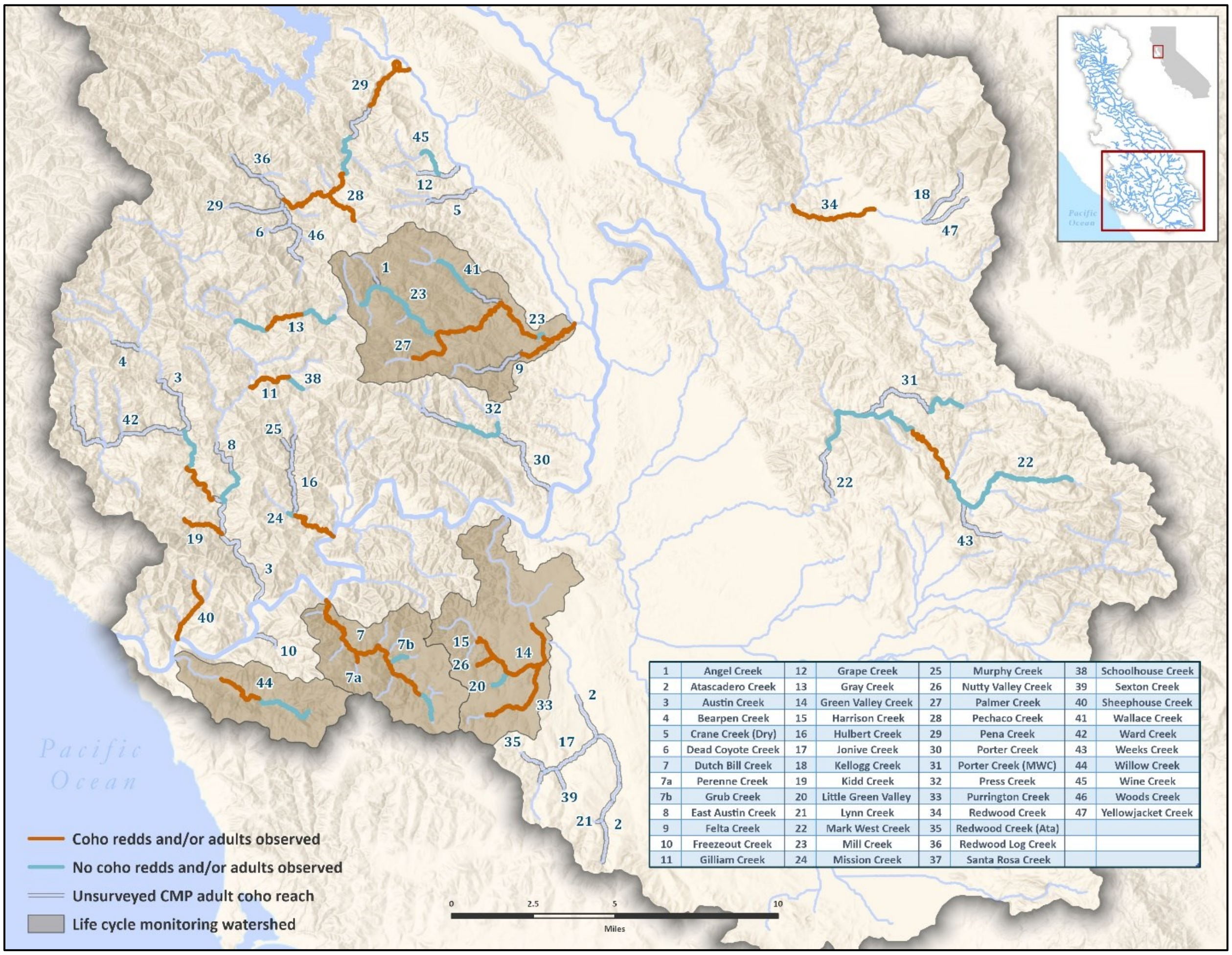


Figure 31. Reaches in the Coho-steelhead stratum where Coho Salmon redds and/or Coho Salmon adults were observed, winter 2023/24. Sampled reaches where the presence of Coho was not documented appear in light blue.

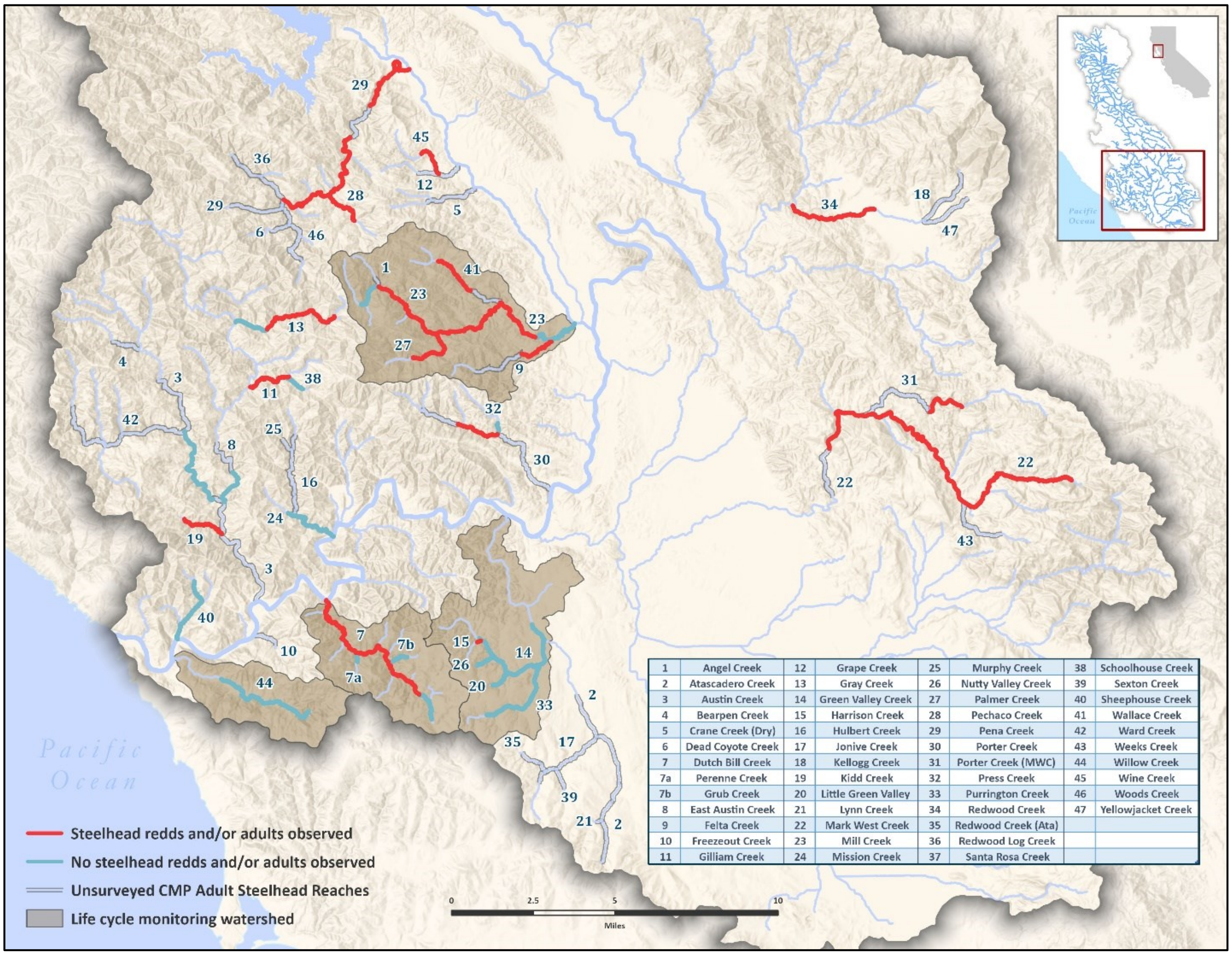


Figure 32. Reaches in the Coho-steelhead stratum where steelhead redds and/or steelhead adults were observed, winter 2023/24. Sampled reaches where the presence of steelhead was not documented appear in light blue.

We first observed Coho Salmon redds in the watershed on December 20 and we continued to observe new Coho redds into late March (Figure 33). Coho Salmon spawn timing peaked in early January, though redds may have been missed during a 5-day gap in surveys due to high flows in late December. Steelhead redd observations began in early January and extended into late April, peaking in mid-March which was later than the average timing of previous years (Figure 34). However, it is possible that steelhead redds were missed due to gaps in surveys in February (Figure 17). The number of observed redds per survey for Coho Salmon was 0.11 and the number of observed redds per survey for steelhead was 0.24 (Figure 35, Figure 36).

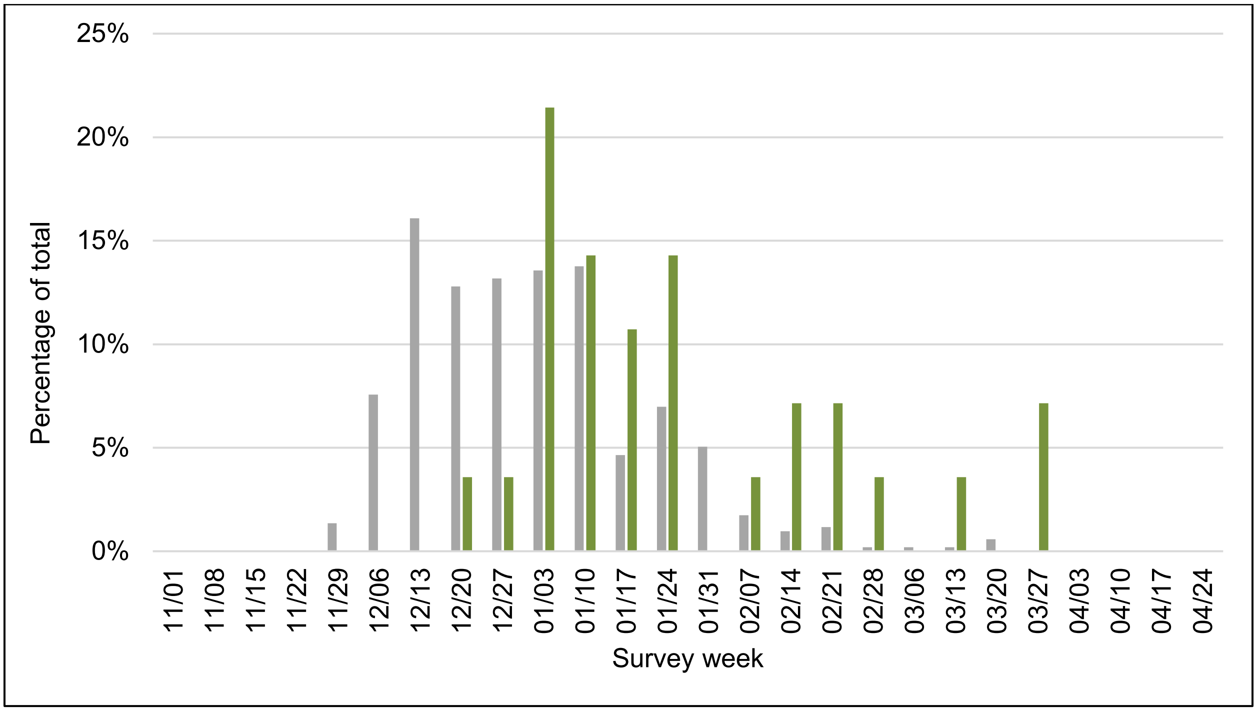


Figure 33. Number of new Coho Salmon redds observed each week in all streams surveyed during the 2023/24 season in comparison to the long-term average.

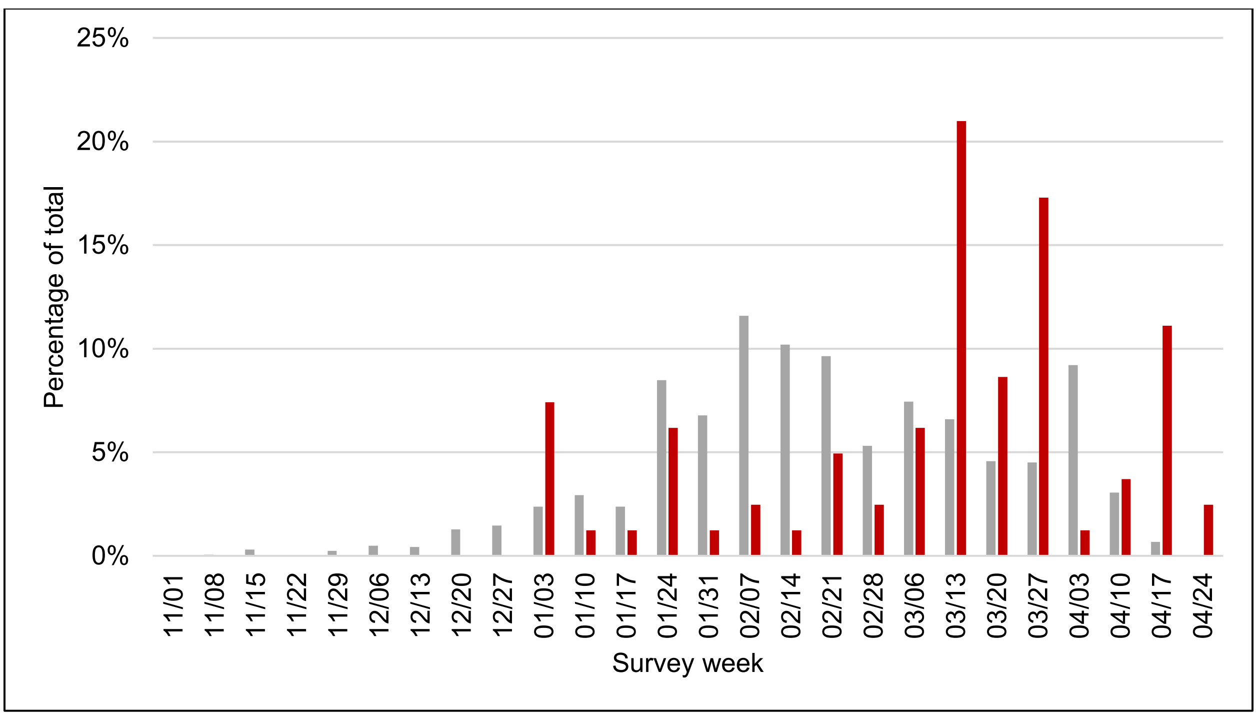


Figure 34. Number of new steelhead redds observed each week in all streams surveyed during the 2023/24 season in comparison to the long-term average.

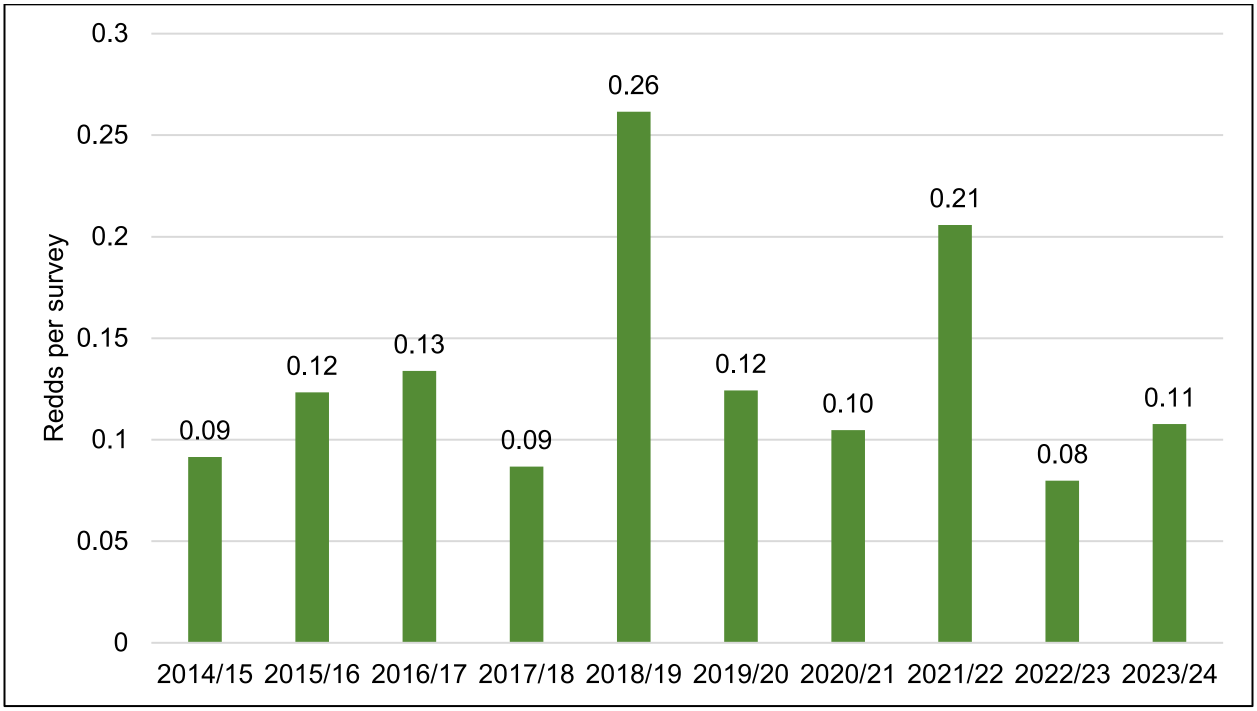


Figure 35. Number of new Coho Salmon redds observed per survey in all streams surveyed during the winter 2023/24 season.

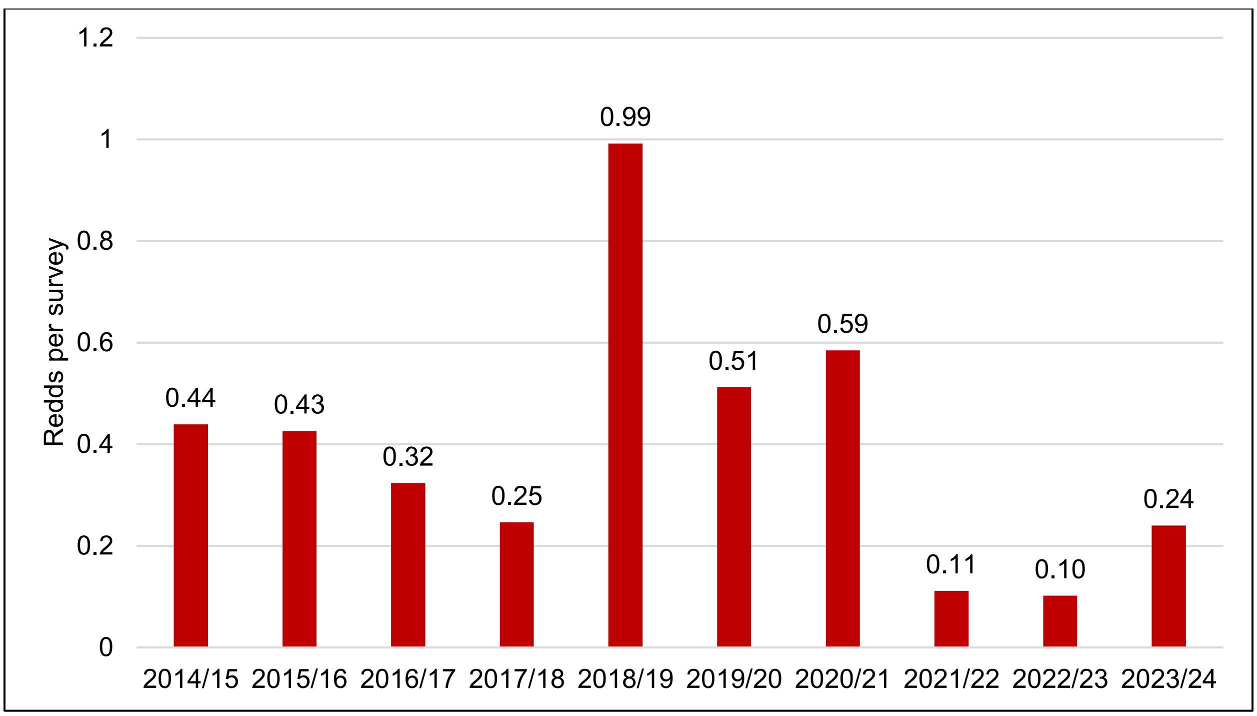
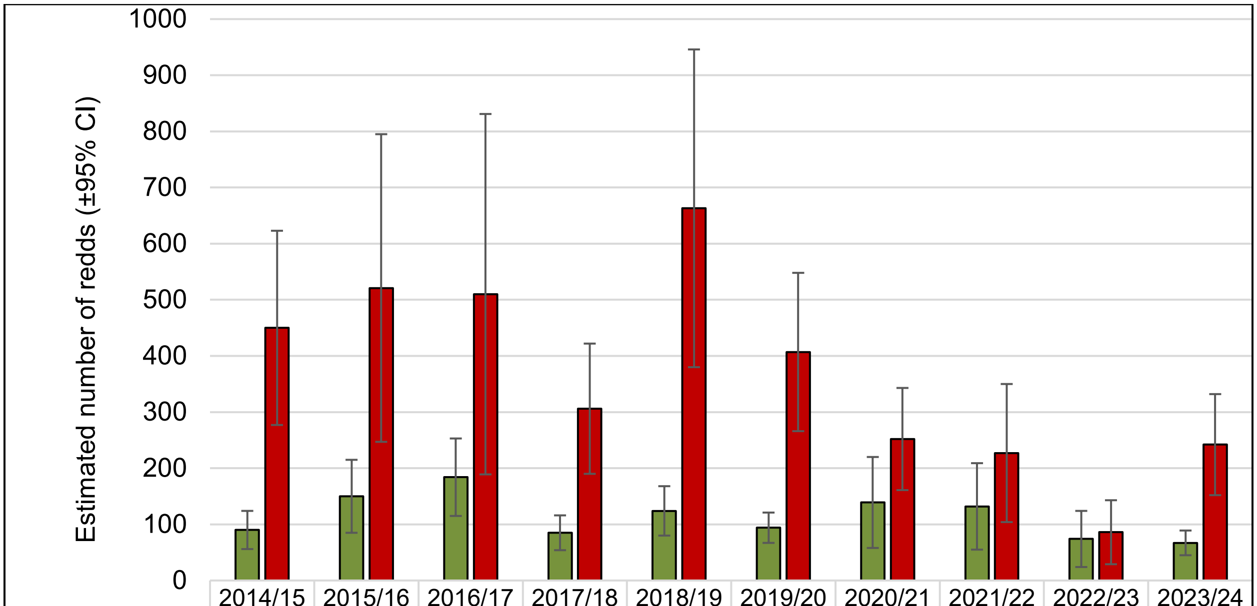


Figure 36. Number of new steelhead redds observed per survey in all streams surveyed during the winter 2023/24 season.

Determination of origin could be made for only 4 Coho encountered during spawner surveys, and of those 4 only 1 was determined to be of hatchery origin as indicated by the presence of a CWT. Of the 48 steelhead recorded, only 5 were determined to be of hatchery origin as indicated by absence of the adipose fin (which is removed from hatchery fish). We recorded only one Floy-tagged steelhead (a carcass) during the season which indicates that the fish was released as an adult from Warm Springs hatchery.

We used 40 reaches (roughly 51% of the stratum) to calculate total redd abundance in the Coho/steelhead stratum. The estimate of Coho redd abundance in the Russian River basin was 67 (±95% CI: 22) for the 2023/24 spawner season. The estimate of steelhead redd abundance in the Coho-steelhead stratum was 242 (±95% CI: 90) for the 2023/24 spawner season. The Coho redd estimate is well below the 10-year average of 114 and the steelhead estimate is well below the 10-year average of 366 (Figure 37).



	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24
Coho salmon	90	150	184	85	124	94	139	132	74	67
Steelhead	450	521	510	306	663	407	252	227	86	242

Figure 37. Basin-wide estimates of Coho Salmon and steelhead redd abundance for the Coho-steelhead sample stratum, return winters 2014/15 through 2023/24. Steelhead estimates do not include the entirety of the range of steelhead in the Russian River, just the portion that overlaps with Coho habitat.

Discussion

Juvenile Coho Salmon occupancy

We recorded the lowest numbers of juvenile Coho Salmon during the 2023 snorkel surveys since CMP surveys began in 2014. Our estimates of PAO, reach occupancy and conditional pool occupancy were the lowest recorded in the last decade as well. Because the 2022/23 spawning season had the lowest basin-wide Coho redd estimates and lowest Coho redd counts of any season so far, these results were not entirely unexpected. During the 2022/23 spawner season, we assumed that high flows and turbidity from frequent storms that prevented regular spawner surveys during the normal peak of Coho spawning activity might have contributed to the lower redd counts and basin-wide estimates, but the low juvenile counts and PAO seem to confirm that what we were indeed seeing (despite fewer opportunities to successfully count redds) was an extremely low return year. When redd numbers from 2022/23 were overlayed with juvenile presence/absence, we noticed a few examples of the disconnect between spawner survey redd counts and summer snorkel juvenile counts. Despite high concentrations of Coho redds during the winter of 2022/23, Mill, Felta, and Pena creeks had only moderate numbers of juvenile Coho counted during the summer of 2023 (Figure 24, Figure 38). Green Valley Creek, while having the highest counts of juvenile Coho during 2023 snorkel surveys, had a relatively small number of Coho redds during the 2022/23 spawner season. However, the high counts in Green Valley may have been a fluke as they were almost exclusively counted in a single pool far downstream in the reach. Regardless, there is a clear disconnect between the 2023 summer juvenile Coho counts Coho redd counts in the previous spawner season.

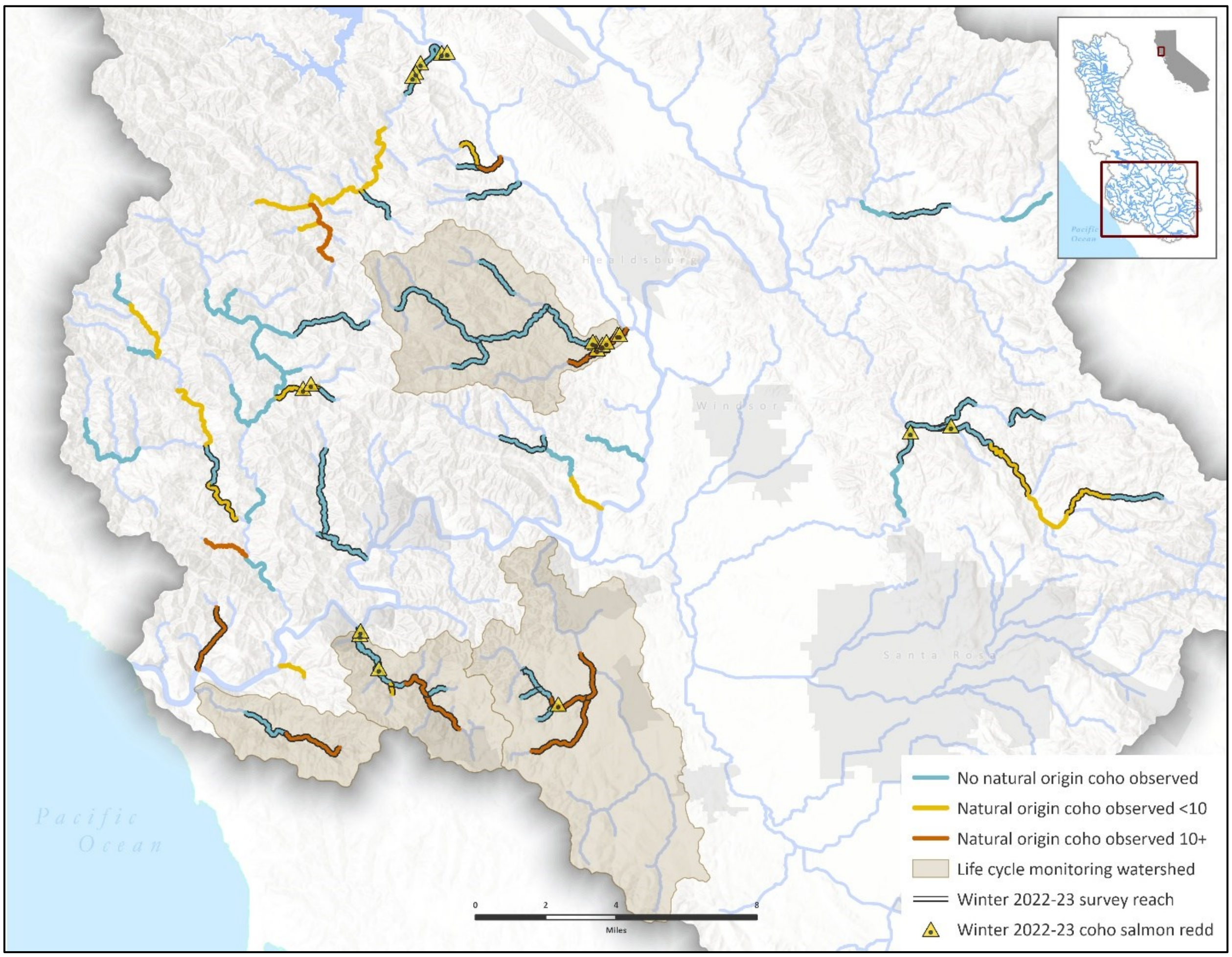


Figure 38. Russian River Coho Salmon redd locations by reach observed during winter 2022/23 in relation to Coho YOY presence/absence in 2023.

Redd abundance

Because of the frequency of large storms and subsequent high flows and turbidity, we assume that Coho Salmon redd abundance estimates derived from repeated spawner surveys may have underestimated Coho redd abundance during the 2023/24 spawner season. This is somewhat supported by the relatively high PIT antenna-based adult Coho estimate. We also assume that steelhead redd abundance was underestimated as a result of the low number of successful surveys performed. The usual peak in steelhead redd activity in the basin is from mid-February to mid-April, considerably later than the usual peak in Coho spawning activity (Figure 33, Figure 34). There was not the same long period of time when we could not survey during this period as there was during the peak in Coho spawning, so the underestimation of steelhead redd abundance may be less severe.

There is another possible reason that the Coho redd estimate may have been underestimated having to do with our methods for assigning species to unknows redds. This task can be challenging and can lead to biased estimates. Compared to last season (2022/23) the basin-wide Coho redd abundance estimate was lower in 2023/24 (Figure 37). To obtain these basin-wide estimates, we estimate species for any redds where the crew in the field was uncertain of the species designation using redd timing and measurements (see Life Cycle Monitoring methods above). If we look at the cumulative redd totals for the last two years (which do not rely on estimation of species after the fact with equations, but on estimation of species from physical characteristics of the redd), it is evident that crews called slightly more Coho redds during the 2023/24 spawner season than during the 2022/23 spawner season (Figure 39). The fact that the number of estimated Coho redds does not track with the Coho redds counted in the field likely points to an underestimation of Coho redds by the estimator we use to determine species for unknown redds. The steelhead basin-wide estimate seems to track well with the number of steelhead redds counted by the crew in the field, so it is possible the same underestimation is not an issue for steelhead (Figure 37, Figure 40). Relying on redd morphology coupled with run-timing has worked well in the Russian in many but not all years. For example, our protocol is not to disturb fish that are actively digging redds meaning that crews may not always measure a redd on first observation (i.e., redd age=1). If the redd is subsequently obscured prior to the next repeated survey, the redd may never be measured. In those cases, we generally substitute the nearest known neighbor (KNN) method of redd estimation (Ricker 2014). However, KNN also has weaknesses. Because KNN relies on Euclidian distance based on XY position, there could be instances where redds are close to each other in Euclidian distance, but extremely far away in stream distance (maybe in completely different subwatersheds). If this is the case, using one redd to determine the species of the other could easily lead to misclassification. In the future, we recommend exploring and testing the utility of other methods of redd species determination including modifying KNN to use stream distance instead of Euclidian distance.

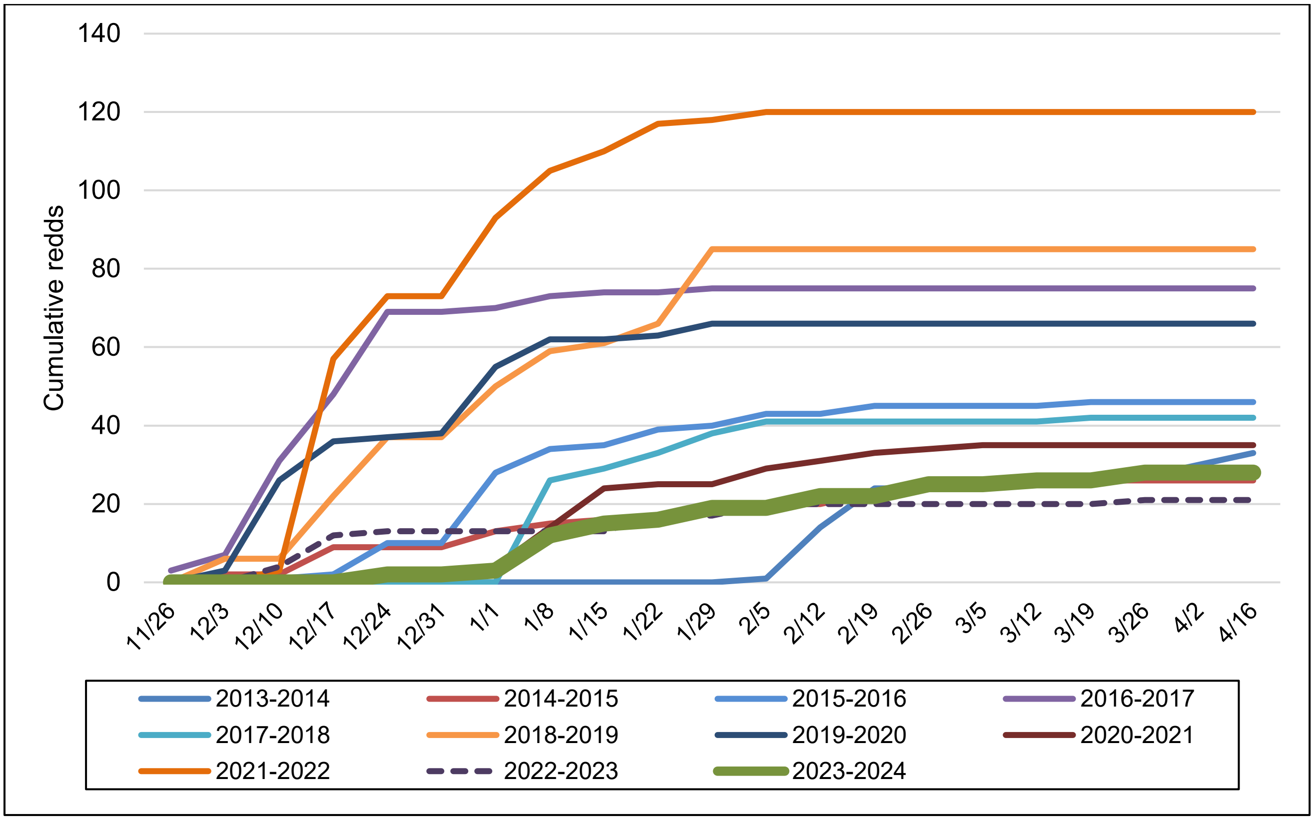


Figure 39. Cumulative Coho Salmon redd counts by survey date from the last decade of CMP spawner surveys. The thickest, green line is the most recent spawning season (2023/24) and the dashed line is the previous spawner season (2022/23).

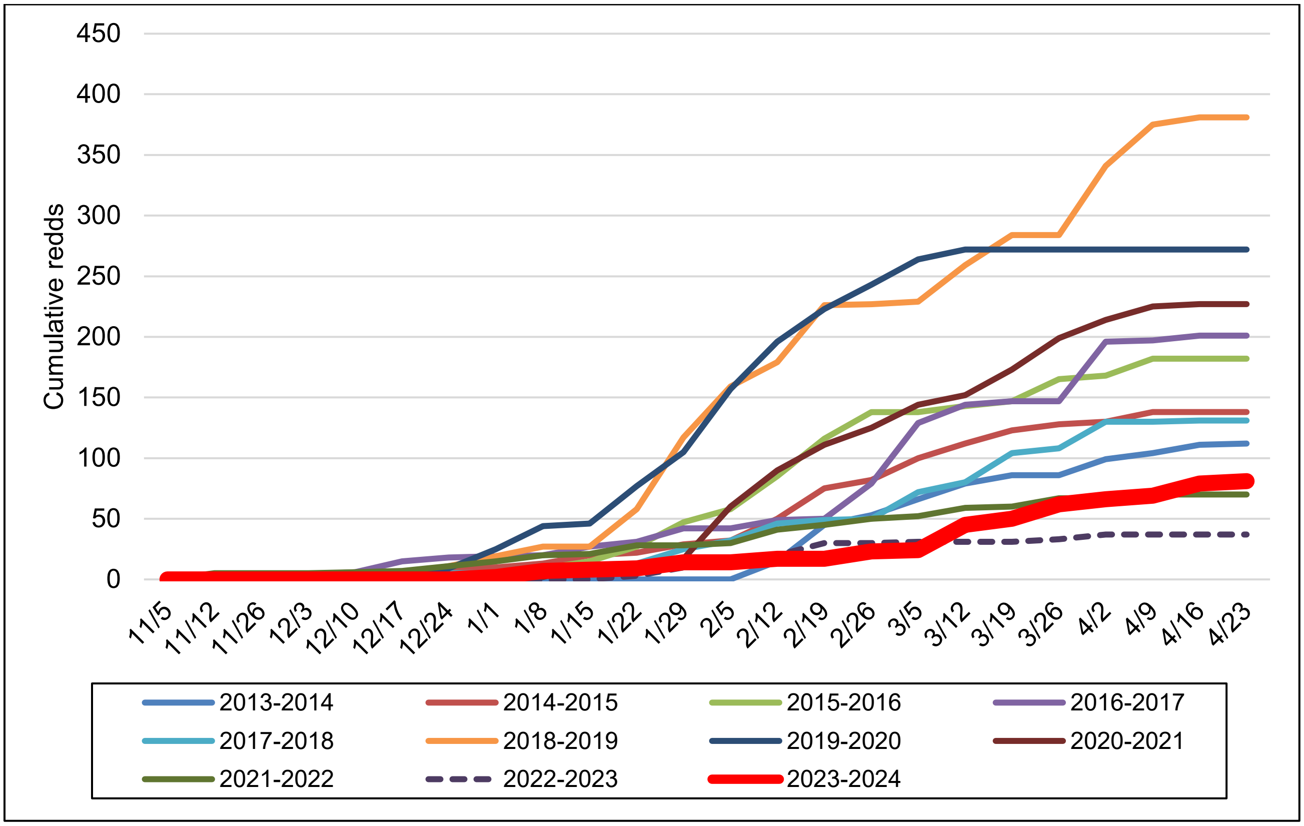


Figure 40. Cumulative steelhead redd counts by survey date from the last decade of CMP spawner surveys. The thickest, red line is the most recent spawning season (2023/24) and the dashed line is the previous spawner season (2022/23).

References

Adams, P. B., L. B. Boydstun, S. P. Gallagher, M. K. Lacy, T. McDonald, and K. E. Shaffer. 2011. California coastal salmonid population monitoring strategy design and methods. CA Department of Fish and Game, Sacramento, CA.

Bjorkstedt, E. P. 2010. DARR 2.02: DARR for R. Addendum to NOAA-TM-NMFS-SWFSC-368. http://swfsc.noaa.gov/textblock.aspx?Division=FED&id=3346. National Marine Fisheries Service, Santa Cruz, CA.

California Sea Grant (CSG). 2004-2024. California Sea Grant Coho Salmon and Steelhead Monitoring Reports. https://caseagrant.ucsd.edu/project/coho-salmon-monitoring/reports.

Chase, S. D., Manning, D. J., Cook, D. G., and White, S. K. 2007. Historic accounts, recent abundance, and current distribution of threatened Chinook Salmon in the Russian River, California. California Fish and Game, 93(3), 130.

Gallagher, S. P., and C. M. Gallagher. 2005. Discrimination of Chinook Salmon, Coho Salmon, and Steelhead Redds and Evaluation of the Use of Redd Data for Estimating

Escapement in Several Unregulated Streams in Northern California. North American Journal of Fisheries Management 25:284-300.

Gallagher, S. P., P. K. Hahn, and D. H. Johnson. 2007. Redd counts. Salmonid field protocols handbook: Techniques for assessing status and trends in salmon and trout populations. American Fisheries Society, Bethesda, Maryland:197-234.

Garwood, J. M., and M. D. Larson. 2014. Reconnaissance of salmonid redd abundance and juvenile spatial structure in the Smith River with emphasis on Coho Salmon (*Oncorhynchus kisutch*). California Department of Fish and Wildlife, Arcata, California.

Garwood, J., and S. Ricker. 2014. 2014 Juvenile Coho spatial structure monitoring protocol: Summer survey methods. California Department of Fish and Wildlife, Arcata, CA.

Gough, S. A. 2010. A comparison of escapement estimate methods plus escapement-recruitment relationships for Chinook Salmon and Coho Salmon in a coastal stream. Humboldt State University.

Hankin, D.G. and Reeves, G.H., 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian journal of fisheries and aquatic sciences, 45(5), pp.834-844

Horton, G., E. McDermott, and M. Obedzinski. 2021. Progress report: Using acoustic telemetry to estimate reach specific riverine and estuarine salmonid survival in the Russian River watershed. Sonoma County Water Agency, Santa Rosa, California.

Martini-Lamb, J. and Manning, D. J., editors. 2024. Russian River Biological Opinion Status and Data Report Year 2009-2022. Sonoma County Water Agency, Santa Rosa, CA.

McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-42,156 p.

Nichols, J. D., L. Bailey, L., A. F. O'Connell Jr., N. W. Talancy, E. H. Campbell Grant, A. T. Gilbert, E. M. Annand, T. P. Husband, and J. E. Hines. 2008. Multi-scale occupancy estimation and modelling using multiple detection methods. Journal of Applied Ecology 45:1321-1329.

Ricker, S., K. Lindke, and C. Anderson. 2014. Results of Regional Spawning Ground Surveys and Estimates of Total Salmonid Redd Construction in the Redwood Creek, Humboldt County California

Sonoma County Water Agency (SW) and University of California Cooperative Extension/California Sea Grant (CSG). 2015. Implementation of California Coastal Salmonid Population Monitoring in the Russian River Watershed. Santa Rosa, CA. 39 pp. + appendices.

Sonoma Water (SW) and California Sea Grant (CSG). 2020. California Coastal Salmonid Population Monitoring in the Russian River Watershed: Fall 2019. FRGP Grant #P1730412; Tri-Annual Progress Report, Reporting Period: June 1, 2019 – October 15, 2019. Santa Rosa, CA. 16 pp.

White, G. C. and K. P. Burnham. 1999. Program MARK: survival estimation from populations of marked animals.46:120-139.