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2016 CDFW FRGP REPORT

LOWER REDWOOD CREEK
JUVENILE SALMONID (SMOLT) ABUNDANCE PROJECT
2004 – 2015 Seasons
CDFW PROJECT 2a7

Fisheries Restoration Grants Program (Project Number: P1210322)

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DEDICATION

This report is dedicated to the memory of Lucille Vinyard (1918 – 2015), an ardent conservationist and friend, who played a key role in the formation of Redwood National and State Parks.

Photograph of Michael Sparkman (CDFW) and Lucille Vinyard at lower Redwood Cr smolt trap, Orick, CA. 2008.

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ABSTRACT

Juvenile anadromous salmonid trapping was conducted for the 12th consecutive year in 2015 in lower Redwood Creek (RC), Humboldt County, California during the spring/summer emigration period (March – August). Trapping in 2015 was initiated earlier than previous study years to account for the earlier migration and subsequent production from adult Chinook Salmon returns in September and October, 2014. The purpose of the study was to describe juvenile salmonid out-migration and estimate smolt population abundances for wild 0+ Chinook Salmon, 1+ Chinook Salmon, 1+ Coho Salmon, 1+ Steelhead Trout, 2+ Steelhead Trout, and Coastal Cutthroat Trout using mark/recapture methods. The long term goal is to monitor the status and trends of out-migrating juvenile salmonid smolts in RC in relation to watershed conditions and restoration activities in the basin, provide data for Viable Salmonid Population Analysis, and to make RC a Life Cycle Monitoring station by combining sonar counts of adults with smolt abundance estimates.

A rotary screw trap and fyke net/pipe trap collectively operated 132 out of 138 days/nights possible, and captured 175,966 0+ Chinook Salmon (ocean type), 10 1+ Chinook Salmon (stream type), 39,779 0+ Steelhead Trout, 8,535 1+ Steelhead Trout, 1,596 2+ Steelhead Trout, 211 juvenile Coastal Cutthroat Trout, 1 0+ pink Salmon, 100 0+ Coho Salmon, and 496 1+ Coho Salmon to total 226,694 juvenile salmonids. Eight adult Coastal Cutthroat Trout were also captured, and for the first time of record one Eulachon and four Staghorn Sculpins were captured. Average weekly trapping efficiencies were 50% for 0+ Chinook Salmon, 50% for 1+ Chinook Salmon, 14% for 1+ Steelhead Trout, 12% for 2+ Steelhead Trout, 29% for Coastal Cutthroat Trout, 28% for 0+ Coho Salmon, and 38% for 1+ Coho Salmon. The 0+ Chinook Salmon population abundance in 2015 equaled 295,664 individuals (95% CI = 284,021 – 307,308), and was 1.3 times greater than the previous 11 year average. Based upon a much higher abundance determined in mid/upper RC (N = 575,353) in 2015, we suspect high flows in March and early April caused considerable mortality to an estimated 260,000 fry that migrated downstream prior to these fry stressor flows. 1+ Chinook Salmon abundance equaled 17 individuals (95% CI = 8 – 25), and was 99% less than abundance in 2014. 1+ Chinook Salmon abundances in a given year were positively related to 0+ Chinook Salmon abundances the previous year ($p < 0.05$). Low abundances over the current 12 year period indicate 1+ Chinook Salmon are relatively rare in RC. Population abundances (with 95% confidence intervals) in 2015 equaled 56,020 (49,180 – 62,860) for 1+ Steelhead Trout, 18,155 (13,912 – 22,397) for 2+ Steelhead Trout, 303 (191 – 416) for 0+ Coho Salmon, 1,923 (1,542 – 2,304) for 1+ Coho Salmon, and 825 (561 – 1,089) for

juvenile Coastal Cutthroat Trout. Although abundance of 1+ Coho Salmon smolts in 2015 was the highest of record, abundances across all years were consistently low. The abundances of 1+ Steelhead Trout, 2+ Steelhead Trout, juvenile Coastal Cutthroat Trout, and 1+ Coho Salmon were greater than average, and indicate that drought conditions during the summer of 2014 did not drastically reduce survival.

The correlation of time (study year) on yearly population abundances was not significant for 0+ Chinook Salmon, 1+ Chinook Salmon, 0+ Coho Salmon, 1+ Coho Salmon, 1+ Steelhead Trout, and 2+ Steelhead Trout ($p > 0.05$). Juvenile Coastal Cutthroat Trout showed a positive increase in abundance over study years ($p < 0.05$). The average size (FL, Wt) of 0+ Chinook Salmon and 0+ Coho Salmon over study years was negatively related to population abundances ($p < 0.05$), indicating density-dependent effects.

The two most important months for migration in 2015 were May/June for 0+ Chinook Salmon, 1+ Steelhead Trout, and juvenile Coastal Cutthroat Trout, and April/May for 1+ Chinook Salmon, 0+ Coho Salmon, 1+ Coho Salmon, and 2+ Steelhead Trout. 0+ Chinook Salmon, 1+ Steelhead Trout, 2+ Steelhead Trout, juvenile Coastal Cutthroat Trout, and 0+ Coho Salmon showed increased migration earlier in the migration period, which may indicate a response to drought conditions. Considerably more 1+ Steelhead Trout emigrated downstream than 2+ Steelhead Trout each study year, suggesting stream habitat conditions are limiting the abundance of the older age class, or favoring a change in the life history to a younger smolt age.

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[1]This paper should be referenced as: Sparkman MD, R Park, L Osborn, S Holt, and MA Wilzbach. 2016. Lower Redwood Creek juvenile salmonid (smolt) abundance project, study year 2015: a report to the Fisheries Restoration Grants Program (Project No. P1210322). CDFW AFRAMP, study 2a7: 85 p.

INTRODUCTION

This report presents results of the twelfth consecutive year of juvenile salmonid downstream migrant trapping in lower Redwood Creek (RC), Orick, California during the spring/summer emigration period of 2015.

The initial impetus for this study was to determine how many wild Salmon and Steelhead Trout smolts were emigrating from the majority of the RC basin before entering the RC estuary and Pacific Ocean. The ‘majority’ of the RC basin includes all anadromous waters upstream of the first major tributary (Prairie Creek, river mile RM 3.7) to RC. Areas downstream of Prairie Creek are generally not used for spawning by adult salmonids, thus the only smolt production the trap will miss is from the Prairie Creek watershed. Beginning in 2004, CDFW AFRAMP successfully determined juvenile Chinook Salmon and Steelhead Trout smolt population abundances from the majority of RC for the first time in RC’s anadromous salmonid monitoring history. Additionally, CDFW AFRAMP and the RC Landowners Association have successfully determined smolt population abundances for juvenile Chinook Salmon and Steelhead Trout emigrating from upper RC for the past sixteen consecutive years (Sparkman 2016). More recently, CDFW and USGS California Cooperative Fish and Wildlife Research Unit have operated a smolt trap in lower Prairie Creek from 2011 to the present. Prior to our studies on juvenile salmonid downstream migration and smolt abundances in RC, scientific studies which quantified anadromous salmonids within the RC watershed were primarily limited to the estuary (juveniles) and Prairie Creek (adults and juveniles).

Adult Salmon and Steelhead Trout populations are difficult to monitor in RC because the adult fish migrate upstream during fall or late fall, winter, and early to mid-spring. Thus, when adults are present, the streamflow is often high and unpredictable, which limits the reliability and usefulness of adult weirs. Additionally, stream flow during this time period often carries large amounts of suspended sediments, which render visual observations of adult fish and redds (e.g. spawning surveys) unreliable and unlikely for long term monitoring, particularly in average or above average water years. However, efforts are currently underway to count adult fish migrating upstream through lower RC with a DIDSON sonar camera (USGS California Cooperative Fish and Wildlife Research Unit), mid to upper RC with a ARIS sonar camera (CDFW AFRAMP), and to count redds in randomly selected areas within the RC watershed using a Coho Salmon sampling frame (CDFW AFRAMP). Thus, with inclusion of sonar counts of adults in the lower basin, and smolt outputs from lower RC and Prairie Cr, we have made RC a Life Cycle Monitoring Station.

Scientific studies which focus on adult salmonids in tributaries to RC are less affected by these processes (high, muddy stream flows), however, the tributaries are less likely to adequately represent or account for the majority of the salmonid populations in RC because the majority of adult salmon and Steelhead Trout spawn in the mainstem. An exception is the Prairie Creek watershed which accounts for a considerable amount of the Coho Salmon and Coastal Cutthroat Trout production in RC (Wilzbach et al. 2016, Sparkman et al. 2015). Tributaries to RC are often steep, with limited anadromy (RNP

1997, Brown 1988), and some of the tributaries dry up prior to late summer, which cause the juvenile fish to migrate into the mainstem of RC.

Determining and tracking smolt numbers over time is an acceptable, useful, and quantifiable measure of salmonid populations which many agencies (both state and federal), universities, consultants, tribal entities, and timber companies perform each year. Juvenile salmonid out-migration can be used to assess: 1) the number of parents that produced the cohort (Roper and Scarnecchia 1999, Ward 2000, Sharma and Hilborn 2001, Ward et al. 2002, Bill Chesney pers. comm. 2006), 2) redd gravel conditions (Cederholm et al. 1981, Holtby and Healey 1986, Hartman and Scrivener 1990), 3) in-stream habitat quality and watershed health (Tripp and Poulan 1986, Hartman and Scrivener 1990, Hicks et al. 1991, Bradford et al. 2000, Sharma and Hilborn 2001, Ward et al. 2002), 4) restoration activities (Everest et al. 1987 *in* Hicks et al. 1991, Slaney et al. 1986, Tripp 1986, McCubbing and Ward 1997, Solazzi et al. 2000, Cleary 2001, Ward et al 2002, McCubbing 2002, Ward et al. 2003, Roni et al. 2006), 5) over-winter survival (Scrivener and Brown 1993 *in* McCubbing and Ward 1997, Quinn and Peterson 1996, Solazzi et al. 2000, McCubbing 2002, Ward et al. 2002, Giannico and Hinch 2003, Ebersole et al. 2009, Sparkman et al. 2014), and 6) future recruitment to adult populations (Holtby and Healey 1986, Nickelson 1986, Ward and Slaney 1988, Ward et al. 1989, Kyle and Litchfield 1989, Unwin 1997, Ward 2000).

This paper will present results of trapping in 2015 with various comparisons to the average of the previous 11 years (YRS 2004 – 2014), and YR 2014.

Site Description

Redwood Creek is an un-regulated, 7th order stream that lies within the Northern Coast Range of California (Brown 1988), and flows 67 miles through Humboldt County before reaching the Pacific Ocean (Fig. 1). Headwaters originate at an elevation of about 5,000 ft and converge to form the main channel at about 3,100 feet. RC flows north to northwest to the Pacific Ocean, and bisects the town of Orick in Northern California. The basin of RC is 179,151 acres, about 49.7 miles long, and 6.2 miles wide (Cashman et. al 1995). The study area upstream of the trap site (Rm 4) encompasses approximately 151,922 acres of the RC basin, with about 93 stream miles (150 km) of accessible salmon and steelhead habitat (Cannata et al. 2006).

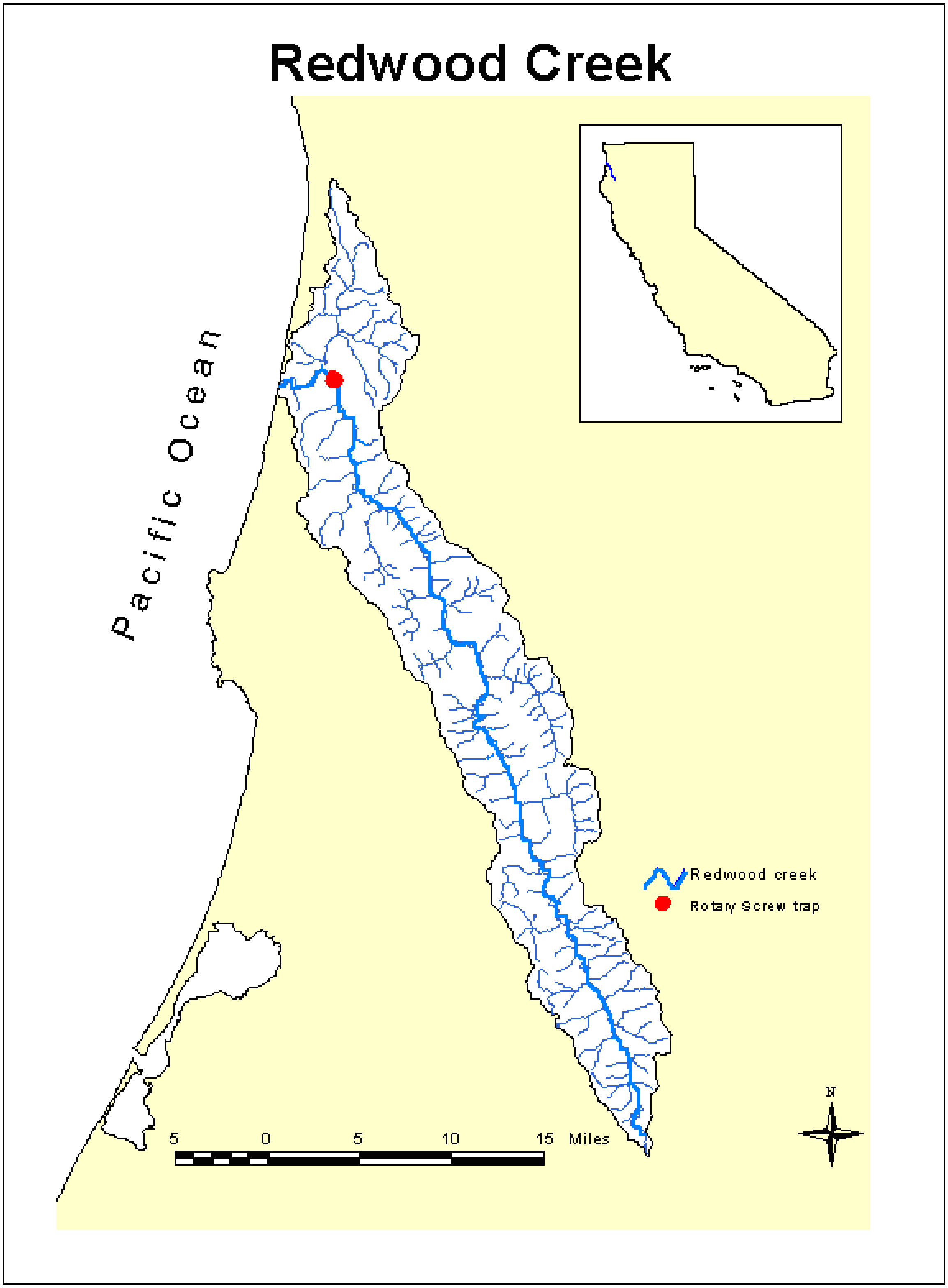

Figure 1. RC basin with rotary screw trap location (RM 4), Humboldt County, CA., (Charlotte Peters pers. com. 2001).

Geology

The RC watershed is situated in a tectonically active and geologically complex area, and is considered to have some of the highest uplift and seismic activity rates in North America (CDFW NCWAP 2004).

The geology of the Redwood Creek basin has been well-studied and mapped (Cashman et. al 1995).

> "Redwood Creek drainage basin is underlain by metamorphic and sedimentary rocks of the Franciscan assemblage of Late Jurassic and Early Cretaceous age and by shallow marine and alluvial sedimentary deposits of late Tertiary and Quaternary age. These units are cut by a series of shallowly east-dipping to vertical north to northwest trending faults. The composition and distribution of bedrock units and the distribution of major faults have played a major part in the geomorphic development of the basin. Slope profiles, slope gradients, and drainage patterns within the basin reflect the properties of the underlying bedrock. The main channel of Redwood Creek generally follows the trace of the Grogan fault, and other linear topographic features are developed along major faults. The steep terrain and the lack of shear strength of bedrock units are major contributing factors to the high erosion rates in the basin" (Cashman et al. 1995).

Climate

The climate of the RC basin varies dependent upon location within the watershed and season. Coastal areas have a moderate climate due to proximity to the ocean, and differ from inland areas (e.g. upper RC) which experience higher and lower temperatures. Summers are typically cool and moist on the coast, and hot and dry inland. Snowfall is common during winter months in the upper basin and relatively rare in the lower basin.

Stream Discharge

A USGS gauging station (#11482500) is located about 850 m downstream of the trap site in lower RC. The gauging station is downstream of the confluence of Prairie Creek with RC, thus the station is influenced by Prairie Creek streamflow. Streamflow records for the Orick gage cover the periods of 1911 – 1913, 1953 – 2015, to total 64 years (USGS 2015, preliminary data for 2015). High streamflows usually occur from November through May, and typically peak in January. However, the months of December, February, March, and April can experience peaks in high flows as well. Using all years' data (historic), mean monthly discharge was 984 cfs (27.9 m3/sec), and ranged from 35 – 2,390 cfs (0.99 – 67.7 m3/sec) (USGS 2015). Average monthly discharge in WY 2015 equaled 597 cfs (16.9 m3/sec), ranged from 11 – 2,589 cfs (0.3 – 73.3 m3/sec), and peaked in December (USGS 2015, preliminary data). Average stream flow in WY 2015 was about 39% less than the historic average (USGS 2015).

The 64 year average monthly flow during the majority of the (normal) trapping season (April – July) equaled 547 cfs (15.5 m3/sec), and ranged from 84 – 1,235 cfs (2.4 – 35.0

m^3/sec) (USGS 2015). Average monthly discharge from April – July in 2015 equaled 184 cfs (5.2 m^3/sec), ranged from 24 – 485 cfs (0.7 – 13.7 m^3/sec), and was 66% less than the historic average for this time frame (USGS 2015, preliminary data). Average daily stream flow (cfs) in May, June, and July in 2015 were the lowest of a 64 year record (USGS 2015, preliminary data). Surface stream flow 75 m downstream of the trapping site ceased in late July, and immediately upstream of the trap site ceased mid to late August. WY 2015 in California was considered a 'severe' drought year for the second year in a row.

Overstory

The overstory of RC is predominately second and third growth Redwood (*Sequoia sempervirens*) and Douglas Fir (*Pseudotsuga menziesii*), mixed with Big Leaf Maple (*Acer macrophyllum*), California Bay Laurel (*Umbellularia californica*), Incense Cedar (*Calocedrus decurrens*), Cottonwood (*Populus spp*.), Manzanita (*Arctostaphylos spp*.), Oak (*Quercus spp*.), Tan Oak (*Lithocarpus densiflorus*), Pacific Madrone (*Arbutus menziesii*), and Red Alder (*Alnus rubra*). The lower portion of RC (ie within Redwood National Park boundaries) contains old growth Redwood, mixed with second growth redwood and other tree species.

Understory

Common understory plants include: dogwood (*Cornus nuttallii*), willow (*Salix lucida*), California hazelnut (*Corylus rostrata*), lupine (*Lupinus spp*.), blackberry (*Rubus spp*.), plantain (*Plantago coronopus*), poison oak (*Toxicodendro diversilobum*), wood rose (*Rosa gymnocarpa*), false Solomon's seal (*Smilacina amplexicaulis*), spreading dog bane (*Apocynum spp*.), wedgeleaf ceanothus (*Ceanothus spp*.), bracken fern (*Pteridium aquilinum*), blackcap raspberry (*Rubus spp*.), and elderberry (*Sambucus spp*.), among other species.

Redwood Creek History (Brief)

RC watershed has experienced extensive logging of Redwood and other commercial tree species. By 1978, 81% of the original forest was logged, totaling 66% of the basin area (Kelsey et al. 1995). Most remaining old growth Redwood is contained within Redwood National and State Parks. In conjunction with clear-cut logging, log removal via tractors, associated road building, geology types and geomorphic processes (eg debris slides and earthflows), and flood events in 1955 and 1964, large amounts of sediments were delivered into the stream channel (Madej and Ozaki 1996) with a resultant loss of stream habitat complexity (filling in of pools and flattening out of the stream channel, Marlin Stover pers. comm. 2000). Additional high flows occurred in 1972, 1975, and 1995 as well, and have helped influence the current channel morphology of RC. The downstream migrant trap in lower RC is located in an area of gravel aggredation, and gravel extraction occurs in this area. RC has been listed as sediment and temperature-impaired under section 303(d) of the Clean Water Act (CWA 2002, SWRCB 2003, USEPA 2003).

Federal ESA Species Status

Chinook (King) Salmon (*Oncorhynchus tshawytscha*), Coho (Silver) Salmon (*O. kisutch*), Steelhead Trout (*O. mykiss*), and Coastal Cutthroat Trout (*O. clarki clarki*) are known to inhabit RC. This study and the study in upper RC and lower Prairie Creek also show that pink Salmon (*O. gorbuscha*) are present in RC. Chinook Salmon (KS) of RC belong to the California Coastal Chinook Salmon Evolutionarily Significant Unit (ESU), and are listed as "threatened" under the Federal Endangered Species Act (Federal Register 1999a). The definition of threatened as used by National Oceanic and Atmospheric Administration (NOAA) and the National Marine Fisheries Service (NMFS) is "likely to become endangered in the foreseeable future throughout all or a significant portion of their range" (NOAA 1999). Coho Salmon (CO) belong to the Southern Oregon/Northern California Coasts ESU and were classified as "threatened" (Federal Register 1997) prior to the Chinook Salmon listing. Steelhead Trout (SH) fall within the Northern California Steelhead ESU (or Distinct Population Segment, DPS), and are also listed as a "threatened" species (Federal Register 2000). Coastal Cutthroat Trout (CT) of Redwood Creek fall within the Southern Oregon/California Coasts Coastal Cutthroat Trout ESU, and were determined "not warranted" for ESA listing (Federal Register 1999b). Despite ESU listings of RC anadromous salmonid populations, relatively little data existed concerning population abundances and life histories. Historically, the most prolific species was most likely the fall/early winter-run Chinook Salmon, and based upon historic knowledge, runs of adult Chinook Salmon were numerous enough to 'walk across their backs' in riffle areas (Joe Hufford, pers. comm. 2013).

Purpose

The purpose of this project is to describe juvenile salmonid downstream migration from the majority of the RC basin, and to determine quantify population abundances for wild 0+ (young-of-year) Chinook Salmon (ocean type), 1+ Chinook Salmon (stream type) (between 1 and 2 years old), 1+ Steelhead Trout, 2+ Steelhead Trout (2 years old and greater), juvenile Coastal Cutthroat Trout (age 1 and older), 0+ Coho Salmon (fry, parr), and 1+ Coho Salmon smolts. The primary long term goal is to monitor the status and trends of out-migrating juvenile salmonid smolts in RC in relation to watershed conditions and restoration activities in the basin, and to provide data needed for Viable Salmonid Population (VSP) Analysis. An additional goal is to provide smolt abundances for the entire basin (when combined with data from Prairie Cr) as part of the RC Life Cycle Monitoring Station. Specific study objectives were as follows:

1) Determine the species composition and temporal pattern of downstream migrating juvenile salmonids.
2) Determine population estimates for downstream migrating 0+ Chinook Salmon, 1+ Chinook Salmon, 1+ Steelhead Trout, 2+ Steelhead Trout, Coastal Cutthroat Trout, 0+ Coho Salmon, and 1+ Coho Salmon.
3) Record fork length (mm) and weight (g) of captured fish.

4) Collect genetic samples from 0+ Chinook Salmon, 1+ Chinook Salmon, 0+ Steelhead Trout, 1+ Steelhead Trout, 2+ Steelhead Trout and juvenile Coho Salmon for future analyses and comparisons (Appendix 1).
5) Collect and handle fish in a manner that minimizes mortality.
6) Statistically analyze data for significance and trends.
7) Compare data between study years.
8) Link data collected from the lower basin, upper basin, Prairie Creek, and estuary (Redwood National Park) to provide a complete study on the life history and abundance of emigrating juvenile salmonids (smolts) in RC.

METHODS AND MATERIALS

Trap Operations

The methods and materials used in this study in 2015 were the same as previous study years (Sparkman 2014). A modified E.G. Solutions (5 foot diameter cone) rotary screw trap was deployed in lower RC (Rm 4) on March 20th, 2015 at the same general location (± 100 m) as previous study years (YRS 2004 - 2014). Trapping in 2015 occurred earlier than previous years to account for the production from an earlier run of adult Chinook Salmon which occurred in September and October 2014.

We operated the rotary screw trap continually (24 hrs/day, 7 days a week) from March 20th through July 21st, with exception to six days of missed trapping. Beyond July 20th, streamflows were too low to operate the rotary screw trap, and on July 21st we installed a fyke net/pipe trap. Weir panels were used to force the remaining downstream migrating fish into the fyke net/pipe trap. The trapping season in 2015 ended August 5th when sections of the stream immediately downstream of the trap site dried up, and all juvenile salmonid downstream migration ceased.

During periods of lesser streamflows, weir panels were used with the rotary screw trap to: 1) keep the trap's cone revolutions relatively high, and 2) maintain good trapping efficiencies by directing fish into the cone area. Weir panels were installed much earlier in 2015 compared to previous years due to drought conditions and low stream flows. The weir panels were held in place using bailing wire and 6 - 8 ft long fence posts, and were first installed in late April. Additional weir panels were later added to increase the overall length, and by early summer the panels were within one foot of the cone's upstream edge. Adjustments to trap placement and the use of weir panels in 2015 helped increase cone revolutions, trapping efficiencies, and trap catches. The 2015 trapping season can be characterized as: 1) closely monitoring the trap in late March and early April because of a large increase in stream flows and subsequent increases in debris amounts within the livebox, 2) making occasional adjustments to the trap configuration to maintain position in the thalweg, and 3) extensively using weir panels early in the season to keep the trap's cone spinning. The largest flow event occurred on March 24th, 2015 when the stream rose from 750 cfs (March 23rd) to 3,650 cfs (March 24th).

Biometric Data Collection

Fishery technicians frequently removed debris by hand (e.g. alder cones, leaves, sticks, detritus, etc.) from within the livebox at night to reduce trapping mortalities the following morning. The trap's livebox was emptied at 09:00 every morning by 2 - 4 technicians. Debris was once again inspected and carefully removed so that the smaller fish would not be released into the stream with the debris.

Young of year fish were removed first and processed before 1+ and 2+ fish to decrease predation or injury to the smaller fish. Captured fish (0+ fish first, then 1+ and older) were placed into 5 gal. buckets and carried to the processing station. At the station, fish were placed into a 23.5 gal. ice chest modified to safely hold juvenile fish. The ice chest was adapted to continually receive fresh water from the stream using a 3,700 gph submersible bilge pump. The bilge pump connected to a flexible line (ID 4 cm or 1.6 in.) that connected to a manifold with four ports. "Y" type hose adapters were connected to each port. Garden hoses connected to the hose adapters, with one line feeding the ice chest, and four lines feeding recovery buckets for processed fish. Additional garden hoses were connected to the hose adaptors to quickly fill buckets if needed, and to relieve any excess back pressure. Plumbing inside the ice chest consisted of two PVC pipes: one that served to dissipate the stream water into the ice chest, and the other to adjust water height in the ice chest and drain excess water. The system worked very well, did not require additional battery operated aerators, and decreased total fish processing time.

Random samples of each species at age (eg 0+ KS, 0+ SH, etc.) were netted from the ice chest for examination, enumeration, and biometric data collection. Each individual fish was counted by species at age, and observed for trap efficiency trial marks. The marks used for each species at age for the lower trap were different than those used for trap efficiencies in upper RC. Marked fish from the trap in upper RC (Sparkman, In progress$_a$) were tallied separately from the marked fish used to determine trapping efficiencies for the lower trap.

<u>Fork Lengths/Weights</u>

Fish were anesthetized with MS-222 prior to data collection in 2 gal. dishpans. Biometric data collection included 30 measurements of fork length (mm) and wet weight (g) for random samples of 0+ Chinook Salmon (0+ KS), 1+ Chinook Salmon (1+ KS, if present), 1+ and greater Cutthroat Trout (CT), 1+ Steelhead Trout (1+ SH), 2+ and greater Steelhead Trout (2+ SH), 0+ Coho Salmon (0+ CO), 1+ Coho Salmon (1+ CO), and 0+ pink Salmon (if present). Only fork lengths were taken from 0+ Steelhead Trout (0+ SH). A 160 and 350 mm measuring board ($\pm$ 1 mm), and an Ohaus Scout ll digital scale ($\pm$ 0.1 g) were used in the study. Fork lengths were taken every day of trap operation, and fork length frequencies of 0+ and older Steelhead Trout, Coho Salmon, and Chinook Salmon were used to determine age-length relationships at various times throughout the trapping period. Scales were occasionally read to verify age class cutoffs. 0+ Chinook Salmon and 1+ Steelhead Trout weights were taken 2 - 7 times per week;

and 0+ and 1+ Coho Salmon, and 2+ Steelhead Trout weights were taken nearly every day of trap operation and collection due to expected, low sample sizes. Individuals were weighed in a tared plastic pan (containing water) on the electronic scale. The scale was calibrated every day prior to data collection, and placed in a large plastic bin when weighing fish to prevent any influences from wind. After biometric data was collected, fish were placed into 5 gal. recovery buckets which received continuously pumped, fresh stream water. Young of year fish were kept in separate recovery buckets from age 1+ and older fish to decrease predation or injury. When fully recovered from anesthesia, 0+ juvenile fish were transported 150 m downstream of the trap site and released in the margin of the stream; and age-1 and older fish were transported 200 m downstream of the trap site and released near the middle of the stream when possible.

Population Estimates

The number of fish captured by the trap represented only a portion of the total fish moving downstream in that time period. Total salmonid out-migration population estimates (by age and species) were determined on a weekly basis for 0+ Chinook Salmon, 1+ Chinook Salmon, 1+ Steelhead Trout, 2+ Steelhead Trout, Cutthroat Trout, 0+ Coho Salmon, and 1+ Coho Salmon using stratified and non-stratified mark-recapture methods described by Carlson et al. (1998). Population estimation methods in 2015 were identical to previous study years (Sparkman et al. 2015), and our goal for error in abundance estimates for all species at age was a coefficient of variation of less than 15% (Crawford and Rumsey 2009) which equates to a population point estimate error of less than 30% (Dr. Robert Van Kirk, pers. comm. 2015). To obtain this for 1+ Coho Salmon and 2+ Steelhead Trout, and to keep the trap's cone spinning by using weir panels, we inadvertently captured more 0+ Chinook Salmon and at a higher rate than necessary for a reliable Chinook estimate. We do not purposely try to catch as many 0+ Chinook Salmon as possible, however, to fulfill grant objectives we must obtain a reliable 1+ Coho Salmon smolt estimate, which are rare in RC. Annual variation in both population abundances and catches over the current 12 year period were characterized by the standard deviation (SD) and standard error of the mean (SEM) for each species at age.

Physical Data Collection

A staff gage with increments in hundredths of a foot was used to measure the relative stream surface elevation (hydrograph) at the trap site each day from March 20th – August 5th, 2015. A graphical representation of the data, along with average daily stream discharge data from the Orick gaging station (USGS 2015, preliminary), is given in Appendix 2. Stream temperatures were recorded with two Optic StowAway® Temp data loggers (Onset Computer Corporation, 470 MacArthur Blvd. Bourne, MA 02532) placed behind the rotary screw trap. The probes were placed into PVC cylinders with holes to ensure adequate ventilation and to prevent influences from direct sunlight. Probes recorded stream temperatures (^{o}C) every 15 minutes and recorded 13,152 measurements per probe over the course of the study. Data from one probe was reported because both probes gave similar results, with the difference between the seasonal average equaling 0.1 ^{o}C. The shallowest stream depth during which measurements were taken (early August) was about 1.5 feet.

Statistical Analyses

The statistical analyses conducted in 2015 were the same as in previous study years (Sparkman et al. 2015). Numbers Cruncher Statistical System software (NCSS 97) (Hintze 1998) was used for linear correlation, regression/ANOVA output, and descriptive statistics. Linear regression was used to estimate the catch for each species at age for days when the trap was not fishing by using data before and after the missed day(s) catch. The estimated catch (except for 0+ Steelhead) was then added to the known catch in a given stratum and applied to the population model for that stratum (Roper and Scarnecchia 1999). Linear correlation slope and equation line were used to determine if total catches and population abundances of a given species at age were increasing or decreasing over the 12 years of study. With respect to 0+ Chinook Salmon, peaks in streamflows in lower RC were great enough to potentially mobilize redd gravels each study year. Flood type flows capable of gravel scour (and deposition) in mid to lower RC are generally thought to occur near 11,000 cfs (Randy Klein, Greg Bundros, Vicki Ozaki, Mary Ann Madej, pers. comm. 2003). Peak winter flows in upper RC, coded as 1 or 0, were included in additional correlation tests with study year on population size for 0+ Chinook Salmon, and 1+ and 2+ Steelhead Trout passing through the lower basin. High bedload mobilizing flows were coded as 1 (for population estimates in YRS 2005 and 2006) and non-bedload mobilizing flows as 0 (for population estimates in YRS 2004, 2007 - 2015) (Zar 1999). The test for 0+ Chinook Salmon would indicate if the relationship of peak winter flows during egg incubation in spawning redds in the upper basin decreased survival, and hence impact the numbers migrating downstream, and tests for 1+ and 2+ Steelhead Trout would indicate if high winter flows were affecting population abundances of Steelhead smolts from mid to upper RC with respect to over-winter survival. Flows considered great enough to mobilize the bedload in upper RC (> 6,000 for 2 hour duration) were identified by Redwood National Park hydrologists and Geologists), and based upon smolt data collected in the upper basin, appear to represent a threshold for Chinook survival.

Descriptive statistics were used to characterize the average FL (mm) and Wt (g) of each species at age on a study year basis. Linear regression was used to test the relationship of average daily discharge on average daily stream temperature, and correlation was used to test whether the average daily stream temperature increased over time (d) during the study period. If data violated tests of statistical assumptions (n = 4 tests for ANOVA, n = 3 tests for regression/correlation; NCSS 97), data was transformed with Log (x +1) to approximate normality (Zar 1999). The term ‘transformed’ in this paper refers to the log (x +1) transformation. Power is defined as the probability of correctly rejecting the null hypothesis when it is false; and can also be thought of as the probability of detecting differences that truly exist (Zar 1999). The level of significance (alpha) was set at 0.05 for statistical analyses. Bonferroni adjustments to alpha were made when appropriate.

RESULTS

The rotary screw trap operated from 3/20/15 – 7/21/15 and trapped 117 days/nights out of a possible 123, and the fyke net/pipe trap operated from 7/20/15 – 8/05/15 and trapped 15 days/nights out of a possible 15. The trapping rate in 2015 was 96%, compared to 97% for the previous 11 year average (ranged from 91 – 99%).

Species Captured

Juvenile Salmonids

Species captured in 2015 included: juvenile Chinook Salmon (*Oncorhynchus tshawytscha*), juvenile Coho Salmon (*O. kisutch*), juvenile Steelhead Trout (*O. mykiss*), juvenile (and adult) Coastal Cutthroat Trout (*O. clarki clarki*), and juvenile Pink Salmon (*O. gorbuscha*). A total of 226,694 juvenile salmonids were captured in 2015 (Fig. 2). In addition, eight adult Coastal Cutthroat Trout were also captured.

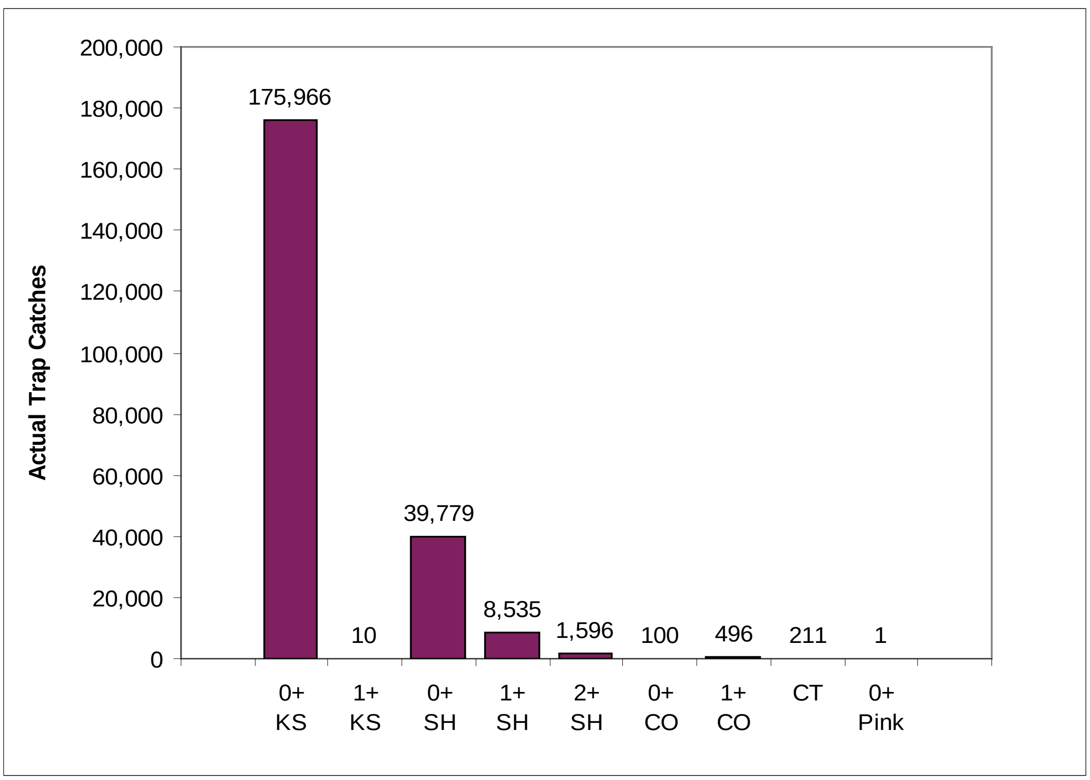

Figure 2. Total juvenile salmonid trap catches (n = 226,694) from March 21st through August 5th, 2015, lower Redwood Creek, Humboldt County, CA. Numeric values above columns represent actual catches. 0+ KS = young-of-year Chinook Salmon, 1+ KS = age 1 Chinook Salmon, 0+ SH = young-of-year Steelhead Trout, 1+ SH = age 1 and older Steelhead Trout, 2+ SH = age 2 and older Steelhead Trout, 0+ CO = young of year Coho Salmon, 1+ CO = age 1 and older Coho Salmon, CT = Cutthroat Trout, 0+ Pink = young-of-year Pink Salmon.

The average total catch by study year equaled 99,476 (n = 12, SD = 59,350; SEM = 17,133). The 12 year average catch equaled 71,514 (SD = 48,453; SEM = 13,987) for 0+ Chinook Salmon, 28 (SD = 58; SEM = 17) for 1+ Chinook Salmon, 20,832 (SD = 16,097; SEM = 4,647) for 0+ Steelhead Trout, 4,889 (SD = 2,274; SEM = 656) for 1+ Steelhead Trout, 816 (SD = 432; SEM = 125) for 2+ Steelhead Trout, 221 (SD = 298; SEM = 86) for 0+ Coho Salmon, 111 (SD = 136; SEM = 39) for 1+ Coho Salmon, 65 (SD = 63; SEM = 18) for Cutthroat Trout, and 0.8 (SD = 1; SEM = 0.4) for 0+ pink Salmon.

<u>Miscellaneous Species</u>

The trap caught numerous miscellaneous species in 2015, including: Prickly Sculpin (*Cottus asper*), Coast Range Sculpin (*Cottus aleuticus*), 3-Spined Stickleback (*Gasterosteus aculeatus*), and Pacific Lamprey (*Entosphenus tridentatus*), among other species (Table 1). Trap catches of adult Pacific Lamprey in 2015 were the highest of record. For the first time of record, one adult Eulachon (*Thaleichthys pacificus*) was captured on 5/04/15, and four Pacific Staghorn Sculpins (*Leptocottus armatus*) were captured in mid to late July 2015 (Table 1). Juvenile captures occurred for Prickly Sculpin (n = 8), Coast Range Sculpin (n = 557), 3-Spined Stickleback (n = 17,237), and Pacific Lamprey (n = 325). Many gravid sculpins (both species) were also captured. Bullheads (catfish; *ameiurus* spp.) were captured in YRS 2010 - 2012.

Table 1. Comparison of miscellaneous species captured by the smolt trap in 2015 with the previous 11 year average, lower Redwood Creek, Humboldt County, CA.

Species Captured	Prev. 11 Yr Avg.	2015
Prickly Sculpin	308	413
Coast Range Sculpin	1,350	2,809
Sucker	164	590
3-Spined Stickleback	2,661	1,091
Bullhead	0.3	0
Adult Pac. Lamprey	9	75
Juvenile Lamprey*	107	325
Brook Lamprey	1	5
Pac. Giant Salamander	7	4
Rough Skinned Newt	5	1
Red-Legged Frog	3	0
Yellow-Legged Frog	3	1
Tailed Frog**	1	0
Western Toad	67	135
Crawfish	6	13
Bull Frog	0.1	0

* Ammocoete stage. ** Includes adult and tadpole stage.

Days Missed Trapping

Six days were not trapped during the course of study in 2015: four days due to high stream flows and debris loads during March 24 -26 and April 7th, one day on July 4th, and one day when streamflows were too low to operate the rotary screw trap (July 21st). The six days of missed trapping did not influence the total catch or population estimate of any species at age to any large degree (Table 2).

Table 2. The estimated catch and expansion (population level) of juvenile anadromous salmonids considered to have been missed due to trap not being deployed (n = 6 d) during the emigration period of March 20th through August 5th (as a percentage of total without missed days catch in parentheses), lower Redwood Creek, Humboldt County, CA., 2015.

Age/spp*	Catch	Population Level
0+ KS	2,023 (1.16%)	9,742 (3.41%)
1+ KS	0 (0.00%)	0 (0.00%)
0+ SH	541 (1.38%)	-
1+ SH	135 (1.61%)	796 (1.44%)
2+ SH	24 (1.53%)	228 (1.29%)
0+ CO	0 (0.00%)	0 (0.00%)
1+ CO	2 (0.40%)	4 (0.21%)
CT	1 (0.48%)	3 (0.54%)

* Age/species abbreviations are the same as in Figure 2.
Note: Regression methods were used to estimate the number of fish caught when the trap was not operating. The estimated catches were then added the known catches for a given stratum (week) and used in the population estimate for that stratum (Roper and Scarnecchia 1999).

Trends in Trap Catches

0+ Chinook Salmon
The total catch in 2015 was the highest of record (n = 175,966). Linear correlation detected a significant, positive relationship of trap catches over study years (n = 12, p = 0.002, r = 0.79, power = 0.98, alpha = 0.05). The correlation of 0+ Chinook Salmon trap catches (transformed) and flood type flows in the upper basin (dummy variable) during egg incubation with study years also showed a significant relationship (n = 12, p = 0.009, Adj. r = 0.75, negative slope for flood flow variable, positive slope for study year, power = 0.72; alpha = 0.05).

1+ Chinook Salmon
The total catch in 2015 was the sixth highest of record (n = 10). Linear correlation failed to detect a significant relationship of 1+ Chinook Salmon trap catches (transformed) over study years (n = 12, p = 0.07, r = 0.53, power = 0.56). The addition of flood type flows (upper basin) in the model did not change the test conclusion (n = 12, p = 0.22, adj. r = 0.36, power = 0.27, alpha = 0.05).

0+ Steelhead Trout
The total catch in 2015 was the third highest of record (n = 39,779). Linear correlation failed to detect a significant relationship of 0+ Steelhead Trout trap catches (transformed) over study years (n = 12, p = 0.52, r = 0.20, power = 0.17, alpha = 0.05).

1+ Steelhead Trout
The total catch in 2015 was the highest of record (n = 8,535). Linear correlation failed to detect a significant relationship of 1+ Steelhead Trout trap catches over study years (n = 12, p = 0.64, r = 0.15, power = 0.13). The addition of flood type flows (upper basin) in the model did not change the test conclusion (n = 12, p = 0.86, adj. r = 0.00, power = 0.11. alpha = 0.05).

2+ Steelhead Trout
The total catch in 2015 was the highest of record (n = 1,596). Linear correlation failed to detect a significant relationship of 2+ Steelhead Trout trap catches over study years (n = 12, p = 0.84, r = 0.07, power = 0.11). The addition of flood type flows (upper basin) in the model did not change the test conclusion (n = 12, p = 0.98, adj. r = 0.00, power = 0.10, alpha = 0.05).

0+ Coho Salmon
The total catch in 2015 was the fifth lowest of record (n = 100). Linear correlation failed to detect a significant relationship of 0+ Coho Salmon trap catches (transformed) over study years (n = 12, p = 0.86, r = 0.06, power = 0.11, alpha = 0.05).

1+ Coho Salmon
The total catch in 2015 was the highest of record (n = 496). Linear correlation failed to detect a significant relationship of 1+ Coho Salmon trap catches (transformed) over study years (n = 12, p = 0.37, r = 0.28, power = 0.23, alpha = 0.05).

Cutthroat Trout
The total catch (n = 211) in 2015 was the highest of record. Linear correlation detected a significant positive relationship of Cutthroat Trout trap catches over study years (n = 12, p = 0.006, r = 0.77, power = 0.95, alpha = 0.05).

Trapping Efficiencies

Average trapping efficiencies by week and seasonal trapping efficiencies for 0+ Chinook Salmon, 1+ Chinook Salmon, 1+ Steelhead Trout, 2+ Steelhead Trout, 0+ Coho Salmon, 1+ Coho Salmon and juvenile Coastal Cutthroat Trout fell within the range of 10 to 54% (Table 3).

Table 3. Average weekly and seasonal trapping efficiencies for 0+ Chinook Salmon, 1+ Chinook Salmon, 1+ Steelhead Trout, 2+ Steelhead Trout, 0+ Coho Salmon, 1+ Coho Salmon, and Cutthroat Trout in 2015, lower Redwood Creek, Humboldt County, CA.

	Trapping Efficiency (percentage)	
Study Year	Average Weekly	Seasonal
0+ Chinook Salmon	49.7	53.9
1+ Chinook Salmon	50.0	33.3
1+ Steelhead Trout	14.2	14.5
2+ Steelhead Trout	11.9	9.8
0+ Coho Salmon	27.5	26.5
1+ Coho Salmon	37.6	30.6
Cutthroat Trout	28.7	28.9

Population Estimates

0+ Chinook Salmon

The population abundance (or production) of 0+ Chinook Salmon emigrating past the trap in lower RC in 2015 equaled 295,664 individuals with a 95% CI of 284,021 – 307,308 (Figure 3). Population estimate error (or uncertainty) equaled $\pm$ 3.9% (CV = 2.0%), or 11,643 individuals. Population abundance in 2015 was 1.3 times greater than the previous 11 year average ($N_{avg\ 11yr}$ = 232,866), and 1.4 times greater than abundance in 2014. The average population abundance over the current 12 year period equaled 238,099 (SD = 160,080; SEM = 46,211).

Correlation of time (study year) on yearly population abundances failed correlation test assumptions, and results were not valid (NCSS 97). Regression of bedload mobilizing flows in upper Redwood Cr (O'Kane gaging station) on population abundances failed to detect a significant relationship (n = 12, p = 0.08, R^2 = 0.28, power = 0.58, alpha = 0.05) (NCSS 97).

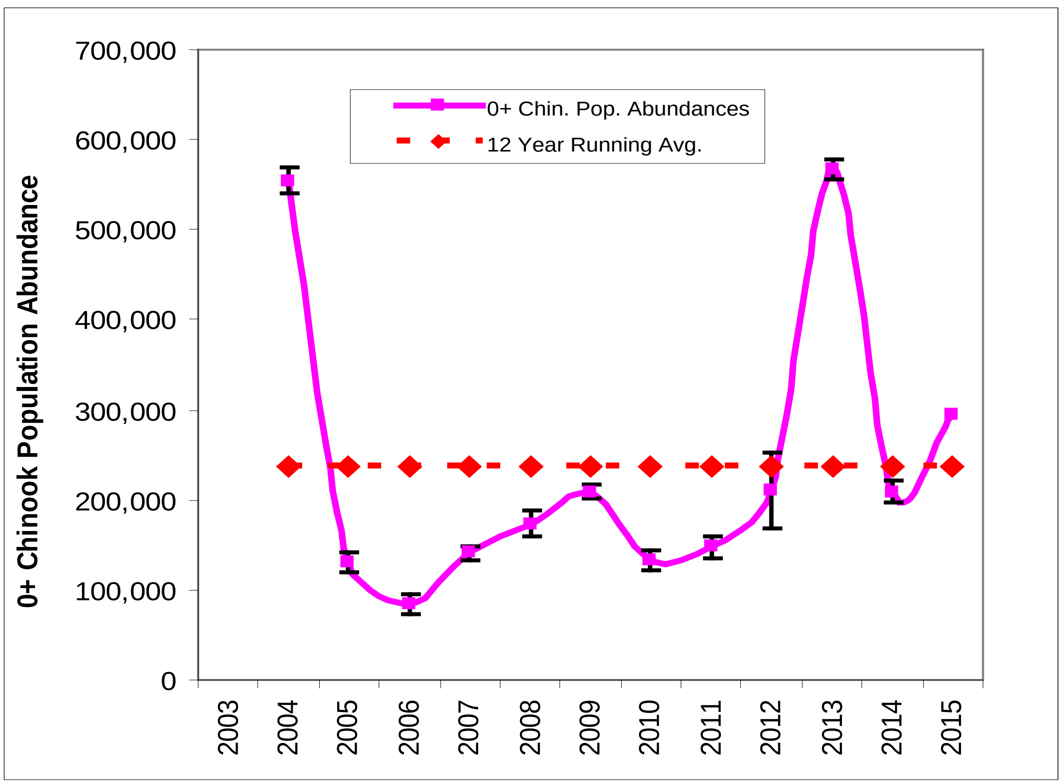

Figure 3. 0+ Chinook Salmon population abundance estimates (error bars are 95% confidence intervals) in twelve consecutive years. Lack of 95% CI's for YR 2015 is due to scale of "Y" axis, lower Redwood Creek, Humboldt County, CA.

The pattern in monthly population abundances in 2015 showed an abundant, earlier migration pattern compared to the previous 11 year average. Migration in May, 2015 was 2.1 times greater than the previous 11 year average for May (Fig. 4). Monthly population emigration peaked in June (N = 122,757 or 42% of total) in 2015, and June (N = 102,738 or 44% of total) for the previous 11 year average (Fig. 4). In 2014, monthly emigration peaked in June as well (N = 83,356 or 40% of total). The two most important months for 0+ Chinook Salmon population emigration were May and June (79% of total) in 2015, and May and June (68% of total) for the previous 11 year average (Fig. 4). In 2014, April and June were the two most important months, and accounted for 67% of the total population abundance.

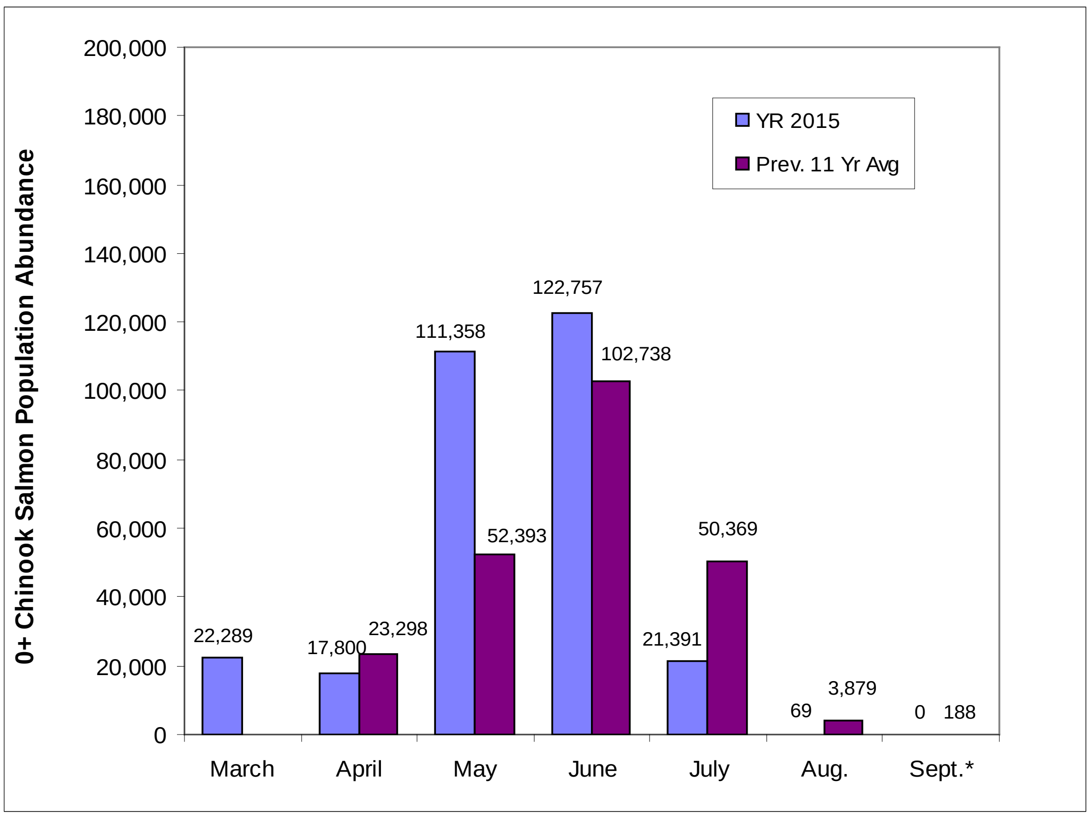

Figure 4. Comparison of 0+ Chinook Salmon population abundance by month in 2015 with the previous 11 year average (* denotes monthly average of years 2010-2014), lower Redwood Creek, Humboldt County, CA.

The peak in weekly population emigration in 2015 occurred 6/04 – 6/10, much later than the peak in 2014 (Table 4). The average FL (mm) for 0+ Chinook Salmon migrants during peak migration in 2015 equaled 72 mm, and consisted of 100% fingerlings.

Table 4. Date of peak weekly 0+ Chinook Salmon population emigration by study year (number of individuals in parentheses), lower Redwood Creek, Humboldt County, CA.

Study Year	Date of peak in weekly emigration (number in parentheses)
2004	6/18 – 6/24 (110,980)
2005	7/16 – 7/22 (29,766)
2006	6/11 – 6/17 (27,889)
2007	6/18 – 6/24 (38,315)
2008	6/25 – 7/01 (37,976)
2009	6/18 – 6/24 (33,430)
2010	7/16 – 7/22 (34,813)
2011	6/25 – 7/01 (27,057)
2012	6/18 – 6/24 (37,818)
2013	5/07 – 5/13 (96,716)
2014	4/23 – 4/29 (26,441)
2015	6/04 – 6/10 (46,295)

0+ Chinook Salmon downstream migrants consisted of fry (FL < 45 mm) and fingerlings (FL > 44 mm), and the number and percentage of 0+ Chinook Salmon migrants grouped into fry or fingerling categories varied among study years (Table 5). In 2015, fry (Avg. FL = 40 mm) comprised 9% and fingerlings (Avg. FL = 68 mm) comprised 91% of the total Chinook Salmon population abundance (Table 5). Fry migration peaked during 3/19 – 3/25 (N = 14,516 fry) and fingerling migration peaked during 6/04 – 6/10 (N = 46,295 fingerlings).

Table 5. Production of 0+ Chinook Salmon partitioned into fry and fingerling categories each study year and for the previous 11 year average (expressed as a percentage in parentheses for 2015 and the previous 11 year average), lower Redwood Creek, Humboldt County, CA.

	0+ Chinook Salmon production as:	
Study Year	Fry (FL < 45mm)	Fingerling (FL > 44 mm)
2004	82,584	472,306
2005	2,052	129,113
2006	71	85,078
2007	3,772	137,287
2008	2,589	171,169
2009	9,839	198,980
2010	11,526	121,207
2011	27,809	119,910
2012	10,258	200,112
2013	122,371	444,488
2014	71,878	137,127
Avg.	31,341 (10.2)	201,525 (89.8)
2015	25,873 (8.8)	269,791 (91.2)

<u>1+ Chinook Salmon</u>

The population abundance (or production) of 1+ Chinook Salmon emigrating past the trap in lower RC in 2015 equaled 17 individuals with a 95% CI of 8 – 25 (Fig. 5). Population estimate error (or uncertainty) equaled 39% (CV = 19.5%), or 8 individuals. Average abundance for YRS 2009 – 2015 equaled 243 individuals (SD = 465; SEM = 176). Correlation of time (study year) on yearly population abundances indicated a non-significant relationship ($n = 7$, $p = 0.56$, $r = 0.27$, power = 0.15, alpha = 0.05) (Fig. 5). 1+ Chinook Salmon population abundance in a given year was positively related to 0+ Chinook Salmon population abundance the previous year (Regression, $n = 7$, $p = 0.001$, $R^2 = 0.89$, power = 1.0, alpha = 0.05).

April and May were the most important months for 1+ Chinook Salmon migration in 2015 (94% of total), and for the previous six year average (97% of total) (Fig. 6).

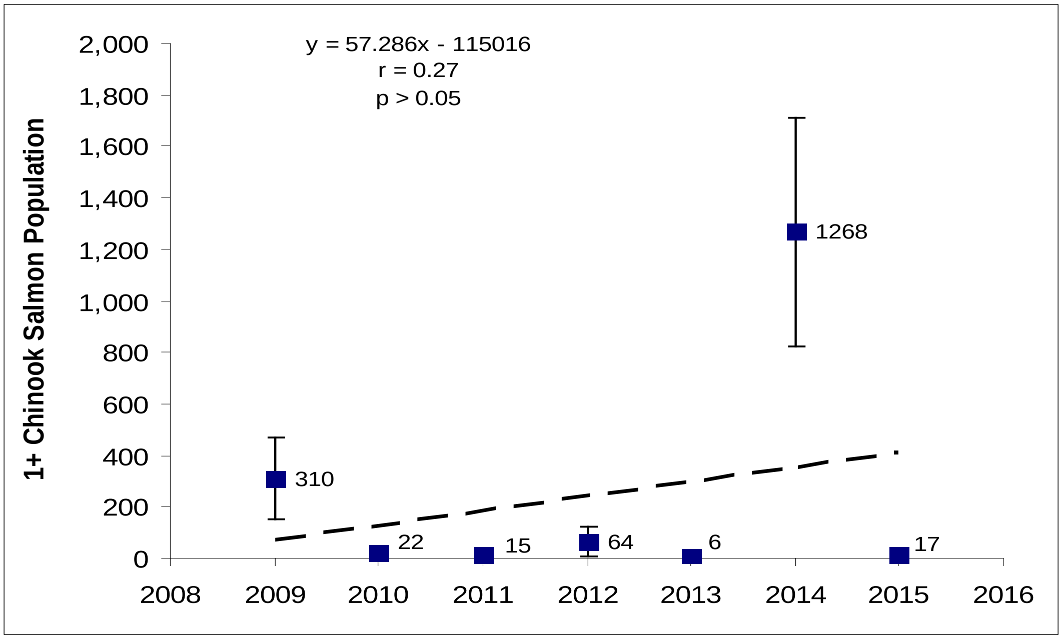

Figure 5. 1+ Chinook Salmon population abundance estimates (error bars are 95% confidence intervals) in YRS 2009 – 2015. Lack of 95% CI's for 2010, 2011, 2013 and 2015 is due to scale of 'Y' axis. Numeric values next to box represent number of individuals. Line of best fit is a regression line (dashed line indicates non-significance) with corresponding equation, correlation value (r), and p value, lower Redwood Creek, Humboldt County, CA.

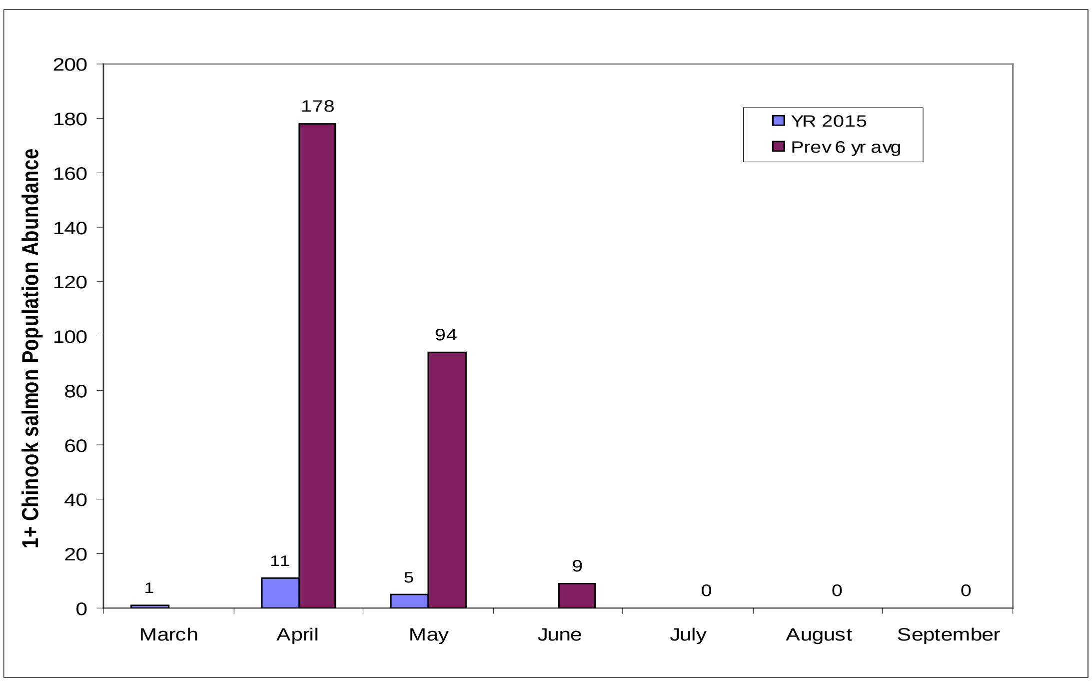

Figure 6. Comparison of 1+ Chinook Salmon population abundance by month in 2015 with the previous six year average, lower Redwood Creek, Humboldt County, CA.

1+ Steelhead Trout

The population estimate of 1+ Steelhead Trout emigrating past the trap site in lower RC in 2015 was the second highest of record, and equaled 56,020 individuals with a 95% CI of 49,180 – 62,860 (Fig. 7). Population estimate error (or uncertainty) equaled ± 12.2% (CV = 6.1%), or 6,840 individuals. Population abundance in 2015 was 1.47 times greater than abundance for the previous 11 year average ($N_{avg\ 11\ yr}$ = 38,022), and 1.50 times greater than abundance in 2014. The average in population abundance over the current 12 year period equaled 39,522 (SD = 15,389; SEM = 4,442).

Correlation of time (study year) on yearly population abundances indicated a non-significant relationship (n = 12, p = 0.25, r = 0.36, power = 0.31, alpha = 0.05) (Fig. 7). The test of time and bedload mobilizing flows in upper Redwood Cr (O'Kane gaging station) on population abundances was not significant (Regression, n = 12, p = 0.39, adj. r = 0.08, power = 0.48, alpha = 0.05).

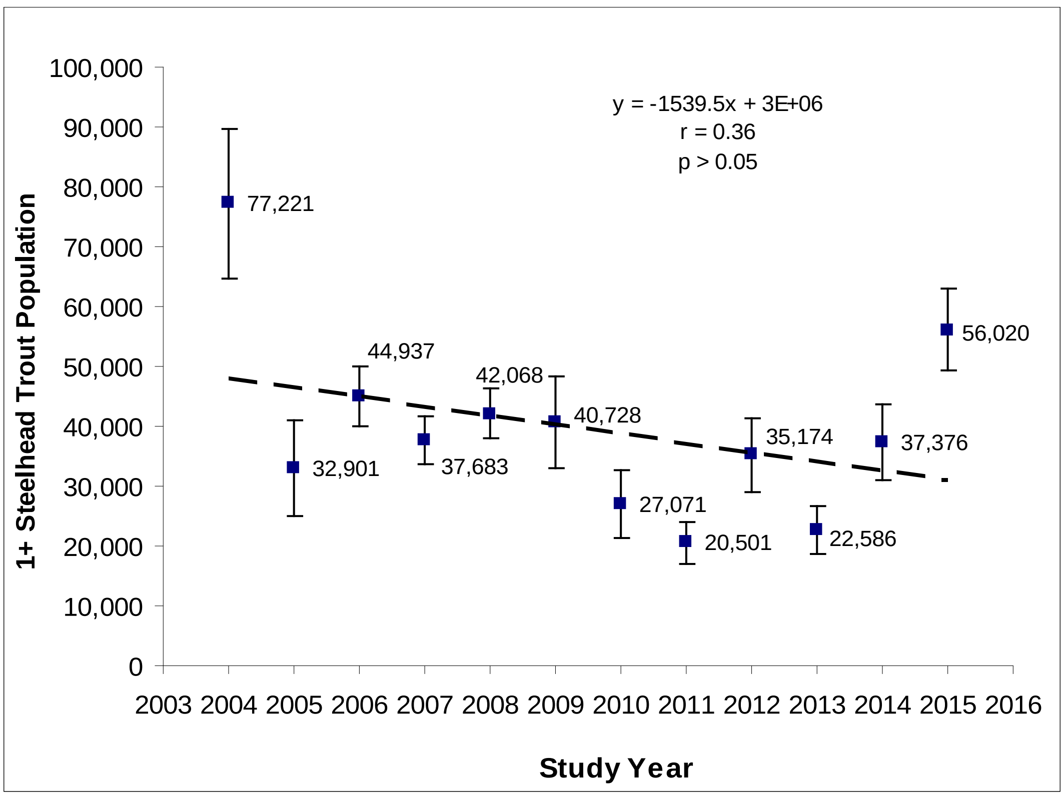

Figure 7. 1+ Steelhead Trout population abundance estimates (error bars are 95% confidence interval) in YRS 2004 – 2015. Numeric values next to box represent number of individuals. Line of best fit is a regression line (dashed line indicates non-significance), with corresponding equation, correlation value (r), and p value, lower Redwood Creek, Humboldt County, CA.

Monthly population emigration peaked in May in 2015 (N = 28,819 or 51% of total), and June (N = 13,552 or 36% of total) for the previous 11 year average (Fig. 8). In 2014 June was also the most important month (N = 14,788 or 40% of total). The two most important months for 1+ Steelhead Trout population emigration were May and June in 2015 (82% of total), and May and June for the previous 11 year average (64% of total). In 2014, April and June were the two most important months and accounted for 68% of the total population abundance.

The peak in weekly population abundance in 2015 occurred 5/28 – 6/3, earlier than the peak in 2014 (Table 6). For the 12 study years, one peak occurred in early to mid-April, two peaks occurred in late April/early May, two peaks occurred in May, two in late May/early June, four in June, and one in late June/early July (Table 6).

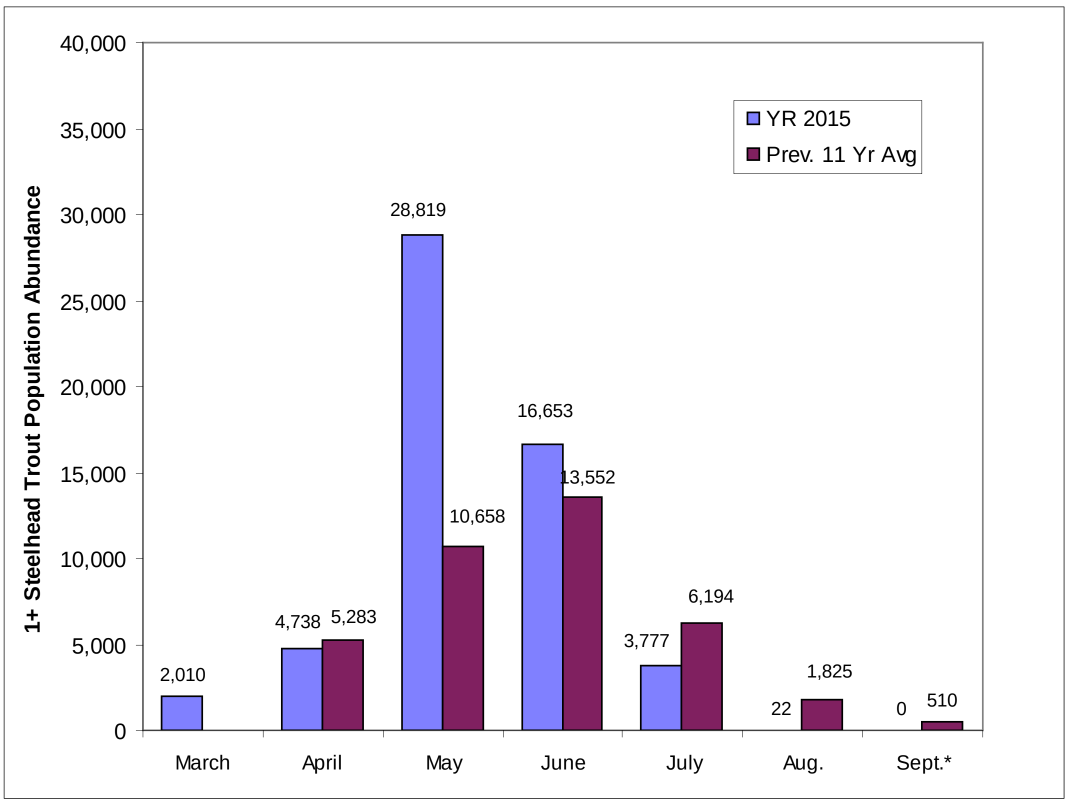

Figure 8. Comparison of 1+ Steelhead Trout population abundance by month in 2015 with the previous 11 year average (* denotes monthly average of years 2010-2014), lower Redwood Creek, Humboldt County, CA.

Table 6. Date of peak weekly 1+ Steelhead Trout population emigration by study year (number of individuals in parentheses), lower Redwood Creek, Humboldt County, CA.

Study Year	Date of peak in weekly out-migration (number in parentheses)
2004	5/14 - 5/20 (9,985)
2005	4/30 - 5/06 (7,494)
2006	6/18 - 6/24 (10,440)
2007	6/18 - 6/24 (5,483)
2008	5/28 - 6/03 (5,533)
2009	5/21 - 5/27 (7,855)
2010	4/30 - 5/06 (4,934)
2011	6/25 - 7/01 (3,647)
2012	6/11 - 6/24 (4,850)
2013	6/04 - 6/10 (3,195)
2014	4/09 - 4/15 (8,597)
2015	5/28 - 6/03 (8,317)

<u>2+ Steelhead Trout</u>

The population estimate (or production) of 2+ Steelhead Trout emigrating past the trap site in lower RC in 2015 equaled 18,155 individuals with a 95% CI of 13,912 – 22,397 (Fig. 9). Population estimate error (or uncertainty) equaled $\pm$ 23.4% (CV = 11.7%) or 4,243 individuals. Population abundance in 2015 was the second highest of record, and 2.05 times greater than abundance for the previous 11 year average ($N_{avg\ 11yr}$ = 8,858). The average in population abundances over the current 12 year period equaled 9,362 (SD = 5,695; SEM = 1,644).

Correlation of time (study year) on yearly population abundances failed to detect a significant relationship (n = 12, p = 0.63, r = 0.15, power = 0.14, alpha = 0.05) (Fig. 9). The test of time and bedload mobilizing flows (flood flows) in upper Redwood Cr (O'Kane gaging station) on population abundances also failed to detect a significant relationship over years (Regression, n = 12, p = 0.90, adj. r = 0.00, power = 0.11, alpha = 0.05).

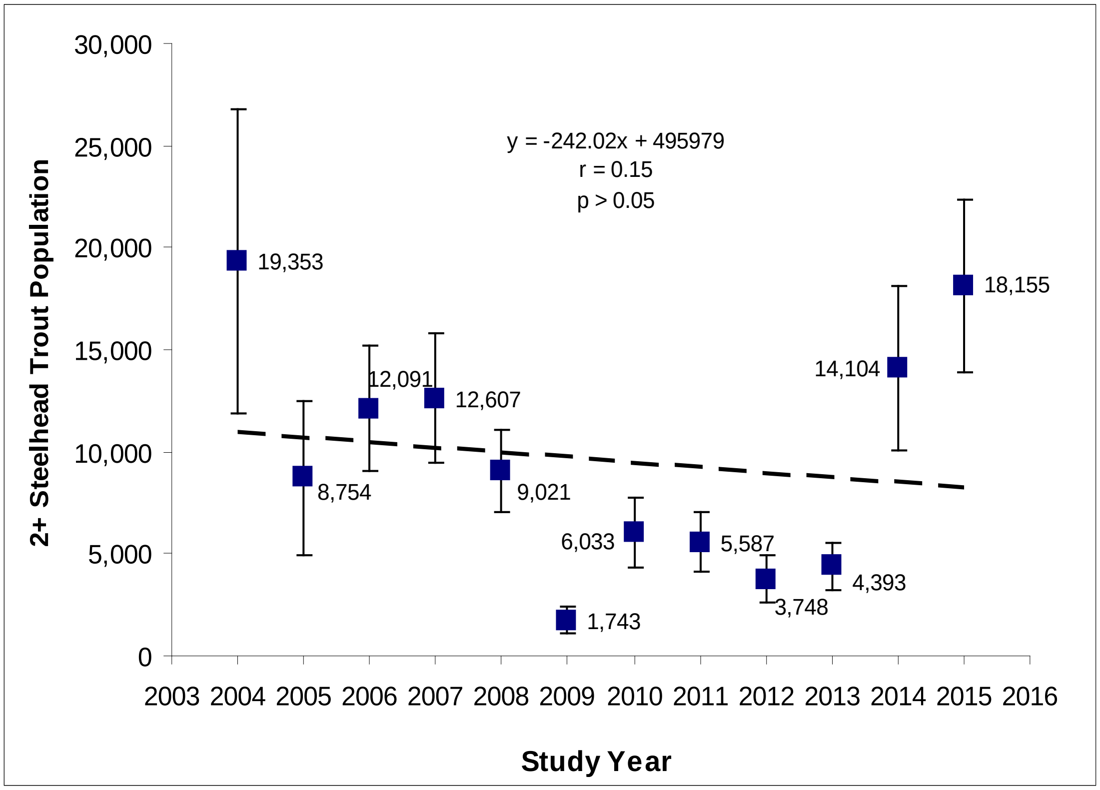

Figure 9. 2+ Steelhead Trout population abundance estimates (error bars are 95% confidence interval) in YRS 2004 – 2015. Numeric values next to box represent number of individuals. Line of best fit is a regression line (dashed line indicates non-significance), with corresponding equation, correlation value (r), and p value, lower Redwood Creek, Humboldt County, CA.

Monthly population abundance peaked in May (N = 9,854 or 54% of total) in 2015 and June for the previous 11 year average (N = 3,305 or 37% of total) (Fig. 10). In 2014, monthly emigration peaked in June (N = 8,492or 60% of total). The two most important months for 2+ Steelhead Trout population emigration in 2015 were April and May (85% of total), compared to May and June (67% of total) for the previous 11 year average (Fig. 10). In 2014, June and July were the two most important months and accounted for 79% of the total abundance.

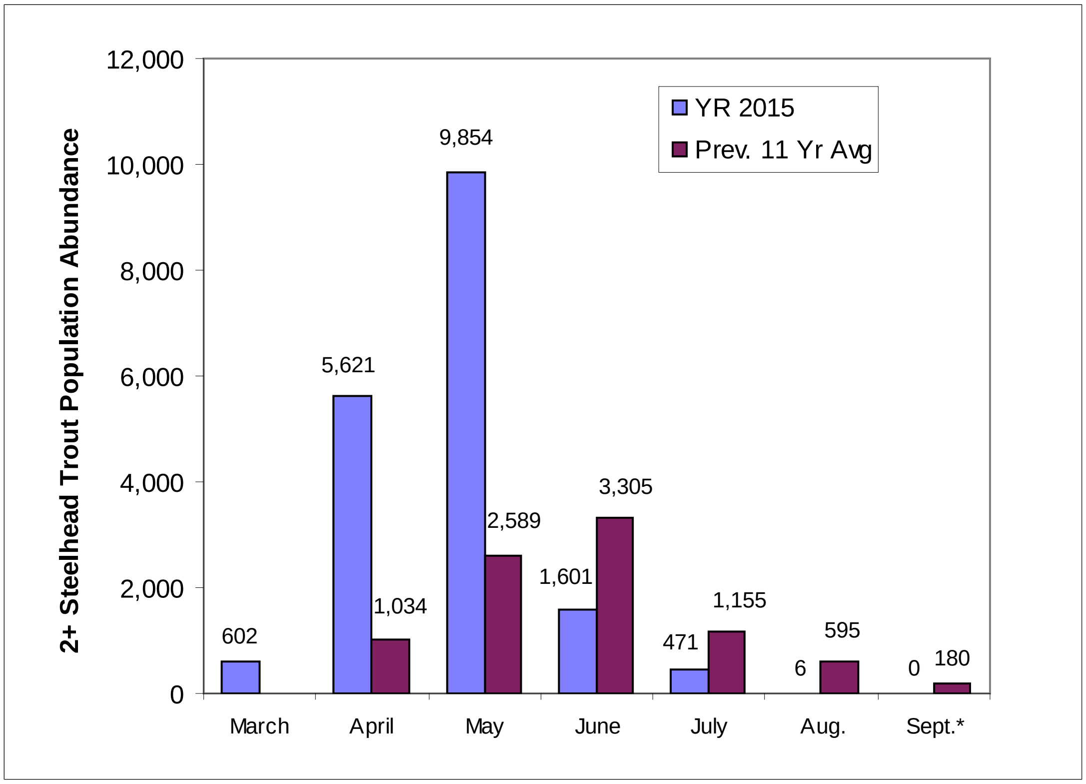

Figure 10. Comparison of 2+ Steelhead Trout population abundance by month in 2015 with the previous 11 year average (* denotes monthly average of years 2010-2014), lower Redwood Creek, Humboldt County, CA.

The peak in weekly abundance in 2015 (5/07 – 5/13) occurred six weeks earlier than the peak in 2014 (Table 7). For the 12 study years, two peaks occurred in late April/early May, one peak occurred early May, one peak occurred during the middle of May, one peak occurred in late May/early June, three peaks occurred in June, two peaks occurred late June/early July, one peak occurred in late July, and one peak occurred in August (Table 7).

Table 7. Date of peak weekly 2+ Steelhead Trout population emigration by study year (number of individuals in parentheses), lower Redwood Creek, Humboldt County, CA.

Study Year	Date of peak in weekly out-migration (number in parentheses)	
2004	4/30 - 5/06	(3,604)
2005	4/30 - 5/06	(2,232)
2006	6/18 - 6/24	(2,883)
2007	6/18 - 6/24	(3,066)
2008	5/28 - 6/03	(2,322)
2009	5/14 - 5/20	(314)
2010	8/20 - 8/26	(913)
2011	6/25 - 7/01	(1,283)
2012	6/25 - 7/01	(600)
2013	7/23 - 7/29	(738)
2014	6/18 - 6/24	(2,518)
2015	5/07 - 5/13	(3,647)

0+ Coho Salmon

The population estimate of 0+ Coho Salmon emigrating past the trap site in lower RC in 2015 equaled 303 individuals with a 95% CI of 191 – 416 (Fig. 11). Population estimate error (or uncertainty) equaled ± 37% (CV = 18.5%) or 112 individuals. Population emigration in 2015 was the fifth lowest of record, 69% less than the previous nine year average, and 92% less than abundance in 2014. The average population abundance over the current ten year period equaled 904 (SD = 1,218; SEM = 385).

Correlation of time (study year) on yearly population abundances failed to detect a significant relationship (n = 9, p = 0.64, r = 0.17, power = 0.13, alpha = 0.05) (Fig. 11).

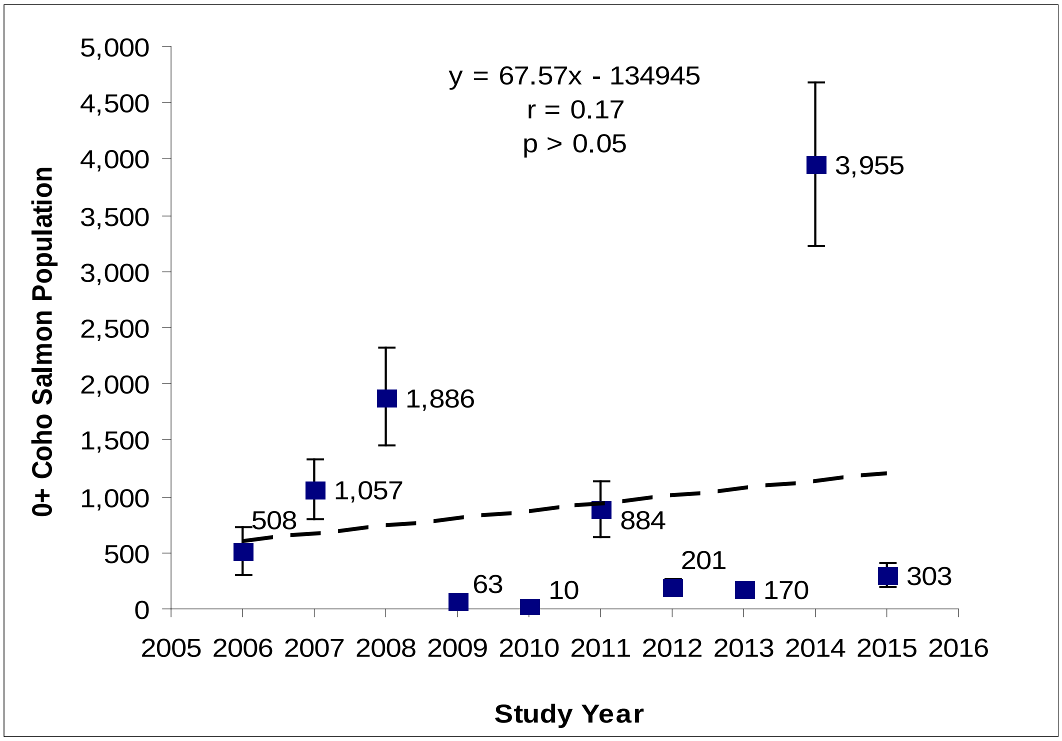

Figure 11. 0+ Coho Salmon population abundance estimates (error bars are 95% confidence intervals) in YRS 2006 - 2015. Lack of 95% CI for YRS 2009, 2010, 2012 and 2013 is due to scale of Y axis. Numeric values next to box represent number of individuals. Line of best fit is a regression line (dashed line indicates non-significance), with corresponding equation, correlation value (r), and p value, lower Redwood Creek, Humboldt County, CA.

Monthly population abundance in 2015 peaked in April (N = 135 or 45% of total), compared to June (N = 277 or 29% of total) for the previous nine year average (Fig. 12). In 2014, monthly emigration peaked in April (N = 1,847 or 47% of the total). The two most important months for 0+ Coho Salmon population emigration were April and May in 2015 (75% of total), compared to April and June (55% of total) for the previous nine year average (Fig. 12). In 2014, April and May were the two most important months, and accounted for 67% of the total population abundance.

Weekly peaks in abundances occurred in April, June, July, and August over nine study years (Table 8).

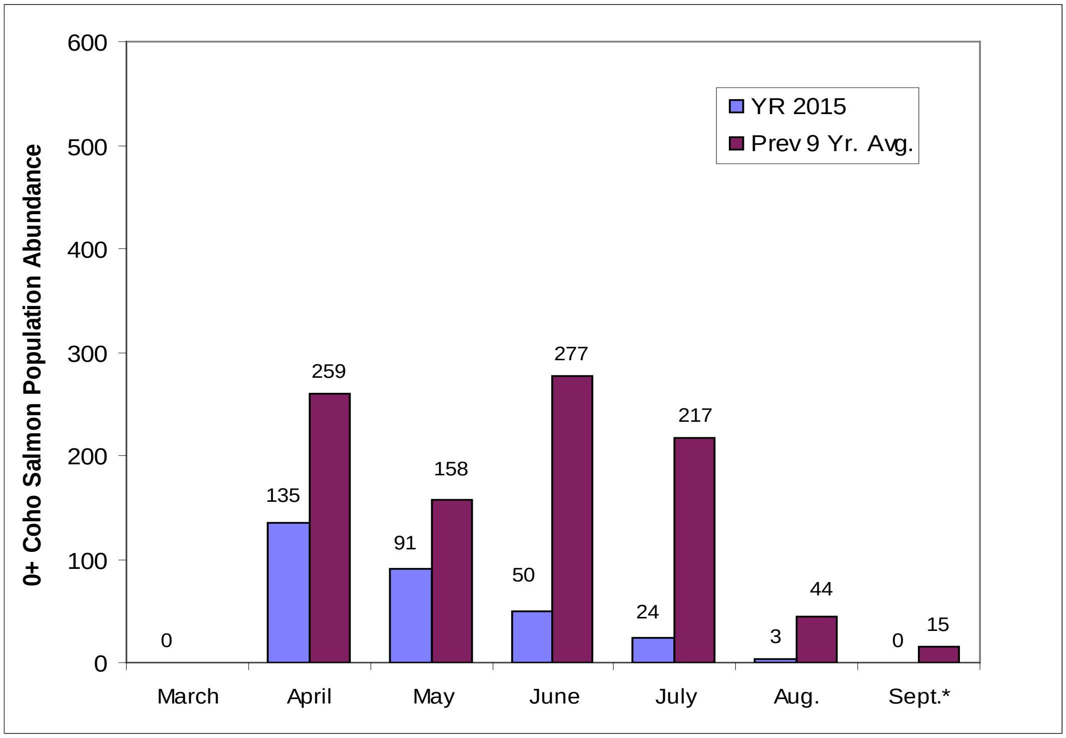

Figure 12. Comparison of 0+ Coho Salmon population abundance by month in 2015 with the previous nine year average (* denotes monthly average of years 2010-2013), lower Redwood Creek, Humboldt County, CA.

Table 8. Date of peak weekly 0+ Coho Salmon population emigration by study year (number of individuals in parentheses), lower Redwood Creek, Humboldt County, CA.

Study Year	Date of peak in weekly out-migration (number in parentheses)
2006	6/25 - 7/01 (113)
2007	6/11 - 6/17 (254)
2008	4/02 - 4/08 (304)
2009	6/25 - 7/01 (15)
2010	8/20 - 8/26 (5)
2011	6/25 - 7/01 (171)
2012	7/16 - 7/22 (48)
2013	7/09 - 7/15 (52)
2014	4/16 - 4/22 (1,099)
2015	4/16 - 4/22 (93)

1+ Coho Salmon

The population estimate (or production) of 1+ Coho Salmon emigrating past the trap site in lower RC in 2015 equaled 1,923 individuals with a 95% CI of 1,542 – 2,304 individuals (Fig. 13). Population estimate error (or uncertainty) equaled ± 19.8% (CV = 9.9%), or 381 individuals. Population abundance in 2015 was the highest of record, 3.4 times greater than abundance in 2014, and 5.4 times greater than abundance for previous 11 year average ($N_{avg\ 11yr}$ = 355). The average population abundance over the current 12 year period equaled 486 (SD = 518; SEM = 149).

Correlation of time (study year) on yearly population estimates failed to detect a significant relationship (n = 12, p = 0.22, r = 0.38, power = 0.33, alpha = 0.05) (Fig. 13).

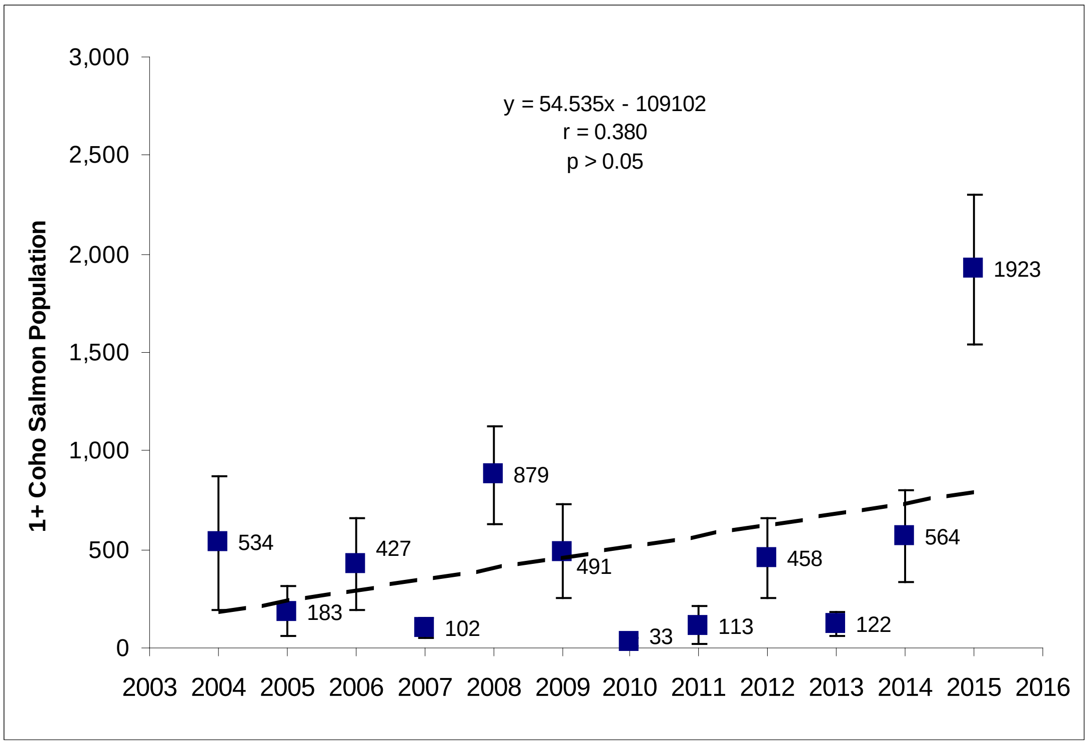

Figure 13. 1+ Coho Salmon population abundance estimates (error bars are 95% confidence interval) in YRS 2004 – 2015. Lack of 95% CI for YRS 2007 and 2010 is due to scale of Y axis. Numeric values next to box represent number of individuals. Line of best fit is a regression line (dashed line indicates non-significance), with corresponding equation, correlation value (r), and p value, lower Redwood Creek, Humboldt County, CA.

Monthly population emigration peaked in May (N = 1,709 or 89% of total) in 2015, and May for the previous 11 year average (N = 256 or 72% of total) (Fig. 14). In 2014, monthly emigration also peaked in May (N = 382 or 67% of total). The two most important months for 1+ Coho Salmon population emigration were April and May in 2015 (97% of average), and April and May (88% of total) for the previous 11 year average (Fig. 14). In 2014, April and May were also the two most important months, and accounted for 88% of the total population abundance.

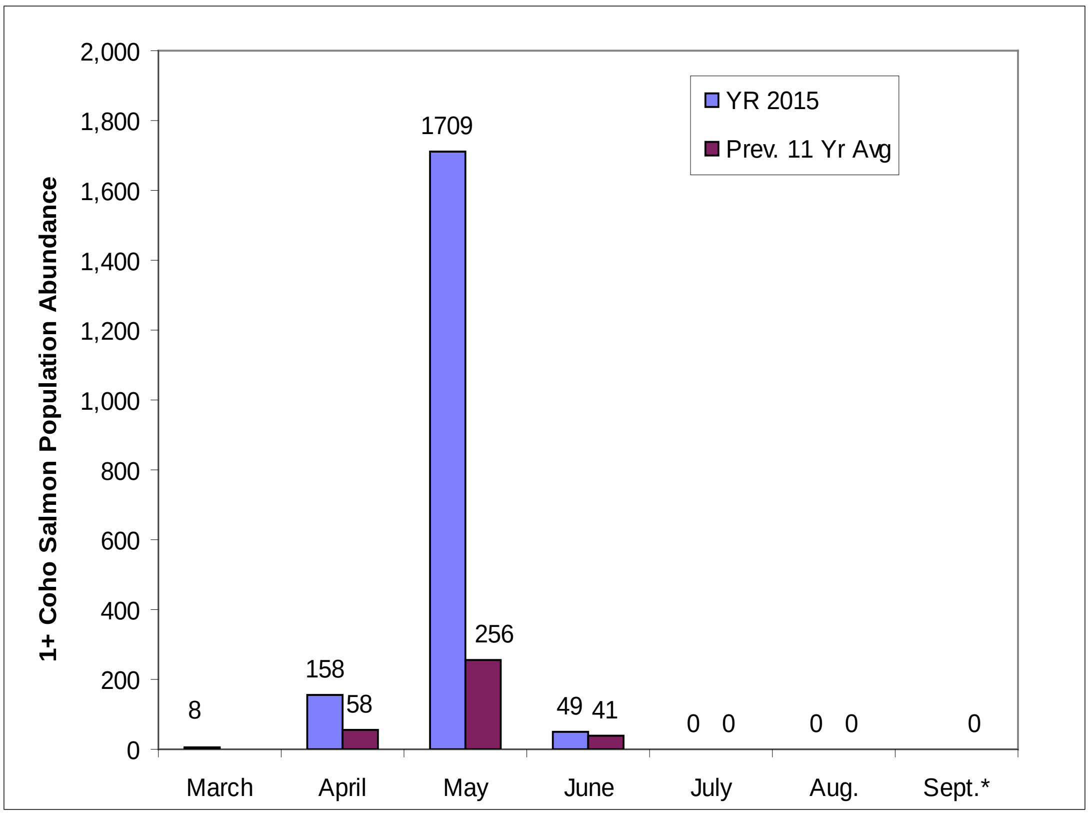

Figure 14. Comparison of 1+ Coho Salmon population abundance by month in 2015 with the previous 11 year average (* denotes monthly average of years 2010-2013), lower Redwood Creek, Humboldt County, CA.

The peak in weekly abundance in 2015 occurred 5/07 – 5/13 (Table 9). For the 12 study years, one peak occurred in late April, three peaks occurred in late April/early May, three peaks occurred in early-mid May, one peak occurred in mid May, two peaks occurred in late May, and two peaks occurred in early-mid June (Table 9).

Population emigration ended during the week 6/25 – 7/01 in 2015, 6/11 – 6/17 in 2014, 6/04 – 6/10 in 2013, 6/25 – 7/01 in 2012, 6/18 – 6/24 in 2011, 6/11 – 6/17 in 2010, 6/11 –

6/17 in 2009, 6/25 – 7/1 in 2008, 6/11 – 6/17 in 2007, 6/25 – 7/01 in 2006, 5/28 – 6/3 in 2005, and 6/4 – 6/10 in 2004.

Table 9. Date of peak weekly 1+ Coho Salmon population emigration by study year (number of individuals in parentheses), lower Redwood Creek, Humboldt County, CA.

Study Year	Date of peak in weekly out-migration (number in parentheses)	
2004	4/30 - 5/06	(182)
2005	5/07 - 5/13	(80)
2006	6/04 - 6/10	(135)
2007	5/21 - 5/27	(32)
2008	5/21 - 5/27	(398)
2009	5/14 - 5/20	(217)
2010	4/30 - 5/06	(12)
2011	5/07 - 5/13	(85)
2012	4/23 - 4/29	(105)
2013	6/04 - 6/10	(32)
2014	5/21 - 5/27	(271)
2015	5/07 - 5/13	(771)

Cutthroat Trout

The population estimate of juvenile Coastal Cutthroat Trout emigrating past the trap site in lower RC in 2015 equaled 825 individuals with a 95% CI of 561 – 1,089 individuals (Fig. 15). Population estimate error (or uncertainty) equaled $\pm$ 32% (CV = 16%) or 264 individuals. Population abundance in 2015 was the highest of record. The average population abundance in YRS 2006 – 2008, and 2010 - 2015 equaled 241 (SD = 250; SEM = 83).

Correlation of time (study year) on yearly population estimates indicated a significant, positive relationship (n = 9, p = 0.03, r = 0.71, power = 0.78, alpha = 0.05) (Fig. 15).

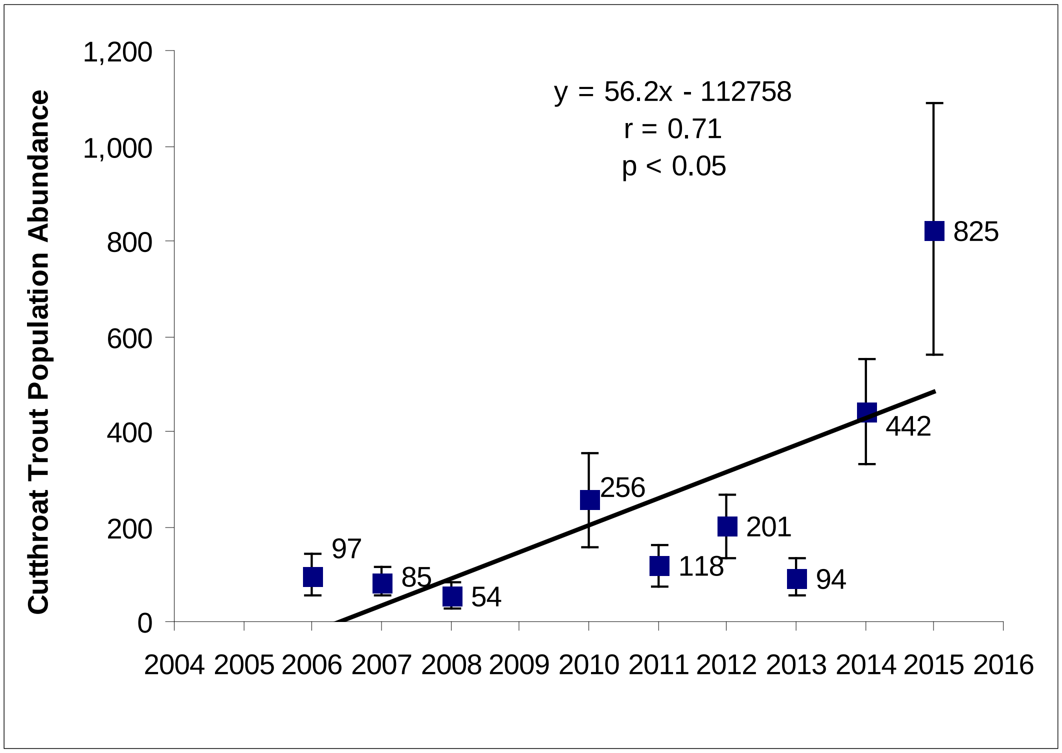

Figure 15. Cutthroat Trout population abundance estimates in YRS 2006 – 2008 and YRS 2010 - 2015 (error bars are 95% confidence intervals). Numeric values next to box represent number of individuals. Line of best fit is a regression line, with corresponding equation, correlation value (r), and p value, lower Redwood Creek, Humboldt County, CA.

Population emigration in 2015 showed a relatively abundant, earlier migration pattern compared to the average (Fig. 16). Migration peaked in May (N = 492 or 60% of total) in 2015, and June (N = 54 or 32% of total) for the average of YRS 2006 – 2008, and 2010 - 2014 (Fig. 16). In 2014, monthly emigration peaked in June (N = 260 or 59% of total). The two most important months were May and June (87% of total) in 2015, compared to June and July (61% of total) for the average of years 2006 - 2008 and 2010 - 2014. In 2014, June and July were the two most important months (80% of total).

The peak in weekly abundance in 2015 occurred 5/07 – 5/13, and was earlier than any previous peaks in abundance (Table 10). For the nine study years when population abundances were determined, one peak occurred in May, on peak occurred in mid June, two peaks occurred in late June/early July, three peaks occurred in July, one peak occurred in August, and one peak occurred in September (Table 10).

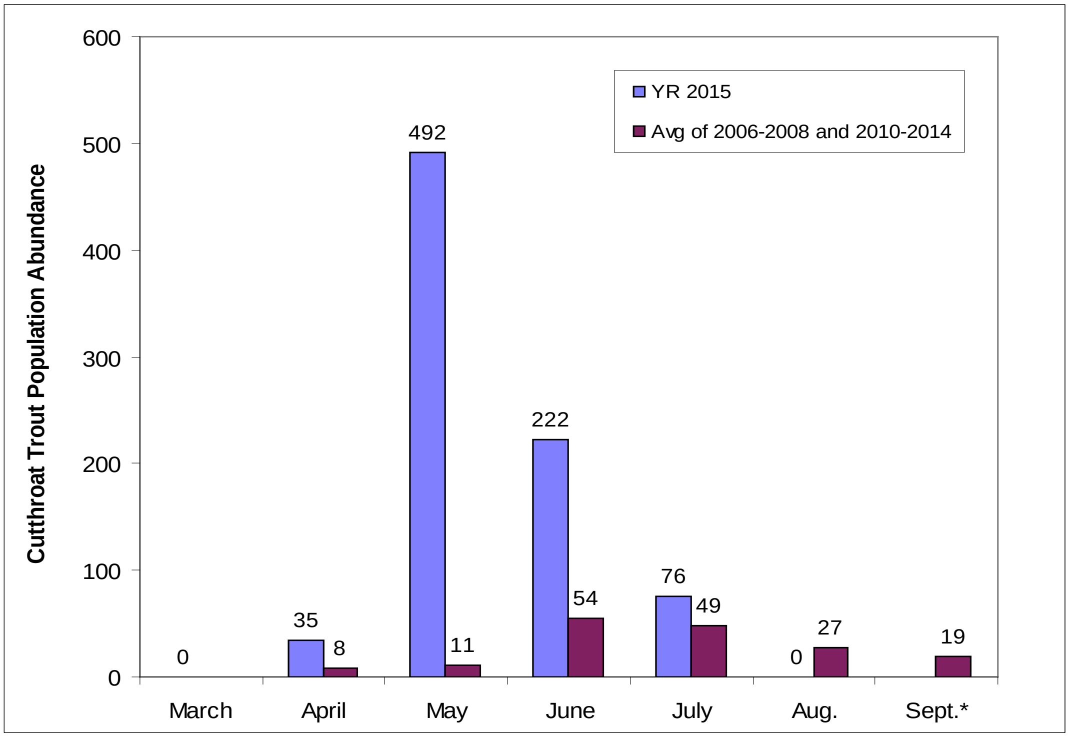

Figure 16. Comparison of Cutthroat Trout population abundance by month in 2015 with the average of YRS 2006 – 2008 and 2010 - 2014 (* denotes monthly average of years 2010-2014), lower Redwood Creek, Humboldt County, CA.

Table 10. Date of peak weekly Cutthroat Trout population emigration by study year (number of individuals in parentheses), lower Redwood Creek, Humboldt County, CA.

Study Year	Date of peak in weekly out-migration (number in parentheses)
2004	
2005	
2006	7/23 – 7/29 (18)
2007	7/09 – 7/15 (15)
2008	6/25 – 7/01 (20)
2009	
2010	9/03 – 9/09 (63)
2011	8/13 – 8/19 (46)
2012	6/25 – 7/01 (40)
2013	7/23 – 7/29 (33)
2014	6/18 – 6/24 (120)
2015	5/07 – 5/13 (163)

Age Composition of Age-1 and older Juvenile Steelhead Trout

Far more 1+ Steelhead Trout migrated downstream than 2+ Steelhead Trout in 2015, and for all years combined (Table 11). The ratio of 1+ Steelhead Trout to 2+ Steelhead Trout equaled 3.1:1 in 2015, 2.7:1 in 2014, 5:1 in 2013, 9.4:1 in 2012, 3.7:1 in 2011, 4.5:1 in 2010, 23:1 in 2009, 5:1 in 2008, 3:1 in 2007, and close to 4:1 in YRS 2004 - 2006.

Table 11. Comparison of 1+ Steelhead Trout and 2+ Steelhead Trout percent composition of total age-1 and older juvenile Steelhead Trout downstream migration in 2015 with the previous 11 year average, lower Redwood Creek, Humboldt County, CA.

	Percent Composition	
Study Year	1+ Steelhead	2+ Steelhead
2015	75.5	24.5
Prev. 11 Yr. Avg.	81.6	18.4
All years combined	80.4	19.6

Fork Lengths and Weights

<u>0+ Chinook Salmon</u>

We measured (FL mm) 3,822 and weighed (g) 2,248 0+ Chinook Salmon in 2015 (Table 12). Average FL (64 mm) and Wt (3.2 g) in 2015 were less than the previous 11 year average (Table 12). Average FL over 12 study years equaled 66.3 mm (SD = 5.0 mm; SEM = 1.5 mm), and for Wt equaled 3.58 g (SD = 0.84 g mm; SEM = 0.24 g).

Average FL's (mm) by year were negatively related to population abundances (Regression, n = 12, p = 0.02, R^2 = 0.46, negative slope, power = 0.86, alpha = 0.05), as were average Wt's (g) (Regression, n = 12, p = 0.03, R^2 = 0.39, negative slope, power = 0.76, alpha = 0.05).

Table 12. 0+ Chinook Salmon average and median fork length (mm) and weight (g) in YRS 2004 - 2015, lower Redwood Creek, Humboldt County, CA.

	0+ Chinook Salmon						
		Fork Length (mm)			Weight (g)		
YR	(N)	n	Avg.	Median	n	Avg.	Median
2004	554,890	3,192	59.8	61.0	1,429	2.55	2.40
2005	131,164	2,723	74.3	80.0	1,284	5.17	5.60
2006	85,149	2,058	76.2	78.0	1,715	4.96	5.10
2007	141,059	2,666	66.6	70.0	2,031	3.28	3.20
2008	173,758	3,113	64.5	67.0	2,099	3.04	3.10
2009	208,819	3,294	64.9	66.0	2,159	3.34	3.10
2010	132,733	3,543	66.8	71.0	2,125	3.71	3.50
2011	147,719	3,511	64.1	69.0	2,135	3.29	3.30
2012	210,370	3,707	70.6	75.0	2,400	4.46	4.50
2013	566,859	4,087	61.0	63.0	2,322	2.76	2.50
2014	209,005	3,715	62.5	68.0	2,180	3.17	3.40
Avg.			66.5			3.61	
2015	295,664	3,822	64.3	67.0	2,248	3.19	3.20

1+ Chinook Salmon

We measured (FL mm) and weighed (g) 9 1+ Chinook Salmon in 2015 (Table 13). Average FL (103.1 mm) and Wt (12.79 g) in 2015 were less than average (Table 13). The average FL using all year's data equaled 110.7 mm (SD = 7.4 mm; SEM = 2.5 mm), and for Wt equaled 15.84 g (SD = 2.97 g mm; SEM = 1.05 g).

Table 13. 1+ Chinook Salmon average and median fork length (mm) and weight (g) in YRS 2005, 2008 - 2015, lower Redwood Creek, Humboldt County, CA.

		1+ Chinook Salmon					
		Fork Length (mm)			Weight (g)		
YR	N	n	Avg.	Median	n	Avg.	Median
2004	>2	2	-	-	-	-	-
2005	>11	11	109.2	111.0	11	13.60	13.50
2006	0	-	-	-	-	-	-
2007	0	-	-	-	-	-	-
2008	>10	10	113.4	113.0	9	15.80	14.2
2009*	310	57	108.8	110.0	57	14.08	14.0
2010*	22	10	125.4	126.0	10	22.00	21.9
2011*	15	11	114.5	117.0	10	17.64	19.25
2012*	64	18	114.2	114.0	18	16.56	16.80
2013*	6	3	100.1	110.0	2	-	-
2014*	1,268	212	107.5	108.5	187	14.26	14.40
Avg.			111.6			16.28	
2015*	17	9	103.1	105.0	9	12.79	13.10

* Denotes year when population abundance was determined.

<u>0+ Steelhead Trout</u>

We measured (FL mm) 2,940 0+ Steelhead Trout in 2015 (Table 14). Average FL (58.2 mm) in 2015 was greater than average (Table 14). The average FL using all year's data equaled 54.7 mm (SD = 3.2 mm; SEM = 0.9 mm), and corresponded to a parr life history stage.

Average FL's (mm) by year were not related to catches by year (Regression, p = 0.48, R^2 = 0.05, power = 0.18, alpha = 0.05).

Table 14. 0+ Steelhead Trout average and median fork length in YRS 2004 - 2015, lower Redwood Creek, Humboldt County, CA.

		0+ Steelhead Trout*					
		Fork Length (mm)			Weight (g)		
YR	(N)	n	Avg.	Median	n	Avg.	Median
2004	> 18,642	2,939	49.6	52.0	-	-	-
2005	> 1,345	1,099	51.1	53.5	-	-	-
2006	> 29,957	2,757	55.8	58.0	-	-	-
2007	> 42,827	3,355	53.8	56.0	-	-	-
2008	> 39,892	2,787	52.9	56.0	-	-	-
2009	> 2,489	1,557	56.7	60.0	-	-	-
2010	> 4,566	2,275	56.9	63.0	-	-	-
2011	> 9,864	2,354	57.5	58.0	-	-	-
2012	> 7,301	2,686	59.3	61.0	-	-	-
2013	> 34,087	3,887	50.9	54.0	-	-	-
2014	> 31,229	3,434	53.1	56.0	-	-	-
Avg.			54.3		-	-	-
2015	> 39,779	2,940	58.2	60.0	-	-	-

* Includes a small, but unknown number of Cutthroat Trout.

<u>1+ Steelhead Trout</u>

We measured (FL mm) 2,948 and weighed (g) 2,254 1+ Steelhead Trout in 2015 (Table 15). Average FL and Wt in 2015 were greater than average. The average FL (mm) over 12 study years equaled 92.2 mm (SD = 6.0 mm; SEM = 1.7 mm), and for Wt (g) equaled 9.12 g (SD = 1.80 g mm; SEM = 0.52 g).

The regressions of population abundances on average FL (mm) and Wt (g) by study year each violated test assumptions (n = 3), and results were not valid (NCSS 97). The average size (FL, Wt) increased over 12 consecutive years (FL, Correlation, p = 0.0002, r = 0.88, power = 1.00; Wt, Correlation, p = 0.00009, r = 0.89, power = 1.0, alpha = 0.05).

Table 15. 1+ Steelhead Trout average and median fork length (mm) and weight (g) in YRS 2004 - 2015, lower Redwood Creek, Humboldt County, CA.

	1+ Steelhead Trout						
		Fork Length (mm)			Weight (g)		
YR	(N)	n	Avg.	Median	n	Avg.	Median
2004	77,221	2,713	84.4	81.0	1,201	7.04	5.80
2005	32,901	1,442	90.8	89.0	919	8.31	7.40
2006	44,937	2,449	87.0	84.0	2,150	7.73	6.50
2007	37,683	2,761	88.6	87.0	2,146	7.88	7.00
2008	42,068	2,875	87.0	85.0	2,025	7.48	6.60
2009	40,728	2,349	87.6	86.0	1,673	7.59	6.80
2010	27,071	2,315	92.1	91.0	1,505	8.94	8.00
2011	20,501	1,945	93.2	92.0	1,168	9.77	8.85
2012	35,174	2,238	96.2	95.0	1,829	10.51	9.70
2013	22,586	1,998	93.4	90.5	1,806	9.68	8.20
2014	37,376	2,152	103.1	103.0	1,591	12.18	11.20
Avg.			91.2			8.83	
2015	56,020	2,948	102.5	101.0	2,254	12.27	11.20

2+ Steelhead Trout

We measured (FL mm) 1,491 and weighed (g) 1,461 2+ Steelhead Trout in 2015 (Table 16). Average FL (157.3 mm) and Wt (39.79 g) in 2015 were the greatest of record (Table 16). The average seasonal FL over 12 study years equaled 143.8 mm (SD = 4.7 mm; SEM = 1.4 mm), and for Wt equaled 31.93 g (SD = 2.95 g mm; SEM = 0.85 g). The regression of population abundances on average FL (mm) by study year violated test assumptions (n = 3), and results were not valid (NCSS 97).

Average Wt's (g) by study year were not significantly related to yearly population abundances (Regression, n = 12, p = 0.23, R^2 = 0.14, power = 0.32, alpha = 0.05). The correlation of average FL's and study years violated test assumptions (n = 3), and results were not valid (NCSS 97). Average Wt's (g) were positively related to study years (Correlation, n = 12, p = 0.02, r = 0.65, power = 0.81, alpha = 0.05).

Table 16. 2+ Steelhead Trout average and median fork length (mm) and weight (g) in YRS 2004 - 2015, lower Redwood Creek, Humboldt County, CA.

	2+ Steelhead Trout						
		Fork Length (mm)			Weight (g)		
YR	(N)	n	Avg.	Median	n	Avg.	Median
2004	19,353	886	141.9	135.0	864	30.69	26.00
2005	8,754	413	143.2	139.0	412	31.25	27.05
2006	12,091	1,056	139.1	133.0	1,020	28.49	24.70
2007	12,607	1,148	141.7	134.0	1,098	31.15	25.60
2008	9,021	1,134	142.6	132.0	1,099	31.27	24.30
2009	1,743	234	140.4	133.0	219	28.65	23.90
2010	6,033	589	141.8	139.0	581	31.02	28.20
2011	5,587	653	146.6	145.0	638	34.49	31.65
2012	3,748	474	142.8	138.0	424	31.45	28.10
2013	4,393	225	142.6	138.0	225	32.21	29.00
2014	14,104	969	145.5	142.0	929	32.70	30.00
Avg.			142.6			31.22	
2015	18,155	1,491	157.3	157.0	1,461	39.79	37.71

<u>0+ Coho Salmon</u>

We measured (FL mm) 100 and weighed (g) 97 0+ Coho Salmon in 2015 (Table 17). Average FL (55.8 mm) and Wt (2.36 g) in 2015 were the second lowest of record (Table 17). The average FL over 12 study years equaled 65.0 mm (SD = 8.2 mm; SEM = 2.4 mm), and for Wt equaled 3.68 g (SD = 1.32 g mm; SEM = 0.38 g).

Average FL's (mm) by year were significantly related to population abundances (transformed) (Regression, p = 0.01, R^2 = 0.57, negative slope, power = 0.91, alpha = 0.05). Average Wt's (g) by year were also negatively related to population abundances (transformed) (Regression, p = 0.01, R^2 = 0.55, negative slope, power = 0.89, alpha = 0.05).

Table 17. 0+ Coho Salmon average and median fork length (mm) and weight (g) in YRS 2004 - 2015, lower Redwood Creek, Humboldt County, CA.

	0+ Coho Salmon						
		Fork Length (mm)			Weight (g)		
YR	(N)	n	Avg.	Median	n	Avg.	Median
2004	> 202	202	66.2	66.0	198	3.76	3.50
2005	> 53	53	61.8	63.0	50	3.38	3.15
2006*	508	106	64.6	67.0	106	3.40	3.50
2007*	1,057	290	67.4	67.0	276	3.83	3.60
2008*	1,886	391	61.1	64.0	383	3.04	3.00
2009*	63	32	66.2	68.0	32	3.48	3.50
2010*	10	6	84.5	84.0	6	7.20	6.90
2011*	884	230	68.5	68.0	227	4.27	3.90
2012*	201	77	69.2	67.0	75	4.33	3.30
2013*	170	60	63.4	65.0	59	3.29	3.50
2014*	3,955	1,047	50.7	53.0	1,036	1.79	1.60
Avg.			65.8			3.80	
2015*	303	100	55.8	59.0	97	2.36	2.20

* Denotes study year when population abundance was determined.

1+ Coho Salmon

We measured (FL mm) and weighed (g) 476 1+ Coho Salmon in 2015 (Table 18). Average FL (105.5 mm) and Wt (12.47) in 2015 were less than the previous 11 year average (Table 18). The average seasonal FL over 12 study years equaled 106.5 mm (SD = 3.1 mm; SEM = 0.9 mm), and for Wt equaled 13.08 g (SD = 1.09 g; SEM = 0.32 g).

Average FL's (mm) and average Wt's (g) by year were not significantly related to yearly population abundances (FL: Regression, n = 12, p = 0.73, R^2 = 0.01, power = 0.12, alpha = 0.05; Wt: Regression, n = 12, p = 0.56, R^2 = 0.03, power = 0.15, alpha = 0.05).

Table 18. 1+ Coho Salmon average and median fork length (mm) and weight (g) in YRS 2004 - 2015, lower Redwood Creek, Humboldt County, CA.

	1+ Coho Salmon						
		Fork Length (mm)			Weight (g)		
YR	(N)	n	Avg.	Median	n	Avg.	Median
2004	535	69	105.3	105.0	67	13.09	12.09
2005	183	39	109.4	110.0	39	13.71	13.40
2006	427	69	105.7	105.0	69	12.77	12.50
2007	102	34	104.9	107.0	34	12.36	12.30
2008	879	242	109.1	110.0	229	13.73	13.70
2009	482	101	100.0	100.0	100	10.70	10.40
2010	33	11	111.0	111.0	11	14.80	14.70
2011	113	24	106.7	106.5	23	13.40	12.90
2012	458	79	104.6	103.0	77	12.58	12.0
2013	122	37	105.2	105.0	37	12.79	12.70
2014	564	116	110.5	109.0	110	14.58	13.95
Avg.			106.6			13.14	
2015	1,923	476	105.5	105.0	476	12.47	12.25

Juvenile Coastal Cutthroat Trout

We measured (FL mm) and weighed (g) 207 Cutthroat Trout in 2015 (Table 19). Average FL and Wt in 2015 were less than the previous 11 year average (Table 19). The average seasonal FL over 12 study years equaled 188.2 mm (SD = 18.6 mm; SEM = 5.4 mm), and for Wt equaled 73.76 g (SD = 15.80 g; SEM = 4.56 g).

Table 19. Cutthroat Trout average and median fork length (mm) and weight (g) in YRS 2004 - 2015, lower Redwood Creek, Humboldt County, CA.

	Cutthroat Trout						
		Fork Length (mm)			Weight (g)		
YR	(N)	n	Avg.	Median	n	Avg.	Median
2004	> 37	36	171.0	161.5	36	61.28	43.15
2005	> 9	9	228.7	185.0	7	70.14	64.80
2006*	97	36	193.4	182.0	35	89.80	65.60
2007*	85	44	201.7	199.0	44	97.09	84.55
2008*	54	22	178.9	163.5	21	65.87	45.10
2009	> 8	8	200.0	156.0	7	93.29	33.10
2010*	256	82	191.1	189.5	80	75.81	64.40
2011*	118	57	204.7	199.0	54	94.01	79.95
2012*	201	70	176.1	176.5	64	60.26	57.8
2013*	94	36	177.1	172.5	34	66.56	58.45
2014*	442	168	164.4	159.0	163	52.68	43.10
Avg.			189.7			75.16	
2015*	825	207	171.1	171.0	207	58.33	53.80

* Denotes study year when population abundance was determined.

Developmental Stages

<u>1+ and 2+ Steelhead Trout</u>

There was an obvious non-random distribution of parr, pre-smolt, and smolt designations (developmental stages) for 1+ and 2+ Steelhead Trout captured each study year (Table 20). A totally random distribution would equal 33.3% for each designation (parr, pre-smolt, smolt). The combined percentage of pre-smolts and smolts in 2015 for 1+ Steelhead Trout equaled Trout 100%, and for 2+ Steelhead Trout equaled 100% (Table 20).

Table 20. Developmental stages of captured 1+ and 2+ Steelhead Trout in YRS 2004 - 2015, lower Redwood Creek, Humboldt County, CA.

	Developmental Stage (as percentage of total catch)					
	1+ Steelhead Trout			2+ Steelhead Trout		
Year	Parr	Pre-smolt	Smolt	Parr	Pre-smolt	Smolt
2004	0.2	31.5	68.3	0.0	5.7	94.3
2005	0.2	13.6	86.2	0.0	1.7	98.3
2006	0.1	25.1	74.8	0.0	2.1	97.9
2007	0.5	22.4	77.1	0.0	6.1	93.9
2008	0.6	15.3	84.1	0.0	1.5	98.5
2009	0.0	12.1	87.9	0.0	0.8	99.2
2010	0.1	11.1	88.8	0.0	0.5	99.5
2011	0.1	17.0	82.9	0.0	0.7	99.3
2012	0.2	19.2	80.6	0.0	1.9	98.1
2013	0.0	24.7	75.3	0.0	4.0	96.0
2014	0.0	14.5	85.5	0.0	1.1	98.9
Avg.	0.2	18.8	81.0	0.0	2.4	97.6
2015	0.0	3.2	96.8	0.0	0.0	100.0

1+ Chinook Salmon, 1+ Coho Salmon, and Cutthroat Trout in 2015

All 1+ Chinook Salmon were classified as smolts. 1+ Coho Salmon catches consisted of 0% parr, 0.2% pre-smolt, and 99.8% smolt. Juvenile Cutthroat Trout catches consisted of 0% parr, 0.5% pre-smolt, and 99.5% smolt.

Trapping Mortality

The mortality of fish that were captured in the trap and subsequently handled was closely monitored over the course of each trapping period. The trapping mortality (includes handling mortality) for a given species at age in 2015 ranged from 0.00 – 0.03%, and using all data (pooling) equaled 0.02% of the total captured and handled (Table 21). Mortality in 2015 was less than average (Table 22). The variation in trapping mortality among study years was primarily due to differences in high stream flows, debris loading in the trap’s livebox, and whether or not large sticks/logs jammed the trap’s cone.

Table 21. Trapping mortality for juvenile salmonids captured in 2015, lower Redwood Creek, Humboldt County, CA.

	Trapping Mortality in 2015		
Age/spp.	No. captured*	No. of mortalities	Percent mortality
0+ Chinook	173,943	40	0.02
1+ Chinook	10	0	0.00
0+ Steelhead	39,238	13	0.03
1+ Steelhead	8,400	1	0.01
2+ Steelhead	1,572	0	0.00
Cutthroat Trout	210	0	0.00
0+ Coho	100	0	0.00
1+ Coho	494	0	0.00
0+ Pink	1	0	0.00
Overall:	223,968	54	0.02

* Not expanded for missed day(s) catch during periods of trap non-deployment.

Table 22. Comparison of trapping mortality of juvenile salmonids in 12 consecutive study years, lower Redwood Creek, Humboldt County, CA.

	Trapping Mortality		
Study Year	No. captured*	No. of mortalities	Percent mortality
2004	88,088	167	0.19
2005	14,736	143	0.97
2006	55,671	93	0.17
2007	92,165	57	0.06
2008	126,201	140	0.11
2009	59,655	1,064	1.78
2010	52,649	113	0.21
2011	70,187	148	0.21
2012	87,632	166	0.19
2013	181,046	161	0.09
2014	132,661	121	0.09
2015	223,968	54	0.02
Avg.	98,722	202	0.34
Pooled	1,184,658	2,429	0.21

* Not expanded for missed day(s) catch during periods of trap non-deployment.

Stream Temperatures

The average daily (24 hr period) stream temperature from 3/22/15 – 8/05/15 was 15.4 ^{o}C (or 59.7 ^{o}F) (95% CI = 14.9 – 15.9 ^{o}C), with daily averages ranging from 9.3 – 19.3 ^{o}C (48.7 – 66.7 ^{o}F). Median daily stream temperature in 2015 equaled 15.9 ^{o}C (or 60.6 ^{o}F). Average stream temperatures during the trapping periods in YRS 2004 – 2015 were similar, with the largest difference among years equaling 2.0 ^{o}C (Table 23). However, average stream temperature in 2014 (severe drought year) was the highest of record (Table 23). Average daily stream temperature (during the trapping period) over study years did not significantly change over time (Correlation, $p = 0.63$, $r = 0.15$, power = 0.14, alpha = 0.05). Average daily stream temperatures during the trapping period in 2015 significantly increased over time (Correlation, $p = 0.000001$, $r = 0.93$, power = 1.0, alpha = 0.05). The minimum stream temperature in 2015 equaled 8.6 ^{o}C (47.5 ^{o}F) and occurred on 4/07/15; the maximum stream temperature equaled 22.1 ^{o}C (71.8 ^{o}F) and occurred on 6/26/15 (Table 23).

Table 23. Average, minimum, and maximum stream temperatures (^{o}C) (standard error of mean in parentheses) at the trap site during the trapping periods in YRS 2004 – 2015, lower Redwood Creek, Humboldt County, CA.

	Stream Temperature					
	Celsius			Fahrenheit		
Study Year	Avg.	Min.	Max.	Avg.	Min.	Max.
2004	15.5 (0.2)	9.3	22.6	60.0 (0.8)	48.7	72.3
2005	15.6 (0.3)	9.0	22.6	60.1 (0.5)	48.2	72.3
2006	15.5 (0.3)	7.1	23.1	60.0 (0.5)	44.8	73.6
2007	15.3 (0.3)	8.1	24.2	59.5 (0.6)	46.6	75.6
2008	14.2 (0.3)	6.9	21.8	57.6 (0.5)	44.4	71.2
2009	14.7 (0.2)	7.4	21.2	58.5 (0.4)	45.3	70.2
2010	14.6 (0.2)	8.2	21.3	58.3 (0.4)	46.8	70.3
2011	14.5 (0.3)	7.4	21.8	58.0 (0.5)	45.3	71.2
2012	15.4 (0.2)	9.6	21.0	59.8 (0.3)	49.3	69.8
2013	15.7 (0.2)	8.1	22.3	60.2 (0.4)	46.6	72.1
2014*	16.2 (0.2)	10.2	21.8	61.2 (0.4)	50.4	71.2
2015*	15.4 (0.2)	8.6	22.1	59.7 (0.4)	47.5	71.8
Avg.	15.2 (0.2)			59.4 (0.3)		

* Severe drought year in California.

Table 24. Average daily stream temperature (^oC) (truncated to 4/18 - 7/27) at the trap site in YRS 2004 – 2015, lower Redwood Creek, Humboldt County, CA.

Study Year	Average Daily Stream Temperature (4/18 – 7/27) (^oC)	(^oF)
2004	16.0	60.8
2005	14.7	58.5
2006	15.5	59.9
2007	15.3	59.5
2008	14.7	58.5
2009	14.8	58.6
2010	13.4	56.1
2011	13.6	56.5
2012	14.5	58.1
2013	15.7	60.3
2014*	16.0	60.8
2015*	16.3	61.3

* Severe drought year in California.

Average monthly stream temperatures during the majority of the trapping season (April – July) in 2015 ranged from 11.9 – 18.3 ^oC (53.4 – 64.9 ^oF) (Table 25). The highest average monthly stream temperature in June occurred in 2015. Highest stream temperatures occurred in the later part of the trapping season each study year.

The MWAT in 2015 was 18.8 ^oC (65.8 ^oF); and occurred on 7/28/15 (Table 25). MWMT in 2015 was 21.4 ^oC (70.5 ^oF) and occurred on 6/25/15 (Table 25). MWAT and MWMT in 2014 were similar to previous study years (Table 25).

The average daily stream temperature increased over the study period (day) in 2015 (Fig. 17), as well as in past study years (Fig. 18).

Table 25. Average monthly stream temperature (ºC) (ºF in parentheses) at the trapping site in study years 2004 - 2015, lower Redwood Creek, Humboldt County, CA.

	Average stream temperature in Celsius (ºF in parentheses)				
Study Year	April	May	June	July	Avg.
2004	11.9 (53.4)	14.7 (58.5)	16.8 (62.2)	18.6 (65.5)	15.5 (59.9)
2005	11.5 (52.7)	12.8 (55.0)	14.6 (58.3)	18.5 (65.3)	14.3 (57.7)
2006	10.4 (50.7)	13.9 (57.0)	16.7 (62.1)	18.2 (64.8)	14.8 (58.6)
2007	10.7 (51.3)	13.4 (56.1)	16.4 (61.5)	18.5 (65.3)	14.8 (58.6)
2008	9.8 (49.6)	13.5 (56.3)	15.6 (60.1)	17.4 (63.3)	14.1 (57.4))
2009	10.7 (51.3)	12.9 (55.2)	15.7 (60.3)	17.3 (63.1)	14.2 (57.6)
2010	10.1 (50.2)	11.1 (52.0)	13.8 (56.8)	17.2 (63.0)	13.1 (55.6)
2011	9.2 (48.6)	11.3 (52.3)	14.5 (58.1)	17.4 (63.3)	13.1 (55.6)
2012	11.5 (52.7)	12.8 (55.0)	15.2 (59.4)	17.2 (63.0)	14.1 (57.4)
2013	11.2 (52.2)	14.3 (57.7)	16.7 (62.1)	17.7 (63.9)	15.0 (59.0)
2014*	12.1 (53.8)	14.8 (58.6)	17.1 (62.8)	18.2 (64.8)	15.6 (60.1)
2015*	11.9 (53.4)	14.6 (58.3)	17.6 (63.7)	18.3 (64.9)	15.6 (60.1)
Avg.	10.9 (51.6)	13.3 (55.9)	15.9 (60.6)	17.9 (64.2)	14.5 (58.1)

* Severe drought year in California.

Table 26. Maximum weekly average temperature (MWAT) and maximum weekly maximum temperature (MWMT) for stream temperatures ºC (ºF in parentheses) at the trap site during trap deployment in lower Redwood Creek, Humboldt County, CA., study years 2004 – 2015.

	MWAT		MWMT	
Study Year	Date of Occurrence	ºC (ºF)	Date of Occurrence	ºC (ºF)
2004	7/22/04	19.3 (66.7)	7/18/04	22.2 (72.0)
2005	7/17/05	19.2 (66.6)	7/17/05	22.1 (71.8)
2006	7/25/06	19.2 (66.6)	7/25/06	22.7 (72.9)
2007	7/21/07	19.2 (66.6)	7/31/07	22.4 (72.3)
2008	7/07/08	18.2 (64.8)	7/07/08	21.1 (69.8)
2009	8/11/09	18.3 (64.9)	8/11/09	20.9 (69.7)
2010	7/14/10	17.9 (64.3)	7/17/10	20.8 (69.4)
2011	7/29/11	18.1 (64.6)	7/29/11	21.2 (70.2)
2012	8/11/12	18.0 (64.4)	8/11/12	20.7 (69.3)
2013	7/01/13	18.8 (65.8)	7/01/13	22.0 (71.6)
2014*	7/07/14	18.4 (65.1)	7/3, 7/7	21.3 (70.3)
2015*	7/28/15	18.8 (65.8)	6/25/15	21.4 (70.5)

* Severe drought year in California.

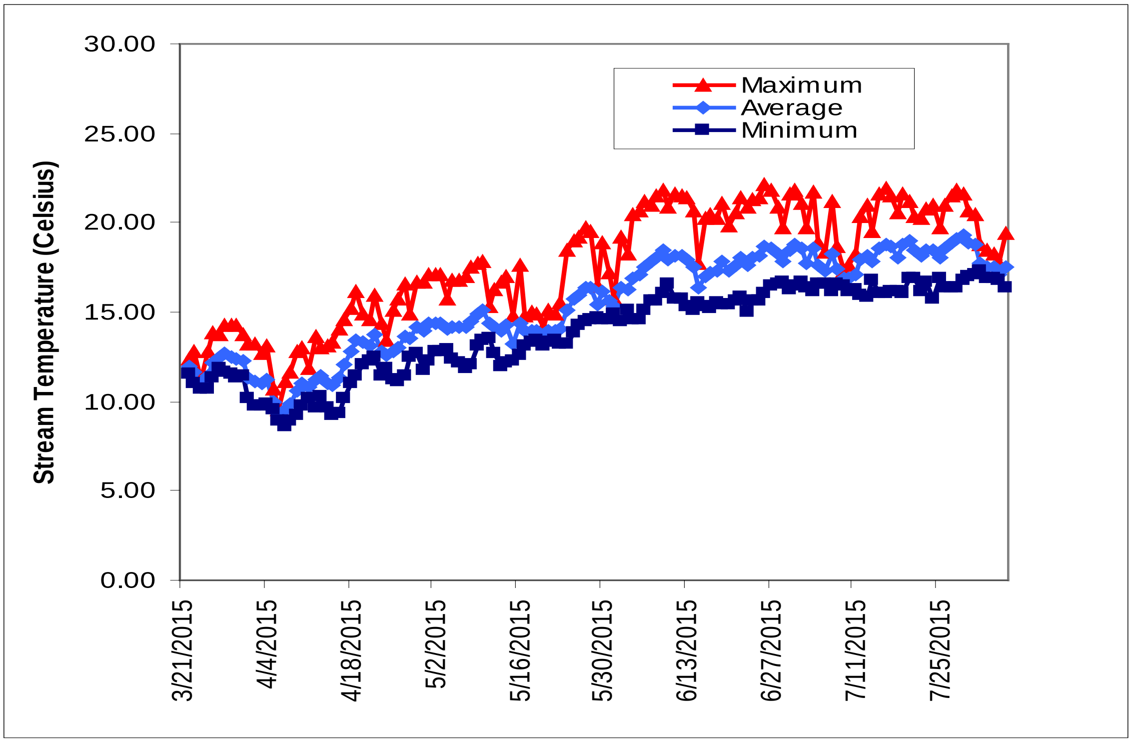

Figure 17. Average, minimum, and maximum stream temperatures (ºC) during trap deployment in lower Redwood Creek, Humboldt County, CA., 2015.

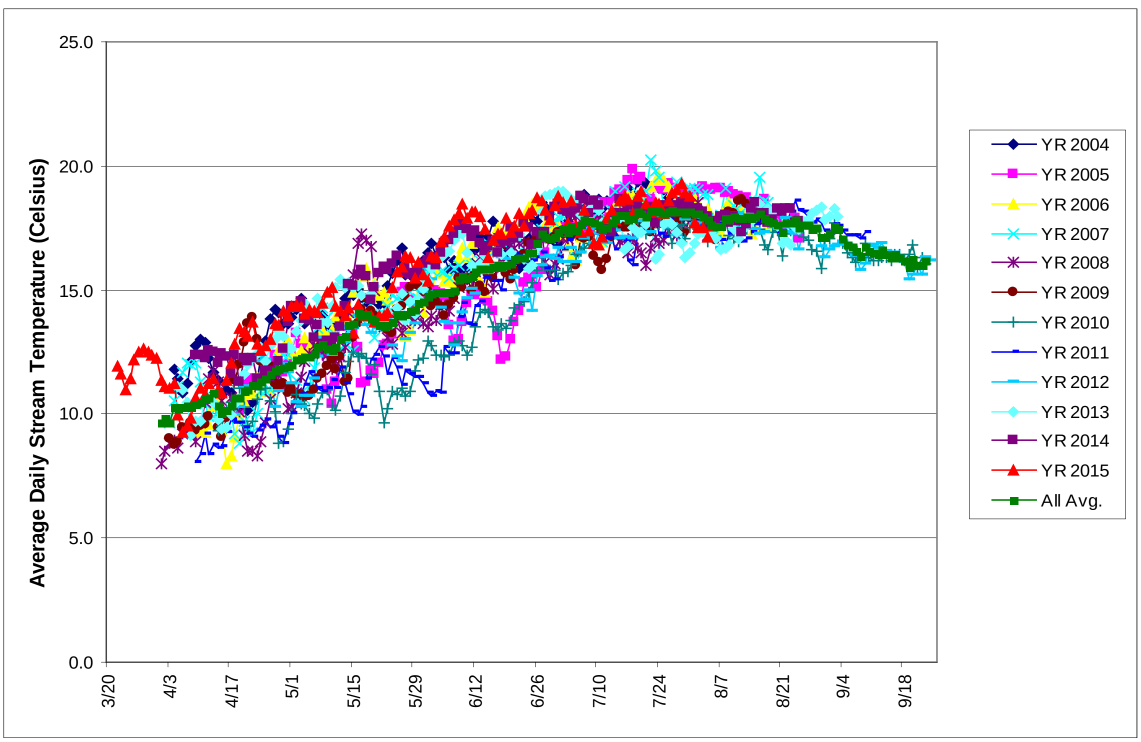

Figure 18. Average daily stream temperatures (ºC) in YRS 2004 – 2015, and average daily stream temperatures (ºC) for all years, lower Redwood Creek, Humboldt County, CA.

DISCUSSION

The main goal of our downstream migration study in lower RC is to estimate and monitor the production of Chinook Salmon, Steelhead Trout, Coho Salmon, and Coastal Cutthroat Trout smolts from the majority of the RC basin in a reliable, long-term manner. The majority of the RC basin includes all streams upstream of the confluence of Prairie Creek, at Rm 3.5. With inclusion of smolt abundances from Prairie Creek and lower RC, we are able to produce smolt population abundances from the entire RC watershed. The long term goal is to monitor trends in smolt abundance and smolt size, and to detect positive or negative changes due to watershed conditions and restoration activities in the basin.

RC is a difficult stream to monitor adult Salmon and Steelhead populations on a long term basis using traditional techniques (weirs and spawning ground surveys) due to adult Salmon and Steelhead run timing, water depth, precipitation, hydrology, and stream turbidity. Recently, adult Salmon and Steelhead Trout are counted as they move upstream through lower RC with a DIDSON sonar unit (Metheny and Sparkman 2015), and redds from spawning adults are being counted in randomly chosen areas within the watershed to get a basin wide estimate of the number of redds present using a Coho Salmon sampling frame (CDFG AFRAMP). The DIDSON sonar will provide adult escapement that will prove useful for understanding smolt population dynamics in RC. The future for fisheries work in RC is to continue enumerating smolts and adults in order to make RC a life cycle monitoring station, which can then be used to assess smolt to adult survival (given age class structure of adults for each brood year), and adult to smolt survival. Knowing the number of adults that produced the smolts would greatly increase our ability to detect positive effects on fish populations attributable to watershed restoration within the RC basin. Determining the abundance of smolts in RC is important for a variety of reasons, irrespective of a life cycle monitoring station. According to Seiler et al. (2004), “quantifying juvenile anadromous salmonid populations as they migrate seaward is the most direct assessment of stock performance in freshwater”. In addition, studies in various streams have found that smolt numbers can relate to stream habitat quality, watershed condition, restoration activities, the number of parents that produced the cohort, and future adult populations.

The 12th consecutive year of trapping in lower RC occurred during a WY with a 39% decrease in streamflow compared to the historic average, and a 66% decrease in average monthly stream discharge during the majority of the trapping season (April – July). Average monthly stream flows in May, June, and July were the lowest of a 64 year record. WY 2015 may be considered a ‘severe’ drought based upon findings provided by Griffin and Anchukaitis (2014) for WY 2014. The environmental conditions for downstream migrant trapping in 2015, with exception to high flows in late March and early April, were difficult to operate the trap in due to low stream flows and drought conditions. As a consequence of drought conditions, we had to panel stream flow into the trap much earlier than previous study years to keep the trap operating throughout the migration period, and to obtain adequate trapping efficiencies for 1+ Coho Salmon and 2+ Steelhead Trout. The main focus of this study with our current funding source is to determine the population abundance of 1+ Coho Salmon smolts, which are relatively rare in Redwood Creek. Thus, to determine a reliable 1+ Coho Salmon (and 2+ Steelhead Trout) estimate, we captured more 0+ Chinook Salmon than necessary, and at a rate (trapping efficiency) higher than necessary. Similar to past study years, we conducted numerous delayed mortality experiments with 0+ Chinook Salmon in 2015 and proved we were not causing immediate or delayed mortality (beyond negligible) from capture and handling.

We missed six days of trapping in 2015 due to high flow events, observing July 4th, and lack of stream flow to spin the trap's cone. However, the estimates for missed catches and subsequent expansions to the population level were negligible for each species at age; the greatest impact on a population estimate was estimated at 3.4%, and for most species at age less than 2%. The number of fish missed when the trap was inoperable did not greatly impacted population estimates. Thus, this season's trapping resulted in very good estimates of wild Chinook Salmon, Steelhead Trout, Cutthroat Trout, and Coho Salmon smolt abundances from areas upstream of the trapping site. The abundance estimates for 1+ Chinook Salmon smolts (+ or – 39%), 0+ Coho Salmon (+ or – 37%), and Cutthroat Trout (+ or – 32%) were not as precise as for other species at age, yet sample sizes for marking these fish were much lower. The decrease in precision should not preclude the fact that 1+ Chinook Salmon smolts, 0+ Coho Salmon, and juvenile Cutthroat Trout smolts were in low abundance in 2015.

0+ Chinook Salmon

0+ Chinook Salmon (ocean-type) were the most numerous migrant captured in 11 of 12 consecutive study years, and over the 12 year period we captured a total of 858,162 individuals. Relatively low catches occurred in YRS 2005 and 2006, and much higher catches occurred in YRS 2004 and 2007 – 2015. The total trap catch (n = 175,966) in 2015 was the highest of record, and 2.8 times greater than the previous 11 year average (Avg. = 58,720). We attribute the high trap catches in 2015 to reduced stream flows, which required paneling earlier than previous study years, and subsequently increased our trapping efficiency. The high catches were not due to a large increase in 0+ Chinook population abundance in 2015 because the population abundance was only 63,000 above average. We normally install weir panels upstream of the trap each study year to force more water to the cone area in order to: 1) increase cone revolutions above the minimum required, and 2) increase our ability to obtain population estimates for 1+ Coho Salmon and 2+ Steelhead Trout with moderate error (goal of CV less than 15%, population point estimate error less than 30%). The by-product of paneling is increasing the capture efficiency of 0+ Chinook Salmon above what is necessary to determine a reliable population estimate. However, if we did not panel, the trap's cone would stop, thus ending the smolt abundance study before migration ended. Additionally, we would not be able to produce a reliable population estimate for 1+ Coho Salmon and 2+ Steelhead Trout smolts. Thus, to determine a reliable 1+ Coho Salmon (and 2+ Steelhead Trout) estimate, we captured more 0+ Chinook Salmon than necessary.

The population abundances of 0+ Chinook Salmon passing through lower RC showed variability nearly each study year. Compared to the 12 year running average, three years were above average, and nine years were below average. The 12 year average in population abundances equaled 238,099 individuals, and on a seasonal basis, ranged from 85,149 – 566,859. Production in 2015 (N = 295,664) was the third highest of record, 1.3 times greater than the previous 11 year average, and 1.4 times greater than abundance in 2014 (N = 209,005). The 0+ Chinook Salmon population abundance measured in lower RC in 2015 was 49% less than the population passing through mid to upper RC in 2015 (N = 575,353) (Sparkman 2016), and 13 times greater than abundance measured in lower Prairie Creek in 2015 (N = 22,562) (Wilzbach et al. 2016). Abundances in mid/upper RC have been greater than abundances in lower RC in four out of 12 years where comparisons were possible. We speculate that, for mid/upper RC where nearly half of the Chinook juveniles migrate as fry, high flows in late March/early April can cause considerable mortality to the downstream migrating fry. In 2015, we estimate that 260,000 fry migrated downstream from mid/upper RC prior to these 'fry stressor' flows, and based upon a much lower abundance in lower RC in 2015, must have faced considerable mortality. Zimmerman et al. (2015) also attributed high mortality to post emergent Chinook Salmon fry to elevated stream flows in the Skagit River, Washington over a 16 year period.

0+ Chinook Salmon migrated downstream through lower RC nearly each day during the trapping period in 2015. Weekly peaks in abundance during a given study year were relatively large, ranging from 26,441 – 110,980 individuals. In 2015 the peak in weekly abundance equaled 46,295 individuals and occurred in early June, much later than the peak in 2014. Migration per month can be variable and quite large, and over 12 years ranged from 25 – 293,155 individuals. The pattern in monthly population abundance in 2015 showed an abundant, earlier migration pattern (similar to 2014) compared to the previous 11 year average. Migration in March 2015 equaled 22,289 individuals, and migration in May 2015 was 2.1 times greater than the previous 11 year average. We attribute the earlier migration pattern to progeny of the September/October run of adult Chinook Salmon, and drought conditions during the juvenile migratory period. However, migration peaked in June in 2015 (same month as the previous 11 year average), and the two most important months were May/June in 2015 and for the previous 11 year average. In upper RC, the two most important months in 2015 were March/April (Sparkman 2016), and for lower PC March/May (Wilzbach et al. 2016).

Each study year 0+ Chinook Salmon (ocean-type) emigrating from RC exhibit two different juvenile life histories (fry and fingerling) based on size and time of downstream migration. The fry (Avg. FL = 40 mm in 2015) are migrating shortly after emergence from spawning redds, and therefore are much smaller than the fingerlings (or smolts) (Avg. FL = 68 mm in 2015) which have reared in the stream for a longer period of time prior to passing the trap site. Similar to past study years, with exception to 2013, there was little overlap in the migration of fry and fingerlings in 2015. The first weekly peak (3/19 – 3/25) consisted of 99% fry, and the second and third peaks in migration consisted solely of fingerlings (100%). Fry and fingerlings that are marked for efficiency trials in the upper basin are captured each year by the trap in lower RC, thus some of the fry from the upper basin are rapidly moving downstream to lower RC. Factors that can influence the temporal component to fry and fingerling migration are: 1) time of adult spawning, 2) how far upstream of the trap site the adults spawned, 3) time from egg deposition to fry emergence from redds, and 4) travel rate, among other factors.

Small numbers of fry relative to the number of fingerlings migrated downstream through lower RC each study year, with exception to YRS 2004, 2011, 2013, and 2014. The greatest number of fry migrating downstream towards the estuary and ocean occurred in 2013 (N = 122,371), and accounted for 22% of the population abundance. In 2014, 34% (or 71,878) of the migrants were in the fry category which was the highest percentage of record. We suspect fry migration was greater in 2014 because adults spawned lower in the basin, and therefore had much less distance to travel before reaching the trap in lower RC (Sparkman et al., In progress$_a$). In 2015, only 8.8% of the migrants were classified as fry, which we attribute to adults spawning higher in the basin (mid-upper RC). The percentages of fry in the 0+ Chinook Salmon populations passing through the lower basin over the current 12 years ranged from 0.1 – 34%, and averaged 10%. The previous 11 year average (excludes 2015) equaled 10% was well. 0+ Chinook Salmon fingerlings comprised the majority of the population each year, with percentages ranging from 66 – 99.9% of total abundance; the greatest number of fingerlings (N = 472,306) migrating downstream occurred in 2004. In 2015, 91.2% (or 269,791) of the 0+ Chinook Salmon population consisted of fingerlings. In contrast, the 0+ Chinook Salmon population emigrating from upper RC consisted of nearly equal numbers of fry (129,055 or 53%) and fingerlings (115,703 or 47%) when averaged over a 16 year period (YRS 2000 – 15) (Sparkman 2016). In 2015, 64% (N = 367,839) of the 0+ Chinook Salmon emigrant population passing through upper RC consisted of fry (Sparkman 2016), and in Prairie Creek 30% (N = 6,785) of the migrants consisted of fry (Wilzbach et al. 2016). Unlike the severe drought in WY 2014 when stream flows restricted upstream passage, streamflows during the adult migratory period in 2014/15 were adequate for adult passage into mid-upper RC. Thus, production of juveniles in mid-upper RC in 2015 was much higher than in 2014, and moderately higher for juveniles passing through lower RC in 2015.

Other streams besides RC experience large migrations of Chinook Salmon fry as well (Allen and Hassler 1986, Healey 1991, Taylor and Bradford 1993, Thedinga et al. 1994, Bendock 1995, Roelofs and Klatte 1996, Seiler et al. 2004, Greene et al. 2005, Zimmerman et al. 2015, among others). Healey (1991) reported that it is common for Chinook Salmon fry to migrate downstream soon after emergence, and cited at least five studies which documented this dispersal. Healy (1991) further reports that fry entering some estuaries may make up the majority of the juvenile population, and that this trait is probably not maladaptive. Bendock (1995) reported ‘large’ numbers of post emergent fry were captured from the beginning of trapping in Deep Creek, Alaska, and Seiler et al. (2004) stated that about 53% (or 386,315 individuals) of the total juvenile Chinook Salmon production (upstream of the trap site) migrated as fry in the Green River, WA. Unwin (1985) reported that 91 - 98% of the juvenile Chinook Salmon emigrants were newly emerged fry in the Glenariffe stream, New Zealand; and Solazzi et al. (2003) show that Chinook Salmon fry emigration in various Oregon streams can be substantial, numbering near one million individuals in the North Fork Nehalem River in 2002. Dalton (1999) determined 93 - 98% of emigrating juvenile Chinook Salmon migrated as fry in the Little North Fork Wilson River, Oregon, and similar percentages were found in the Little South Fork Kilchis River, Oregon. In contrast, Roper and Scarnecchia (1999) found only 10% of the juvenile Chinook Salmon production emigrated at lengths < 50 mm FL (size of fry) in the South Umpqua River basin, Oregon.

Healey (1991) commented that fry are not surplus or lost production that will never augment future adult populations, and we also believe fry should be part of a juvenile Chinook Salmon emigrant population estimate. Chinook Salmon fry in upper and lower RC often appear smolt-like (very silvery, parr marks nearly absent or obscured to some degree by silver colored scales) and can undergo smoltification while migrating downstream from upstream spawning or rearing areas (Allen and Hassler 1986, Quinn 2005). In addition, Myers el al. (1998) summarize that ocean-type Chinook Salmon fry can migrate immediately to the ocean in sizes ranging from 30 – 45 mm FL. Healey (1980), Carl and Healey (1984), Allen and Hassler (1986), and Healey (1991) also report that Chinook Salmon fry can immediately migrate downstream to the estuary and ocean. Numerous authors also claim that estuaries are important areas for ocean-type fry to rear for some time period prior to ocean entry, however, the RC estuary is in an impaired condition. Although fry to adult survival is likely less than that of fingerlings, some of the fry do survive to adulthood (Unwin 1997) and thus make a contribution to the adult population (Healey 1991). Other anadromous salmonids (Chum Salmon, Pink Salmon) show this life history to a larger degree. Supportive evidence of fry to adult survival is hard to find in the literature probably because most long lasting marks or tags are too big for fry, with the exception of coded wire tags (1/2 tags) and otolith marking (during egg incubation). The exact reasons (environmental, genetic, behavioral, or some combination thereof) why Chinook Salmon fry migrate downstream immediately after redd emergence is worthy of additional study, as is their contribution to adult returns.

The average FL (64 mm) of 0+ Chinook Salmon migrants in 2015 was 1 mm greater than average FL (mm) in 2014, and Wt (g) in 2015 was 0.02 g heavier than the average in 2014. These differences are unlikely to have biological meaning. Both average FL (mm) and Wt (g) in 2015 were below the previous 11 year average by 2.3 mm and 0.42 g. The average size (FL mm) over 12 years ranged from 60 – 76 mm, and fell within the range provided by Healey (1991). The size of 0+ Chinook Salmon migrants passing through lower RC over the 12 consecutive years was negatively related to population abundances ($p < 0.05$), indicating density dependence. Although 0+ Chinook Salmon migrating through lower RC were, on average, larger than those emigrating from upper RC (Avg. = 50 mm in 2015) and lower Prairie Creek (Avg. = 61 mm in 2015), the relatively small size indicates that 0+ Chinook Salmon migrants in lower RC need to increase size to increase survival to adulthood. Unfortunately, lower RC and estuary are currently in an impaired condition, and most likely limit any additional increases in freshwater growth (and survival) which are needed to increase smolt to adult survival. Given successful stream restoration, a reversal of the small size and negative relationship with population abundances would be beneficial for increasing smolt to adult survival since larger smolts are considered to have greater survival than smaller smolts (Martin et al. 1989, Nicholas and Hankin 1989, Duffy and Beauchamp 2010, Claiborne et al. 2011, Tipping 2011). The reasons for relative increases in smolt abundances over years are most likely due to a greater number of returning adults (Roper and Scarnecchia 1999), and whether or not they are able to reach mid-upper RC for spawning. Reasons for decreased production are likely due to a lesser number of adult returns, spawning lower in the basin, and whether or not spawning redds were subjected to redd scouring flows in the mid-upper basin. Although adult harvest is not allowed in RC, the ocean Salmon fishery in California does harvest (mixed stock fisheries) an unknown number of adult Chinook Salmon that belong to RC. Therefore, scientific studies designed to determine the harvest and take of RC Chinook Salmon in the ocean fisheries are warranted.

The DIDSON sonar escapement data for RC will provide information that can be used to assess ocean harvest levels on returning adult Chinook Salmon to RC. Given enough study years, we can compare the trends of returning adults to RC to those returning to the Klamath River and Trinity River stocks, which are the target of local ocean fisheries. If the trends are different, for example negative for RC and positive for Klamath-Trinity Rivers, then a logical conclusion is that the RC stock is being harvested at a higher rate in the ocean than the Klamath and Trinity River stocks. Additionally, if a given smolt cohort is numerous in RC, then we should see higher adult returns to RC if ocean conditions are favorable, and ocean harvest on the RC stock is low. If an abundant smolt cohort fails to return as adults at moderate to relatively high numbers during periods of favorable ocean conditions, then a logical conclusion would be that the ocean harvest of adults was excessive.

The combination of smolt data and sonar data of returning adults has allowed for RC to become a Life Cycle Monitoring Station. This in turn will provide data for critically examining smolt numbers in light of the number of adults responsible for smolt production, drought, stream flow, stream habitat conditions, watershed restoration activities, and flood flows. We now have the technology and means to conduct such a detailed study, however, funding is problematic, and not likely.

1+ Chinook Salmon

One year old juvenile Chinook Salmon (stream-type) in RC represent the third juvenile Chinook Salmon life history. 1+ Chinook Salmon can be confused with 1+ Coho Salmon because they appear very similar. However, 1+ Chinook Salmon have wider parr marks, and an anal fin that appears as a triangle or pyramid when the fish is held upright (horizontal) and out of water. 1+ Coho Salmon have narrower parr marks, and an anal fin that has a leading edge that extends beyond the posterior insertion point of the fin. The most difficult juvenile salmonids to identify in RC are distinguishing 1+ Chinook Salmon smolts and 1+ Coho Salmon smolts; however, crew members have extensive experience identifying the two juvenile species. Stream-type juvenile Chinook Salmon are easily differentiated from ocean-type juvenile Chinook Salmon by size at time of downstream migration, and general appearance. The average size (FL mm) in April 2015, for example, was 94 mm for 1+ Chinook Salmon and 49 mm for 0+ Chinook Salmon.

1+ Chinook Salmon in RC are in very low abundance as evidenced by trap catches totaling 341 individuals over 12 consecutive study years. In contrast, we captured a total of 858,162 0+ Chinook Salmon over 12 consecutive years passing through lower RC. Trap catches of 1+ Chinook Salmon in 2014 equaled 205, and was the highest of record. The population abundance of yearling Chinook Salmon smolts equaled 1,268 in 2014, and was also the highest of record. We suspect catches and population abundances were higher in 2014 because 0+ Chinook Salmon abundance in 2013 was the highest of record, and some of the juveniles in 2013 stayed in the stream to later migrate downstream in 2014. In addition, sections of RC near the trap site dried up in 2013, which prevented some of the juveniles from migrating to the estuary and ocean as young of year. In 2015, population abundance was much lower, and equaled 17. The abundance in mid-upper RC was zero in 2015 (Sparkman 2016) and only three were captured moving through lower Prairie Creek in 2015 (Wilzbach et al. 2016). Over all study years, population abundances through lower RC ranged from 0 – 1,268 individuals, and averaged 243. 1+ Chinook Salmon population abundance in a given year was positively correlated to 0+ Chinook Salmon population abundance the previous year, and supports our hypothesis that with higher 0+ Chinook Salmon abundances we find more 1+ Chinook Salmon the following year.

The migration period of 1+ Chinook Salmon is compressed compared to most juvenile (smolt) salmonids, with most emigrating downstream during April – early June. In 2015, migration occurred during March, April, and May.

When present, 1+ Chinook Salmon in RC are more likely to be progeny of fall/winter-run Chinook Salmon adults than from spring-run adults because few if any spring-run Chinook Salmon are observed during spring and summer snorkel surveys in RC (Dave Anderson, pers. comm. 2015). For example, in 27^{+} years of adult summer Steelhead snorkel dives, adult spring Chinook Salmon were only observed in one year (1988) and in very low numbers (< 7 individuals) (Dave Anderson, pers. comm. 2015). Although anecdotal, local citizens in Orick, CA state that there used to be a moderate run of spring-run Chinook Salmon in RC. Current stream conditions are not suitable for spring-run Chinook Salmon because stream flows during late spring/summer months can become so low that adult upstream passage into RC can become problematic. Additionally, high average stream temperatures (eg > 20 °C) may also prevent any adult spring-run Chinook Salmon migration into RC, or inhibit their ability to over-summer in pools. The sedimentation in RC and subsequent decrease in pool depths and other stream habitats may also limit the ability to over-summer as well.

Thus, a spring run of Chinook Salmon adults was probably not responsible for the production of yearling Chinook Salmon juveniles in RC. Bendock (1995) found both stream-type and ocean-type juvenile Chinook Salmon in an Alaskan stream which only has one adult Chinook Salmon race, and Conner et al. (2005) reported that fall Chinook Salmon in the Snake River produced juveniles exhibiting an ocean-type or stream-type juvenile life history. Zimmerman et al. (2015) reported that for six spawning populations (spring, summer, and fall) of Chinook Salmon in the Skagit River, all produced progeny showing ocean-type and stream-type life histories. Teel et al. (2000) found that for some populations of coastal Chinook Salmon, ocean-type and stream-type juveniles were genetically undifferentiated, and probably arose from a common ancestor. They further conclude that the stream-type life history probably evolved after the ocean-type colonized (post glacial period) the rivers in study. An important question which may be unanswerable, is whether the one year old life history for juvenile Chinook Salmon in RC was more prevalent prior to the changes in the watershed associated with land use activities, flood events, and natural, geologic processes. Perhaps with continued stream restoration and maturation of the riparian zone in RC, we will see an increase in the numbers of stream-type Chinook Salmon smolts. The 1+ Chinook Salmon life history may be important for increased ocean survival of Chinook Salmon juveniles, and general species diversity (author, Don Chapman pers. comm. 2003).

0+ Steelhead Trout

The number of 0+ Steelhead Trout that can remain upstream of the trap site is considered to be some function of a fish's disposition to out-migrate (or not out-migrate) and habitat carrying capacity. Meehan and Bjornn (1991) comment that juvenile Steelhead Trout have a variety of migration patterns that can vary with local conditions, and that the trigger for out-migration can be genetic or environmental. They further state that some Steelhead populations normally out-migrate soon after emergence from redds to occupy other rearing areas (we observe this as well in both upper and lower RC, and Prairie Creek). Passive or involuntary downstream migration can also occur when stream discharge increases, and small individuals are swept downstream. Habitat carrying capacity is generally thought to be related to environmental (hydrology, geomorphology, stream depth and discharge, stream temperatures, cover, sedimentation, etc.) and biological variables (food availability, predation, salmonid behavior), and any interactions between the two types of variables (Murphy and Meehan 1991). The general idea is that when habitat carrying capacity is exceeded (e.g. over-seeding, surplus production), juvenile fish emigrate to find other areas to rear. A problem with the view of habitat carrying capacity's affect on migration is that it fails to explain why juvenile salmonids (e.g. 0+ SH, 0+ CO) emigrate downstream at low, upstream densities or low, upstream population levels.

Young-of-year Steelhead Trout downstream migration in RC is considered to be stream redistribution (passive and active) because juvenile Steelhead Trout in California normally smolt and enter the ocean at one to two years old, with lesser numbers out-migrating at an age of 3^+ years (Busby et al. 1996). Perhaps the most important findings with respect to 0+ Steelhead Trout movements in RC were from experiments conducted in YRS 2006, 2007, 2010, 2011, and 2014 in which we marked 0+ Steelhead Trout (FL 40 – 60 mm) in the upper basin to later see if we would recapture a given percentage at the trap in lower RC. Recaptures occurred within each study year of the experiments, and in 2014 we recaptured 15 out of 300 marked with a small, partial upper caudal fin clip (snip). Time to travel the 29 miles downstream in 2014 ranged from 5 – 27 d, and averaged 14.1 d (SD = 7.3 d). Travel rate ranged from 1.1 – 5.8 mi/day, and averaged 2.7 mi/d (SD = 1.6 mi/d). To the best of our knowledge, these were the first experiments to show 0+ Steelhead Trout may travel considerable distances (29 mi.) while moving downstream in search of rearing areas.

We did not consider any of the young-of-year Steelhead Trout to be progeny of Cutthroat Trout in this study because few age-1 and older Cutthroat Trout were captured in any given year. Far more age-1 and older juvenile Steelhead Trout (1+ and 2+) migrated through lower RC than Cutthroat Trout as evidenced by trap catches and population abundances. In 12 study years, for example, the ratio of 1+ and 2+ Steelhead Trout combined catches to Cutthroat Trout catches each year ranged from 29:1 to 596:1, and averaged 182:1. In other words there was, on average, 182 times more 1+ and 2+ Steelhead Trout captured than Cutthroat Trout. Ratios would be even higher if population data were used instead of catch data; thus it seems very unlikely that low numbers of Cutthroat Trout could produce a significant or even moderate portion of the young of year Trout captures. Therefore, we considered the percentage of 0+ Cutthroat Trout included in the 0+ Steelhead Trout catch to be low and negligible.

We are unable to determine population abundances of 0+ Steelhead Trout migrants because many are too small to mark without injury, and potentially affecting survival and growth. The total trap catch of 0+ Steelhead Trout (n = 39,779) in 2015 in lower RC was the third highest of record, and much greater than catches for 1+ Steelhead Trout and 2+ Steelhead Trout in 2015. Trap catches of 0+ Steelhead Trout in YRS 2004 – 2015 ranged from 1,345 – 42,827 individuals, and averaged 21,832. In 2015, the majority of catches occurred in June and July (n = 33,859 or 85% of total; data not given in report).

Relatively high catches of young-of-year Steelhead Trout by downstream migrant traps in small and large streams is not uncommon (USFWS 2001, Rowe 2003, Johnson 2004, Don Chapman pers. comm. 2004, Sparkman 2016). For example, 0+ Steelhead Trout catches in upper RC from YRS 2000 – 2015 ranged from 32,585 - 128,885, averaged 71,296 per year, and in 2015 a total of 100,672 0+ Steelhead Trout were captured moving downstream (Sparkman 2016), and 939 0+ Trout (includes young of year Steelhead Trout and Cutthroat Trout) were captured moving downstream in lower Prairie Creek (Wilzbach et al. 2016). Similar to 0+ Chinook Salmon in RC, mid to upper RC is important for adult Steelhead Trout spawning. The high trap catches in upper and lower RC may indicate that adequate numbers of adult Steelhead Trout return to spawn in most years, and that habitat may be limiting the abundance of older juvenile Steelhead Trout, which in turn may limit a greater abundance of adult Steelhead Trout in following years.

The 0+ Steelhead Trout captured by the trap in lower RC indicate these fish are going to rear for some time period in lower RC (including the estuary), or Prairie Creek. Dave Anderson (pers. comm. 2015), for example, occasionally captures young-of-year Steelhead Trout (and Coho Salmon) in the estuary during summer and early fall sampling. The relatively large number of 0+ Steelhead Trout migrating downstream past the trap site in 2015 indicates the condition of lower RC (and estuary) is important for rearing, and that habitat impairment could negatively impact survival and growth of 0+ Steelhead Trout, which in turn could influence the number of older, juvenile Steelhead Trout in following years.

1+ Steelhead Trout

One-year-old Steelhead Trout smolts, on a population level, were the most numerous age-1 and older juvenile Steelhead Trout migrating downstream through lower RC each study year. The ratio of 1+ Steelhead Trout population abundances to 2+ Steelhead Trout population abundances over 12 years ranged from 2.7:1 – 23.4:1, averaged 5.9:1, and in 2015 equaled 3.1:1. For comparison, the ratio in 2015 equaled 7.5:1 in upper RC (Sparkman 2016) and 1.7:1 in lower Prairie Creek (Wilzbach et al. 2016). On a percentage basis, 1+ Steelhead Trout migrating through lower RC comprised 73 – 96% of the total juvenile Steelhead Trout age-1 and older population abundance each study year, and in 2015 1+ Steelhead Trout comprised 76% of the total juvenile Steelhead Trout age-1 and older population abundance. Clearly, 1+ Steelhead Trout comprise the majority of Steelhead Trout smolts passing the trap site in lower RC.

Information in the literature indicates Steelhead Trout smolting at age-1 is not uncommon, particularly in streams that are south of British Columbia (Quinn 2005, Busby et al. 1996). The percentage of 1+ Steelhead Trout showing parr characteristics in lower RC was very low each study year (0.0 - 0.6%), and indicated few 1+ Steelhead Trout migrated downstream in a stream-residence form (parr). In contrast, the majority of 1+ Steelhead Trout (68 – 97%) in a given study year were emigrating in a smolt stage, and 97% were classified as smolts in 2015. A caveat to our visual determination of developmental stages (parr, pre-smolt or smolt) is that fish were examined under a tarp (used as a roof for the processing station), and were shielded from direct sunlight. On several occasions we observed that fish seen in direct sunlight were more smolt like in appearance than if observed in the shade. Thus, the percentage of pre-smolts would be lower if observed in direct sunlight, and the percentage of smolts would be higher. Given more data years, we may find relationships between developmental stages and physical variables measured in the stream. Quinn (2005) reported both photo period and steam temperature play important roles in smoltification by providing an external stimulus for the endocrine system, which in turn drives the internal physiological changes necessary for smoltification.

1+ Steelhead Trout population abundances over 12 years ranged from 20,501 – 77,221 and averaged 39,522. Abundance in 2015 (N = 56,020) was the second highest of record, and 1.5 times greater than abundance in 2014. In comparison, abundance in upper RC in 2015 equaled 33,809 (Sparkman 2016) and in lower Prairie Creek equaled 7,786 (Wilzbach et al. 2016). With high abundance in 2015, the negative trend over time for populations passing through lower RC was no longer statistically significant ($p > 0.05$). The high abundance determined in 2015 indicated that 1+ Steelhead Trout successfully survived the rather harsh summer conditions in 2014 (drought year) as young of year with respect to low stream flows and high stream temperatures. For example, in lower RC stream temperatures averaged 17.6 °C (63.7 °F) from June – August, 2014, and reached a maximum of 21.8 °C (71.2 °F); in upper RC, stream temperatures from June 1, 2014 – August 7, 2014 averaged 19.3 °C (66.7 °F), and reached a maximum of 26.3 °C (79.3 °F). The high abundance in 2015 also showed that high trap catches of 0+ Steelhead the previous year were not negatively impacting recruitment to age-1.

1+ Steelhead Trout migrated downstream through lower RC nearly each day during the trapping period in 2015, with exception to early August when migration tapered off to zero. Weekly peaks in abundance during a given study year were fairly large, ranging from 3,195 – 10,440 individuals. In 2015 the peak in weekly abundance equaled 8,317 and occurred late May/early June, seven weeks later that the peak in 2014. Migration per month can be variable and large, and over 12 years ranged from 0 – 32,906 individuals. The pattern in monthly population abundances in 2015 showed an abundant earlier migration compared to the previous 11 year average, and may indicate a response to decreasing stream flows attributable to drought conditions. Monthly migration in 2015 peaked in May and was 2.7 times greater than average. The two most important months for migration through lower RC were May/June in 2015, compared to April/May in upper RC (Sparkman 2016) and lower Prairie Creek (Wilzbach et al. 2016).

The average size of 1+ Steelhead Trout migrants in lower RC increased over years, and ranged from 84 – 103 mm and 7.04 – 12.27 g. The average FL over 12 years equaled 92.2 mm and average Wt equaled 9.12 g, and average FL in 2015 equaled 103 mm, and average Wt equaled 12.27 g. In comparison, average FL (mm) and Wt (g) in 2015 for populations emigrating from upper RC equaled 94.1 mm and 10.1 g (Sparkman 2016), and for populations emigrating though lower Prairie Creek equaled 99.5 mm and 10.81 g (Wilzbach et al. 2016). Thus, 1+ Steelhead Trout passing through lower RC in 2015 were larger than those passing through upper RC and lower Prairie Creek.

1+ Steelhead Trout are actively migrating from the upper basin to the lower basin as evidenced by trap catches in lower RC of efficiency trial fish and pit tagged fish released from the upper trap site. The marked 1+ Steelhead Trout emigrating from upper RC and through lower RC have also been captured in the estuary (Dave Anderson, pers. comm. 2015) since the beginning of our smolt trapping studies. 1+ Steelhead Trout marked and released at the lower trap (for trap efficiencies) have also been captured in the estuary each study year (Dave Anderson, pers. comm. 2015). Prior to 2015, we had not observed re-migration of 1+ Steelhead Trout into lower or upper RC based upon elastomer marked releases from 2001, 2004, and 2005 (total marked and released equaled 1,097), and pit tagged releases in 2005 – 2013 (total tagged and released equaled 2,354). All 2+ Steelhead Trout captured by the traps were inspected for marks and scanned for pit tags, which would have been applied at age-1. These tests confirmed that the elastomer marked and pit tagged fish did not migrate back upstream to rear for another year and emigrate as age-2 Steelhead Trout smolts. However, in 2015 we captured one 2+ Steelhead Trout that had been pit tagged as a yearling the previous year. Although the sample size was small (eg 1 out of 572, or 0.2%) in 2015, some re-migration can happen. Elastomer mark retention was assumed to be adequate for the studies because Fitzgerald et al. (2004) assessed elastomer mark retention in Atlantic Salmon smolts and found that tag retention in the lower jaw was greater than 90% for the first 16 months. Pit tag retention was also assumed to be sufficient based upon a study by Newby et al. (2007).

As previously mentioned, far more 1+ Steelhead Trout emigrated past the lower trap than older, juvenile Steelhead Trout age classes (2+). The ratio of 1+ Steelhead Trout:2+ Steelhead Trout in 2015 equaled 3:1 in lower RC, 7.5:1 in upper RC (Sparkman 2016), and 1.7:1 in lower Prairie Creek (Wilzbach et al. 2016). 1+ Steelhead Trout downstream migration is not unique to RC, and other downstream migration studies have routinely documented 1+ Steelhead Trout emigration (USWFW 2001, Ward et al. 2002, Johnson 2004; B. Chesney pers. comm. 2011, among many others). However, the ratio of 1+ Steelhead Trout to 2+ Steelhead Trout (range of 3:1 to 23:1) passing through lower RC over 12 consecutive years was much higher than that determined in a nearby river (Mad River), which equaled 1:6 in 2001 and 1:3 in 2002 (Sparkman 2002). Whether these differences are indicative of stream conditions or attributable to the different stock in each stream is unknown. In the Keogh River, British Columbia about 20% of the total Steelhead Trout smolt yield consisted of 1+ Steelhead Trout (McCubbing and Ward 2003).

Based upon studies in other streams, the number of returning adult Steelhead Trout that migrated to the ocean as one-year-old smolts was relatively low, and usually less than 29% (Pautzke and Meigs 1941, Maher and Larkin 1955, Busby et al. 1996, McCubbing 2002, McCubbing and Ward 2003). Based upon scale samples collected from adult Steelhead Trout in RC, the percentage of adults showing the one year old smolt life history equaled 50% in 2008, 40% in 2009, 33% in 2010, 40% in 2012, 70% in 2013, and 30% in 2014 (Sparkman In progress$_a$). CDFW AFRAMP is currently collecting scale samples from adult Steelhead Trout in RC to increase sample size (Sparkman In progress$_a$). The percentage of adult Steelhead Trout that smolt and enter the ocean at age-1, and the reason(s) for the relative large numbers of 1+ Steelhead Trout emigrating from areas upstream of the RC estuary warrants further investigation. Our pit tagging experiments with 1+ Steelhead smolts provide useful insights when conducted over multiple consecutive years because if most of the 1+ Steelhead Trout are not actually entering the ocean, we should then be able to recapture a given percentage of those fish at age-2 the following year with the rotary screw trap in lower RC and seine nets in the estuary; if we fail to recapture any of the marked 1+ Steelhead Trout the following year, then a logical conclusion would be that the fish either stayed in the stream and suffered severe mortality during winter, actually entered the ocean, or some combination of the two factors. To date, we have recaptured one 2+ Steelhead Trout that was marked as a 1+ Steelhead Trout the previous year (1 out of 4,023 or 0.02%). Thus, our data is showing, in combination with adult scale analyses (Sparkman In progress$_a$), that 1+ smolts are entering the ocean at age-1.

We hypothesize that 1+ (and 0+) Steelhead Trout have changed their life history to limit the time spent in freshwater in order to avoid high, and at times, lethal stream temperatures that occur during summer months. In 2006 we observed and documented lethal stream temperatures in upper RC, and every summer in late July we observe maximums in stream temperatures that range from 24.4 – 29.5 ^{o}C (or 75.9 – 85.1 ^{o}F)

(Sparkman 2016). In addition, streamflow during summer months is very low, which decreases the amount of physical space available for rearing. Over-summer conditions, particularly in mid to late July to August, could be limiting the production of older age classes (2+ Steelhead Trout) in RC. However, we may see decreases in sedimentation and stream temperatures due to restoration activities in the basin, which in turn should provide more suitable over-summer conditions for 0+ and 1+ Steelhead Trout. The confound with the effect of summer conditions upon 1+ Steelhead Trout population abundances is that in 2015 we observed a large increase in smolt numbers even though conditions during the summer of 2014 were relatively harsh.

2+ Steelhead Trout

In several studies investigating Steelhead Trout life histories, the majority of the returning adult Steelhead spent two or more years as juveniles in freshwater prior to ocean entry (Pautzke and Meigs 1941, Maher and Larkin 1955, Busby et al. 1996, Smith and Ward 2000, McCubbing 2002, McCubbing and Ward 2003). Pautzke and Meigs (1941), for example, reported that 84% of returning adult Steelhead Trout in the Green River had spent two or more years as juveniles in freshwater. Maher and Larkin (1955) found that 98% of the adult Steelhead they examined had spent two or more years in freshwater prior to entering the ocean, McCubbing (2002) reported 92% of Steelhead adults in a British Columbia stream had spent two or more years as juveniles in freshwater, and McCubbing and Ward (2003) reported that 71% of the adult returns in 2003 had entered the ocean as 2 or 3 year old smolts. If this applies to Steelhead Trout in RC, then 2+ Steelhead Trout are the most important (and most direct) group of juvenile Steelhead Trout that contribute to future adult Steelhead Trout populations. The paradox for the 2+ Steelhead Trout smolts passing through lower RC is that they were far less abundant (by about 62 - 96%) than 1+ Steelhead Trout smolts in any given study year. With respect to the combined population of 1+ and 2+ Steelhead Trout smolts each year, 2+ Steelhead Trout comprised 4 – 27% of the population, and in 2015, 2+ Steelhead Trout comprised 25% of the combined population.

2+ Steelhead Trout are a very difficult smolt to enumerate on the population level because they are very wily and difficult to capture. Our weir paneling, besides keeping the trap operable, is focused to increase the capture and trapping efficiency of 2+ Steelhead Trout in order to achieve a CV for the population estimate less than 15%. 2+ Steelhead Trout population abundances over 12 years ranged from 1,743 – 19,353 and averaged 9,362. Abundance in 2015 (N = 18,155) was the second highest of record, and 1.3 times greater than abundance in 2014. In comparison, abundance in upper RC in 2015 equaled 4,486 (Sparkman 2016) and in lower Prairie Creek equaled 4,520 (Wilzbach et al. 2016). With inclusion of 2014 and 2015 data, linear correlation failed to detect a trend in 2+ Steelhead Trout population abundances in lower RC over years. As discussed in the section for 0+ Chinook Salmon, testing trends in abundance often require numerous, consecutive years of data to determine a reliable trend. The high abundances in 2014 and 2015 could be related to increased over-winter survival for age-1 Steelhead Trout because stream flow conditions in the winter were less harsh due to the severe drought in WY's 2014 and 2015. Similar to 1+ Steelhead Trout, the high abundance determined in 2015 indicated that 2+ Steelhead Trout successfully survived the rather harsh summer conditions in 2014 (drought year) with respect to low stream flows and high stream temperatures as yearling Steelhead Trout.

2+ Steelhead Trout smolts migrated downstream through lower RC nearly each day during the trapping period in 2015, with exception to August when migration tapered off to zero. Weekly peaks in abundance during a given study year were fairly large, ranging from 314 – 3,647 individuals. In 2015 the peak in weekly abundance equaled 3,647 individuals and occurred near mid May. Depending upon study year, weekly peaks in abundances occurred in late April/early May, May, June, late July, and late August. Migration per month can be variable and large, and over 12 years ranged from 0 – 11,956 individuals. Monthly migration in 2015 showed a relatively abundant, earlier migration than previous study years. For example, migration in April was 5.4 times greater than the previous 11 year average, and migration in May was 3.8 times greater. The two most important months for migration in 2015 were April/May, compared to April/May in upper RC (Sparkman 2016) and March/April in lower Prairie Creek (Wilzbach et al. 2016).

Average FL (157 mm) and Wt (39.8 g) of 2+ Steelhead Trout smolts in 2015 were the highest of record, and greater than the previous 11 year average. The size of 2+ Steelhead Trout smolts over 12 years was not related to population abundances, thus density dependence was not detected. Average Wt (g) over study years positively increased, even with larger population abundances. The average FL (mm) of 2+ Steelhead Trout passing through lower RC in 2015 was greater than the average size of migrants from upper RC in 2015 (Avg. = 151), and lower Prairie Creek in 2015 (Avg. = 152 mm). The average Wt (g) of 2+ Steelhead Trout passing through lower RC in 2015 was also larger than 2+ Steelhead Trout in upper RC (Avg. = 39.3 g) (Sparkman 2016) and lower Prairie Creek (Avg. = 36.5 g) (Wilzbach et al. 2016).

The percentage of 2+ Steelhead Trout showing parr characteristics was zero each study year, and indicated 2+ Steelhead Trout do not emigrate through lower RC in a parr stage (stream resident form). Rather, most of the 2+ Steelhead Trout were emigrating in a smolt form. The percentage of 2+ Steelhead Trout emigrants showing smolt characteristics in 2015 (100%) was two percentage points greater than the previous 11 year average. The percentage of 2+ Steelhead Trout showing smolt characteristics in lower RC (analysis not given in text) was not related to population abundances ($p = 0.34$) or stream temperatures ($p = 0.33$). Analysis of trapping data ($n = 15$ years) in upper RC during YRS 2000 – 2014 showed that smolt percentages in a given study year were negatively related to 2+ Steelhead Trout population abundances, and negatively related to stream temperatures (Sparkman 2015). Thus, there were less smolt designations for higher population abundances and during study periods with higher stream temperatures. Quinn (2005) reported that stream temperatures play an important role in smoltification, and our data from the upper basin showed 48% of the variation in smolt percentages over 15 study years can be attributed to the variation in stream temperatures (Sparkman 2015).

Whether this will be true for 2+ Steelhead Trout populations emigrating through lower RC remains to be tested.

2+ Steelhead Trout are actively emigrating from upper RC through lower RC because the trap in lower RC (RM 4) has consistently captured efficiency trial fish from upper RC each study year. Additionally, 2+ Steelhead Trout from upper and lower RC have occasionally been observed in the estuary of RC since the beginning of our smolt trapping studies (Dave Anderson, pers. comm. 2014). Elastomer marked 2+ Steelhead Trout released at the upper trap in YRS 2004 and 2005 were also captured by the lower trap in those years, and in 2015 we recaptured four pit tagged 2+ Steelhead Trout that were tagged and released at the upper trap. Future trapping efforts will try to increase the sample size for travel time and growth information by increasing the sample size of pit tagged releases from upper RC. The lack of large numbers of 3+ Steelhead Trout captured at upper and lower RC provides more evidence that 2+ Steelhead Trout are actively migrating to the ocean, rather than re-distributing (within the basin) to later migrate to the ocean at age-3.

Although there are few studies that specifically look at Steelhead smolt to adult survival, Steelhead life history studies in a British Columbia stream (Keogh River) show there is a positive linear relationship between out-migrating 2+ smolts and returning adult Steelhead (Ward and Slaney 1988, Ward 2000, Ward et al. 2002). Ward (2000) cites other authors who report similar positive linear relationships between smolts and adults along the British Columbia coast as well (eg Smith and Ward 2000). Survival from smolt to adult in the Keogh River can be variable, and may range from an average of 15% (during 1976-1989) to an average of 3.5% (during 1990-1995) (Ward 2000). Ward and Slaney (1988), reporting on data from the Keogh River for 1978 – 1982 cohorts, determined survival from smolt to adult ranged from 7% to 26%, and averaged 16%. Meehan and Bjornn (1991) reported Steelhead smolt to returning adult survival can be a relative high ranging from 10 – 20% in streams that are coastal to a low survival of 2% in streams where Steelhead must overcome dams and travel long distances to reach spawning grounds. It is difficult to make specific inferences about 2+ Steelhead Trout smolt to adult survival for RC Steelhead based upon successful studies in the literature because of differences in latitude/longitude, geography, ocean conditions (physical and biological), estuaries, and trap locations in the watershed. However, the belief that the number of 2+ smolts relate to future adults (and watershed conditions) is hard to dismiss or invalidate.

With respect to younger juvenile stages (0+ and 1+), the 2+ Steelhead Trout smolt is the best candidate for assessing Steelhead status, trends, and abundance when information on adult Steelhead is unavailable or unreliable. 2+ Steelhead Trout have overcome the numerous components of stream survival that younger Steelhead (0+ and 1+) have not yet completely faced (over-summer, over-winter, etc), and 2+ Steelhead smolts are the most direct, juvenile recruit to adult Steelhead Trout populations. The 2+ Steelhead Trout are also an excellent indicator of watershed and stream conditions because they spend the longest amount of time in freshwater habitat prior to ocean entry. Along these same lines, Ward et al. (2003) reported that the 2+ Steelhead smolt was a more reliable response variable with respect to stream restoration than late summer juvenile densities because of being less variable.

Juvenile Coastal Cutthroat Trout

A very low number of juvenile Coastal Cutthroat Trout were captured each study year relative to other juvenile salmonids, and over the current 12 years a total of 787 individuals were captured passing through lower RC. The total catch of Cutthroat Trout over 12 years was about 99% less than the total catch of 1+ and 2+ Steelhead Trout. The population abundances of Cutthroat Trout passing through lower RC also show that relatively few Cutthroat Trout emigrated from the majority of the RC basin. The lowest abundance occurred in 2008 (N = 54), and the highest abundance occurred in 2015 (N = 825). Abundance in 2014 equaled 442. The relatively high abundance in 2015 could be due to drought conditions, in which low stream flows in tributaries and mainstem RC forced fish to migrate downstream. The pattern in monthly migration supports this assertion because considerably more Cutthroat Trout migrated downstream earlier in the migration period. The average population abundance over nine years (2006-2008 and 2010-2015) equaled 241 individuals. Low catches and low population abundances support our hypothesis that few Cutthroat Trout are emigrating from the majority of the RC basin, upstream of the confluence with Prairie Creek. Trap catches in upper RC over a sixteen year period were even lower (Total = 109, Avg. = 7), and only 23 individuals were captured in 2015 (Sparkman 2016). Similar to juvenile Coho Salmon, the Prairie Creek watershed is the largest contributor to Cutthroat Trout populations in the RC basin based upon this study, the study in upper RC, and the smolt abundance study in lower Prairie Creek (Sparkman et al. 2015, Wilzbach et al. 2016). For example, juvenile Cutthroat Trout population abundances in Prairie Creek from 2011 – 2015 ranged from 4,581 to 8,572, and averaged 5,782; abundance in 2015 equaled 8,572 in Prairie Creek (Wilzbach et al. 2016), compared to 825 in lower RC.

Monthly population emigration through lower RC was earlier than previous study years, and peaked in May, compared to June for the eight year average. Migration in May 2015 was 45 times greater than migration in May for the eight year average. The two most important months were May/June (87% of total) in 2015, compared to June/July (61% of total) for the average of years 2006 - 2008 and 2010 - 2014. In Prairie Creek, monthly migration in 2015 peaked in April (N = 5,264), and the two most important months were April/May (Wilzbach et al. 2016).

The average size of Cutthroat Trout migrants in lower RC over 12 study years showed more variation than other juvenile salmonids. The average size in 2015 equaled 171 mm (FL) and 58.3 g (WT), and was below average. In comparison, average FL (mm) and Wt (g) for Cutthroat Trout smolts in upper Redwood Creek in 2015 equaled 167 mm and 55.8 g (Sparkman 2016), and in lower Prairie Creek equaled 151 mm and 37.8g (Wilzbach et al. 2016). Thus, Cutthroat Trout emigrating through lower Redwood Creek were larger than those emigrating from upper RC and lower Prairie Creek.

The majority of Cutthroat Trout captured in lower RC in 2015 were in a smolt stage (99.5%), and only 0.5% were classified as pre-smolts. An unknown number or percentage of Cutthroat Trout will residualize in the stream for varying years, and not out-migrate to the estuary and ocean, thus the low trap catches (and population estimates) may not necessarily reflect a very low population size in RC. However, if there were large numbers present within the RC basin upstream of Prairie Creek, we would probably catch much more than we do, as they re-distribute or migrate downstream. For example, juvenile salmonid trapping efforts in middle Prairie Creek consistently captured hundreds (Roelofs and Klatte 1996, Roelofs and Sparkman 1999), and more recently 2,398 Coastal Cutthroat Trout smolts were captured moving downstream in lower Prairie Creek in 2015 (Wilzbach et al. 2016).

We used three characteristics to identify Coastal Cutthroat Trout: upper maxillary that extends past the posterior portion of the eye, slash marks on the lower jaws, and hyoid teeth; spotting is also usually more abundant on Coastal Cutthroat Trout. Hybrid juveniles, the product of mating between Steelhead Trout and Cutthroat Trout, are commonly noted to be missing one or two of these characters. We have observed less than seven potential hybrids in the 12 years of study, and based upon visual identification, the number of (potential) hybrids (age-1 and older) was extremely rare in RC. Similar findings occurred in upper RC as well (Sparkman 2016).

0+ Coho Salmon

Similar to 0+ Steelhead Trout, trap catches of 0+ Coho Salmon are not all inclusive because only a given percentage of the total number present upstream of the trapping site will migrate downstream, this also pertains to the population point estimate. Thus, catches and population estimates are for those fish that were migrating past the trapping site. Trap catches of 0+ Coho Salmon moving downstream is typical for most streams, including relatively pristine streams like Prairie Creek (Sparkman et al. 2015). Koski (2009) called these migrating 0+ Coho Salmon 'nomads' and considered this life history strategy important for species resilience and diversity. More recently, Bennett et. al (2014) found that young of year Coho Salmon that migrate downstream within their first year of their life may enter the ocean and survive to contribute to adult populations.

Few 0+ Coho Salmon were captured by the trap in lower RC each study year (total catch = 2,648 individuals, ranged from = 6 – 1,094 per year), and in 2015 only 100 individuals were captured. The low catches of 0+ Coho Salmon in lower RC was contrasted by higher catches in Prairie Creek. For example, trap catches of 0+ Coho Salmon in mid to upper Prairie Creek from 1996 – 1998 ranged from a low of 372 to a high of 25,492, and averaged 9,659 per trapping season (Roelofs and Sparkman 1999). However, recent trap catches in lower Prairie Creek from 2011 – 2015 ranged from 223 – 2,742, and 329 were captured in 2015 (Wilzbach et al. 2016). Similar to lower RC, catches in lower Prairie Creek in 2015 were much lower than in 2014, when we observed the greatest catches for both trap locations.

In 2015 we determined the population abundance of emigrating 0+ Coho Salmon for the tenth time during our monitoring studies in lower RC. Population abundance equaled 303 in 2015, and ranged from 10 – 3,955 over the past ten years. Currently, there is no relationship with abundance and year(s). Although we have no reliable trend in abundance, the point estimates (of abundance) were low each study year, and indicate relatively few young-of-year Coho Salmon emigrated through lower RC, upstream of the confluence with Prairie Creek. The high abundance measured in lower RC in 2014 (N = 3,955) was likely attributable to an increase in adult returns to RC, upstream of where Prairie Creek enters RC. We further hypothesize that drought conditions during the adult migratory period, in which Prairie Creek had low discharge and shallow depths, encouraged Prairie Creek adult Coho Salmon to stray upstream into the mainstem of RC where stream flow and depths were greater. In addition, the adults probably spawned lower in the RC system (similar to adult Chinook populations in 2014), and the young of year Coho Salmon re-distributed downstream to be caught in relatively larger numbers, and at a smaller size. The percentage of fry (58%) in the population in 2014 was the highest of record, and indicated that the time from fry emergence from redds to trap capture was relatively less compared to previous years. The population abundance of young of year Coho Salmon (N = 14,126) passing through lower Prairie Creek in 2014 was the highest of record for that data set and trap location as well, for similar reasons concerning adult spawning locations and young of year migration (Sparkman et al. 2015). In 2015, the percentage of fry in the population migrating through lower RC equaled 45%, compared to 98% in lower Prairie Creek (Wilzbach et al. 2016).

The pattern of monthly population migration for 0+ Coho Salmon passing through lower RC in 2015 contrasted the previous nine year monthly average. Monthly migration in 2015 was skewed to the left, and the two most important months were April/May, compared to April/June for the previous nine year average. Migration in June 2015 was 82% less than June for the previous nine year average. Monthly migration through lower Prairie Creek in 2015 was also skewed to the left as well, and the two most important months were March/April (Wilzbach et al. 2016).

The migration of 0+ Coho Salmon through lower RC and lower Prairie Creek indicate these fish were moving downstream to rear, or possibly to enter the ocean at age-0. If the young-of-year Coho Salmon from lower RC do not move into Prairie Creek or Strawberry Creek, then they must be moving downstream to the estuary. Thus, lower RC and the estuary may serve as an important place for young-of-year Coho Salmon to rear. Madej et al. (2006) reported that large areas of the RC mainstem may be inhospitable for juvenile Coho Salmon to rear because of high stream temperatures during summer months. Data from trapping efforts in the upper basin supports this assertion because juvenile Coho Salmon were only captured in four of 16 consecutive study years (Sparkman 2016). Therefore, determining the spatial distribution of 0+ Coho Salmon within the RC basin is recommended. CDFW (AFRAMP) recently determined the spatial distribution within RC in reference to areas chosen for adult spawner surveys in 2013 and 2014 (T. Moore, pers. comm. 2014). We should see an increase in the spatial distribution of juvenile Coho Salmon if restoration activities are successful, the riparian matures and increases canopy cover, stream temperatures decrease, and Coho Salmon recover from depressed levels.

1+ Coho Salmon

1+ Coho Salmon smolts are relatively rare in RC, and are the focus species of the FRGP grant funding this study. Thus, we must panel the trap to catch the few that we do, and to keep the trap operating under moderate to low flows. Low numbers of one plus-year-old Coho Salmon were caught moving downstream through lower RC each study year, with the total catch over 12 years equaling 1,332 individuals (ranged from 13 – 496 per year). The total catch of 1+ Coho Salmon smolts accounted for 0.04% of the total juvenile salmonid trap catches over 12 years. The highest catch of 1+ Coho Salmon smolts occurred in 2015 (n = 496), and the lowest catch occurred in 2010 (n = 13). We attribute the high catches in 2015 to a relatively strong brood year in 2014, when we captured more young of year at both lower RC and lower Prairie Creek smolt traps. Similar to 0+ Coho Salmon, low catches of 1+ Coho Salmon in lower RC are contrasted by much higher catches in Prairie Creek. For example, trap catches of 1+ Coho Salmon in mid to upper Prairie Creek from 1996 – 1999 ranged from 1,475 – 2,302, and averaged 1,965 per trapping season (Roelofs and Sparkman 1999). More recently, catches in lower Prairie Creek from 2011 – 2015 ranged from 2,455 to 11,355, and averaged 7,342 per year (Wilzbach et al. 2016). In 2015, a total of 11,355 1+ Coho Salmon were captured moving through lower Prairie Creek (Wilzbach et al. 2016).

The population abundance of 1+ Coho Salmon in RC in 2015 (N = 1,923) was the highest of record, and 5.4 times greater than the previous 11 year average abundance. We attribute the high abundance in 2015 to a stronger brood year in 2014, which was reflected by higher young of year abundances at lower RC and lower Prairie Creek smolt traps in 2014. The average 1+ Coho Salmon population abundance in lower RC over 12 years equaled 486 individuals, and should be considered a very low number. The trend in abundance from 2004 - 2015 was non-significant, and indicates more study years will be required to determine a reliable trend in abundance. Population estimates for 1+ Coho Salmon should be viewed cautiously (due to relatively large error terms for some estimates, range equaled 28 - 86%), and the proper context could be that we are 95% sure that the greatest population abundance during any given study year prior to 2015 was less than 1,127 individuals (upper 95% CI for 2008 estimate). In 2015 the abundance error equaled 20% (CV = 10%), and was the lowest of record. The population abundances we determined over the current 12 year period can be considered very low (alarmingly so), particularly for a stream the size of RC. The low abundances observed in 2011 (N = 113), 2010 (N = 33), 2007 (N = 102), and 2013 (N = 122) may indicate year class failures. The population abundances of 1+ Coho Salmon smolts in lower Prairie Creek over 2011 - 2015 ranged from 8,446 – 23,580, and in 2015 abundance equaled 21,536 (Wilzbach et al. 2016). Thus, Prairie Creek is extremely important for production of Coho Salmon smolts, and an important refuge for Coho Salmon within the RC watershed.

1+ Coho Salmon smolts in RC have a restricted temporal pattern to migration compared to other juvenile salmonids, similar to 1+ Chinook Salmon smolts. The majority of the 1+ Coho Salmon population emigrated during May in any given study year, and in 2015 May accounted for 89% of the total. The two most important months for migration through lower RC were April/May in 2015 and for the previous 11 year average. The peak in monthly emigration through lower Prairie Creek in 2015 occurred in April, and April/May were also the two most important months (Wilzbach et al. 2016). The migration of 1+ Coho Salmon smolts in Prairie Creek in YRS 2011 – 2015 was more protracted compared to the smolt migration through lower RC. For example, the migratory period through lower Prairie Creek in 2015 ended on July 12th, compared to an end date of June 30th for lower RC.

The average size of 1+ Coho Salmon smolts in lower RC in 2015 (FL = 106 mm, Wt = 12.5 g) was close to average, and slightly greater than the average size in Prairie Creek determined in 2015 (FL = 102 mm, Wt = 11.4) (Wilzbach et al. 2016). The average FL (mm) in upper RC in 2015 equaled 112 mm (Sparkman 2016). The average sizes in lower RC, lower Prairie Creek, and upper RC in 2015 fell within the ranges put forward by Sandercock (1991).

The reason(s) for the lack of sufficient numbers of 1+ Coho Salmon smolts emigrating through lower RC warrants further study, as does their current distribution within the RC basin.

0+ Pink Salmon

Pink Salmon in California are recognized as a "Species of Special Concern", and California is recognized as the most southern border for the species (CDFW 1995). Although not in large numbers, Pink Salmon have been historically observed in the San Lorenzo River, Sacramento River and tributaries, Klamath River, Garcia River, Ten Mile River, Lagunitas River, Russian River, American River, Mad River, and once in Prairie Creek, which is tributary to RC at RM 3.7. Pink Salmon were observed spawning in the Garcia River in 1937, the Russian River in 1955 (CDFW 1995), the Garcia River in 2003 (Scott Monday pers. comm. 2004), and in Lost Man Creek (tributary to Prairie Creek) in 2004 (Baker Holden, pers. comm. 2005). More recently, adult Pink Salmon were observed and photographed in lower RC during the fall of 2010 (D. Anderson, pers. com. 2010), and observed in the nearby Mad River during the fall of 2015 (M. Sparkman pers. comm. 2015).

We know of no historic records or anecdotal information documenting Pink Salmon presence in the mainstem of RC prior to our downstream migrant trapping efforts. The Pink Salmon in RC are in very low numbers, and were only observed in lower RC in YRS 2005 (n = 2), 2013 (n = 4), 2014 (n = 3), and 2015 (n = 1). In upper RC we captured small numbers of juvenile Pink Salmon in eight out of 16 years, with the most recent captures occurring in 2015 (n = 6) (Sparkman 2016). We also captured a small number in lower Prairie Creek in 2013 (n =1) and 2015 (n =1) (Wilzbach et al. 2016). It is hard to say if the parents of the juvenile Pink Salmon were strays or remnants of a historic run because so little information about adult Salmon in RC exists. However, the current occurrence suggests that their presence is not random. According to the Habitat Conservation Planning Branch (HCPB) of CDFW, Pink Salmon are considered to be "probably extinct" in California (CDFG 1995). The HCPB further states that "more efforts need to be conducted to prove (or disprove) that reproducing populations exist anywhere in California" (CDFG 1995). Based upon our trapping efforts in upper RC, lower RC, and Prairie Creek, adult Pink Salmon are present in RC and reproducing, albeit in low numbers.

RECOMMENDATIONS

This study is one of the few studies designed to document smolt abundances and population trends of the California Coastal Chinook Salmon ESU, Southern Oregon/Northern California Coasts Coho Salmon ESU, Northern California Steelhead Trout DPS, and Southern Oregon/California Coasts Coastal Cutthroat Trout ESU over a relatively long time period. With respect to the Chinook Salmon ESU and Steelhead Trout DPS, this study might be the only one that provides population data for a relatively large stream. *Unfortunately, this study is having funding problems, and most likely this report will be the second of last*. The most important recommendation to make is to continue this study over multiple consecutive years (20+) in order to:

1. Encompass as much environmental and biological variation as possible, and detect variation attributable to climate change.

2. Cover multiple cohort life cycles over time.

3. Collect baseline data for future comparisons:

    a. Collect data on juvenile salmonid life histories in RC, which will increase our understanding of juvenile salmonids (smolts).

    b. Detect changes in population abundance which can be used to assess the status and trends of Chinook Salmon, Steelhead Trout, Coho Salmon, and (possibly) Cutthroat Trout in RC.

    c. Detect any fish response (population abundance, fish size, age class composition, etc) to stream and watershed conditions and restoration activities in RC.

4. Help focus habitat restoration efforts and needs in the basin.

5. Investigate relationships between the number of adults (using DIDSON sonar technology for adult escapement) and smolt production; continue to support RC monitoring as a Life Cycle Monitoring Station.

This study, when combined with juvenile salmonid monitoring in the upper basin (RM 33, lower Prairie Creek, and estuary (Redwood National Park), will also help determine bottlenecks to anadromous salmonid production in RC.

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APPENDICES

Appendix 1. Reasons for collecting genetic samples from Chinook Salmon, Steelhead Trout smolts, and Coho Salmon fry, parr, and smolts.

Chinook Salmon:

1. To genotype the Chinook Salmon stock in RC.
2. To test for possible genetic differences between 0+ Chinook (Ocean-Type) and 1+ Chinook (Stream-Type).
3. To test for possible genetic differences between 0+ Chinook Salmon fry and 0+ Chinook Salmon fingerlings.

Steelhead Trout:

1. To test for any hatchery introgression into the wild Steelhead stock in Redwood Cr.
2. To test for possible genetic differences between age-1 and age-2 smolts.
3. To test for possible genetic differences between emigrating 0+ Steelhead Trout and 1+ Steelhead Trout the following year.

Coho Salmon

1. To determine the number of parents responsible for the juveniles captured in the fish trap.

All Species:

1. To test for possible genetic differences between fish captured in the lower basin and upper basin.
2. To construct a genetic data base for future comparisons and analyses.

Appendix 2. Graphical representation of daily stream gage height (ft.) at trap site and average daily streamflow (cfs) measured at Orick gaging station (USGS 2015, preliminary data) in 2015, lower Redwood Creek, Humboldt County, CA.