Distribution and Abundance of California Central Valley steelhead/Rainbow Trout and Late-fall Chinook Salmon Redds in Clear Creek, Winter 2015 to Spring 2016

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Abstract — Since 1995, the Central Valley Project Improvement Act, Clear Creek Restoration Program, and later the California Ecosystem Restoration Program have taken restoration actions to improve anadromous salmonid habitat in Clear Creek. The Red Bluff Fish and Wildlife Office, as part of the Clear Creek Restoration Program, has conducted Central Valley steelhead/Rainbow Trout *Onchorynchus mykiss* and late-fall run Chinook Salmon *O. tshawytscha* spawning ground surveys in Clear Creek since 2003. The purpose of these surveys is to evaluate population trends of these species on an annual basis through redd counts and carcass recoveries. Surveyors observed 149 California Central Valley steelhead/Rainbow Trout and 22 late-fall Chinook Salmon redds over 8 creek-length surveys from December 2015 to April 2016. Eighty-one percent of California Central Valley steelhead/Rainbow Trout and 100% of late-fall Chinook Salmon redds were located in the unconfined alluvial reach spanning from the Gorge Cascade to the confluence of the Sacramento River and seven of 27 Chinook Salmon carcasses inspected had a hatchery mark (26%).

Table of Contents

List of Tables

List of Figures

Introduction

The National Marine Fisheries Service listed California Central Valley steelhead *Oncorhynchus mykiss* as a threatened species in 1998 under the Federal Endangered Species Act (NMFS 1998). In this report *O. mykiss* refers to both stream resident (Rainbow Trout) and anadromous (steelhead) life histories because of difficulty differentiating resident and anadromous forms in the field. Threatened status of steelhead was reaffirmed following a five-year review in 2016 (NMFS 2016). Central Valley late-fall run Chinook Salmon *O. tshawytscha* (late-fall Chinook) were listed as a species of special concern in 2004 (NMFS 2004). Since 1995, the Central Valley Project Improvement Act, Clear Creek Restoration Program, and later the California Ecosystem Restoration Program have taken restoration actions to improve anadromous salmonid habitat in Clear Creek (Bureau of Reclamation and U.S Fish and Wildlife Service 2016; California Department of Fish and Wildlife et al. 2014). Restoration actions have included increased minimum instream flows, water temperature control through flow management, spawning gravel supplementation, dam removal, and large-scale stream channel and floodplain restoration (Bureau of Reclamation and U.S. Fish and Wildlife Service 2016).

Clear Creek is a west side tributary of the Sacramento River, located in Shasta County, California (Figure 1). The Bureau of Reclamation controls water releases into Clear Creek at Whiskeytown Dam. Releases are approximately 200 cubic feet per second (cfs) from October 1 to June 1 to provide sufficient habitat and water temperature for salmonid egg incubation and juvenile salmonid rearing. Winter storms often increase discharge from the accumulation of additional sources of accretion flow in the watershed. Clear Creek provides a variety of habitat types for *O. mykiss* and late-fall Chinook due to variation in catchment size, gradient, and sediment supply.

The Red Bluff Fish and Wildlife Office has conducted kayak-based spawning ground surveys since 2003 to assess populations of adult *O. mykiss* and late-fall Chinook on Clear Creek and to evaluate effects of restoration actions on their recovery. We have found kayak-based surveys to be an effective method to obtain redd counts and collect carcasses during the spawning season when flows are variable due to winter storm events. This annual report summarizes monitoring efforts for the 2015-2016 spawning season.

Study Area

The study area extends from Whiskeytown Dam, at river mile (RM) 18.1, downstream to the Clear Creek Video Station (CCVS) (RM 0) near the confluence with the Sacramento River south of Redding, CA (Figure 2). McBain and Trush (2001) summarized the setting found in Clear Creek by categorizing them into four major reaches. The upstream most reach extends from Whiskeytown Dam to Need Camp Bridge (RM 16.1) and is primarily characterized by an unconfined alluvial stream type. The second reach, from Need Camp Bridge to the Clear Creek Road Bridge (RM 8.6), is primarily composed of confined bedrock channels. The Saeltzer Dam Reach, extends from the Clear Creek Road Bridge through the Gorge Cascade (RM 6.5) and it is characterized by a lower stream gradient and increasing alluvial nature. The downstream most reach is characterized by an unconfined alluvial morphology, which extends from the Gorge Cascade to the confluence with the Sacramento River. (Figure 2).

Methods

The primary objective of this annual survey is to detect and enumerate *O. mykiss* and late-fall Chinook redds on Clear Creek. Additional objectives include collecting data on the size and location of identified redds, documenting live adult fish observations, documenting pre-spawn mortality, collecting genetic samples, and determining the influence of hatchery-origin fish on the natural population. In order to achieve these objectives during the 2016 survey period, kayak surveys were scheduled at two week intervals from December through April depending on instream flow and precipitation.

Redd aging data has shown that redds are visible to surveyors for at least two weeks in Clear Creek, but redd detection diminishes during or following precipitation and high instream flow events (Giovannetti and Brown 2007). Elevated instream flow and precipitation increase water surface turbulence, turbidity, and surveyor pace which can reduce visibility and inhibit surveyor redd detection. Flattening, scouring, and accumulation of fine sediment on redds can also occur, limiting surveyor redd detection. Efforts were made to execute surveys at two week intervals, but adjustments were made as necessary to accommodate storm events. Survey schedules were altered when flows exceeded 500 cfs or visibility in the water was less than three feet. Surveys were additionally altered if storms were predicted, and postponed for several days if instream flow exceeded 1,000 cfs to allow sufficient time for new redd construction.

The study area was divided into 7 reaches based on distance, creek access, and key monitoring locations (Table 1). One reach (Reach 3; RM 13.2-11) was omitted due to surveyor safety concerns and historic absence of redds. One or two reaches were covered in a survey day and full creek surveys were completed in two to four consecutive days. Surveys were conducted by three or four member crews moving downstream on Hyside™ inflatable kayaks. The creek was apportioned longitudinally and crewmembers were assigned sections of the creek to monitor. Surveyors counted, measured, and attributed redds to species. Live adult late-fall Chinook were counted and salmonid carcasses were recovered for sampling. For each observation or recovery, crews collected GPS location and associated data using a Trimble® GeoExplorer 6000 XH GPS (Trimble Navigation Ltd, Sunnyvale, CA). Surveyors received five hours of training in the field to ensure uniformity in redd identification and data collection. Additionally, steps were taken to ensure an experienced crew member was on every survey.

Redd Identification

While scanning for redds, kayakers looked for clean gravel patches and areas of mounded and sorted gravel which contrast from the surrounding substrate. In areas of spawning habitat where swift water or overhanging vegetation made redd observation difficult, crews parked the kayaks and waded the area to look for redds. Redds needed to have a clearly defined pit, a clearly defined tail, and consensus among the crew to be counted. A snorkel and mask were used to examine redds underwater more thoroughly if necessary. Areas of clean substrate that fish may have disturbed, but lacking a pit and tail, were not counted. These areas were marked as test redds and reexamined on subsequent surveys.

There was potential for surveyors to encounter *O. mykiss*, late-fall Chinook, and Pacific Lamprey *Entosphenus tridentatus* (Lamprey) redds while surveying. When redds were observed, a combination of the following characteristics were used to attribute each redd to species: (1) redd size, (2) redd location, and (3) substrate type. Spawning Chinook females are generally larger than spawning *O. mykiss* females. With their greater body mass, Chinook are capable of turning over larger substrate sizes and typically construct larger redds than *O. mykiss*. Each redd was attributed to either *O. mykiss* or late-fall Chinook based on its overall size and the size of substrate moved in its construction. Lamprey redds can be quite small and typically have a circular shape atypical of salmonid redds.

Each new salmonid redd was marked with flagging and assigned an identification number. Flagging included the date, channel location, and identification number to prevent double counting on subsequent surveys. Flagging was tied to vegetation in line with the leading upstream section of the disturbed area. Each redd was examined to determine if it was observed on a prior survey by checking for flagging and using GPS.

To track the length of time redds are visible to observers each survey, all new redds and redds from previous surveys were assigned an age classification based on specific criteria as follows: Age 2: clearly visible and clean (clearly defined pit and tail-spill and no periphyton or fines), Age 3: less visible with minor tail-spill flattening (pit and tail-spill still defined, periphyton growth, invertebrate presence), Age 4: barely visible with shallow pit and flattened tail-spill (periphyton growth, invertebrates), and Age 5: pit and tail-spill indistinguishable from the surrounding substrate.

Redd Measurements

Measurements were taken to describe physical redd characteristics. Redds were measured when first observed, unless a fish was present or if it was determined to be in progress and not completed. Surveyors identified substrate type (injection gravel, native gravel, or a combination of injection and native gravel) for all new redds encountered. The predominant substrate size around each redd was recorded at three locations: (1) the undisturbed area just upstream of the redd (pre-redd), (2) the sides of the pit, (3) the excavated tail material behind the pit (tail-spill). Comprehensive measurements were taken from a sub-sample of every third redd identified. Water depth measurements were taken at an estimated average location within the pre-redd, at the deepest part of the pit, and at the shallowest point on the tail-spill. Surveyors measured redd length parallel to the flow and redd width perpendicular to the length, at the longest and widest part of the disturbed area. Redd area was calculated by using the formula for an ellipse (area = π ½ L ½ W). Differences in mean redd area for redds identified in the field as *O .mykiss* or late-fall Chinook were tested for significance by a Welch's two sample t-test.

Mean water column velocity was measured with a General Oceanics (General Oceanics, Inc., Miami, FL) model 2030 mechanical flow meter at the pre-redd depth location. Flow meters were operated for a minimum of 100 seconds. Velocity was calculated following the General Oceanics model 2030 operators manual. Velocities were taken at 60 percent depth from the water surface if the water depth was $<$2.5 feet. If water depth was $\geq$2.5 feet, flow measurements were taken at 20 percent and 80 percent from the water surface (Allan and Castillo 2007).

Live Adult late-fall Chinook and Carcasses

In addition to locating salmonid and Lamprey redds, crew members detected and recorded live adult late-fall Chinook. When live late-fall Chinook were observed, the survey crew would proceed to the end of the habitat unit (pool, run, etc.) enumerating all live late-fall Chinook encountered, and collected geospatial data with a handheld GPS device. The number of fish counted and any observed characteristics (sex, tail wear, and level of senescence) or external tags (Floy) were also reported.

Biological data were collected from all retrievable salmonid carcasses. Each carcass was assigned a sample identification number and biological information was recorded including fork length, gender, spawn status, adipose fin status (clipped or not), and stage of decomposition (fresh or non-fresh). Heads were collected from adipose-fin clipped carcasses and carcasses of unknown adipose-fin status for coded-wire tag (CWT) retrieval. Adipose-fin status could be unknown due to decomposition or lack or a complete carcass. If present, CWTs were extracted from heads in the laboratory for determination of hatchery origin. Fin tissue samples were taken for genetic analysis; however, skin or operculum were used if fins were highly decayed. Otoliths were removed and stored for future analysis. Scales were removed from the left side of the carcass, at the second or third row of scales above the lateral line, in the region bisected by a line drawn between the back of the dorsal fin and the front of the anal fin. Caudal fins were removed from each recovered carcass to prevent re-sampling on subsequent surveys. Biological information was also recorded for adult salmonid carcasses retrieved from the CCVS resistance board weir and in rotary screw traps; however, those carcasses were not sampled for otoliths, scales, or tissue.

Discharge, Temperature, and Turbidity Measurements

Water temperature and discharge data were obtained from the U.S. Geological Survey Clear Creek Igo gauging station (site 11372000 [IGO]) at RM 11.1 to determine survey feasibility, summarize temperature, and monitor instream flow throughout the survey period (https://waterdata.usgs.gov). Water temperature data were also collected during each survey using Onset® Hobo® Water Temp Pro instream temperature loggers distributed spatially at roughly 2 RM intervals throughout Clear Creek. These data were summarized by calculating mean daily discharge and temperature each day during the survey period. Water samples were collected at the beginning and end of each survey reach for measuring turbidity in nephelometric turbidity units (NTU) using a turbidimeter (Model 2100Q; Hach® Company, Loveland, CO).

Results

A total of eight creek-length surveys were completed between December 1, 2015 and April 4, 2016 (Table 2). Surveys occurred every two weeks except survey 5, which was delayed one week, and survey 8 which was delayed two weeks. Both delays were due to unsafe survey conditions (>1,000 cfs) caused by winter storm events.

Redd Identification

Over the 2015-2016 survey period, crews attributed 149 redds to *O. mykiss* (Table 2). The highest proportion (81%) of *O. mykiss* redds were observed in the unconfined alluvial reach spanning from the Gorge Cascade at RM 6.5 to the CCVS at RM 0. Thirty eight percent of redds were observed in a half mile stretch of habitat called Renshaw Riffle (RM 5.6-5.1). Eleven percent were located in the upstream alluvial reach between Whiskeytown Dam (RM 18.1) and NEED Camp Bridge (RM 16.1). The remaining 7% of redds were detected in the canyon and Saeltzer Dam reaches (RM 16.1-6.5). Over 90% of the total redd count was observed by the February 15 survey week (Figure 3). The highest number of *O. mykiss* redds were detected on survey 3 (week of December 29, 2015), when 52 redds were observed (Table 2). For the 2016 monitoring period, 75% of *O. mykiss* redds were undetectable 34 days after first observation (Figure 4).

Crews attributed 22 redds to late-fall Chinook (Table 2). All late-fall Chinook redds were observed in the unconfined alluvial reaches below the gorge (RM 6.5). Over 90% of counted redds were observed by the January 15 survey week with peak redd detection on a mean survey date of December 29 (n = 9) (Table 2). The highest proportion of late-fall Chinook redds (36%) were detected in Renshaw Riffle (RM 5.6-5.1) (Figure 5). For the 2016 monitoring period, 75% of late-fall Chinook redds were undetectable 33 days after the first observation (Figure 6). Surveyors also observed 62 live adults over all surveys, with the highest proportion (40%) observed during the December 29 survey week (Table 2). Live adult late-fall Chinook were first detected during the second survey (mean survey date of December15, 2015) and were not detected after a mean survey date of March 2.

Redd Measurements

Thirty-three percent of *O. mykiss* redds and 55% of late-fall Chinook redds were measured over all surveys. Average *O. mykiss* redd surface area was 21.6 ft^2 (n = 49) whereas late-fall Chinook were found to have a mean redd surface area of 151.4 ft^2 (n = 12). Overlap was found in redd areas between the two species (Figure 7). Two late-fall Chinook redds (7.2 ft^2 and 47.0 ft^2) were smaller than the largest O. mykiss redd (57.27 ft^2). Results from Welch's two sample t-test indicate that mean redd area for redds identified by surveyors as late-fall Chinook and *O. mykiss* were statistically different ($p < 0.05$).

Average *O. mykiss* pre-redd depth was 1.3 ft, and average water velocity was 1.8 ft/s (n = 49) (Figure 8). The most frequent dominant substrate size class identified for *O. mykiss* redds was 1-2 inch gravel (n = 149) (Figure 9). Average late-fall Chinook pre-redd depth was 1.7 ft (n = 12), average water velocity was 1.8 ft/s (n = 12), and the most frequent dominant substrate size class identified was 1-3 inch gravel (n = 22) (Figure 10, Figure 11).

Carcasses and Live Adult late-fall Chinook

During the survey period, 33 salmonid carcasses were recovered. Of the 33 carcasses recovered, 19 were found during kayak surveys and the remaining carcasses were found on the CCVS weir and in a rotary screw trap (Table 2). Unknown length, gender, and adipose clip status from recovered late-fall Chinook carcasses were due to predation or advanced decomposition. Median late-fall Chinook fork length was 716 mm (n = 28; range = 500-1,100 mm). Gender comprised of 60% female, 36% male, and 4% unknown. Scale, otolith, and tissue samples were taken from 16 late-fall Chinook carcasses on kayak surveys, however, none were taken from the carcasses collected on the CCVS (Table 3).

Of the 28 late-fall Chinook carcasses recovered, 27 were in sufficient condition to identify the presence or absence of a hatchery mark. Seven carcasses (26%) were adipose-fin clipped and two were unknown adipose-status. Coded wire tag recovery revealed five (72 %) late-fall Chinook produced from Coleman National Fish Hatchery, one (14%) fall-run Chinook produced from Nimbus Fish Hatchery, and one (14%) fall-run Chinook produced Mokelumne Fish Hatchery (Table 4). One of two unknown adipose-status heads was examined and determined to have no tag detected therefore considered to be of non-hatchery origin. The other unknown adipose-status head for CWT analysis was not retrieved due to advanced decomposition.

Five *O. mykiss* carcasses were recovered during the survey period. Median fork length was 420 mm (*n* = 5, range = 380-460), 3 were female and 2 male. Two carcasses were recovered during kayak surveys, two were found on the CCVS, and one was found in the upper rotary screw trap (RM 8.4). Tissue, otolith, and scale samples were taken from three carcasses (Table 5).

Discharge, Temperature, and Turbidity Measurements

For the 2015-2016 survey season, the average discharge at IGO (RM 11.1) was 272 cubic feet per second (cfs) during active surveying. Four flow events exceeded 1,000 cfs and 2 events exceeded 3,000 cfs during the survey period, with peak instream flow at IGO of 3,920 cfs on March 13, 2016 (Figure 12). Instream flow events > 1,000 cfs occurred on January, 17-19, January 23, March 5, and March 10-16 and instream flow events > 3,000 cfs occurred on January 19 and March 13. The average water temperature during active surveying was 48.8 °F. As measured at IGO (RM 11.1), stream temperature was lowest in early January (about 46 °F) and warmed to nearly 52 °F by the end of the survey season in April (Figure 12). Average turbidity over active surveying was 1.9 NTUs (Table 2). The greatest turbidity measured on an individual survey was 2.45 NTUs on a mean survey date of February 1, 2016 (Table 2).

Discussion

Winter storm events that frequent the California Central Valley overlap the spawn timing of *O. mykiss* and late-fall Chinook, which can make spawning surveys difficult. The 2015-2016 survey season was no exception as El Niño weather patterns caused elevated instream flow, predominately in January and March 2016. Increases in instream flow can introduce error during surveys for a couple of reasons: (1) Redds can be obscured from observers due to elevated turbidity that commonly accompanies heightened instream flow and (2) redds can scour before they are observed. Each of these occurrences could cause the number of redds to be undercounted and misrepresent the spawning population in Clear Creek.

Average measured turbidity during active surveying was relatively low (1.9 NTUs) and not considered to have detrimental effects on redd observation. Redd flattening has been observed at nearly 1,000 cfs (Giovannetti and Brown 2008) and Graham Mathews and Associates (2017) state that full bed mobility occurs at 3,000 cfs in Clear Creek. Instream flow events > 1,000 cfs and > 3,000 cfs occurred in January and March, 2016. Peak spawning occurred on survey 3 (mean survey date of December 29, 2015) and the majority of *O. mykiss* (79%) and late-fall Chinook (63%) redds were detected by survey 4 (mean survey date of 1/12/2016), before the first flow > 3,000 cfs on January 19, 2016. Redds constructed shortly after survey 4 may have been scoured prior to the following survey on February 2, 2016, leaving them undetectable to surveyors and uncounted. Instream flow events in March may have had a similar, though reduced, impact on redd counts since an average of 91% of *O. mykiss* redds have been detected through February 18 from 2009-2015 (unpublished data, S. Gallagher, RBFWO). Redd age tracking data shows the length of time redds are visible to surveyors. Our observations (Figure 4, Figure 6) suggest that redds are visible for at least 20 days (median 34) for *O. mykiss* and late-fall Chinook (median 33). As mentioned above, it is possible for redd construction to have occurred in between a survey and a high flow event; however, these occurrences represent a small part of our survey period and we believe survey frequency was acceptable for meeting our objectives.

From 2003-2015, *O. mykiss* redd counts on Clear Creek have ranged from 43 to 409 (Figure 13). The 149 redds observed in 2016 were lower than the 13-year average (mean 206). Late-fall redd counts have ranged from 14 to 122 (Figure 13) during the same period, and the 22 redds observed in 2016 were also lower than the 13-year average (mean 37). While redd counts are useful for evaluating salmonid population trends, the addition of the CCVS on Clear Creek in 2012 could also provide valuable information regarding passage of *O. mykiss* and late-fall Chinook. Determination of anadromy for adult *O. mykiss* is difficult without handling or lethal take of otoliths. Identification of larger sized fish (>16") recorded on video passing upstream may be useful for determining how many anadromous *O. mykiss* are migrating in to Clear Creek.

Salmonid redd size is strongly correlated with the size of the spawning female (Riebe et al 2014). California Central Valley *O. mykiss* are generally smaller than late-fall Chinook and produce smaller redds. Based on Clear Creek redd measurement data from past surveys, average area of an *O. mykiss* redd is 20 ft^2 compared to 118 ft^2 from late-fall Chinook. It is possible to find intermediate-size redds that could have been produced by either a large *O. mykiss* or small Chinook Salmon (Gallagher and Gallagher 2005). The distribution of *O. mykiss* and late-fall Chinook redd area in Clear Creek is usually bimodal with some overlap between species expected. During the 2016 survey season, one redd identified as late-fall Chinook was unusually small (Figure 7) and highlight inherent challenges differentiating redds between species. To remove some of this uncertainty, redd area is only one of multiple criteria taken into account by surveyors to categorize identified redds. Since *O. mykiss* and late-fall Chinook redds, by some accounts, differ spatially in Clear Creek (Giovannetti et al. 2013), other criteria such as instream redd location, evaluation of substrate size, and redd definition are also used to categorize identified redds. Even so, we acknowledge some subjectivity in species determination. This potential source of error is unquantified by our methods.

The influence of hatchery origin late-fall Chinook on Clear Creek has varied annually (Figure 14) but decreased in recent years, indicating that returning cohorts were produced naturally and potentially in Clear Creek. Since 2003, almost all CWT recoveries have been late-fall Chinook from Coleman National Fish Hatchery. In contrast, during the 2015-2016 survey period two fall Chinook carcasses recovered originated from Nimbus and Mokelumne River Hatcheries (Table 4). Each fish originated from a juvenile release group held in net pens in the Sacramento-San Joaquin River Delta or San Pablo Bay, increasing their likelihood to stray (Palmer-Zwahlen and Kormos 2015). Also, fall Chinook from Nimbus and Mokelumne River Hatcheries are known to spawn later than fall Chinook from Coleman National Fish Hatchery and the Upper Sacramento River, which might further explain their presence in Clear Creek during the late-fall period.

Kayak based surveys appear to be an effective method for determining spawn timing and distribution of *O. mykiss* and late-fall Chinook in Clear Creek. While survey conditions on Clear Creek in the winter months can be negatively affected by high instream flow and elevated turbidity, conditions for most of the survey period are conducive for observing redds, live adults, and carcasses. Summarizing and interpreting previous years flow and redd age tracking data may help improve annual redd counts. Completing assessments of video passage data, following the methods outlined by Killam et al. (2017), for comparison to redd counts may inform anadromous contribution to the spawning population of *O. mykiss* on Clear Creek. Installing pit tag arrays, conducting otolith studies, and other assessments outlined in the Central Valley Steelhead Monitoring Plan would also help obtain information regarding the contribution of anadromous

O. mykiss. Implementing these measures will give further insights to migration timing and population size of both species, assist in determining the anadromous contribution of *O. mykiss*, and help focus future management and restoration efforts.

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Tables

Table 1. Clear Creek kayak survey reach breaks during the 2015-2016 season.

Location	Reach break	River mile
Reach 1 (start)	Whiskeytown Dam	18.1
Reach 2	Need Camp Bridge	16.1
Reach 3 (not surveyed)	Kanaka Creek	13.2
Reach 4	Igo Gauging Station	11
Reach 5	Clear Creek Road Bridge	8.6
Reach 6	Gorge Cascade	6.5
Reach 7	Lower Rotary Screw Trap	1.8
Reach 7 (end)	Video Weir Station	0.0

Table 2. Counts of late-fall Chinook Salmon and California Central Valley (CCV) steelhead/Rainbow Trout redds and carcasses, live late-fall Chinook Salmon, and environmental conditions during kayak surveys in Clear Creek, 2015-2016. Carcasses collected on the Clear Creek video station weir (CCVS) and the rotary screw trap (RST) during the survey season are also included.

	Late-fall Chinook			CCV steelhead/ Rainbow Trout		Environmental conditions		
Survey week (average date)	Redds	Carcass	Live	Redds	Carcass	Average turbidity (NTU)	Average flow (cfs)	Average water temperature(°F)
1 (12/2/15)	1	0	0	4	0	1.70	246	51.4
2 (12/15/15)	4	2	14	23	0	1.67	253	49.0
3 (12/29/15)	9	8	25	52	1	1.91	225	46.6
4 (1/12/16)	5	4	12	39	0	2.14	338	46.9
5 (2/1/16)	1	2	5	10	0	2.45	330	47.1
6 (2/15/16)	2	1	5	15	0	2.01	248	48.7
7 (3/2/16)	0	0	1	3	1	1.12	240	49.3
8 (3/31/16)	0	0	0	2	0	2.21	296	51.4
Snorkel[a]	0	0	0	1	0			
CCVS[b]	0	11	0	0	2			
RST[c]	0	0	0	0	1			
Total	22	28	62	149	5	1.90	272	48.8

[a] Redd identified on spring-run Chinook Salmon survey
[b] Carcasses recovered 12/22/15 through 4/1/16 on the CCVS weir at the end of Reach 7.
[c] Carcass collected on 12/13/15 on the upper rotary screw trap in Reach 5.

Table 3. Date observed and samples collected from late-fall Chinook Salmon carcasses retrieved on Clear Creek, 2015-2016. Carcasses retrieved from the Clear Creek video station weir (CCVS) during the survey period are included.

								Biological samples		
Survey	Method	Date	River mile	Species	Gender	Adipose	Fork length (mm)	Genetics	Scales	Otoliths
2	Kayak	12/16/2015	5.7	Chinook	Female	Present	735	1	1	1
2	Kayak	12/16/2015	2.9	Chinook	Female	Present	580	1	1	1
N/A	CCVS	12/22/2015	0.0	Chinook	Male	Unknown	700	0	0	0
3	Kayak	12/30/2015	3.2	Chinook	Male	Present	590	1	1	1
3	Kayak	12/30/2015	3.0	Chinook	Female	Present	695	1	1	1
3	Kayak	12/30/2015	1.3	Chinook	Female	Present	745	1	1	1
3	Kayak	12/30/2015	1.1	Chinook	Male	Present	715	1	1	1
3	Kayak	12/30/2015	5.5	Chinook	Female	Present	680	1	1	1
3	Kayak	12/30/2015	4.9	Chinook	Male	Absent	845	1	1	1
3	Kayak	12/30/2015	4.6	Chinook	Female	Present	695	1	1	1
3	Kayak	12/30/2015	4.0	Chinook	Female	Present	880	1	1	1
N/A	CCVS	01/02/2016	0.0	Chinook	Male	Absent	500	0	0	0
N/A	CCVS	01/05/2016	0.0	Chinook	Male	Present	910	0	0	0
4	Kayak	01/11/2016	6.1	Chinook	Female	Present	870	1	1	1
4	Kayak	01/12/2016	3.2	Chinook	Female	Present	740	1	1	1
4	Kayak	01/12/2016	2.8	Chinook	Female	Absent	770	1	1	1
4	Kayak	01/12/2016	0.9	Chinook	Female	Present	720	1	1	1
N/A	CCVS	01/19/2016	0.0	Chinook	Female	Absent	710	0	0	0
N/A	CCVS	01/19/2016	0.0	Chinook	Female	Absent	960	0	0	0
N/A	CCVS	01/21/2016	0.0	Chinook	Female	Absent	825	0	0	0
N/A	CCVS	01/24/2016	0.0	Chinook	Female	Present	600	0	0	0
N/A	CCVS	01/26/2016	0.0	Chinook	Female	Absent	0	0	0	0
N/A	Kayak	01/28/2016	3.3	Chinook	Male	Present	833	1	1	1
5	Kayak	01/28/2016	3.2	Chinook	Female	Present	740	1	1	1
N/A	CCVS	01/29/2016	0.0	Chinook	Male	Present	920	0	0	0
7	Kayak	03/03/2016	1.6	Chinook	Unknown	Unknown	0	0	0	0
N/A	CCVS	03/06/2016	0.0	Chinook	Male	Present	960	0	0	0
N/A	CCVS	04/01/2016	0.0	Chinook	Male	Present	1100	0	0	0

Table 4. Clear Creek coded wire tag (CWT) results from late-fall Chinook Salmon carcasses recovered during kayak surveys and from the video weir monitoring station in 2015-2016. NTD = No tag detected. Tag data was retrieved from the Regional Mark Processing Center https://www.rmpc.org

Date	Gender	Adipose status	CWT code	Hatchery	Run	Brood year	Release strategy
12/22/2015	Male	Unknown	NTD	---	---	---	---
12/30/2015	Male	Absent	060481	MOKE[b]	Fall	2012	Sherman Island Net Pens
1/2/2016	Male	Absent	055739	CNFH[a]	Late-Fall	2014	CNFH[a]
1/12/2016	Female	Absent	055538	CNFH[a]	Late-Fall	2012	CNFH[a]
1/19/2016	Female	Absent	055667	CNFH[a]	Late-Fall	2013	CNFH[a]
1/19/2016	Female	Absent	060396	NIMB[c]	Fall	2011	Mare Island Net Pens
1/21/2016	Female	Absent	055543	CNFH[a]	Late-Fall	2012	CNFH[a]
1/26/2016	Female	Absent	055674	CNFH[a]	Late-Fall	2013	CNFH[a]

[a] CNFH= Coleman National Fish Hatchery
[b] MOKE= Mokelumne River Hatchery
[c] NIMB= Nimbus Fish Hatchery

Table 5. Date observed and samples collected from California Central Valley steelhead/Rainbow Trout carcasses retrieved on Clear Creek, 2015-2016. Carcasses collected on the Clear Creek video station weir (CCVS) and the rotary screw trap (RST) during the survey season are also included.

								Biological samples		
Survey	Method	Date	River mile	Species	Gender	Adipose	Fork length (mm)	Genetics	Scales	Otoliths
N/A	RST	12/13/2015	8.4	ONMY[a]	Female	Present	420	1	1	1
3	Kayak	12/30/2015	5.1	ONMY[a]	Male	Present	425	1	1	1
N/A	CCVS	02/23/2016	0.0	ONMY[a]	Male	Present	460	0	0	0
N/A	CCVS	03/01/2016	0.0	ONMY[a]	Female	Present	380	0	0	0
8	Kayak	03/29/2016	0.1	ONMY[a]	Female	Present	415	1	1	1

[a] ONMY= California Central Valley steelhead/ Rainbow Trout

Figures

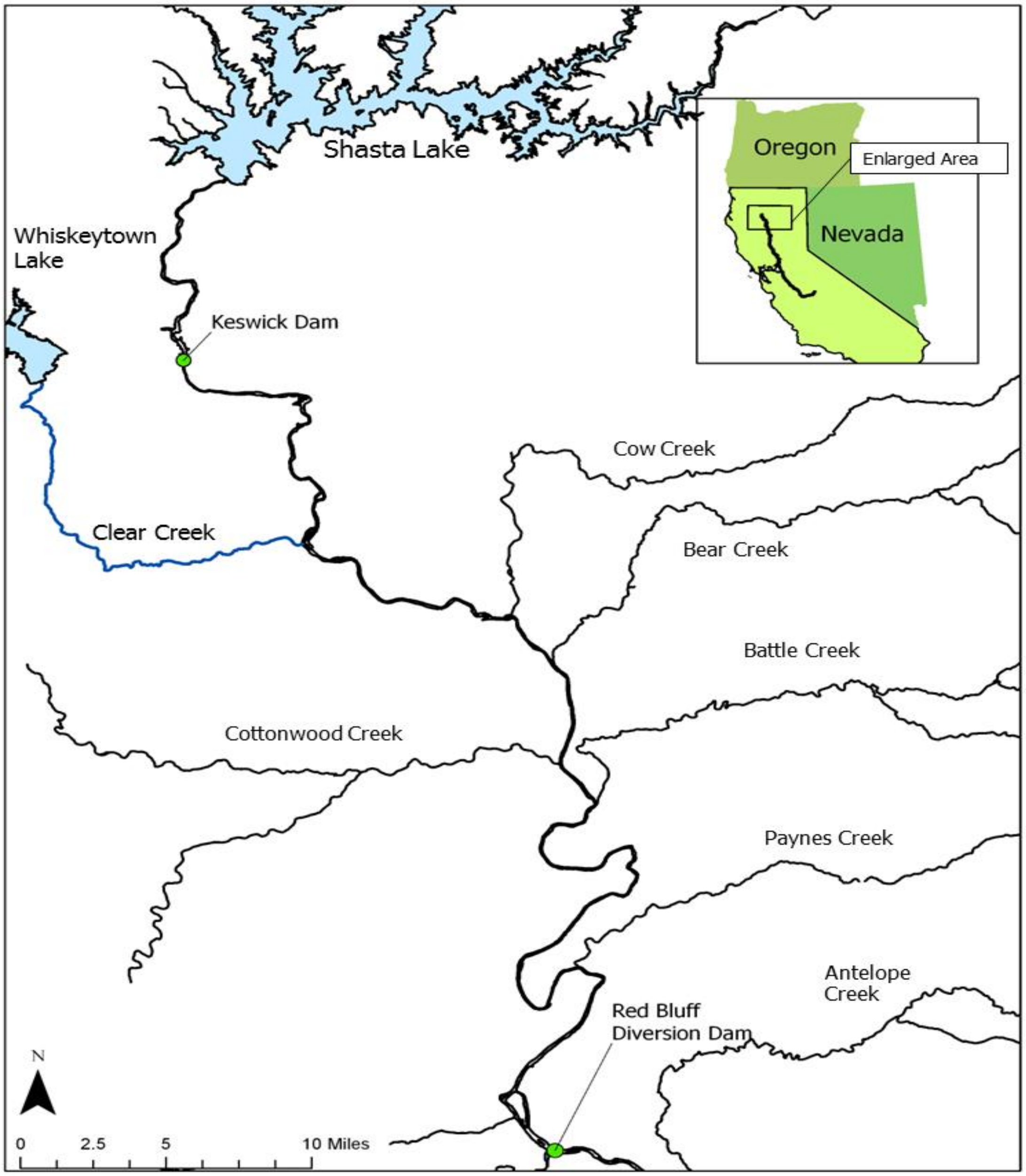

Figure 1. Map of the Sacramento River and tributaries between Keswick Dam and Red Bluff Diversion Dam in the Northern Central Valley, California.

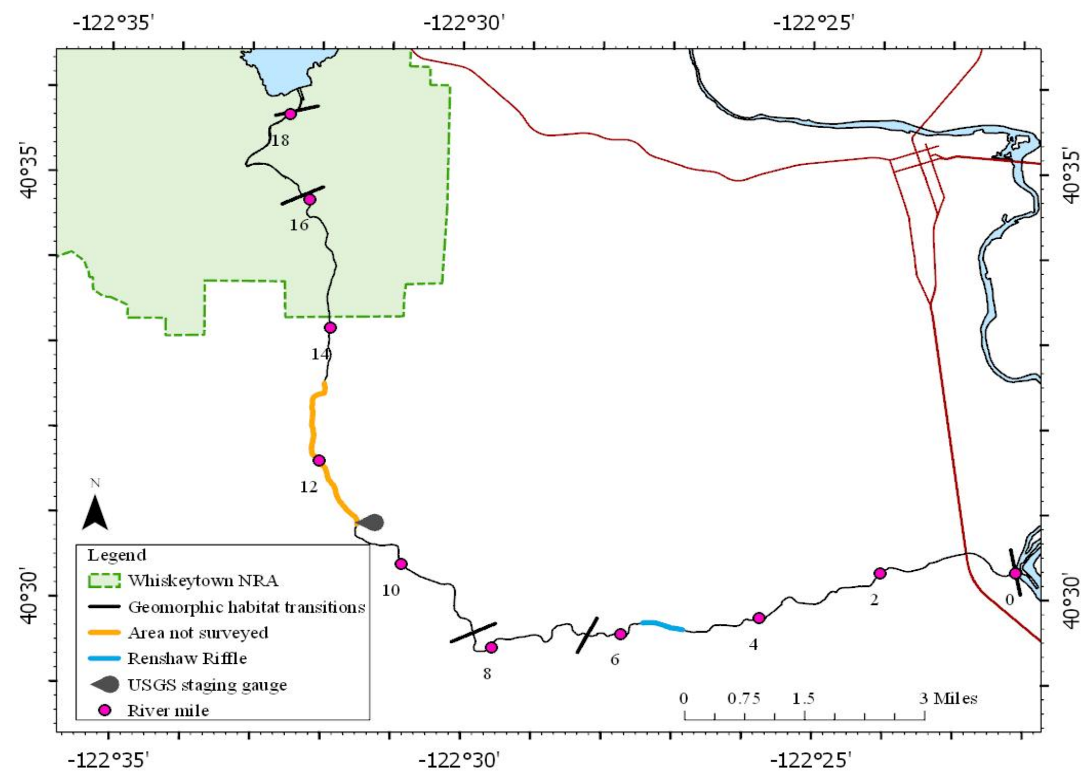

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Figure 2. Map of study area in lower Clear Creek. The study area of the survey includes the length of the stream between Whiskeytown Dam and the Sacramento River, excluding the area noted in the map. From upstream to downstream, the major geomorphic habitat sections found in Clear Creek are: upstream alluvial reach (through RM 16.1), canyon reach (through RM 8.6), Saeltzer Dam Reach (through RM 6.5) and an unconfined alluvial reach to the confluence with the Sacramento River. The U. S. Geological Survey gauging station (IGO) and Renshaw Riffle (area of greatest spawning activity) are also indicated.

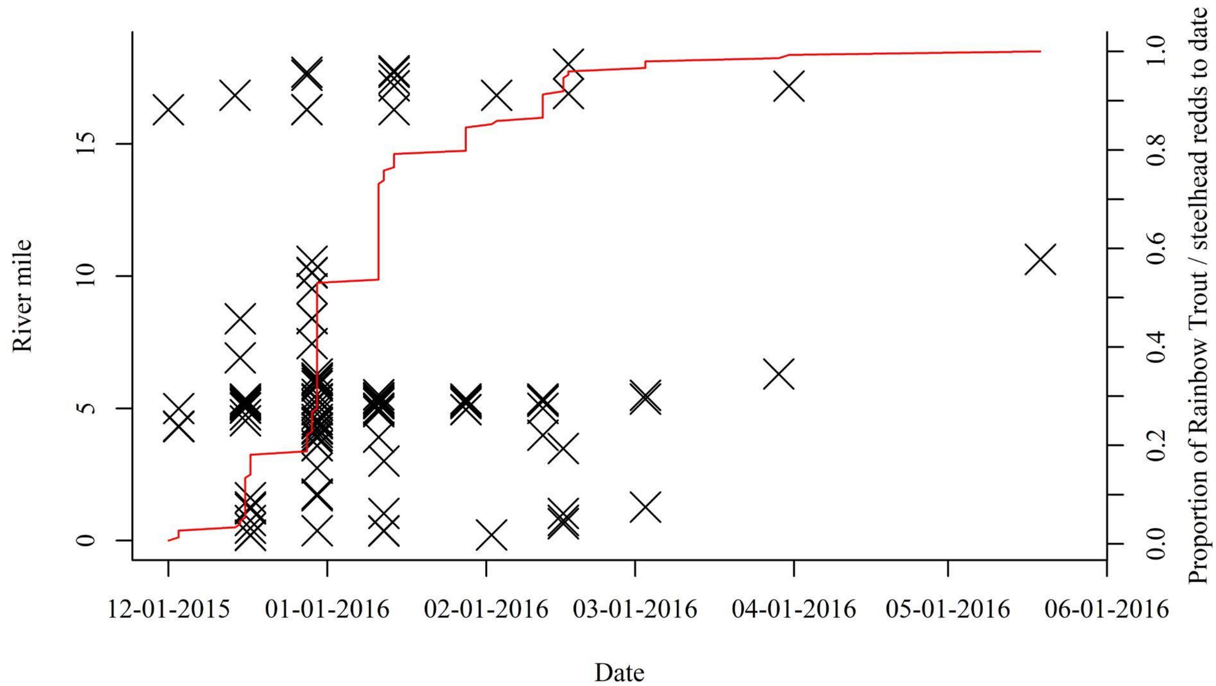

Figure 3. Number and proportion of California Central Valley steelhead/Rainbow Trout redds observed by date and river mile during the 2016 survey season. One redd detected during a spring-run Chinook Salmon survey on 5/19/2016 is also included. The x-axis indicates the initial survey date individual redds were observed. The left y-axis is the river mile on Clear Creek. The red line displays the cumulative proportion of redds to date scaled to the right y-axis.

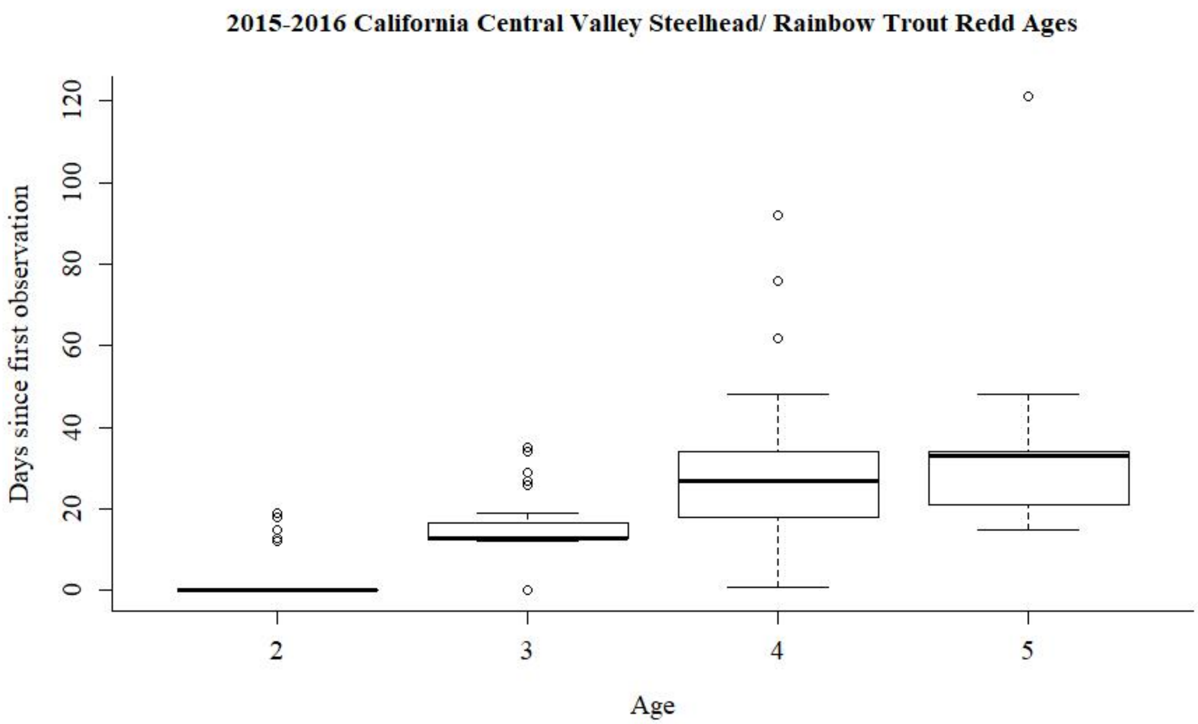

Figure 4. Number of California Central Valley steelhead/Rainbow Trout redds at each age class and the number of days since first observation for the 2016 monitoring period. The x-axis is the age classification of observed redds. The y-axis indicates the number of days since first observation. The bold line inside each box represents the median measurement. The "box" encloses the interquartile range or the range of 25% of the measurements above and below the mean. The horizontal line above and below each box represents the maximum and minimum days since first observation.

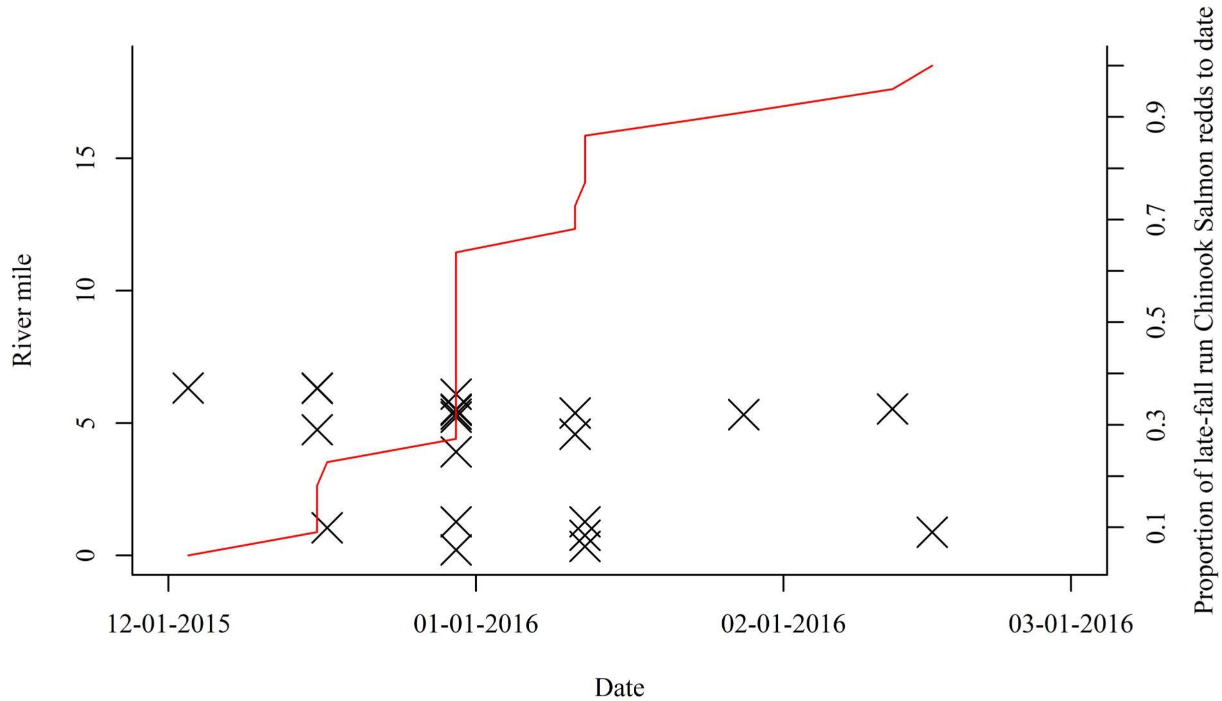

Figure 5. Number and proportion of late-fall Chinook Salmon redds by river mile and date during the 2016 survey season. The x-axis indicates the initial survey date individual redds were observed. The left y-axis is the river mile on Clear Creek. The red line displays the cumulative proportion of redds to date scaled to the right y-axis.

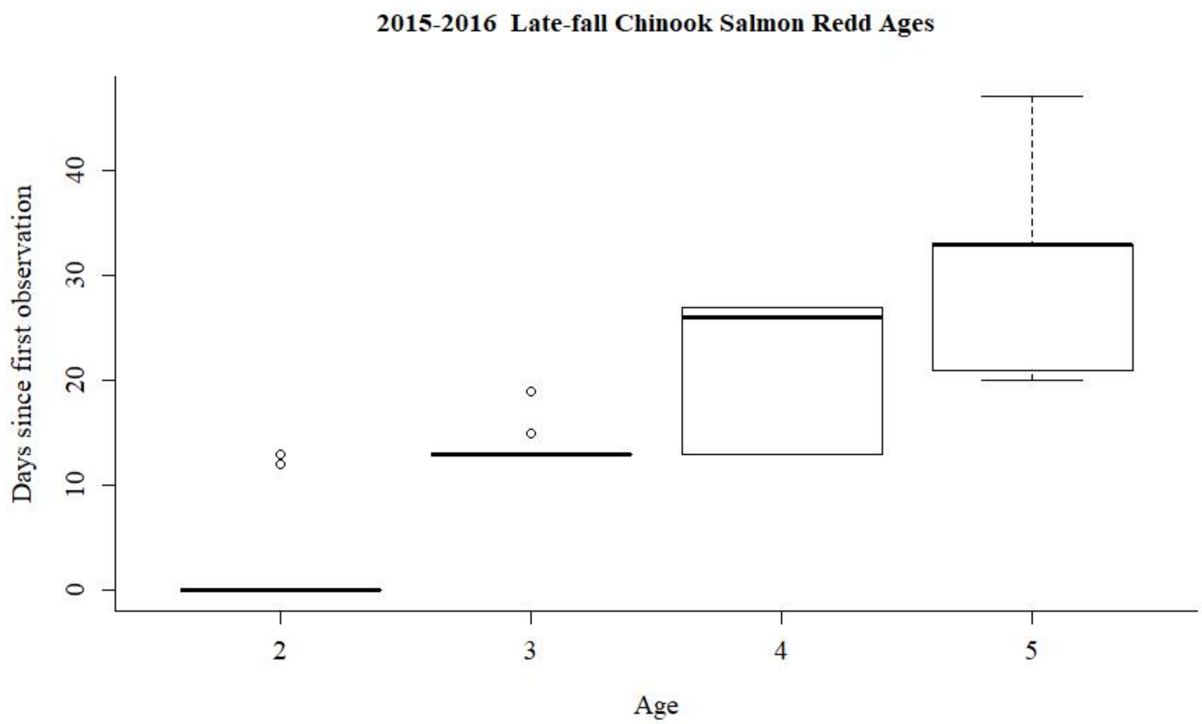

Figure 6. Number of late-fall run Chinook Salmon redds at each age class and the number of days since first observation for the 2016 monitoring period. The x-axis is the age of observed redds. The y-axis indicates the number of days since first observation. The bold line inside each box represents the median measurement. The "box" encloses the interquartile range or the range of 25% of the measurements above and below the mean. The horizontal line above and below each box represents the maximum and minimum days since first observation.

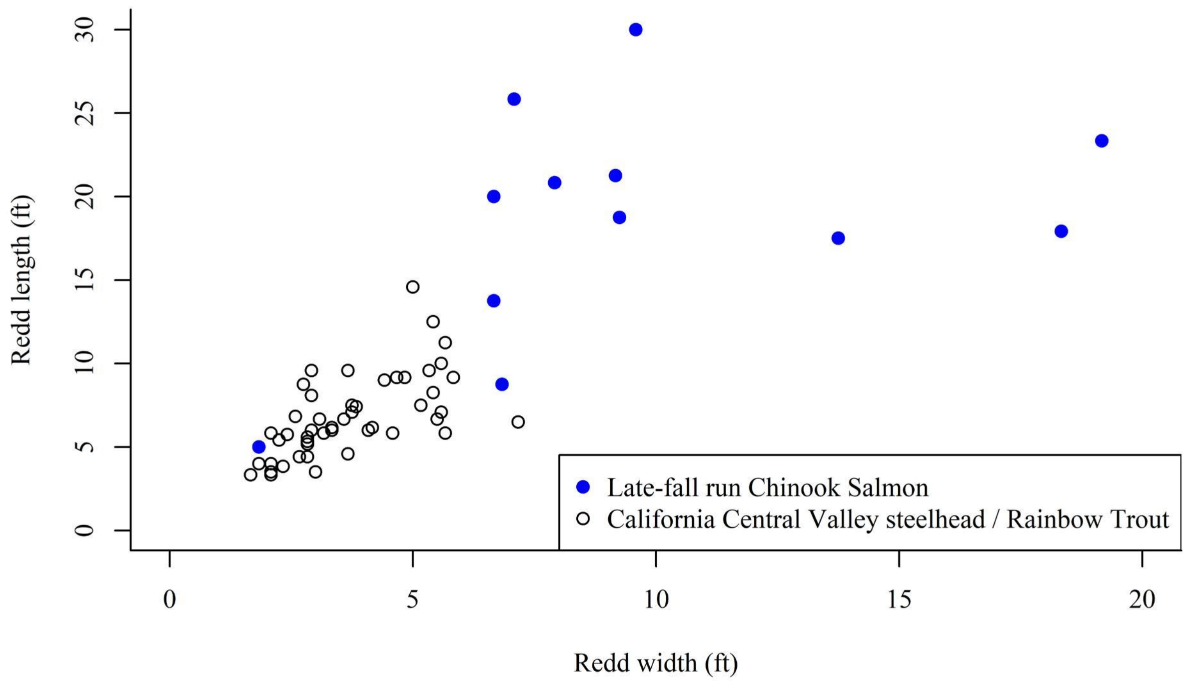

Figure 7. Length and width measurements taken of late-fall run Chinook Salmon and California Central Valley steelhead/Rainbow Trout redds during the 2016 survey season.

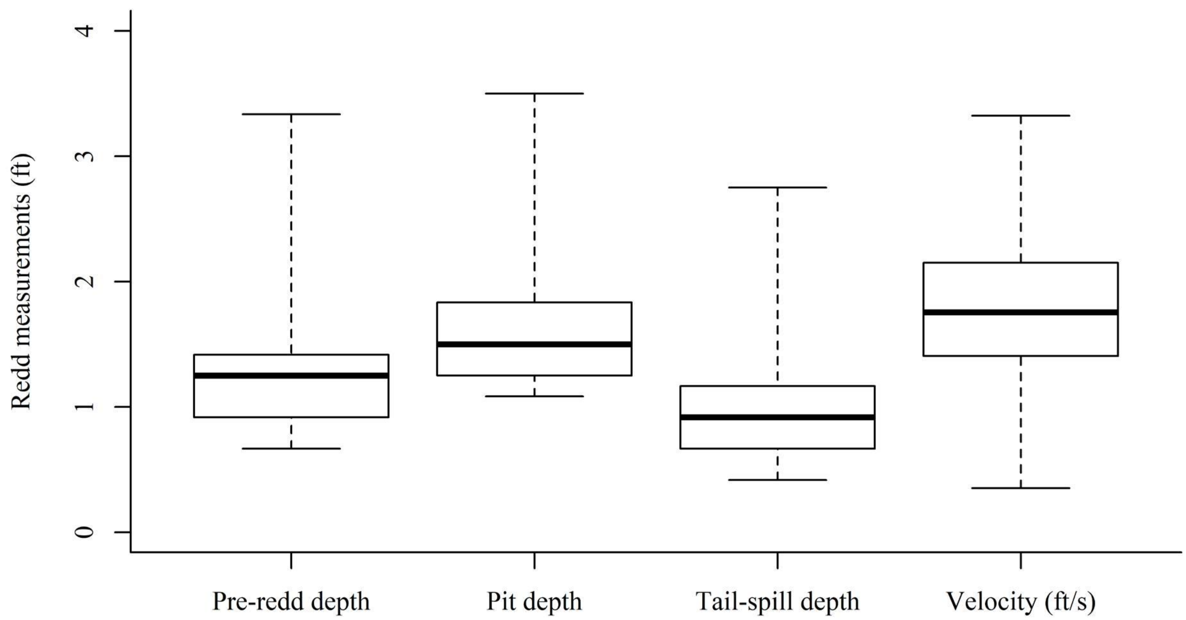

Figure 8. Depth and velocity measurements at 49 California Central Valley steelhead/Rainbow Trout redds (33% of total observed California Central Valley steelhead/Rainbow Trout redds). Depths were measured at the pre-redd, pit, and tail-spill of each redd. Velocity measurements were taken at the pre-redd. *n* = the number of redds measured. The bold line inside each box represents the median measurement. The “box” encloses the interquartile range or the range of 25% of the measurements above and below the mean. The horizontal line above and below each box represents the maximum and minimum measurements.

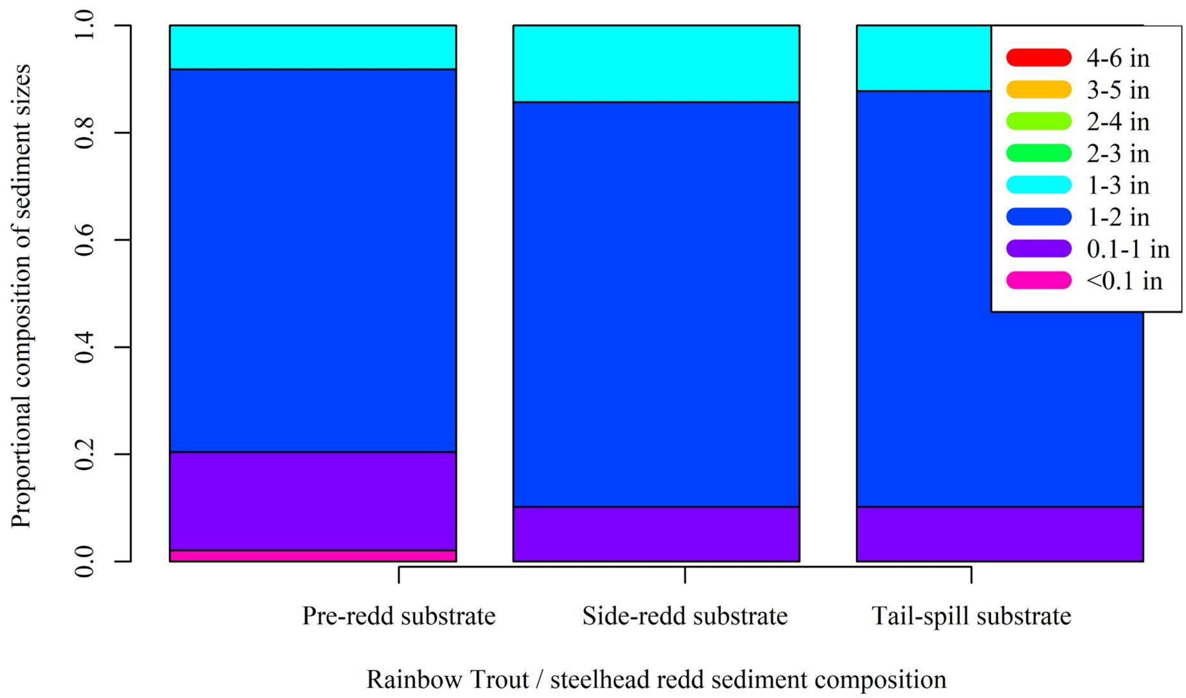

Figure 9. Sediment size at California Central Valley steelhead/Rainbow Trout redds. Sediment size class was visually assessed at the pre-redd, pit and tail spill of each Rainbow Trout/steelhead redd. The stacked bar graphs display the proportion of redds with a certain dominant size classes for each area of the redd.

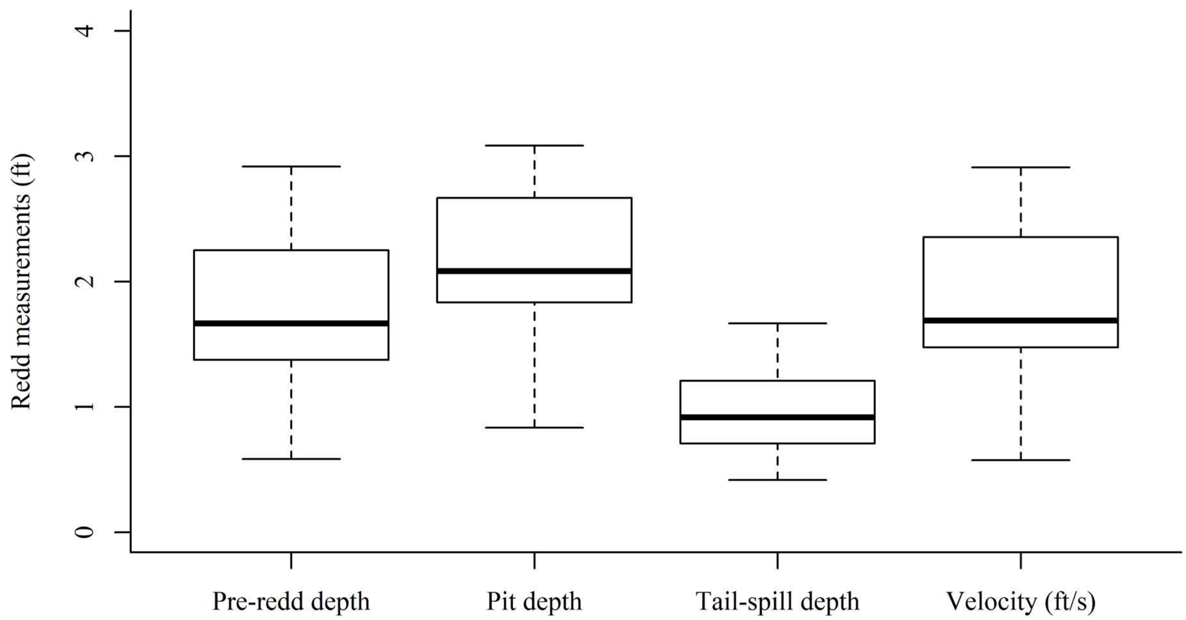

Figure 10. Depth and velocity measurements at 12 late-fall run Chinook Salmon redds (55% of total observed late-fall run Chinook Salmon redds). Depth measurements taken at the pre-redd, pit and tail-spill of each redd. Velocity measures were taken at the pre-redd. *n* = the number of redds measured. The bold line inside each box represents the median measurement. The “box” encloses the interquartile range or the range of 25% of the measurements above and below the mean. The horizontal line above and below each box represents the maximum and minimum measurements.

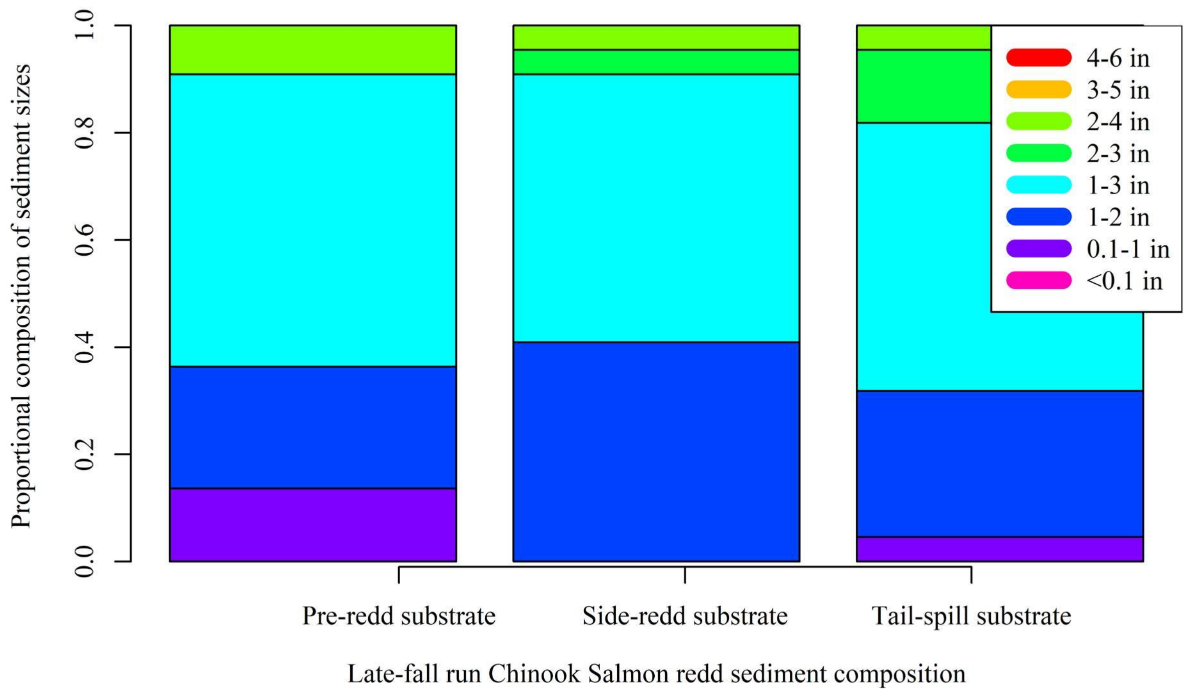

Figure 11. Dominant sediment size at late-fall run Chinook Salmon redds. Dominant sediment size class was visually assessed at the pre-redd, pit and tail spill of each late-fall Chinook Salmon redd. The stacked bar graphs display the proportion of redds with a certain dominant size classes for each area of the redd.

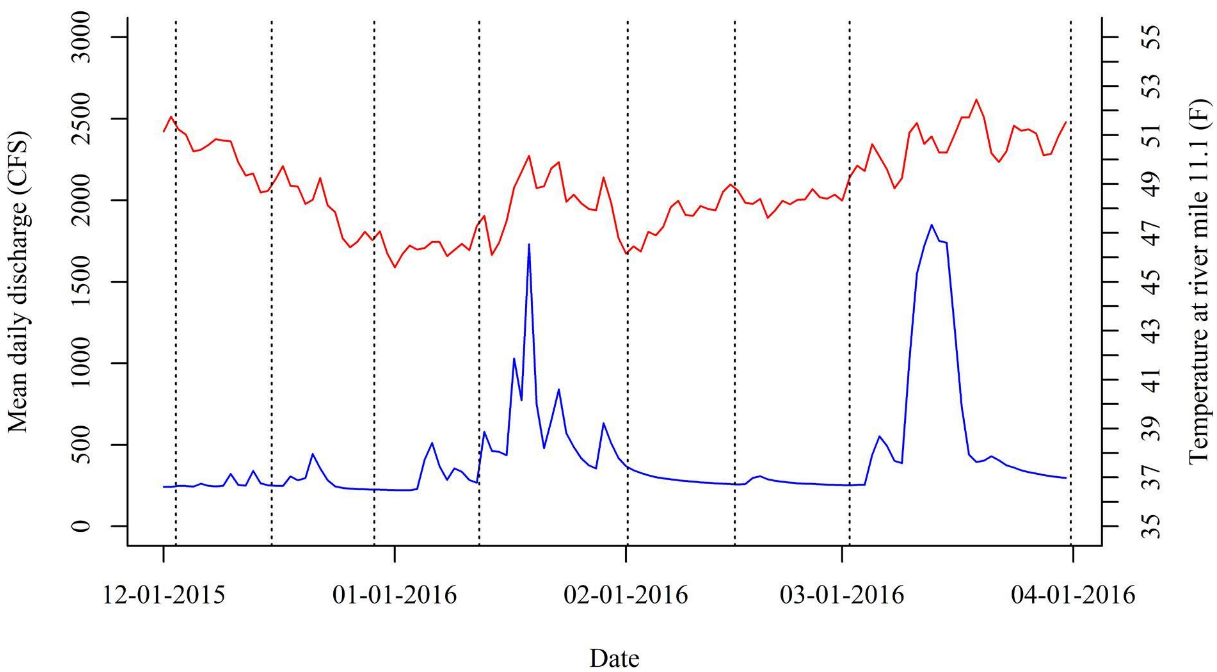

Figure 12. Temperature and stream discharge at IGO gauging station USGS (11372000) in Clear Creek December 2015 to April 2016. Stream temperature measured at river mile (RM) 11.1 is represented by a red line and scaled by the right y-axis. Mean stream discharge as measured at RM 11.1 is represented by a blue line and scaled by the left y-axis. Vertical dotted lines indicate when surveys occurred.

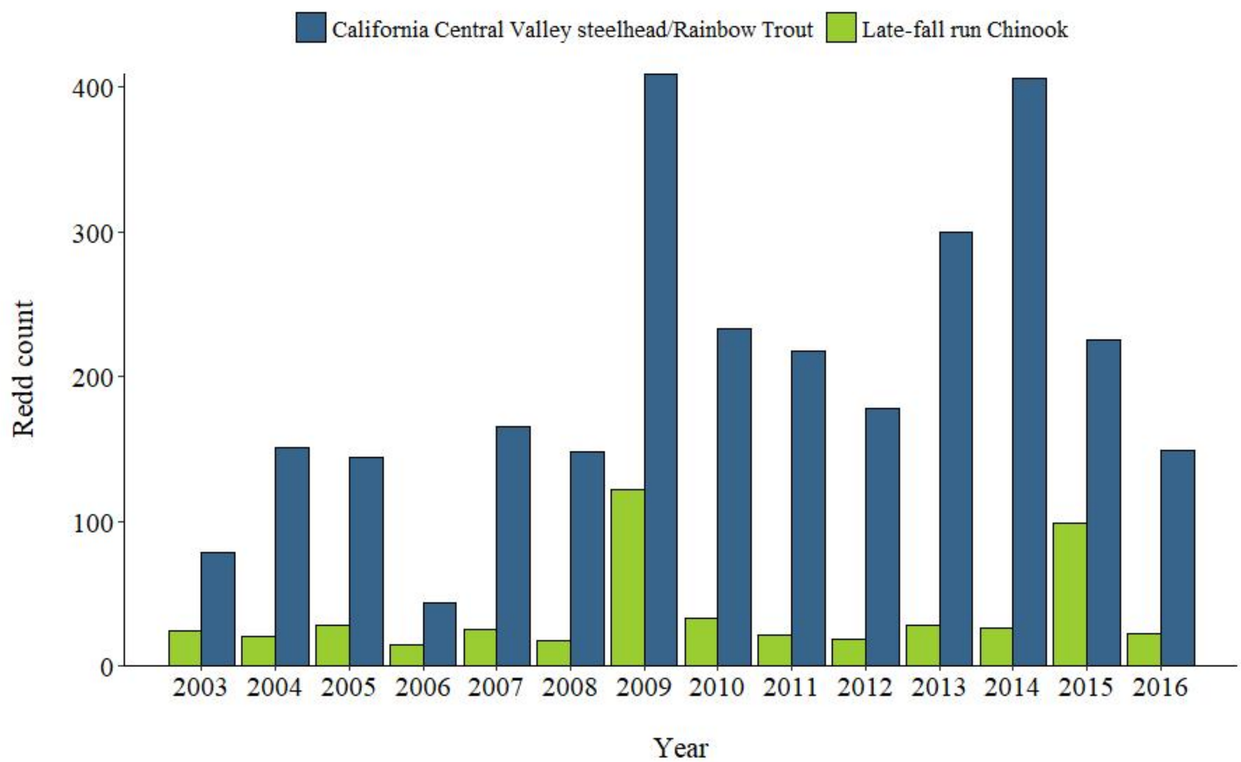

Figure 13 California Central Valley steelhead/Rainbow Trout and late-fall run Chinook Salmon redd counts in Clear Creek, 2003-2016. Bars represent total number of redds attributed to Rainbow Trout/steelhead and late-fall run Chinook Salmon during kayak and snorkel surveys. The x-axis shows the year from 2003 to 2016. Each year represents data collected from December through July (e.g. 2003 is December 2002-July 2003).

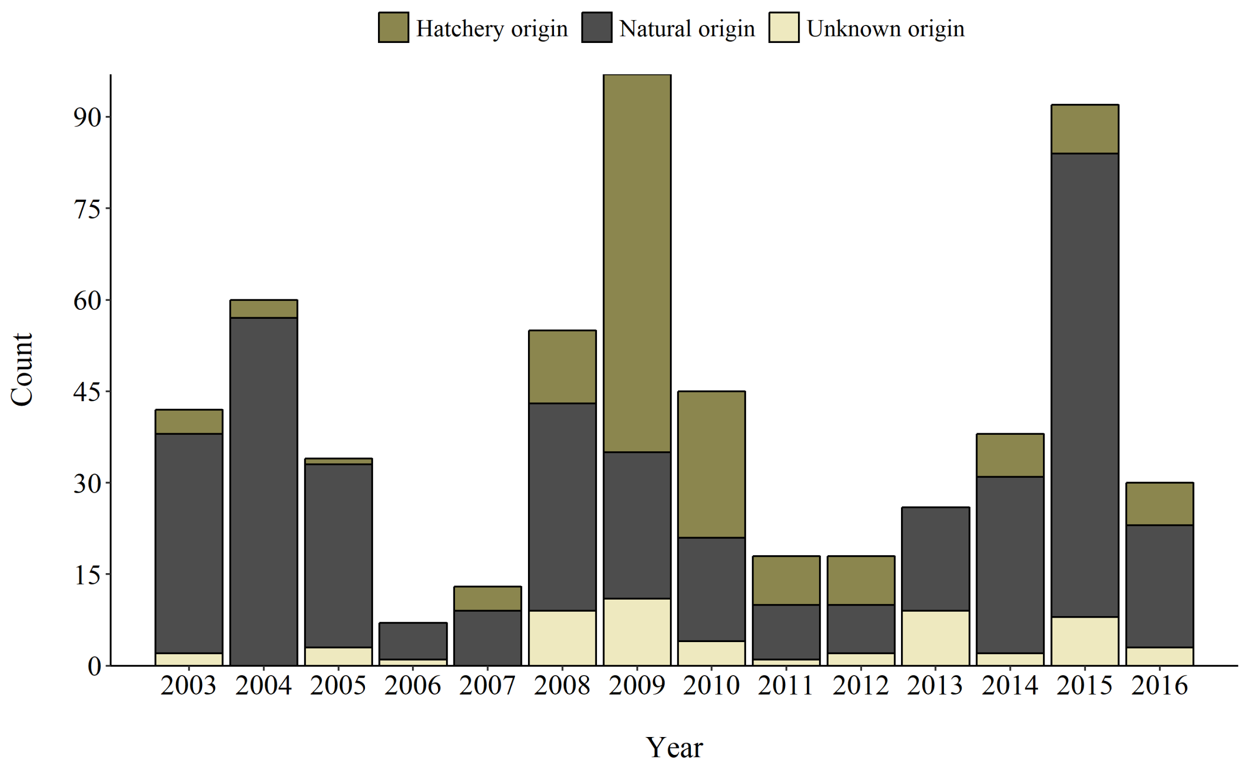

Figure 14. Chinook Salmon carcasses recovered during the kayak survey season, Clear Creek, 2003-16. Bars represent the total carcasses recovered and number of hatchery, natural, and unknown origin based on adipose fin clips and coded wire tag recovery. Each year is represented data collected from December through April (e.g. 2003 is December 2002-April 2003).