California Coastal Salmonid Population Monitoring in the Russian River Watershed: 2020

FRGP Grant #P1730412; Annual Report
Reporting Period: March 1, 2019 – October 15, 2020

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Executive Summary

On March 1, 2019 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 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 the goals of the CMP, we performed basin-wide spawner surveys in the Russian River for Coho and steelhead, basinwide snorkel surveys for juvenile Coho, and operated life cycle monitoring (LCM) stations 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 basinwide adult Coho and steelhead abundance, basinwide spatial structure of juvenile Coho, freshwater survival of successive cohorts of Coho and steelhead in LCM creeks, and marine survival of successive cohorts of Coho and steelhead in the LCM creeks.

This annual report provides a summary of salmonid abundance at multiple life stages and at multiple spatial scales. We estimated Coho and steelhead adult abundance at lifecycle monitoring stations and at the basinwide scale with spawner surveys in a GRTS ordered random sample of reaches and we esimated Coho and steelhead smolt abundance at multiple life cycle monitoring (LCM) stations. Sonoma Water also operated a downstream migrant and adult migrant LCM station at Mirabel dam on the mainstem Russian River at rkm 39.67 which added to our data set for assessing status and trends of Chinook Salmon. Juvenile Coho spatial structure in the Coho/steelhead sample stratum was estimated with snorkel surveys in a GRTS ordered random sample of reaches And Juvenile steelhead abundance was estimated using a modified basinwide visual estimation technique (BVET) at multiple LCM stations. The goal of these annual reports is to keep CDFW informed of the tasks accomplished in accordance with the primary activities and deliverables outlined in FRGP Grant #P1730412. Related monitoring data collected by CSG but funded by non-FRGP sources is reported in CSG (2004-2020).

Report Status

a) The funding agreement for this project was executed on May 30, 2018 and Amendment 1 was executed on November 6, 2018. The term of the grant is June 1, 2018 – November 15, 2021. The agreement between Sonoma County Water Agency (Sonoma Water) and Regents of the University of California was executed on January 30, 2019.
b) Issues or concerns affecting schedule and/or budget: None
c) Activities for next annual reporting period:
    a. Adult monitoring
    b. Smolt monitoring
    c. Juvenile monitoring

d) Financial Reporting/Invoices:

$860,864.03 has been requested for reimbursement through October 15, 2020. During this same period, Sonoma Water has contributed $1,119,637.29 in cost share. $119,932.71 in cost share and $891,357.97 in grant funds remain.

Task Updates

Task 1. Monitoring Coordination and Planning

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, downstream migrant trapping (DSMT), snorkel surveys, and electrofishing surveys. Prior to each season of field work, training materials were provided to crews and crew trainings were coordinated to bring new technicians up to speed as well as familiarize returing technicians with changes (if any) to field protocols. Fish identification was also a component of most trainings. After the completion of each season of field work, monitoring data was rigorously error checked and final estimates of redd abundance, smolt abundance, and juvenile spatial structure were calculated for LCM streams and the Russian River basin. On May 27, 2020 a meeting of the Russian River CMP Technical Advisory Committee was convened remotely so that Sonoma Water and CSG could receive technical advice and guidance regarding CMP implementing in the Russian River basin. On June 8, 2020 a data package containing spawner survey data from the 2019/20 spawner season was submitted to CDFW for inclusion in the statewide CMP database. Three tri-annual progress reports based on adult, smolt, and juvenile monitoring were prepared and submitted to CDFW for review on July 1, November 1 (2020), and March 1 (2021). Because of the ongoing COVID-19 pandemic, new field protocols for all field activities related to CMP monitoring were developed that include direction for social distancing, mask wearing, disinfection of field equipment, and restrictions on vehicle sharing.

Because of the rotating panel design (Adams et al. 2011; SW and CSG 2015), new reaches need to be surveyed for spawner surveys every year. Preparations for the 2020/21 spawner season began in July, 2020 and included a substantial landowner outreach effort. We attempted to gain access to roughly 15 new reaches which necessitated contacting over 100 landowners. The first step was a GIS exercise comparing the streams layer to the parcels layers for Mendocino and Sonoma counties. We identified all parcels that were adjacent to the reaches next in the draw list that had not yet been accessed or contacted. We then used online resources to track down contact information for each landowner with property on each stream. All contact information obtained was vetted to determine validity. In many cases landowner contact information was outdated or unobtainable, so we attempted to contact neighbors of missing landowners to obtain updated information. In all over 300 contacts were made by phone, email, and personal communication to gain access to new reaches for the 2020/21 spawner season. All landowner contact records, contact information, response information and details about landowner preferences were stored in a relational database designed for that purpose. After access was obtained to a large enough portion of each new reach, crews were sent to determine habitat suitability and record relevant reach information. Parking spots, entry points, details of landowner access, and other details were recorded using Survey 123 (Esri) forms and stored in a relational database for use during the spawner season.

Task 2. Life Cycle Monitoring

Introduction

The objective of CMP life cycle monitoring is to detect trends in abundance of smolts and adults (Adams et al. 2011). The systems we selected for life cycle monitoring of Coho 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 tributaries were chosen for Coho and steelhead LCM because of the substantial monitoring infrastructure already in place and because of long-term datasets for smolt and adult Coho monitoring data collected by CSG to evaluate the Russian River Coho Salmon Captive Broodstock Program. Life cycle monitoring for Chinook was conducted on the mainstem Russian River at Mirabel dam. This site also had monitoring infrastructure in place and long-term datasets for smolt and adult Chinook monitoring data collected by Sonoma Water to fullfill obligations outlined in the Russian River Biological opinion.

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). From past experience, we know that 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. In 2020, despite a truncated trapping season (due to COVID-19 restrictions), we were able to generate estimates of Coho smolts using a combination of DSMT and PIT antennas to generate estimates. Chinook estimates were generated with a DSMT immediately donstream of the Mirabel dam.

A significant issue with relying on downstream migrant trapping for steelhead smolt abundance is the fact that steelhead smolt migration occurs well before DSMTs can be safely installed and operated. Using DSMTs alone, steelhead smolt abundance will be underestimated in Russian River tributaries. 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 pre-winter abundance estimates coupled with efficiency-adjusted detections of PIT-tagged steelhead at stationary PIT antenna arrays 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. Thus far, we have been successful in producing defensible estimates of steelhead smolt abundance.

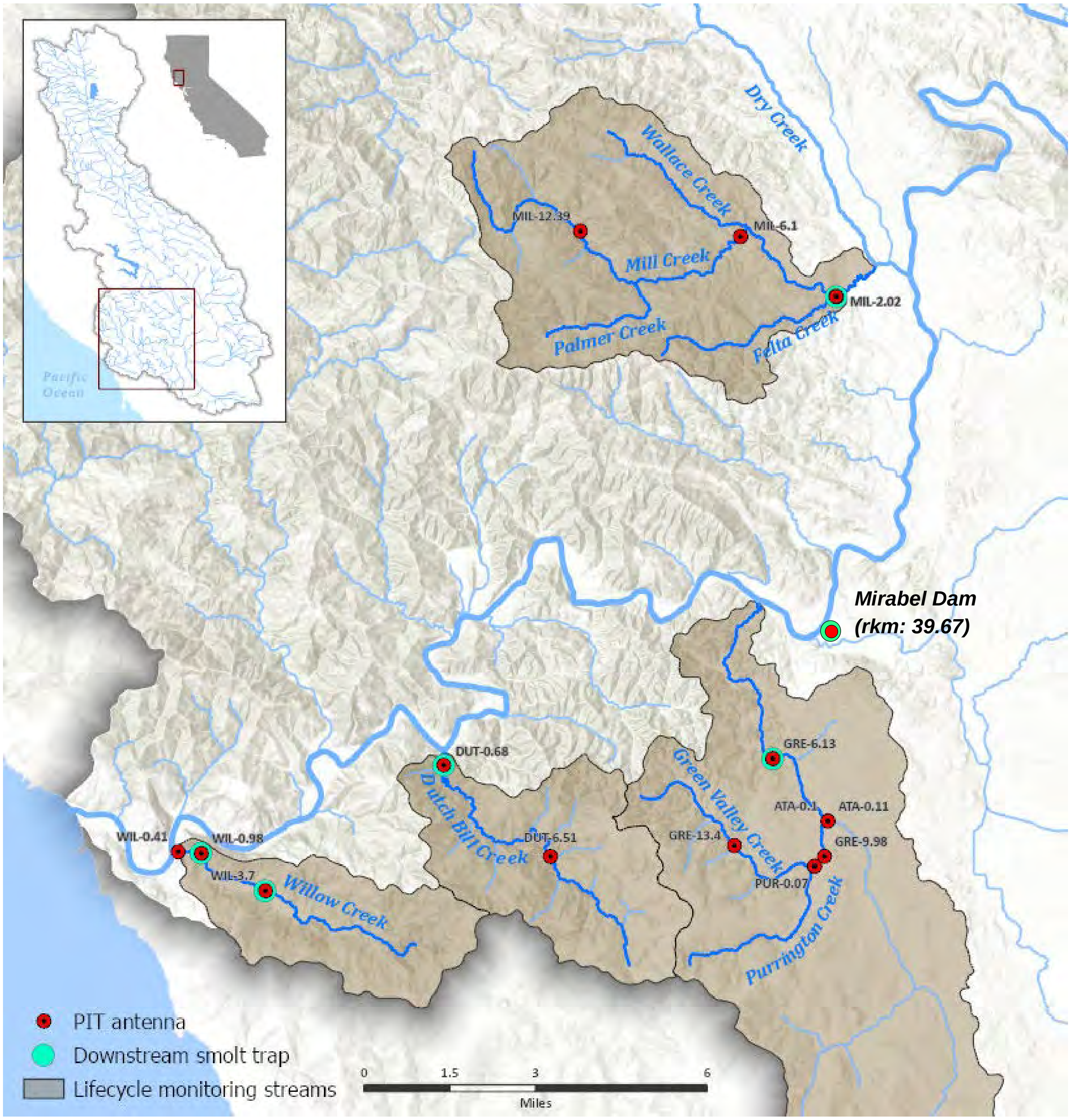


Figure 1. Coho Salmon and steelhead LCM watersheds (shaded polygons) and stationary PIT antennas (red circles with black dots). Green circles are downstream migrant trapping sites. Blue line segments represent reaches containing habitat for one or more species/life stage of anadromous salmonids. The Chinook LCM station at Mirabel dam is marked with a green circle and red circle without a black dot.

Methods

Spawner Survey Field Methods

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 the 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. 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 taken for all live fish and carcass observations.

Redd species estimation

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 frst 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, (making 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).

Redd abundance estimation

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) then recaptured on each survey occasion. 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·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.

PIT antenna field methods

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 in stream channels near the mouths of the four LCM streams (Figure 1). Paired antenna arrays are used 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 in the source population (i.e., at the downstream migrant trap), we can use that ratio for a final expansion to arrive at an estimate for all adults returning to each LCM. Detailed field methods can be found in California Sea Grant (2004-2020). We plan to use similar methods 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.

Adult abundance and spawner to redd ratio estimation

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. Detailed data analysis methods can be found in California Sea Grant (2004-2020).

Coho smolt abundance

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 the mainstem Russian River (Mirabel dam, rkm 39.67) during the spring when the majority of the Coho 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 high flow and/or debris load.

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 (2020).

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 2005, 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.

Because traps were removed for over a month during outmigration due to public health measures implemented in response to COVID-19, trap captures could not be used to calculate out-migration for that period. Antenna detections were used to estimate abundance for that time period by multiplying the number of unique PIT tags detected during that time period by the ratio of untagged to tagged fish observed on each tributary during the period that traps were in operation. This number was then adjusted for the efficiency of each antenna array as calculated during the survival analysis in order to estimate abundance over that time period. This abundance was then added to the estimated abundance for the period where traps were operating to obtain an estimate for the whole season (CSG 2020).

Chinook smolt abundance

At the mainstem Russian River trap site (rkm 39.67), 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 (Figure 2). All fish captured in the trap were identified to species and enumerated. All salmonids ≥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 smolts was fin-clipped and released upstream of the trap. A one-trap mark-recapture design and analytical methodology was used to estimate the total number of Chinook Salmon Chinook smolts emigrating past the trap during the time when traps were in use (Bjorkstedt 2005, 2010). 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.

Figure 2. A downstream migrant trap at Sonoma Water's Mirabel dam in Forestville (Chinook smolt LCM station, rkm 39.67).

Steelhead pre-smolt abundance

An end-of-summer abundance estimate of juvenile steelhead in life cycle monitoring streams was obtained using single pass snorkel surveys conducted between August 18 and September 17, 2020. Sampling efforts during this season were impaired by multiple factors. With the need for extra precautions to maintain compliance with Sonoma Water and CSG's COVID-19 safety protocols, field efforts were reduced due to limitations in crew size. Additionally, the outbreak of the Walbridge Fire on August 18 suspended field activities briefly due to safety concerns.

Unlike in previous years, snorkel counts were not 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 2020 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 the pools that were not sampled to provide the abundance estimates. Steelhead abundance in riffle habitat was not calculated for the 2020 season.

Single pass backpack electrofishing surveys were conducted to apply PIT tags to juvenile steelhead and Coho in some LCM streams. Detections of PIT tagged steelhead as they leave their natal streams will be the basis for calculating a survival index, which will then be applied to the pre-smolt abundance estimates to complete the calculation of the steelhead smolt abundance. All salmonids ≥60 mm captured during electrofishing were anesthetized, weighed (±0.1 g) and measured (±1 mm), and scanned for PIT tags and coded wire tags in order to determine hatchery- vs. natural-origin. PIT tags were applied to untagged steelhead and Coho ≥60 mm and 2 g so that emigration from the tributary of tagging could be detected with a stationary PIT antenna array. Once fish were completely recovered from the anesthetic, they were released into the pool from which they were captured.

Allegro field computers were used for data entry and, upon returning from the field, data files were downloaded, QA/QC'd, and transferred to a SQL database.

Steelhead smolt abundance

For steelhead smolt estimation we employed a pre-smolt abundance model that relied on backpack electrofishing in the late summer/early fall and year-round, stationary PIT antenna monitoring to estimate smolts and/or juvenile steelhead leaving each LCS. Detailed steps are described in SW and CSG (2020). During our pre-smolt steelhead abundance sampling steelhead estimates were generated for both pool and riffle habitat, (SW and CSG 2020). For the purpose of generating a smolt estimate we only included the pre-smolt estimate for steelhead found in pool habitat. In the absence of trapping and handling steelhead to determine which individuals are smolts, we rely on their downstream movement out of their natal stream to classify these individuals as smolts. Individual steelhead were classified as smolts if they were detected at the LCS mouth during the period from November 1, 2019 through June 30, 2020.

Results

Redd and adult abundance

Spawner surveys for Coho Salmon and steelhead began December 4, 2019 and were completed March 17, 2020. Surveys in past years have continued until mid-April, but had to be cut short this season due to COVID-19 and the resulting state-wide shelter in place order. During that time, we completed 150 surveys in LCM tributary reaches. For the 2019/20 season, we observed Coho redds in 10 reaches and steelhead redds in 13 reaches out of the 16 LCM reaches surveyed. We observed the largest number of Coho and steelhead redds in the Mill Creek watershed. Overall, Mill Creek had the highest number of observed salmonid redds (Figure 3). We observed the largest number of Coho individuals (live fish and carcasses) in the Green Valley watershed and the largest number of steelhead individuals in the Mill watershed (Figure 4). Estimates of Coho redd abundance in LCM tributaries (± 95% CI) were 40 (±27) in the Mill watershed, 9 in the Green Valley watershed, and 2 in Dutch Bill Creek, and 3 in Willow Creek. Mill watershed and Green Valley watershed generally have the highest numbers of Coho redds compared to the other LCM tributaries, and while Mill had a greater than average redd total, Green Valley was considerably lower than in past years (Figure 5). Estimates of steelhead redd abundance in LCM tributaries (± 95% CI) were 43 (±21) in the Mill watershed, 9 in the Green Valley watershed, and 27 in Dutch Bill Creek, and 2 in Willow Creek. Similar to Coho, steelhead redd production is generally higher in Mill and Green Valley watersheds than other LCM creeks, but steelhead redd production in Mill was lower than most of the past seasons and Green Valley was much lower than last season, but closer to average (Figure 6). 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 and Green Valley watersheds saw the highest adult Coho estimates this year, but (like all LCM tributaries except Dutch Bill Creek) most returning adult Coho were 2-year olds (Figure 7). Overall, the total adult Coho estimate for all LCM streams combined was above average (Figure 8) while Chinook adults continues continued a downward trajectory (Figure 9). Spawner to redd ratios varied considerably (from 2.4 to 21) among LCM streams (Table 1).

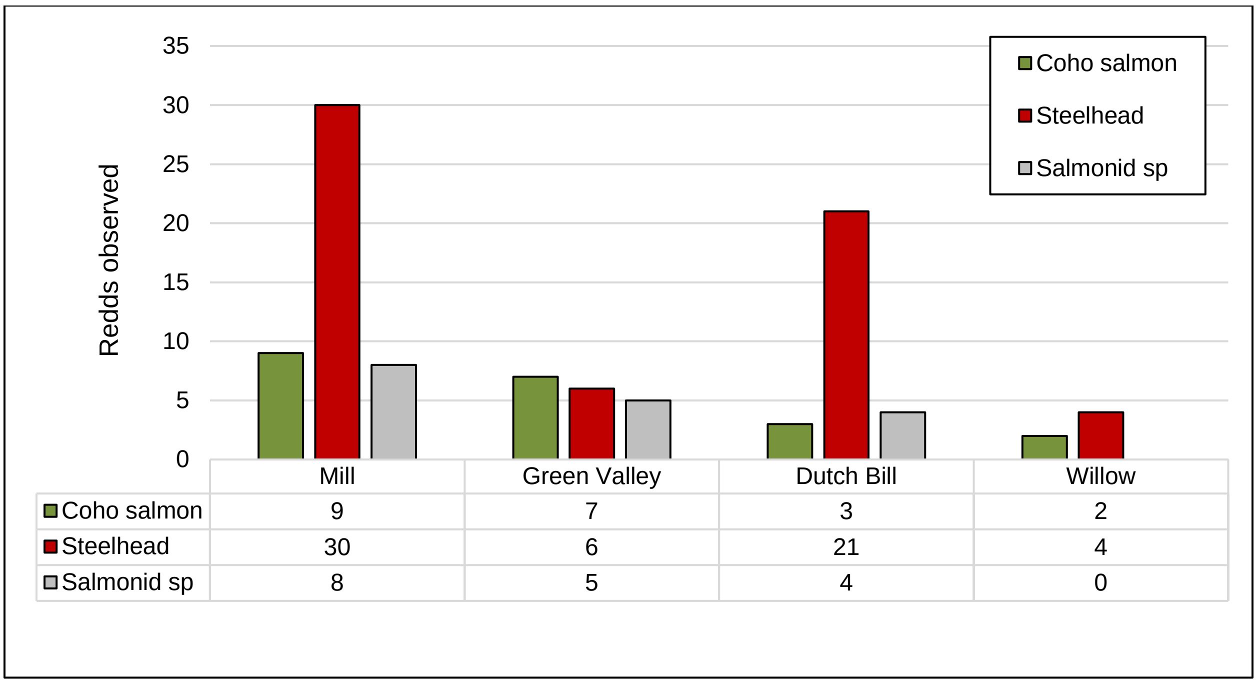
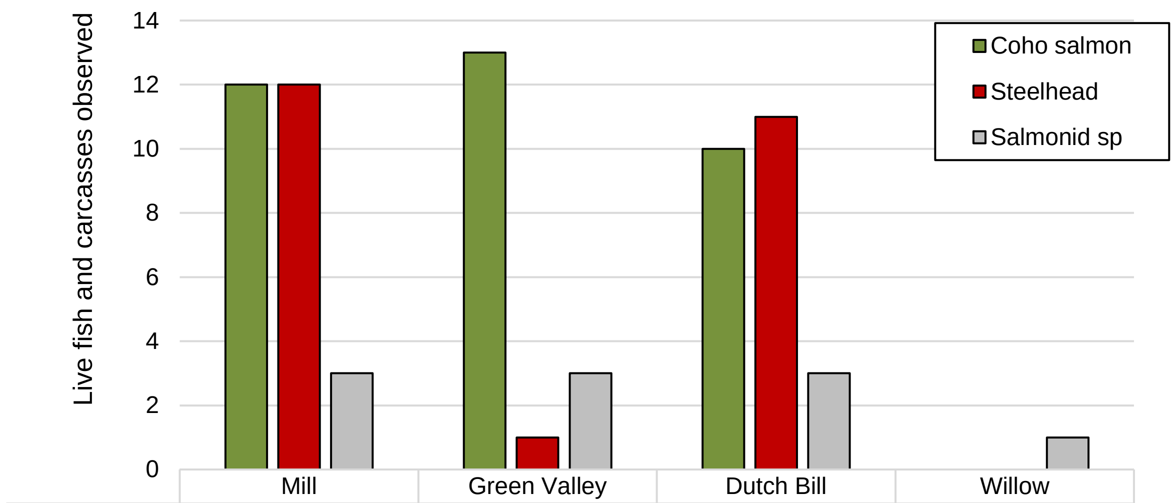


Figure 3. New redds counted in LCM tributaries for all three levels of redd species certainty during the 2019/20 spawner season. Mill watershed totals include all tributaries (Felta, Wallace, and Palmer Creeks) and Green Valley watershed totals include Purrington Creek.



	Mill	Green Valley	Dutch Bill	Willow
Coho salmon	12	13	10	0
Steelhead	12	1	11	0
Salmonid sp	3	3	3	1

Figure 4. Live fish and carcasses counted in LCM tributaries for all three levels of redd species certainty during the 2019/20 spawner season. Mill watershed totals include all tributaries (Felta, Wallace, and Palmer Creeks) and Green Valley watershed totals include Purrington Creek.

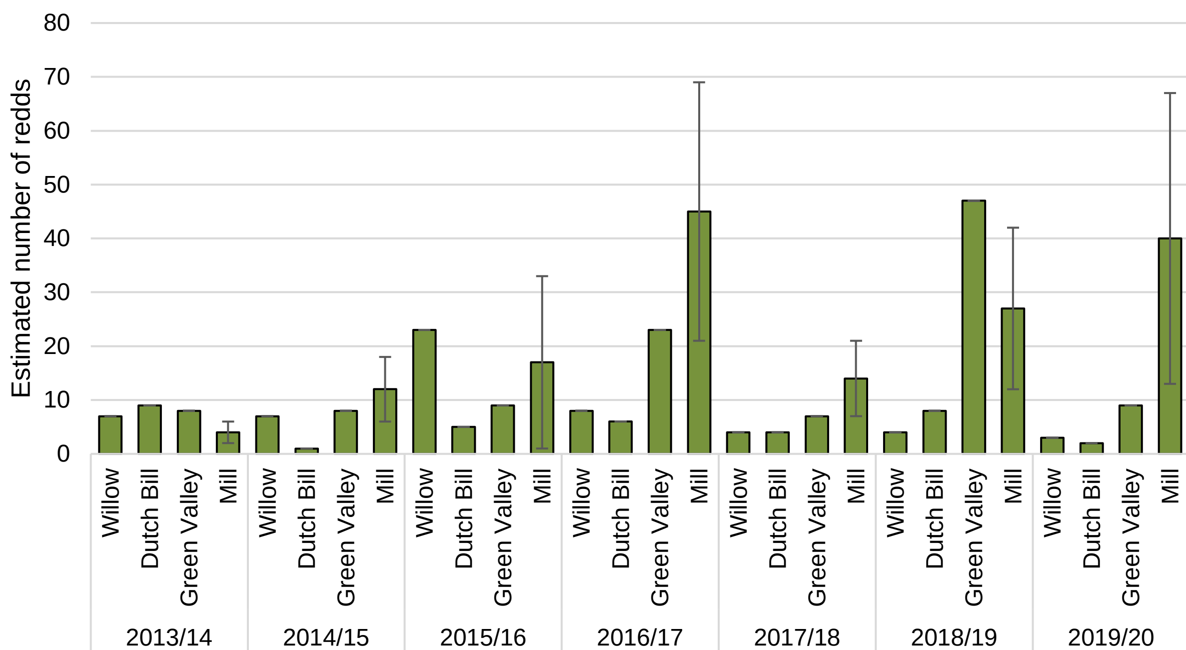


Figure 5. Estimated Coho redd abundance in LCM tributaries by spawner season. Estimates for previous seasons are shown in order to display trends.

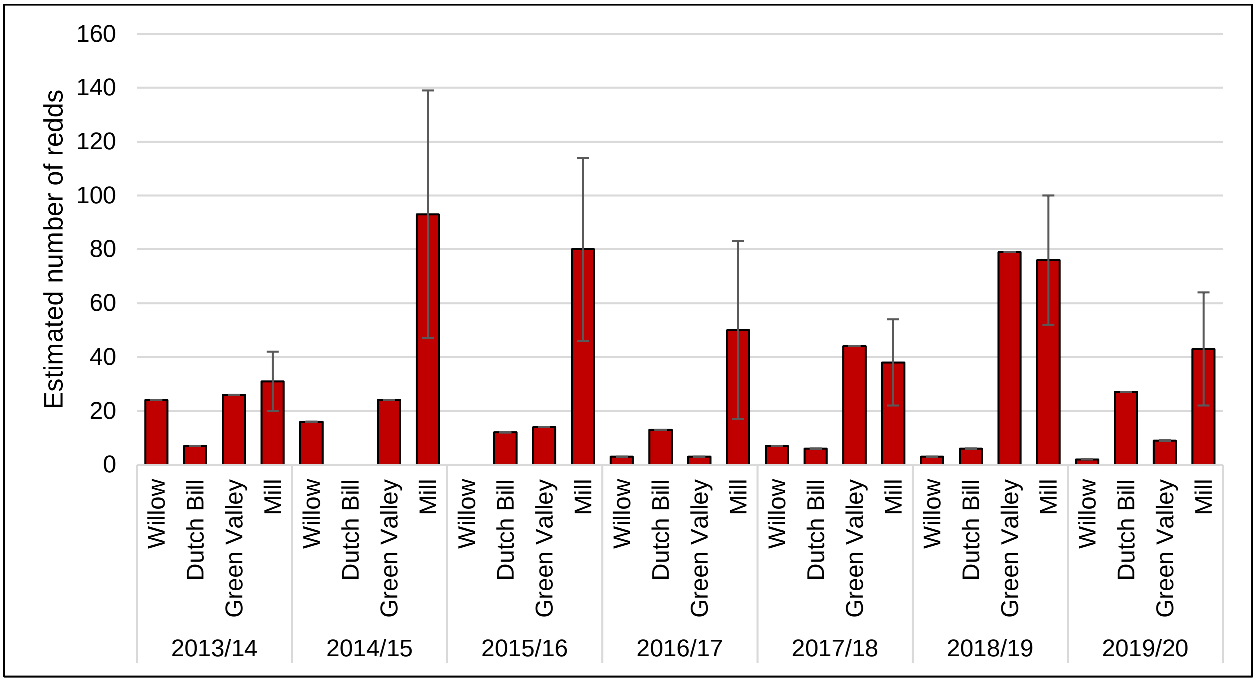


Figure 6. Estimated steelhead redd abundance in LCM tributaries by spawner season. Estimates for previous seasons are shown in order to display trends.

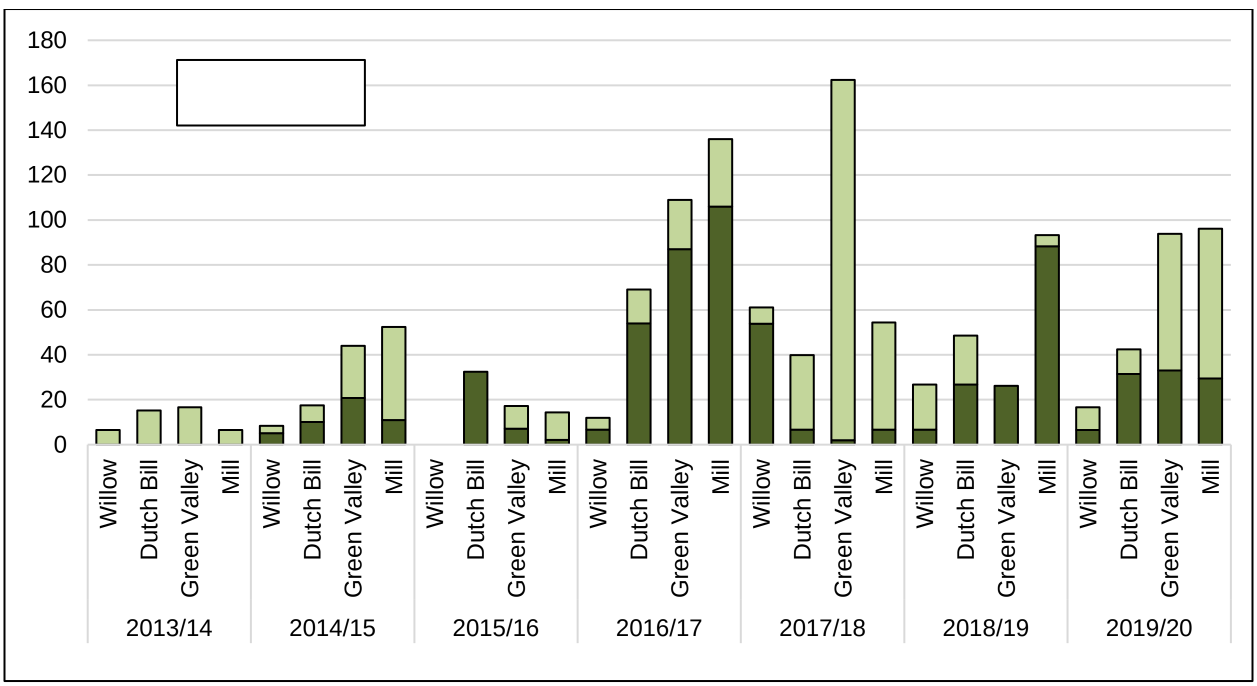
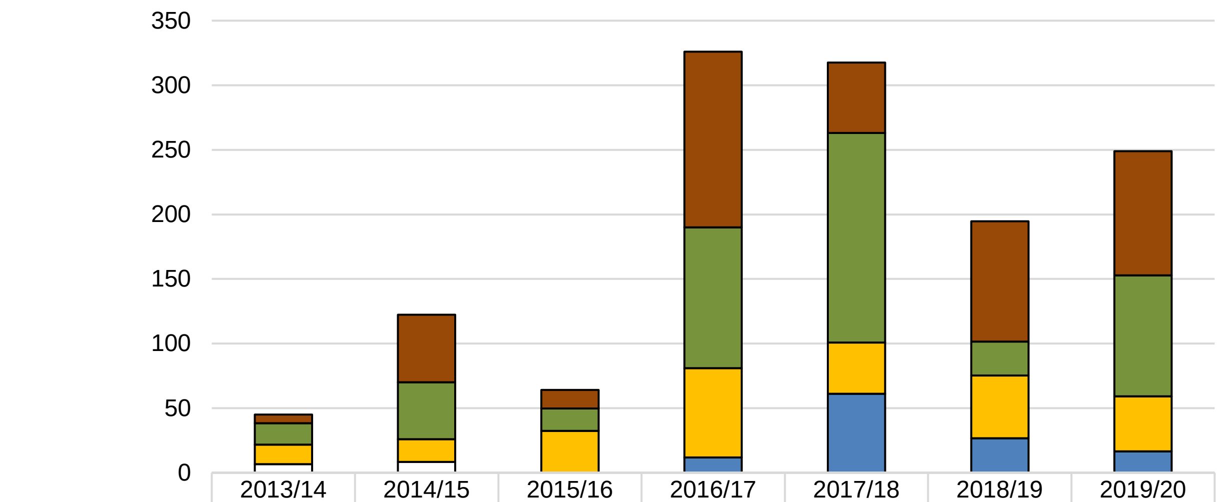


Figure 7. Adult Coho abundance in LCM tributaries by spawner season. Total adult estimates are broken out by age class.



	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20
Mill	7	52	14	136	54	93	96
Green Valley	17	44	17	109	162	26	94
Dutch Bill	15	18	33	69	40	49	42
Willow	7	8	0	12	61	27	17

Figure 8. Trends in estimated adult Coho Salmon abundance in LCM tributaries.

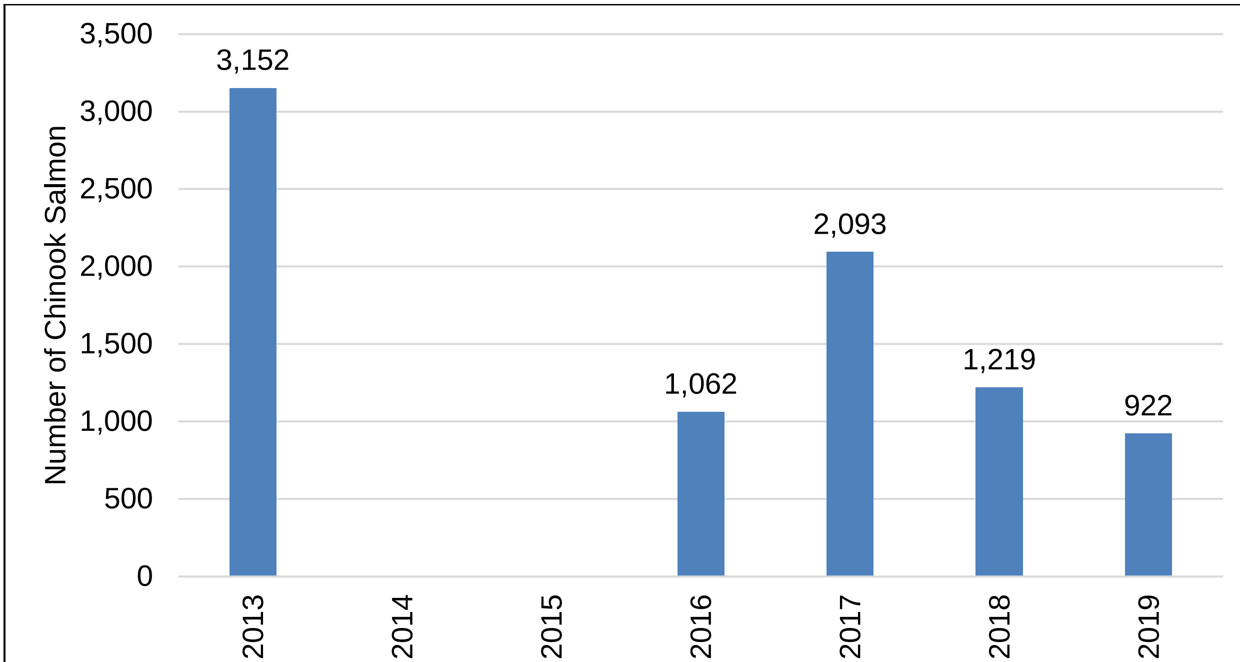


Figure 9. Trends in estimated adult Chinook Salmon abundance at mainstem Mirabel Mirabel dam LCS (rkm 39.67).

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

	Adult Estimate	Redd Estimate	Spawner to Redd Ratio
Mill Watershed	96	40	2.4
Green Valley Watershed	94	9	10.5
Dutch Bill Creek	42	2	21
Willow Creek	17	3	5.7

Smolt abundance

DSMT operation- In 2020, traps aimed at LCM objectives for Coho and steelhead were installed in early March but operations were suspended in mid-March in order to comply with public health measures in response to COVID-19. Trap operation was resumed in mid- to late-April once safety protocols had been developed and implemented. Traps were operated until stream flow in the vicinity of traps became disconnected. PIT antennas were operated throughout the period when traps were not being operated for reasons related to COVID-19 and/or issues related to high flows, etc. More detailed information on trap operation dates can be found in CSG (2020).

Because of COVID-19, the downstream migrant trap at the Mirabel dam on mainstem Russian River that serves as an LCS for Chinook Salmon could not be installed until 4/20. Trap operation was ceased on 6/15 when the cone stopped spinning due to low river flow.

Coho smolt abundance- Smolt abundance estimates indicate that thousands of smolts emigrated from each of the four LCM tributaries during the spring of 2020 (Figure 10). Smolt abundance was highest in Green Valley Creek; however, Green Valley Creek had the highest number of total fish released from Warm Springs hatchery and was the only creek in which smolts were released. Catch was lowest in Willow and Dutch Bill creeks; again, this was expected as the number of fish released was lower than on Green Valley and Mill creeks. The proportion of fish that were estimated to have emigrated while traps were out was low for all streams except for Green Valley where approximately half of the smolts were estimated to leave when traps were out. Abundance estimates were higher in 2020 than estimates in 2019 for all LCM tributaries except Green Valley Creek, which was slightly lower.

Chinook smolt abundance- A total of 3,813 Chinook salmon smolts were captured in the mainstem Russian River trap. Of those, 1,407 were released upstream of the trap but only 24 (1.7%) were recaptured leading to an very imprecise one-trap DARR estimate of 220,196 (±126,658).

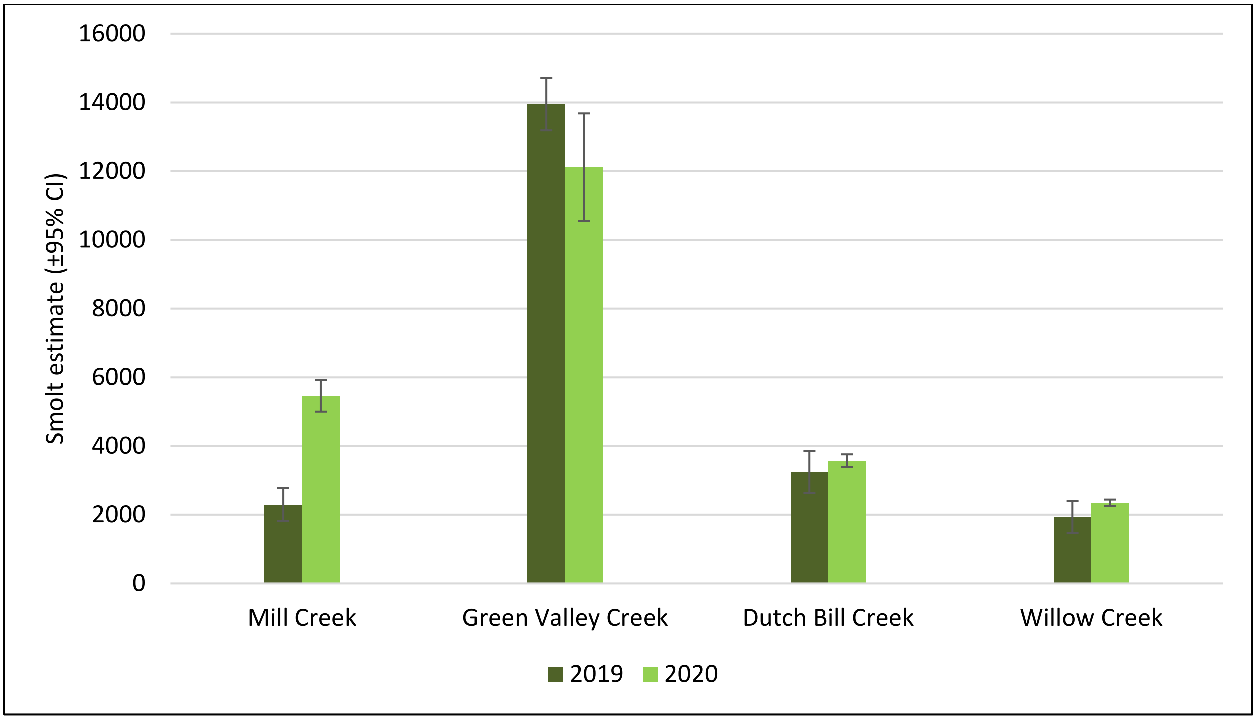


Figure 10. Coho Salmon smolt abundance estimates (±95% confidence intervals) for Mill, Green Valley, Dutch Bill, and Willow Creeks in 2019 and 2020.

Steelhead smolt abundance- Based on PIT antenna detections near the mouth of all four LCM streams, the timing of steelhead emigration varied between LCSs (Figure 11). Over half of the steelhead in the Mill Creek and Dutch Bill Creek LCS emigrated between November 15, 2019 and December 15, 2019 (65% and 55% respectively), whereas in Green Valley Creek over 72% of the steelhead emigrated between March 15, 2020 and April 15, 2020. Almost all of the steelhead emigrating from the Willow Creek LCS were detected after March 15, 2020 (94%) with the last detection on July 25, 2020.

During fall through spring steelhead emigration period in 2019/20, the raw proportion (i.e., not adjusted for antenna efficiency) of fish that were tagged in the summer and then emigrated from each LCS ranged from 18% at Mill Creek to 7% at Willow Creek (Table 2). PIT antenna efficiency was similar in all LCSs (range 0.79 – 0.90, Table 2). The estimated number of steelhead emigrating from all LCSs ranged from 2,319 in Mill Creek to 338 in Willow Creek for 2019/20 (Table 3).

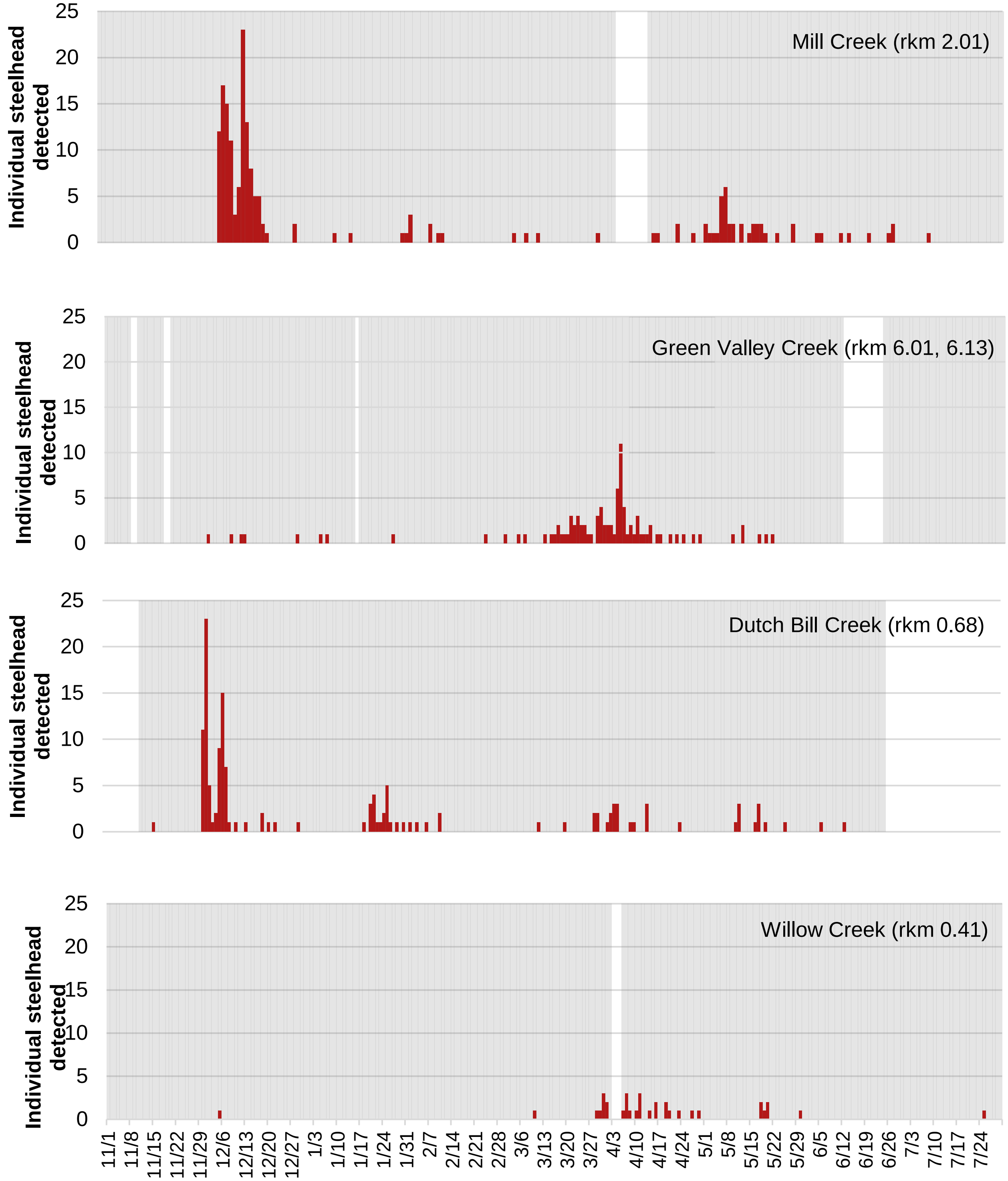


Figure 11. Number of individual steelhead tagged during late summer sampling that were detected at LCS antenna arrays based on maximum detection date. Shaded grey area indicates the period of antenna operation.

Table 2. Number of steelhead PIT-tagged by LCS in fall of 2019 and number of fish detected at the mouth of respective streams during the ensuing steelhead emigration period of November 1 through June 30.

LCS sub-watershed	Number PIT-tagged	Raw detections at mouth	Raw proportion emigrating	Antenna efficiency	Survival index
Mill Creek	1,031	185	0.18	0.90	0.20
Green Valley Creek	1,003	94	0.09	0.86	0.11
Dutch Bill Creek	973	140	0.14	0.85	0.17
Willow Creek	523	33	0.06	0.79	0.08

Table 3. Estimated number of steelhead emigrants based on fall 2019 pre-smolt estimates in pool habitat.

LCS sub-watershed	Survival index	Fall pre-smolt abundance	Number of emigrants
Mill Creek	0.20	11,595 (± 2,910)	2,319 (± 582)
Green Valley Creek	0.11	9,431 (± 2, 263)	1,037 (± 249)
Dutch Bill Creek	0.17	7,864 (± 2,053)	1,337 (± 349)
Willow Creek	0.08	4,220 (± 904)	338 (± 72)

<u>Steelhead life history variation</u>- Nineteen steelhead juveniles tagged during the 2018 sampling season in the Mill Creek watershed (SW and CSG 2019) were detected emigrating from Mill Creek during the 2019/2020 emigration period (Figure 11). While these individuals are of unknown hatch year, based on their size at tagging (average fork length 67.7mm) they are likely 2+ steelhead at time of emigration. This life history strategy has been document in previous sampling seasons. Of the steelhead tagged in the 2017 sampling season, 43 individuals were detected at the antenna array at the mouth of the Mill Creek LCS during the 2018/2019 emigration period (Figure 13).

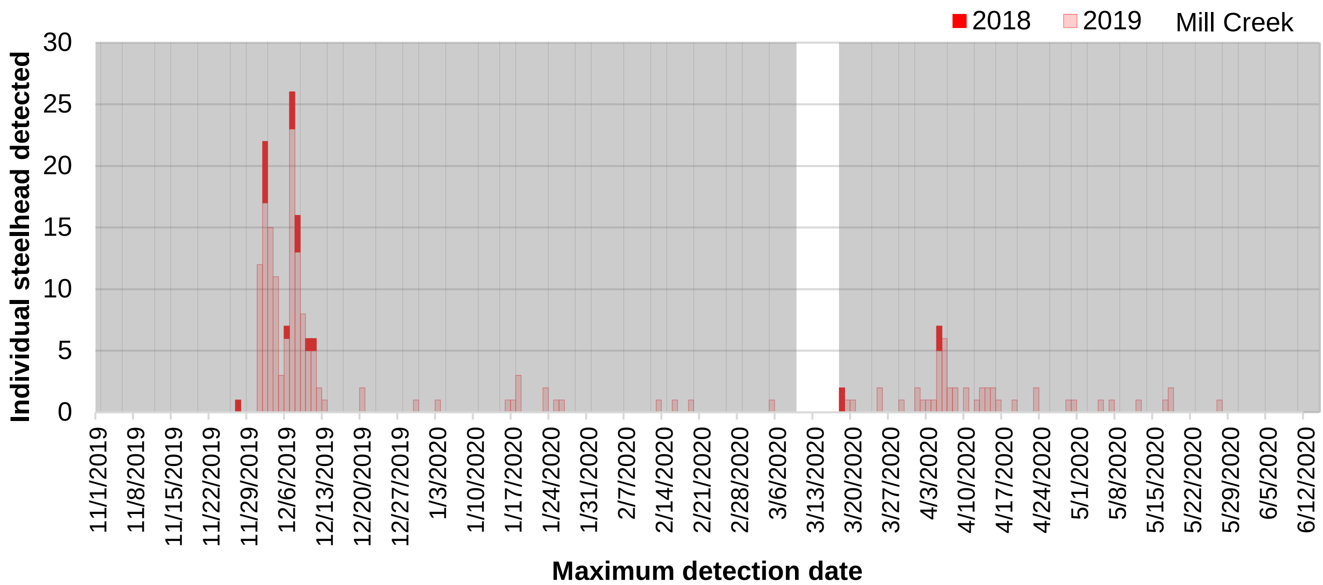


Figure 12. Number of individual steelhead detected at the mouth of Mill Creek LCS by tagging year. Shaded grey area indicates that the antenna array was functioning on a given date.

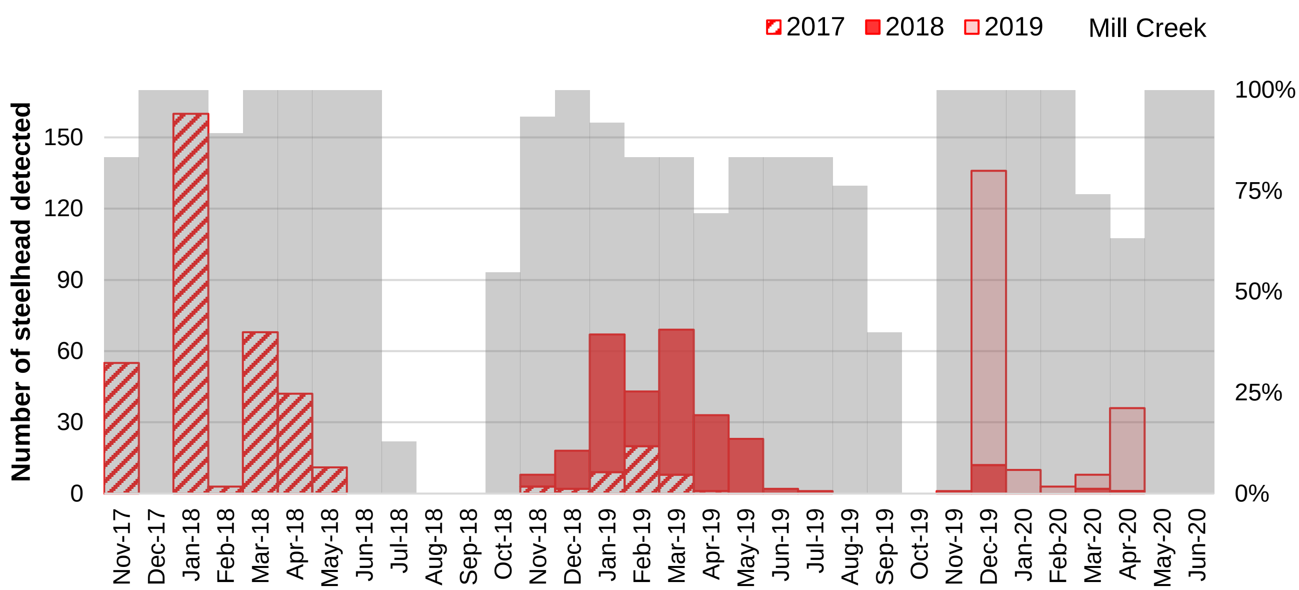


Figure 13. Total individual steelhead detected each month at the mouth of Mill Creek LCS by tagging year. Shaded grey area represents the percentage of days the antenna array was functioning each month.

Pre-smolt steelhead abundance

During the 2019 season we found that the number of steelhead observed in each pool during single pass snorkel surveys had the strongest effect on the number of steelhead estimated in each pool during second-stage electrofishing surveys (SW and CSG 2020 - Fall). Due to the limitations experienced in the 2020 season these calibration ratios ($\hat{R}_p = \hat{n}_{ef} \cdot n^{-1}{}_{sn}$;where $\hat{n}_{ef}$ is the number of juvenile steelhead estimated based on depletion electrofishing and $\hat{n}_{sn}$ is the number of juvenile steelhead observed during snorkel surveys) were applied to number of steelhead observed during the single pass snorkel surveys. Direct impacts of the Walbridge Fire in the Mill Creek watershed limited our safe access to the streams and no snorkel surveys were conducted in those streams. Limited backpack electrofishing surveys were conducted on lower reaches of Mill Creek for the purpose of applying PIT tags to juvenile steelhead and Coho. In Green Valley and Willow Creeks water quality was too poor to conduct any backpack electrofishing in 2020 (Table 4). In Willow Creek most pools were disconnected, with 49% of sampled pools disconnected at both ends. Dissolved oxygen in Willow Creek ranged from 0.1-6.9 mg/L with an average of 2.5 mg/L and in Green Valley Creek dissolved oxygen ranged from 0.6-7.8 mg/L with an average of 3.5 mg/L (Table 4).

Table 4. Water quality conditions of LCM streams at the end-of-summer 2020. Sampling occurred between August 18 and September 17, 2020; every other pool was sampled. Pools were considered to be disconnected if either the lower or upper ends, or both, were not connected.

LCM watershed	Stream	Number of pools sampled (n)	Average dissolved oxygen (mg/L)	Average water temperature (°C)	% of pools disconnected
Green Valley Creek	Green Valley Creek	57	3.2	19.2	54%
	Purrington Creek	31	8.7	15.3	2%
Dutch Bill Creek	Dutch Bill Creek	64	6.0	15.5	27%
Willow Creek	Willow Creek	63	2.5	14.5	69%

The stratum-specific correction factor $(\hat{R}_y)$ for snorkel counts was applied to the number of steelhead juveniles observed during snorkel surveys in the late summer/early fall to calculate an annual population estimate for LCM watersheds (Table 5). Pools were grouped based on the number of steelhead observed (≤ 10 and >10) and the corresponding correction factor was applied to snorkel counts. To generate a population estimate, the sum of corrected snorkel counts (i.e., after applying $\hat{R}_y$) for each tributary stream was doubled to account for the fact that we only snorkeled every other pool.

Table 5. Stratum- specific calibration ratio ($\hat{R}_Y$) applied to snorkel counts used to derive juvenile steelhead population estimates for end-of-summer 2020.

Stratum	$\hat{R}_Y$	95% LCI	95% UCI
≤ 10 steelhead	3.73	3.23	4.22
> 10 steelhead	1.93	1.33	2.53

A total of 300 pools were snorkeled in 2020, representing roughly 50% of accessible pool habitat in the LCM watersheds of Green Valley, Dutch Bill, and Willow Creeks. End-of-summer steelhead population estimates for pool habitat in the LCM watersheds ranged from over 3,800 in Green Valley Creek watershed to just under 800 in Willow Creek watershed (Table 6).

Juvenile steelhead abundance was greatly reduced in 2020 compared to previous years with an 81% decline in the Dutch Bill and Willow Creek watersheds and 59% decline in the Green Valley Creek watershed (Figure 14). The total estimated abundance of pre-smolt steelhead from the LCM watersheds that were sampled was 6,166 (±1,035 95% CI) for pool habitat (Table 6).

Table 6. Juvenile steelhead population estimates and sampling effort in LCM watersheds during end-of-summer 2020. Sample size (n) is based on number of pools with at least one steelhead observed.

LCM watershed	Stream	Total pools snorkeled	sample size (n)	Juvenile steelhead estimate: pool	± 95% CI
Mill Creek watershed		Not sampled			
	Green Valley Creek	76	44	1,429	250
	Purrington Creek	65	63	2,417	438
	Harrison Creek	Not sampled			
	Little Green Valley Creek	5	2	30	4
	Nutty Valley Creek	Not sampled			
Green Valley Creek watershed		146	109	3,876	692
	Dutch Bill Creek	71	57	1,435	222
	Grub Creek	4	1	7	1
	Perenne Creek	8	6	67	9
Dutch Bill Creek watershed		83	64	1,509	232
	Willow Creek	71	44	781	111
Willow Creek watershed		71	44	781	111

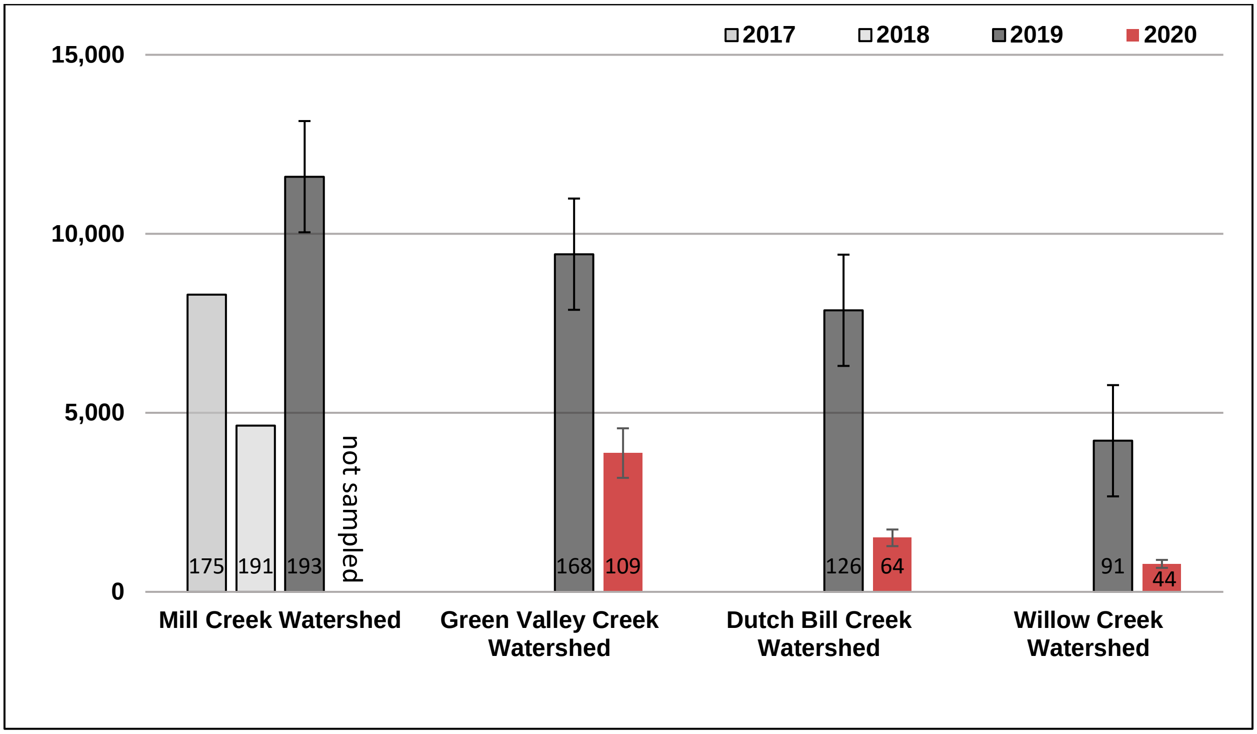


Figure 14. End-of-summer estimates for juvenile steelhead (found in pool habitat) from four Russian River watersheds. Green Valley Creek, Dutch Bill Creek and Willow Creek watersheds were added as LCM stations in 2019. The number at the base of each column represents the number of pools sampled to generate the population estimate.

Discussion

Redd/adult abundance

Similar to previous spawner seasons (California Sea Grant 2004-2020), there was considerable variability in spawner to redd ratios from different LCM watersheds for the 2019/20 season. The ratio in Mill Creek of 2.4 adults per redd is not far from the ratio Gallagher et al. (2010) calculated in several years of salmon and steelhead monitoring in Mendocino Coast streams, but the ratios from other streams were all higher (especially Green Valley and Dutch Bill). One explanation for the variability in ratios among streams are possible differences in age-2 to age-3 return ratios. A higher jack rate would suggest more fish overall but relatively fewer fish to contribute to redd building therefore a higher spawner to redd ratio. Accodingly, it is logical that the high jack rate estimated in the Green Valley watershed (64% jack rate) may explain the large spawner to redd ratio. However, because we estimated a much lower jack rate in Dutch Bill Creek (26%), the large ratio in that stream (21) was unexpected. The low ratio in Mill Creek is also surprising because of the relatively high percentage of PIT-tagged age-2 fish detected entering that stream (70%). Although jack rates certainly must be a factor in explaining spawner to redd ratios, these apparent inconsistencies between expected relationships between jack rates and spawner to redd ratios suggest that other factors must be at work. For example, because of the extremely low numbers of PIT-tagged adults returning, a difference of 1 or 2 fish or redds could have a significant effect on spawner to redd ratios.

The difficulties with the methods we use for adult abundance calculation notwithstanding, there do not seem to be other (better) potential methods that would work in the Russian River basin. Weir counts and underwater video counting systems have essentially the same problem – i.e., the period when it is most important to visually distinguish salmonid runs is usually the time of high winter flows (that lead to weir failure) and turbidity (that makes video counting impossible). DIDSON systems have the advantage of being more effective in turbid conditions, but it is difficult or impossible to distinguish different species of salmonids from each other and from other species with a similar size and shape (SW and CSG 2019). We conclude that the PIT-antenna approach we are using to estimate adult abundance in LCMs is the most effective and feasible approach.

Coho and Chinook smolt abundance

Because PIT antennas were operated near the mouth of each LCM stream, we were able to calculate robust abundance estimates of Coho salmon smolts despite the late start and interruption to the trapping season. Though Adams et al. (2011) provides little direction on the use of PIT tag antennas and tagging for accomplishing the goals of life cycle monitoring, we have found it to be an indispensable tool for studying both adult and juvenile life stages of salmonids in LCM streams, especially steelhead. Successful estimation of smolt abundance would likely not have been possible without the change in LCM methods we undertook in 2019 when we switched LCM activities from Dry Creek to Mill, Green Valley, Dutch Bill, and Willow creeks.

Because the Chinook Salmon LCS is on the mainstem Russian River where flows can be very high during the typical Chinook smolt emigration season, estimates of abundance can be both imprecise (due to low trap efficiency) and inaccurate (due to a late start or interrupted trapping season). Despite this issue, we have confidence that in most years we can generate estimates that should give us some idea of longer term trends in abundance.

Steelhead smolt abundance

The 2019-2020 season was our first opportunity to generate a steelhead smolt estimate in all four LCSs. Variation among the LCSs was evident in the timing of emigration and the survival index. Repeated sampling in the Mill Creek LCS has allowed us to observe variation in the age at which steelhead emigrate from their natal streams. Subsequent sampling on all the LCSs will allow us to compare these differences in life cycle strategy across watersheds, and between years.

Steelhead found in riffle habitat were excluded from the generation of the steelhead smolt estimate. This decision was made based on the difficulty in sampling the riffle habitat consistently during our fall 2019 pre-smolt surveys (CSG SCWA 2020). The majority of riffles sampled had no salmonids present and many riffles were small and shallow, and would not provide adequate habitat even for very small steelhead young-of-the-year (YOY). In future years we plan to develop a method for sampling the non-pool habitat that would include riffles, glides and flatwaters (Flosi et al. 2010) in order to generate a more robust estimate for steelhead not residing in pools.

Smolt monitoring conclusions and recommendations

Consequences of the difficult sampling conditions in winter/spring 2020 along with interruption in trapping due to the COVID-19 pandemic included what is perhaps an inaccurate Chinook smolt abundance estimate. Coho smolt abundance estimates were likely comparatively less-biased in the four LCM streams because we could fill in gaps in trapping with PIT antenna detections. Because we operated PIT antenna arrays near the mouth of each LCM stream, we were also able to apply the pre-smolt steelhead estimation model to estimate probable smolts leaving the four LCM streams.

Pre-smolt steelhead abundance

Juvenile steelhead estimates generated in 2020 relied on data gathered during the two-stage sampling efforts conducted in 2019. Based on previous findings we did not collect habitat metrics on pools sampled in 2020 as they were not found to be correlated with snorkeler accuracy (SW and CSG 2020 - Fall). Instead, we were able to stratify our snorkel surveys based on the number of steelhead observed in each pool to apply the appropriate calibration ratio. Having previously calculated this ratio we were able to calculate a juvenile estimate in streams where poor water quality prohibited the use of electrofishing needed to complete the two-stage sampling.

The lack of sampling in Mill Creek greatly reduced the total number of juvenile steelhead estimated. We could extrapolate a steelhead juvenile estimate for Mill Creek from the number of steelhead estimated in 2019 and the percent decline observed in other LCM streams this year. With a range for decline in abundance between 59-81% we could assume that the Mill Creek watershed had somewhere between 2,203 and 4,754 juvenile steelhead in 2020. Based on basinwide snorkel surveys conducted earlier in the summer in the Mill Creek watershed (Task 3), 2,316 total steelhead juveniles were observed during the first pass sample.

Calculation of the end-of-summer steelhead estimates is an important part of our life cycle monitoring but it is only the first step in estimating the number of steelhead smolts produced each year in LCM watersheds. Detections of PIT-tagged steelhead at stationary antenna arrays located at the mouth of some LCM will be used in conjunction with the tributary-specific, juvenile steelhead survival model to estimate the number of smolts produced from the watershed where PIT tags were applied. However, conditions such as poor water quality and safety concerns following the Walbridge Fire that limited our ability to sample some reaches will likewise limit our ability to calculate a steelhead smolt estimate in Mill, Green Valley and Willow Creeks.

Tasks 3 and 4. Basinwide Monitoring

Introduction

Basinwide 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 basinwide adult redd abundance sampling (from spawner surveys) and juvenile spatial structure sampling (from snorkel surveys) aimed at accomplishing basinwide CMP objectives.

Methods

Redd abundance

Field methods for basinwide 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 basinwide surveys were chosen based on the GRTS ordering and placed into rotating panels. During the 2019/20 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 both the Coho-steelhead sample stratum and the steelhead-only sample stratum with separate estimates calculated in each stratum for each species. 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 basinwide redd abundance in the Coho-steelhead sample stratum (81 reaches) and in the steelhead sample stratum (386 reaches) for the 2019/20 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 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 (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 on the pass 1 survey. Due to logistical challenges resulting from the COVID-19 pandemic we were unable to conduct two pass surveys on all reaches within the juvenile Coho stratum. Only reaches where 2- pass surveys were implemented were included in the occupancy estimate but we opted to conduct single pass surveys on the remaining reaches in order to maintain long term data sets.

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. Allegro field computers 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 probability of 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 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. One reach on Yellowjacket Creek, considered juvenile Coho habitat, was not included in the occupancy estimate because YOY were released from a remote site incubator (RSI) into that reach making it impossible to determine origin while snorkeling.

Results

Redd abundance

The start date for basinwide spawner surveys was December 4, 2019, 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 March 17, 2020 (due to COVID-19 as mentioned above). Over the course of the season we completed 628 surveys in 72 reaches in the Coho-steelhead and steelhead-only sample strata. In the Coho-steelhead sample stratum, we used 32 reaches (roughly 40% of the stratum) to calculate total redd abundance for the stratum. In the steelhead-only sample stratum, we used 30 reaches (roughly 8% of the stratum) to calculate total redd abundance for the stratum. The average time between surveys (± 95% CI) for reaches in both strata was 11.6 days (±0.24) with a maximum time between repeated surveys on any reach of 31 days. We observed the largest number of Coho, steelhead, and Chinook redds in Pena Creek. Overall, Pena Creek had the highest number of observed salmonid redds of any reach sampled in the basin (Figure 15). We also observed the largest number of Coho and Chinook individuals (live fish and carcasses) in Pena Creek but the largest number of steelhead individuals were observed in Austin Creek (Figure 16). We recorded 19 individual Coho carcasses and 7 of those 19 were CWT-tagged. One of the CWT-tagged Coho also had a PIT tag indicating it was from a group of hatchery fish released in Purrington Creek on Dec 12, 2017 (the carcass was found in Pena Creek). We observed 187 individual steelhead (live fish and carcasses, combined). Of those, 37 had observable adipose clips and 24 were floy-tagged (21 orange, 3 green). These were observed mostly in lower Austin and Dutch Bill Creeks, but a few were seen in Pena and Hulbert Creeks and the mainstem Russian River. We also anecdotally (not during a survey) observed 5 floy-tagged steelhead (4 green, 1 yellow) in lower Big Sulphur Creek. Coho redds were generally concentrated in the LCM streams, but many were also seen in Pena and Austin Creeks outside the LCM watersheds (Figure 17). Steelhead redds were seen in almost every reach sampled in the steelhead-only and Coho-steelhead sample strata (Figure 18). The estimate of Coho redd abundance in the Russian River basin (± 95% CI) was 104 (±32) for the 2019/20 spawner season. The estimate of steelhead redd abundance in the Russian River basin (± 95% CI) was 1606 (±831) for the 2019/20 spawner season. The Coho estimate is slightly below average but the steelhead estimate was only intermediate between the other two years where basin-wide steelhead abundance was lower than the highest we have recorded in the (Figure 19**,** Figure 20).

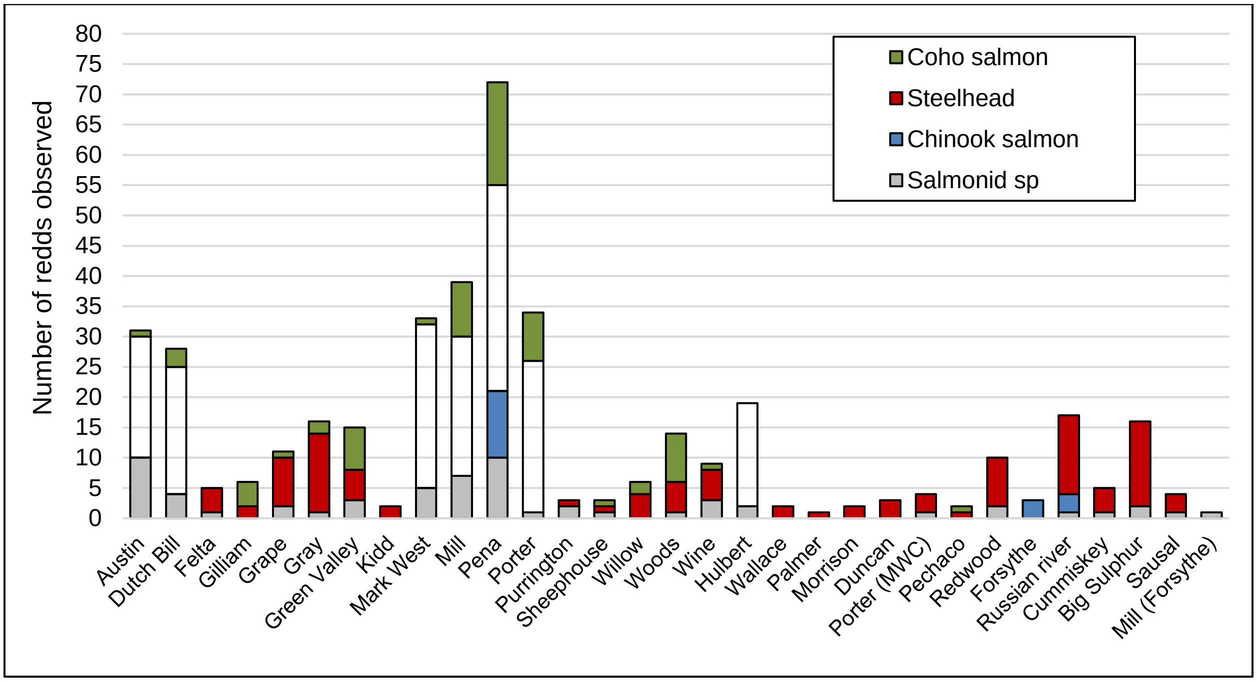


Figure 15. New redds counted in basin-wide spawner surveys by tributary for all three levels of redd species certainty. Only tributaries where redds were found are included. Note that not all habitat within each creek may have been surveyed in a given year (i.e., only reaches included in the rotating panel for a given season were surveyed).

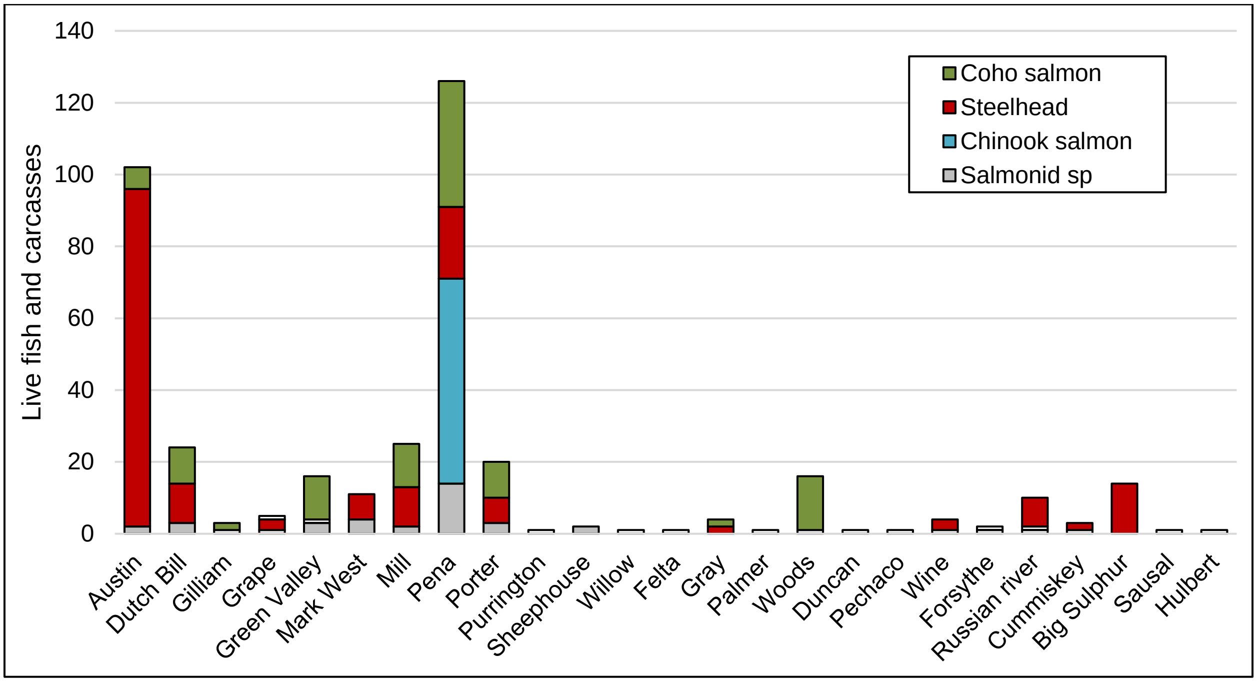


Figure 16. Live adult salmonids and carcasses counted in basin-wide spawner surveys by tributary for all three levels of fish species certainty. Only tributaries where live fish and carcasses were found are included. It is possible that some fish could have been counted more than once. Note that not 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).

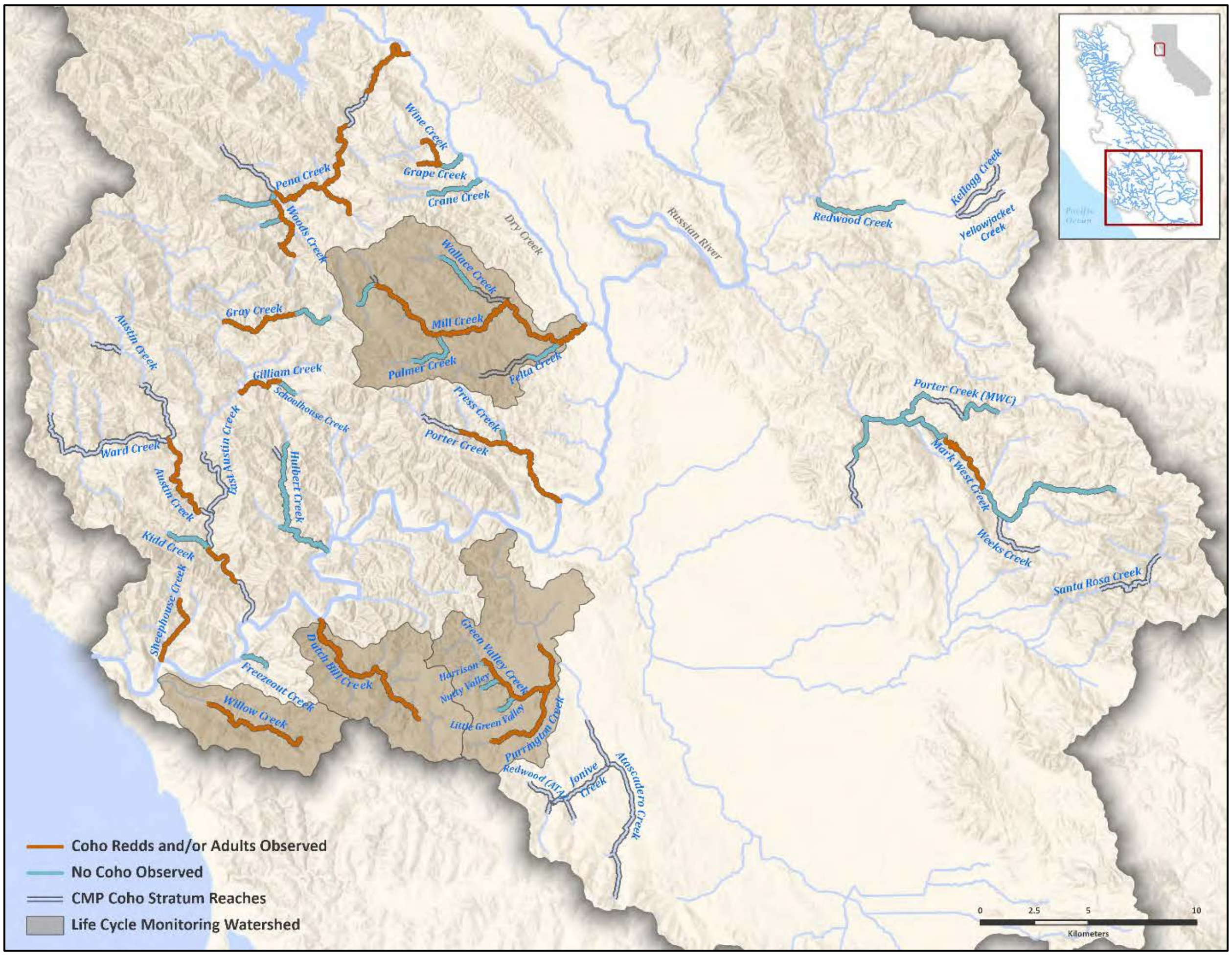


Figure 17. Coho-steelhead stratum reaches where Coho Salmon redds and/or Coho Salmon adults were observed (no Coho redds or adults were observed in the steelhead-only stratum).

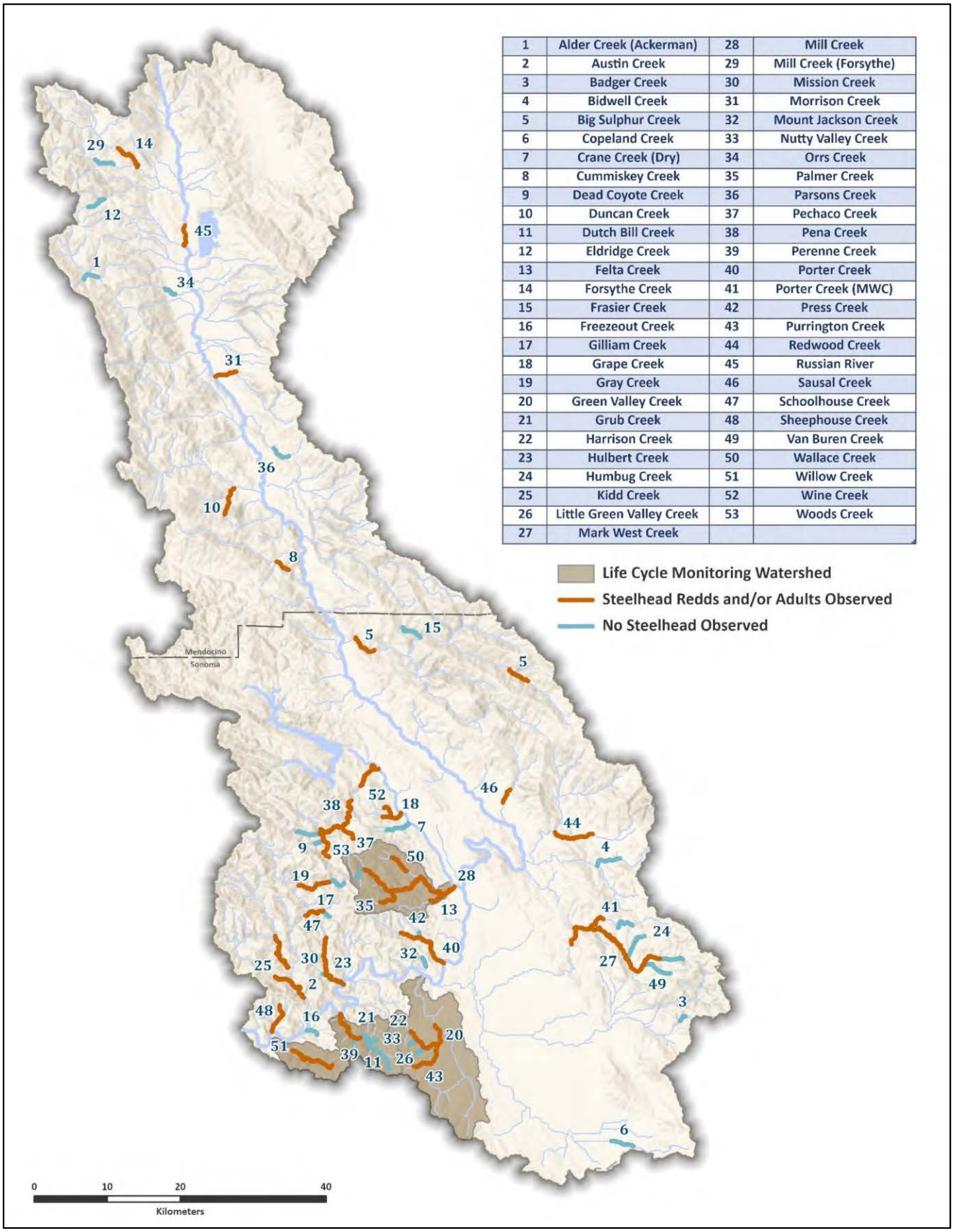
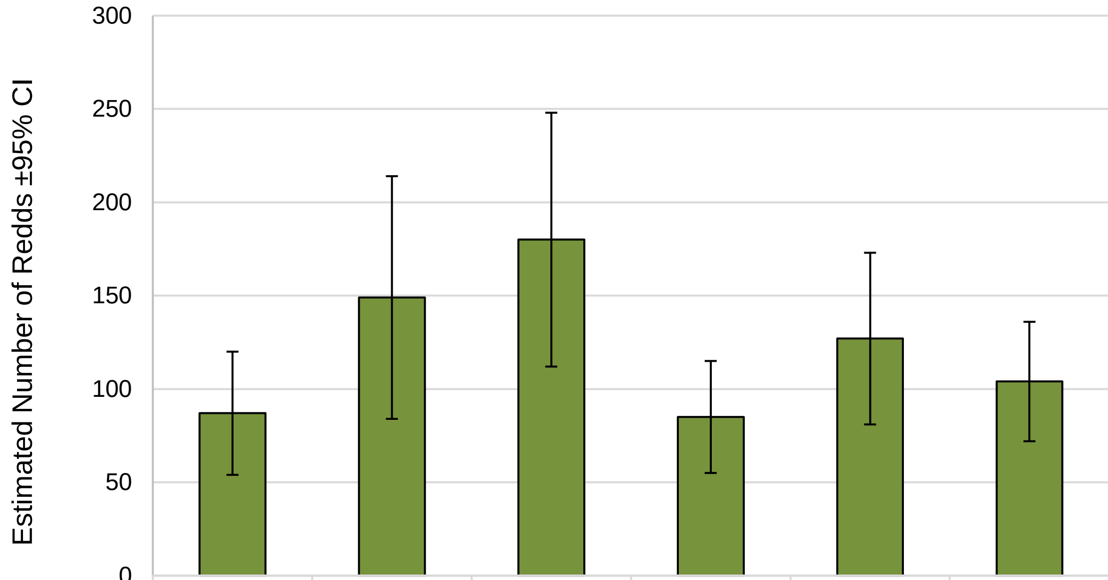
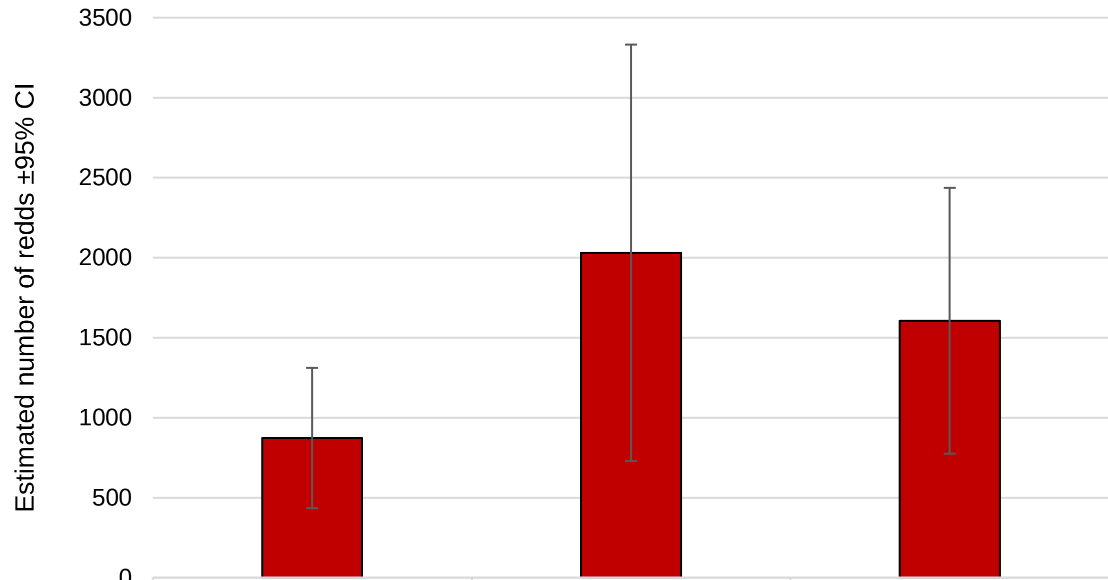


Figure 18. Steelhead-only stratum and Coho-steelhead stratum reaches where steelhead redds and/or steelhead adults were counted.



	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20
Total redd estimate	87	149	180	85	127	104

Figure 19. Trend in basin-wide estimates of Coho redd abundance by season.



	2017/18	2018/19	2019/20
Total redd estimate	873	2031	1606

Figure 20. Trend in basin-wide estimates of steelhead redd abundance by season.

Juvenile coho occupancy

Juvenile Coho Salmon were observed in 31 tributaries and 68% of the 74 reaches snorkeled (Figure 21). Based on results of the multiscale occupancy model, we estimate that the probability of Coho Salmon YOY occupying a given reach within the basinwide Russian River Coho stratum in 2020 was 0.64 (0.50 - 0.76, 95% CI), and the conditional probability of Coho YOY occupying a pool within a reach, given that the reach was occupied was 0.59 (0.54 – 0.63, 95% CI). The proportion of the Coho stratum occupied (PAO) was 0.38.

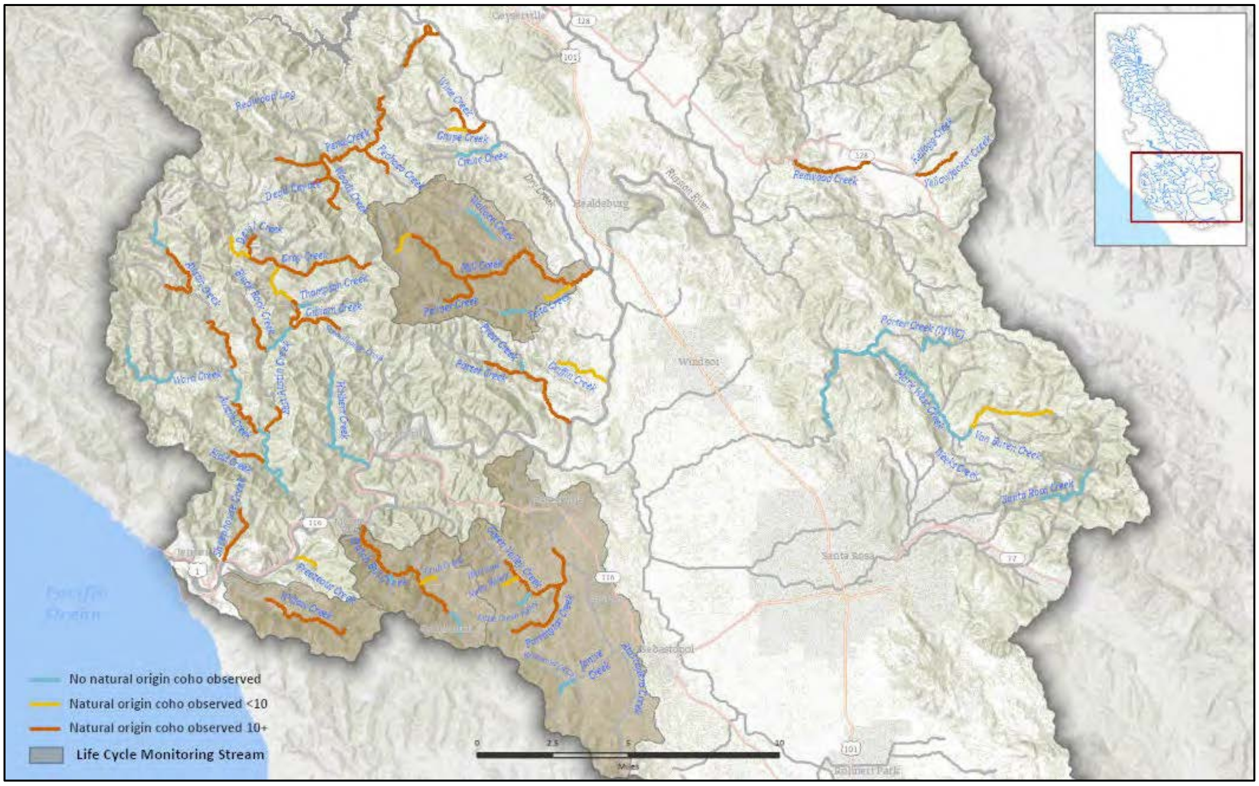


Figure 21. Natural-origin juvenile Coho Salmon distribution from snorkel surveys in the Russian River basin, 2020.

Discussion

Redd abundance

Under normal circumstances spawner surveys begin in early December and continue through April 15, but this year we were forced to cut surveys short on March 17 (about a month early) because of COVID-19 and subsequent shelter-in-place orders. Based on the timing of Coho spawning in previous seasons, it is likely we captured the entire Coho spawning season. However, we likely missed a significant portion of steelhead spawning this year. In the past two seasons that we have completed surveys in the steelhead-only sample stratum, we have seen several peaks in steelhead spawning activity after March 17 (Figure 22) amounting to roughly 40% of the total steelhead redds for those seasons. Comparing years directly is slightly problematic as the previous two seasons were considerably wetter than this season. In addition, as we finished up our last week of surveys in March 2020, we were experiencing very dry conditions and several creeks in the steelhead stratum were becoming disconnected. However, it seems likely that given rain in late March and April we would have counted more steelhead redds if we had been able to continue surveys.

Given that we may have missed a significant portion of the steelhead run, the redd estimate for this season is surprisingly high compared to last season. It seems likely that it would have been as high or higher than last season if we had been able to continue until the end of the season. This high estimate may be due to the number of surveys we were able to complete. We completed 628 surveys (despite the truncated season) in 71 reaches this year, compared to 319 surveys in 51 reaches last year. Large storms with resulting heavy flows and turbidity prevented us from surveying several times throughout the season in 2018/19 and these storms were relatively absent this year allowing us to survey more frequently.

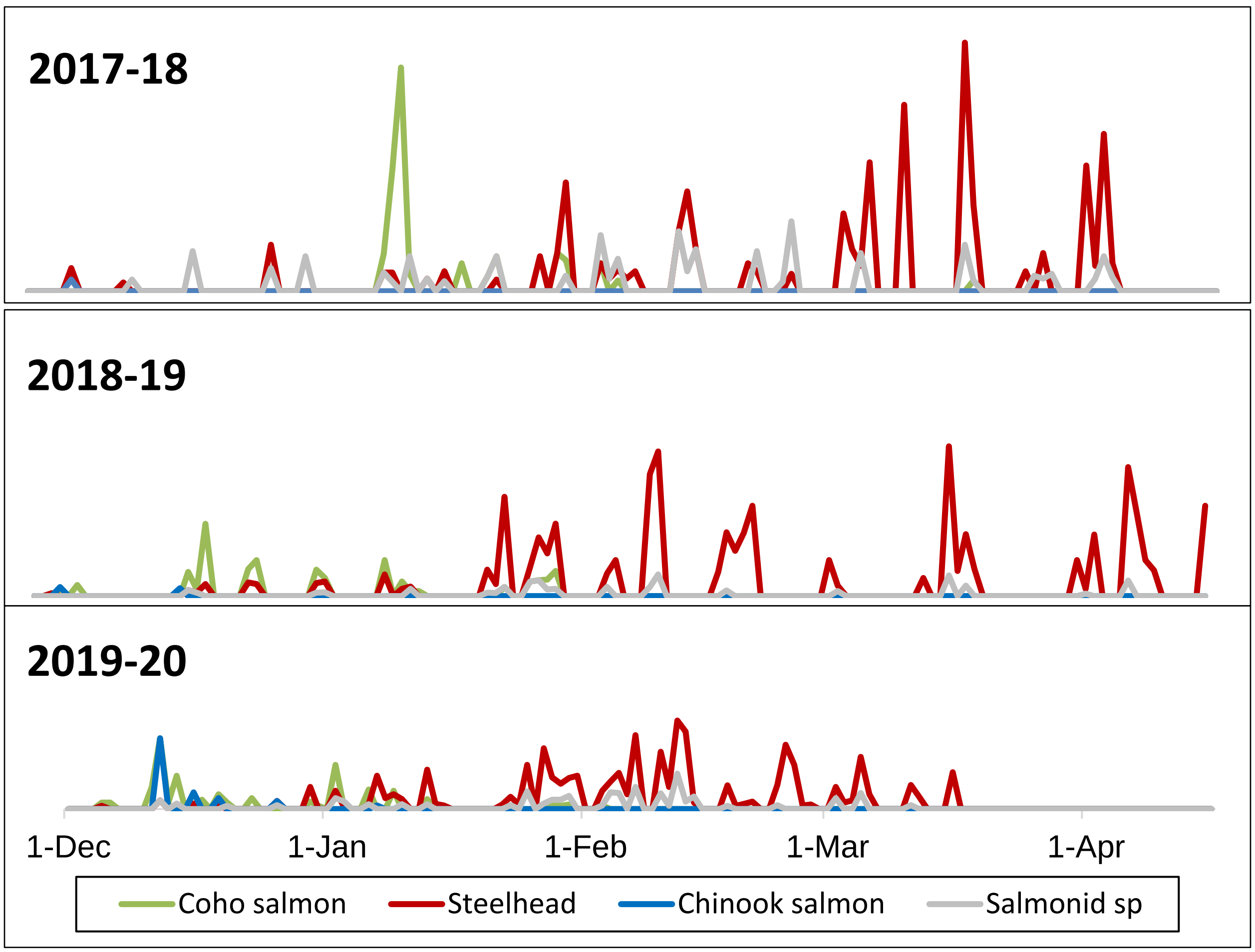


Figure 22. Redds counted per unit of effort for the last three spawner seasons by date.

Another circumstance that may have led to a higher steelhead redd estimate was the release of hatchery fish into the lower Russian River mainstem. From January 3 to March 17 (when we finished surveys) there were 27 groups of fish released into the Russian River mainstem, 4 of them (totaling 322 fish) released from Vacation Beach which is adjacent to several reaches in the Coho-steelhead sample stratum. This was the first season that Vacation Beach releases took place, and there was considerable anecdotal evidence that these fish were being counted during our spawner surveys. On the next survey after a release of 129 fish steelhead at Vacation beach we counted 14 new redds in the lowest reach in Hulburt Creek (the mouth of which is just upstream of Vacation Beach). We have surveyed that reach in Hulburt the last 4 years and the total redds seen in all previous seasons was only 8. We saw similar increases in spawning activity in Dutch Bill Creek (where we saw an increase in redd production) and Austin Creek (where we saw an increase in live fish) associated with lower river hatchery releases.

Juvenile coho occupancy

Coho PAO was the highest it has been since we began conducting basinwide snorkel surveys to estimate spatial structure in 2015 (Table 4, Figure 23), 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 below the five-year average in the winter of 2019/2020 (SW and CSG 2020 - Winter) so it seems probable that the broad spatial distribution of Coho YOY was due to greater than average redd success. Low flows in the winter of 2019/2020 may have enabled redds to survive in a wider range of streams than in higher water years such as 2018/2019 when we observed very low PAO in the following summer despite an above average number of redds. 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 salmonids. It also provides further support for the idea that, along with efforts to increase summer flows, land management practices designed to reduce peak flows could be highly beneficial to the Coho salmon population in the Russian River. As we continue to build our data sets, we intend to overlay redd count estimates with juvenile occupancy and smolt abundance estimates in LCM streams to evaluate stock-recruit relationships.

Table 7. Summary of results from basinwide snorkel surveys for Coho Salmon in the Russian River Basin (2015-2020).

Year	PAO	Reach scale occupancy ($\widehat{\psi}$) (95% CI)	Pool scale occupancy ($\widehat{\theta}$) (95% CI)	Number of reaches sampled
2015	0.37	0.68 (0.54-0.79)	0.54 (0.49-0.59)	58
2016	0.33	0.7 (0.58-0.8)	0.47 (0.43-0.51)	72
2017	0.2	0.5 (0.38-0.61)	0.42 (0.39-0.46)	73
2018	0.25	0.58 (0.46-0.69)	0.43 (0.39-0.46)	69
2019	0.16	0.46 (0.34-0.58)	0.34 (0.3-0.39)	72
2020	0.38	0.64 (0.50-0.76)	0.59 (0.54-0.63)	50

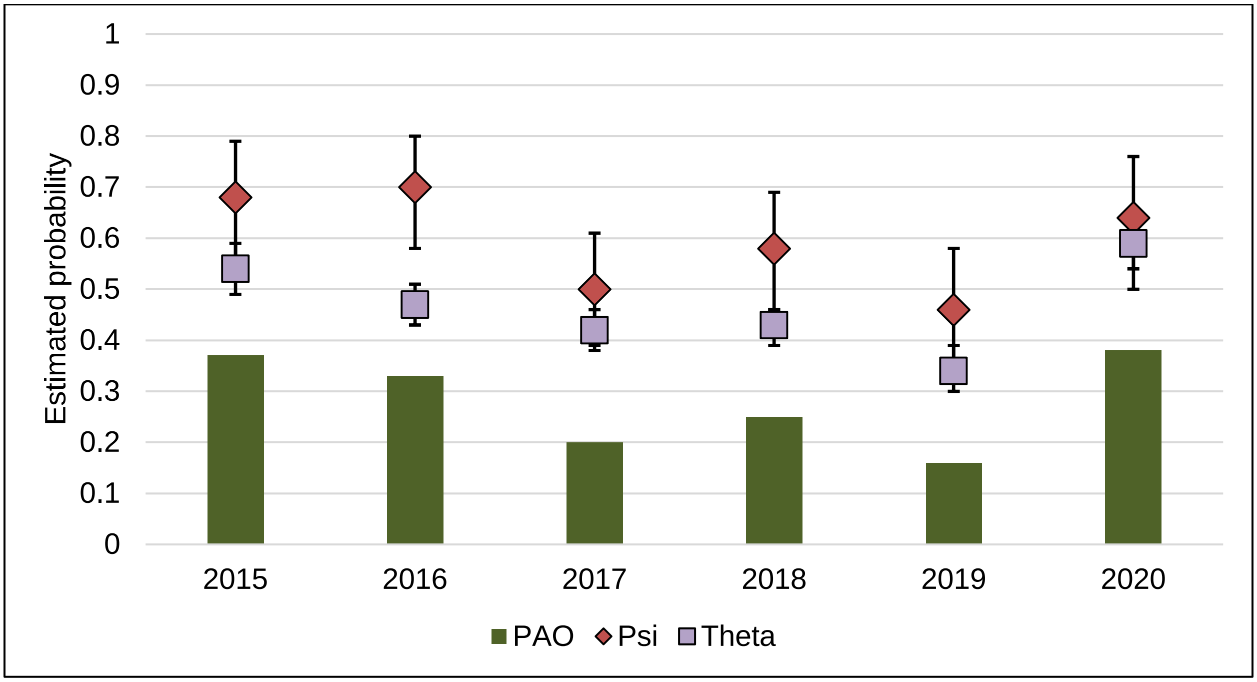


Figure 23. Estimated proportion of area occupied (PAO), occupancy at the reach scale ($\hat{\psi}$), and occupancy at the pool scale ($\hat{\theta}$) for Coho Salmon in the Russian River Basin (2015-2020).

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