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The Resources Agency
DEPARTMENT OF FISH AND GAME

2010 REPORT

UPPER REDWOOD CREEK
JUVENILE SALMONID (SMOLT) ABUNDANCE PROJECT
2000 - 2010 Seasons
PROJECT 2a5

Prepared by

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Northern Region

Anadromous Fisheries Resource Assessment and Monitoring Program
Fisheries Restoration Grant Program (Project No. S02079)

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ABSTRACT

Juvenile anadromous salmonid trapping in YR 2010 was conducted for the eleventh consecutive year in upper Redwood Creek, Humboldt County, California during the spring/summer emigration period (March – August). The purpose of the study is to describe juvenile salmonid out-migration and estimate smolt population abundances for wild 0+ Chinook salmon, 1+ coho salmon, 1+ steelhead trout, and 2+ steelhead trout using mark/recapture methods. The long term goal is to monitor the status and trends of out-migrating juvenile salmonid smolts in upper Redwood Creek in relation to watershed conditions and restoration activities in the basin. These data are also utilized for Viable Salmonid Population (VSP) Analysis.

A rotary screw trap and fyke net/pipe trap collectively operated 147 day/nights out of 156 possible, and captured 24,146 0+ Chinook salmon (ocean type), 11 1+ Chinook salmon (stream type), 34,475 0+ steelhead trout, 4,045 1+ steelhead trout, 491 2+ steelhead trout, and 13 cutthroat trout to total 63,181 individuals. Juvenile pink salmon and coho salmon were not captured in YR 2010. Average weekly trapping efficiency was 28% for 0+ Chinook salmon, 16% for 1+ steelhead trout, and 14% for 2+ steelhead trout. The total 0+ Chinook salmon population estimate with 95% confidence intervals in YR 2010 equaled 90,485 (83,088 – 97,882), and was 61% less than abundance for the previous ten year average. The large decrease in YR 2010 compared to the previous ten year average most likely reflected a large decrease in the number of adult spawners upstream of the trap site since no streambed mobilization from flood flows occurred after reproduction. The population estimate for 1+ steelhead trout equaled 28,323 (24,546 – 32,101), and was 24% less than abundance for the previous ten year average. 2+ steelhead trout population emigration equaled 3,015 (2,311 – 3,719) and was 34% less than abundance for the previous ten year average. Population abundances of 0+ Chinook salmon, 1+ steelhead trout, and 2+ steelhead trout each showed a significant, negative trend over the eleven current study years ($p < 0.10$).

With respect to successful watershed restoration, we expect: 1) stream temperatures to decrease in the summer, 2) a change in the age class structure of steelhead migrants to favor older, larger smolts, and 3) a general increase in smolt population abundances.

[1/] This paper should be referenced as: Sparkman MD. 2011. Upper Redwood Creek juvenile salmonid (smolt) abundance project, study year 2010: a report to the Fisheries Restoration Grants Program. CDFG AFRAMP, 2a5: 51 p.

INTRODUCTION

This report presents results of the eleventh consecutive year of juvenile salmonid downstream migrant trapping in upper Redwood Creek, Redwood Valley, Humboldt County, California during the spring/summer emigration period. The study began in YR 2000, and was funded by the Redwood Creek Landowners Association (RCLA). Study years 2001 – 2009 have been a cooperative effort between the California Department of Fish and Game Anadromous Fisheries Resource Assessment and Monitoring Program (AFRAMP) (formerly Steelhead Research and Monitoring Program) and RCLA. The Fisheries Restoration Grant Program (FRGP) has assisted in funding this study from YR 2005 to the present (YR 2010, FRGP Project No. S02079), and in YR 2010 the CDFG's Steelhead Trout Fishing Report-Restoration Card Program also provided financial assistance.

The initial impetus for the study was to determine how many wild salmon and steelhead smolts were emigrating from upper Redwood Creek. Prior to this study, no information about smolt emigration and population estimates from upper Redwood Creek existed; this also applied to the remainder of mainstem Redwood Creek as well. Scientific studies which quantified anadromous salmonids within the Redwood Creek watershed were primarily limited to the estuary (juveniles) and Prairie Creek (adults and juveniles), which is tributary to lower Redwood Creek at river mile (RM) 3.7.

Redwood Creek is a difficult stream to monitor adult salmon and steelhead populations because the adult fish migrate upstream during late fall, winter and early spring. Thus, when the adults are present, the stream flow is often high and unpredictable, which limits the reliability and usefulness of any adult weir. Additionally, the stream flow during this time period often carries large amounts of suspended sediments, which render visual observations of adult fish (both live and carcass) and redds (eg spawning surveys) unreliable and unlikely for long term monitoring, particularly in average or above average water years. Scientific studies which focus on salmonids in tributaries to Redwood Creek are less affected by these processes, however, the tributaries are less likely to adequately represent or account for the majority of the salmonid populations in Redwood Creek because the majority of adult salmon and steelhead trout spawn in the mainstem. A possible exception is the Prairie Creek watershed which probably accounts for a considerable amount of the coho salmon and cutthroat trout production in Redwood Creek. Tributaries to Redwood Creek are often steep, with limited anadromy (RNP 1997, Brown 1988). Additionally, some of the tributaries can dry up prior to late summer, which cause the juvenile fish to migrate into the mainstem Redwood Creek to rear.

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 (Schmidt et al. 1996, 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 (Bisson and Sedell 1984; 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), and 6) future recruitment to adult populations (Holtby and Healey 1986, Nickelson 1986, Ward and Slaney 1988, Ward et al. 1989, Unwin 1997, Ward 2000).

This paper will present the results of trapping in study year 2010 with various comparisons to the average of the previous ten study years (YRS 2000 - 2009).

Site Description

Redwood Creek lies within the Northern Coast Range of California, and flows about 67 miles through Humboldt County before reaching the Pacific Ocean (Figure 1). Headwaters originate at an elevation of about 5,000 ft and converge to form the main channel at about 3,100 feet. Redwood Creek flows north to northwest to the Pacific Ocean, and bisects the town of Orick in Northern California. The basin of Redwood Creek is 179,151 acres, and about 49.7 miles long and 6.2 miles wide (Cashman et. al 1995). The study area upstream of the trap site encompasses approximately 65,000 acres of the middle and upper Redwood Creek watershed, with about 37 stream miles (59.5 km) of accessible salmon and steelhead habitat (Brown 1988).

Geology

The Redwood Creek 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 (CDFG 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).

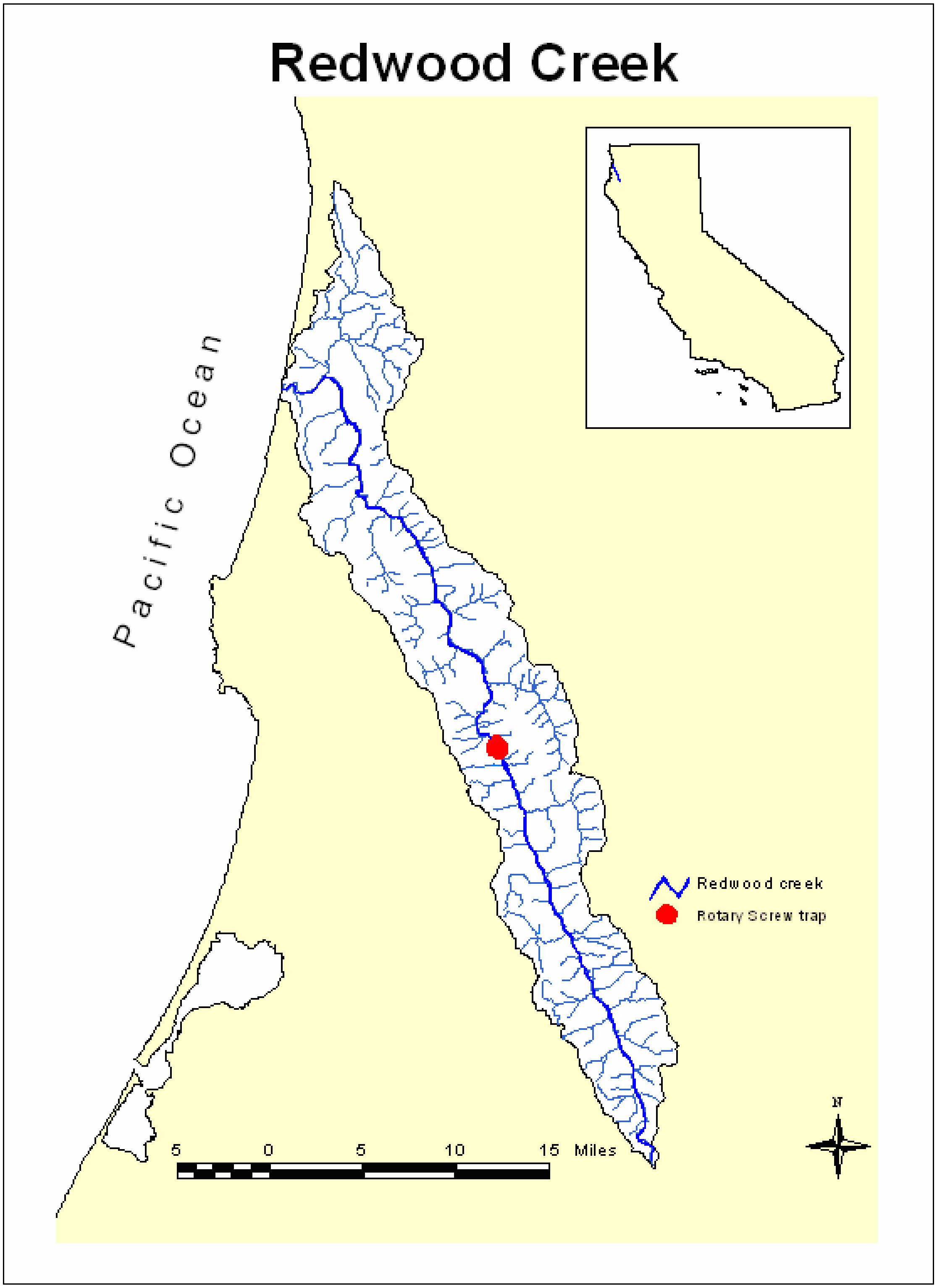

Figure 1. Redwood Creek watershed with rotary screw trap location (RM 33) in Redwood Valley, Humboldt County, CA., (scale is slightly inaccurate due to reproduction process; Charlotte Peters pers. comm. 2001).

Climate and Annual Precipitation

The climate of Redwood Creek 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 (i.e. upper Redwood Creek) which experience higher and lower temperatures. Summers are typically cool and moist on the coast, and hot and dry inland. Ambient air temperatures in Redwood Valley often exceed 32 ^{o}C (or 90 ^{o}F) during summer months. Upper Redwood Creek experiences cold temperatures during the winter, and snowfall is common. Rainfall in upper Redwood Creek is influenced by orographic effects, and can fall in considerable amounts.

Stream Discharge

A USGS/CDWR gaging station (Blue Lake O'Kane, #11481500) is located about 8.4 miles upstream of the trap site on Redwood Creek. Stream flow records cover the periods of 1953 – 1958, 1972 – 1993, and 1997 – 2010 to total 39 years (USGS 2010; Vicki Ozaki, pers. comm. 2010). Following the pattern of rainfall, most of the high flows occur in the months of November - April, and typically peak in February; low flows usually occur from July - October (USGS 2010). Using all years' data, mean monthly discharge in upper Redwood Creek was 230cfs (6.5 m^3/sec), and ranged from 7 - 550 cfs (USGS 2010). Average monthly discharge in WY 2010 equaled 188 cfs (5.3 m^3/sec) and was 18% less than the historic discharge (USGS 2010). However, average monthly discharge during the majority of the trapping season (April – July) in YR 2010 (261 cfs) was much higher than the average for the previous ten years (136 cfs).

Overstory

The overstory in the Redwood Creek watershed 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*).

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)

Redwood Creek 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, if not all, remaining old growth Redwood is contained within Redwood National Park, which is downstream of the trap site. 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 Redwood Creek. Redwood Creek within the study area appears to have experienced channel incision in flood gravel deposits, scouring of pools to increase depth, riparian growth, and input of woody debris (small), which collectively increased stream complexity. However, in YR 2005 and to a much larger degree in YR 2006, large amounts of small gravels/sands were deposited at the trap site and areas downstream of the trap site; these deposits at the trap site were up to 2.5 ft deep. In YRS 2007 - 2010 we noticed that some scouring of the deposits had occurred, however, most of the rocks and cobbles were still covered by the deposits, with the finer sediments present along the stream margin as well. Redwood Creek 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 cutthroat trout (*O. clarki clarki*) are known to inhabit Redwood Creek. This study also shows that pink salmon (*O. gorbuscha*) are present in Redwood Creek. Chinook salmon (KS) of Redwood Creek 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 ranges" (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 DPS (Distinct Population Segment), 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 Redwood Creek anadromous salmonid populations, relatively little data exists concerning abundance and population sizes, particularly for juvenile (and adult) life history stages. Historically, the most prolific species in Redwood Creek was most likely the fall/early winter-run Chinook salmon.

Purpose

The purpose of this project is to describe juvenile salmonid downstream migration in upper Redwood Creek, and to determine smolt population abundances for wild 0+ (young-of-year) Chinook salmon (ocean-type), 1+ Chinook salmon (stream- type, between 1 and 2 years old), 1+ (between 1 and 2 years old) steelhead trout, 2+ (2 years old and greater) steelhead trout, 1+ coho salmon, and cutthroat trout. The long term goal is to monitor the status and trends of out-migrating juvenile salmonid smolts in Redwood Creek 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 document the presence or absence of juvenile coho salmon and 1+ Chinook salmon (Stream-type). Specific study objectives were as follows:

1) Determine the species composition and temporal pattern of downstream migrating juvenile salmonids, and enumerate species out-migration.
2) Determine population estimates for downstream migrating 1+ steelhead trout, 2+ steelhead trout, 0+ Chinook salmon, 1+ coho salmon, and cutthroat trout.
3) Record fork length (mm) and weight (g) of captured fish.
4) Collect and handle fish in a manner that minimizes mortality and potential stress.
5) Statistically analyze data for significance and trends.

METHODS AND MATERIALS

Trap Operations

The methods and materials used in this study in YR 2010 were the same as previous study years (Sparkman 2010). A modified E.G. Solutions (5 foot diameter cone) rotary screw trap was deployed in upper Redwood Creek (RM 33) on March 23rd, 2010 at the same location as in previous study years.

We operated the rotary screw trap continually (24 hrs/day, 7 days a week) from March 23rd through August 6th, except for when stream flow and debris loading in the livebox were too high to safely trap. Beyond August 6th, a fyke net/pipe trap was used to trap smolts until the study ended on August 26th, 2010. The trapping season in YR 2010 was discontinued on August 26th when the catch distribution for most species at age reached zero, or when relatively few individuals were caught in consecutive days.

During periods of reduced stream flows, rock type weirs and weir panels were used with the rotary screw to: 1) keep the trap's cone revolutions relatively high, and 2) maintain good trap efficiencies by directing the fish into the cone area. The weir panels were set to fall down under any unexpected, high stream flows. Plastic drop cloths were used to cover the weirs in June, July, and August to further increase flow into the cone area.

Biometric Data Collection

Fishery technicians carefully removed debris (e.g. alder cones, leaves, sticks, detritus, varying amounts of filamentous green algae, etc) from within the livebox nearly every night of trapping to reduce trap 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. 1+ fish were also kept separate from 2+ fish. Captured fish (0+ fish first, then 1+ and older) were placed into 5 gal. buckets and carried to the processing station. The methods of holding fish at the processing station were the same as in previous study years (Sparkman 2010).

Each individual fish was counted by species and age, and observed for trap efficiency trial marks. Random samples of each species at age (eg 0+ KS, 0+ SH, etc.) were netted from the ice chest for enumeration and biometric data collection.

<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), 0+ coho salmon (0+ CO), 1+ coho salmon (1+ CO), 1+ and greater cutthroat trout (CT), 1+ steelhead trout (1+ SH), and 2+ and greater steelhead trout (2+ SH). 0+ steelhead trout were only measured for fork length (Sparkman 2010). Methods for aging juvenile salmonids were the same as previous study years (Sparkman 2010). 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 157 m downstream of the trap site, and aged 1 and older fish were transported 170 m downstream of the trap site and released into the river.

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 estimates (by age and species) were determined on a weekly basis for 0+ Chinook salmon, 1+ steelhead trout, and 2+ steelhead trout using stratified and non-stratified mark-recapture methods described by Carlson et al. (1998). Population estimation methods in YR 2010 were the same as previous study years (Sparkman 2010). Annual variation in both catches and population abundances over the 11 year period for each species at age were characterized by the standard deviation and standard error of the mean (for each species at age).

Physical Data Collection

Stream temperatures were recorded with an Optic StowAway® Temp data logger (Onset Computer Corporation, 470 MacArthur Blvd. Bourne, MA 02532) placed behind the rotary screw trap. A second probe was deployed at the same location for comparison. Both probes gave similar results, therefore only data from one probe is reported. Probes were set to record stream temperatures (^{o}C) every 30 minutes and recorded about 6,400 measurements per probe over the course of the study (3/24/10 – 8/26/10). The shallowest stream depths during which measurements were taken (in August) were about 2 - 3 feet.

Statistical Analyses

The statistical analyses conducted in YR 2010 were the same as in previous study years (Sparkman 2010). 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 size of a given species at age were increasing or decreasing over the eleven years of study. Peak winter flows coded as 1 or 0 were also included in additional correlation tests with study year on total catch and population size for 0+ Chinook salmon, and 1+ and 2+ steelhead trout. The test for 0+ Chinook salmon would indicate if the relationship of peak winter flows during egg incubation in spawning redds decreased survival, and hence impact the numbers migrating downstream. High bedload mobilizing flows were coded as 1 (for population estimates in YRS 2003, 2005, and 2006) and non-bedload mobilizing flows as 0 (for population estimates in YRS 2000 - 2002, 2004, 2007, 2008, 2009, and 2010) (Zar 1999). Tests for 1+ and 2+ steelhead trout would indicate if high winter flows were affecting population abundance with respect to over-winter survival. Flows considered great enough to mobilize the bedload in upper Redwood Creek (> 5,500 cfs) were identified by Redwood National Park Hydrologists and Geologists (Sparkman 2010). Descriptive statistics were used to characterize the mean FL (mm) and Wt (g) of each species at age on a study year basis. If data violated tests of statistical assumptions, 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. "X" could be the independent or dependent variable in linear regression, or the response variable for a given treatment using ANOVA (NCSS 98). 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 0.10 for trend analysis purposes.

RESULTS

The rotary screw trap operated from 3/23/10 - 8/26/10 and trapped 126 day/nights out of a possible 135; the fyke net/pipe trap operated from 8/06/10 – 8/26/10 and trapped 21 day/nights out of a possible 21. The trapping rate in YR 2010 was 94% compared to 97% for the previous ten year average (ranged from 92 - 100%).

Species Captured

Juvenile Salmonids

Species captured in YR 2010 included: juvenile Chinook salmon (*Oncorhynchus tshawytscha*), juvenile steelhead trout (*O. mykiss*), and coastal cutthroat trout (*O. clarki clarki*). A total of 63,181 juvenile salmonids were captured in YR 2010 (Figure 2). The total trap catch of juvenile salmonids in YR 2010 was the third lowest of record, and about 31% less that the total catch in YR 2009. Over the 11 study years, we captured a total of 1,715,822 individuals.

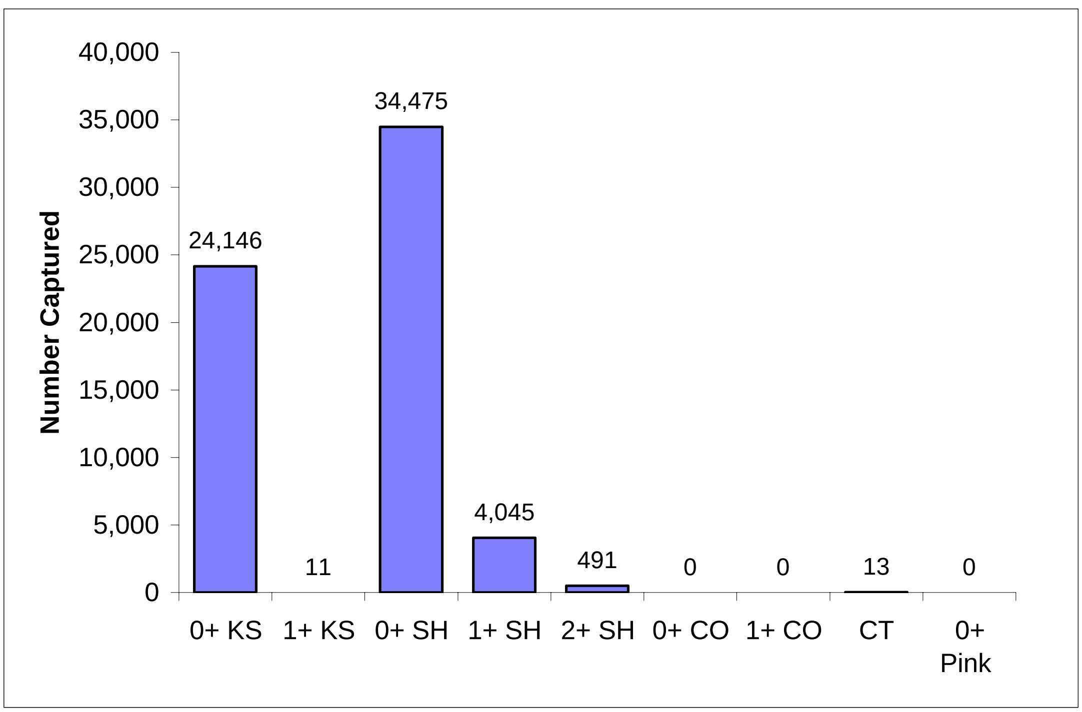

Figure 2. Total juvenile salmonid trap catches (n = 63,181) from March 24 through August 26, 2010, upper Redwood Creek, Redwood Valley, Humboldt County, CA. Numeric values above columns represent actual catches. 0+ KS = young-of-year Chinook salmon, 1+ KS = age 1 and older Chinook salmon, 0+ SH = young-of-year 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 155,984 (SD = 114,460). The 11 year average catch equaled 74,014 (SD = 81,642) for 0+ Chinook salmon, 9 (SD = 10) for 1+ Chinook salmon, 72,516 (SD = 35,755) for 0+ steelhead trout, 8,640 (SD = 4,548) for 1+ steelhead trout, 795 (SD = 415) for 2+ steelhead trout, 5 (SD = 4) for cutthroat trout, 3 (SD = 10) for 0+ coho salmon, less than 1 (SD = 2) for 1+ coho salmon, and 2 (SD = 3) for 0+ pink salmon.

Days Missed Trapping

Nine days were not trapped during the course of the study in YR 2010 due to high flow events and high debris loading in the trap's livebox. Days missed trapping did not influence the total catch or population estimate of any species at age to any large degree (Table 1).

Table 1. The estimated catch and expansion (population level) of juvenile anadromous salmonids considered to have been missed due to trap not being deployed (n = 9 d) during the emigration period of March 23 through August 26 (as a percentage of total without missed days in parentheses), upper Redwood Creek, Humboldt County, CA., 2010.

Age/spp.*	Catch	Population Level
0+ KS	349 (1.45%)	2,746 (3.03%)
1+ KS	0 (0.00%)	-
0+ SH	315 (0.91%)	-
1+ SH	226 (5.59%)	1,506 (5.62%)
2+ SH	24 (4.89%)	167 (5.54%)
0+ CO	N/A	N/A
1+ CO	N/A	N/A
CT	0 (0.00%)	-

* 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 to the known catches for a given stratum (week) and used in the population estimate for that stratum (Roper and Scarnecchia 1999).

Trends in Catches

0+ Chinook Salmon
Linear correlation detected a significant, negative relationship of trap catches over study years (n = 11, p = 0.07, r = 0.56, power = 0.44). The correlation of 0+ Chinook salmon trap catches and flood type flows (dummy variable) during egg incubation with study

years was significantly negative (n = 11, p = 0.06, adj. r = 0.62, negative slope for both ‘x’ variables, power = 0.30).

0+ Steelhead Trout
Linear correlation detected a significant, negative relationship of 0+ steelhead trout trap catches over study years (n = 11, p = 0.04, r = 0.62, power = 0.55).

1+ Steelhead Trout
Linear correlation detected a significant, negative relationship of 1+ steelhead trout trap catches over study years (n = 11, p = 0.02, r = 0.67, power = 0.68). The correlation of 1+ steelhead trout trap catches and flood type flows during winter months with study years was significantly negative as well (n = 11, p = 0.004, adj. r = 0.83, negative slope for both ‘x’ variables, power = 0.71).

2+ Steelhead Trout
Linear correlation detected a significant, negative relationship of 2+ steelhead trout trap catches over study years (n = 11, p = 0.03, r = 0.64, power = 0.60). The correlation of 2+ steelhead trout trap catches and flood type flows during winter months with study years was also significantly negative as (n = 11, p = 0.03, adj. r = 0.69, negative slope for both ‘x’ variables, power = 0.40).

Trend analysis for 0+ Coho, 1+ Coho, cutthroat trout, 1+ Chinook salmon, and 0+ pink salmon could not be conducted because catches were either too low, or infrequent over the eleven study years.

Trapping Efficiencies

The average trapping efficiency by week and seasonal trapping efficiency for 0+ Chinook salmon, 1+ steelhead trout, and 2+ steelhead trout in YR 2010 fell within the range of 13 to 32% (Table 2).

Table 2. Average weekly and seasonal trapping efficiencies for 0+ Chinook salmon, 1+ steelhead trout, and 2+ steelhead trout, Upper Redwood Creek, Humboldt County, CA., YR 2010.

	Trapping Efficiency (percentage)	
Spp. at age	Average Weekly	Seasonal
0+ Chinook Salmon	28.3	32.3
1+ Steelhead Trout	16.4	15.4
2+ Steelhead Trout	13.6	12.9

Population Estimates

0+ Chinook Salmon

The population estimate (or production) of 0+ Chinook salmon emigrating from upper Redwood Creek in YR 2009 equaled 90,485 with a 95% CI of 83,088 – 97,882. Population estimate error (or uncertainty) equaled ± 8.2% or about 7,397 individuals. Population emigration in YR 2010 was 37% less than emigration in YR 2009 (N = 144,490), and 61% less than the previous ten year average (Nav_{10} = 234,854). The average population abundance over 11 years equaled 221,729 (SD = 223,484). The standard error of the mean equaled 67,383 individuals. On average, there were about 39,064 less individuals each study year (Figure 3). Correlation of time (study year) on population estimates indicated a significant, negative relationship (n = 11, p = 0.06, r = 0.58, power = 0.40, alpha = 0.10) (Figure 3). The best model describing population trends (transformed) over time (11 years) included study year and whether or not a flood type flow occurred during the spawning season (Correlation, p = 0.01, Adj. r = 76, slope is negative for both variables, power = 0.52).

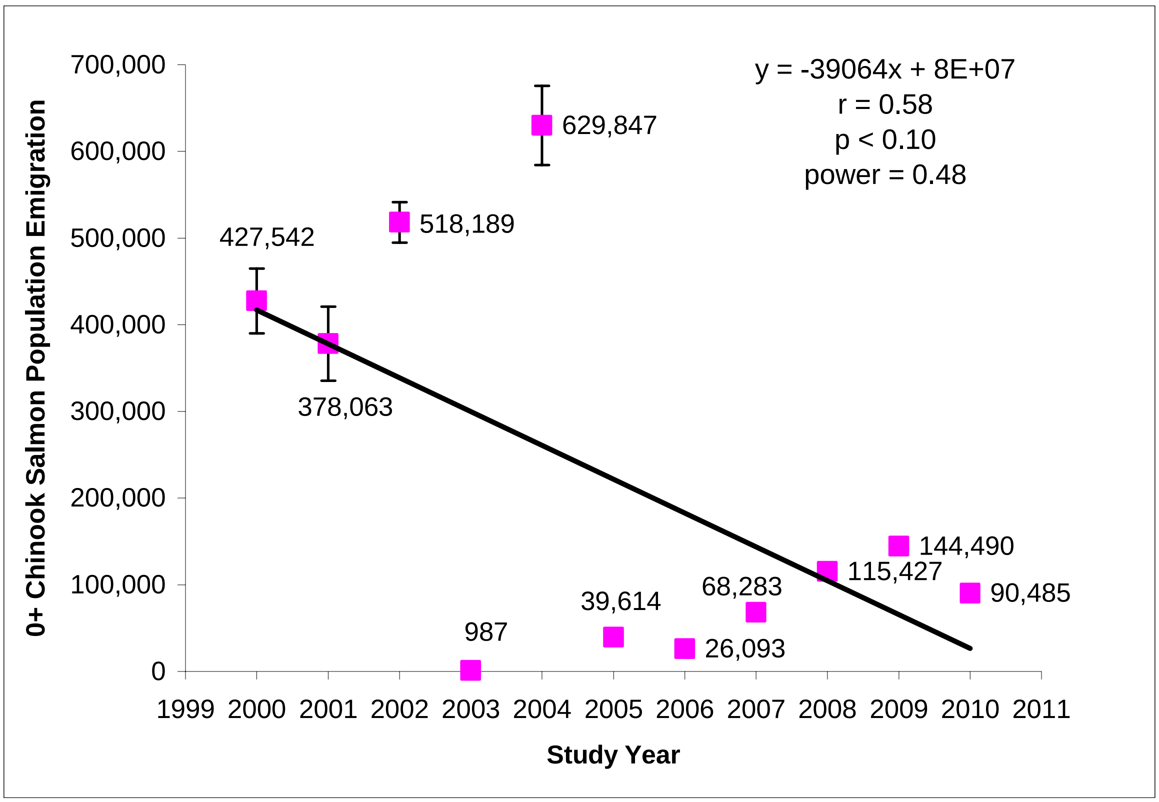

Figure 3. 0+ Chinook salmon population estimates (error bars are 95% confidence interval) in eleven consecutive years. Lack of 95% CI for YRS 2003, 2005, 2006 - 2010 is due to scale of Y axis. Numeric values next to box represent number of individuals. Line of best fit is a regression line, with corresponding equation, correlation value (r), p value, and power of the statistical test.

0+ Chinook salmon population emigration by month in YR 2010 was considerably less than emigration by month for the previous ten year average (Figure 4). The biggest reductions in YR 2010 occurred in April (79% reduction or 69,080 less individuals), and May (38% reduction or 30,661 less individuals). The pattern of migration in YR 2010 contrasted the pattern for the previous ten year average (Figure 4).

The majority of 0+ Chinook salmon population emigration occurred in May and July in YR 2010 (60% of total) compared to April and May for the previous ten year average (70% of total) (Figure 4).

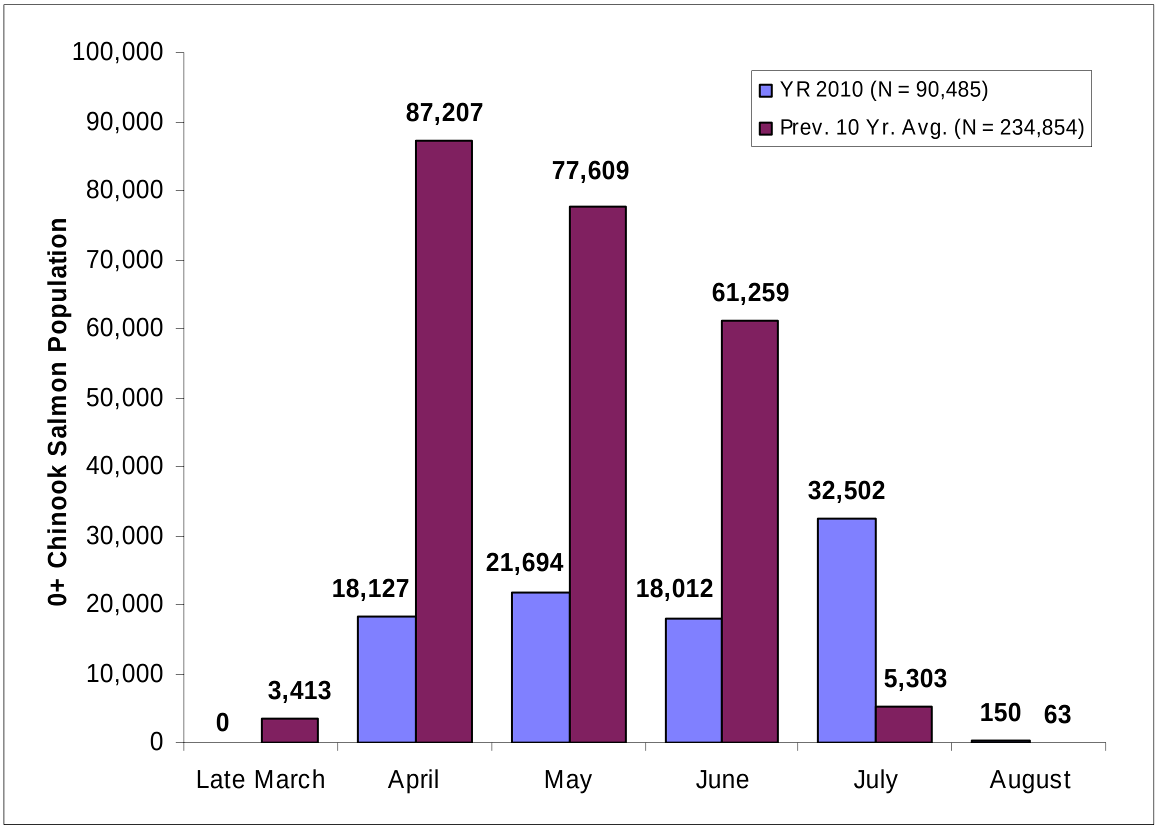

Figure 4. Comparison of 0+ Chinook salmon population emigration by month in YR 2010 with the previous ten year average, upper Redwood Creek, Humboldt County, CA. Numeric values above columns represent number of individuals.

The peak in weekly population emigration in YR 2010 occurred 7/02 – 7/08, which was much later than migration peaks in previous years (Table 3). The largest weekly peak occurred in YR 2004 (N = 165,782 individuals) and the smallest peak occurred in YR 2003 (N = 316 individuals) (Table 4). The average FL (mm) for 0+ Chinook salmon migrants during the two modes in emigration in YR 2010 equaled 39.4 mm for 4/30 – 5/06, and 66.6 mm for 7/02 – 7/08 (Figure 5).

Table 3. Date of peak weekly 0+ Chinook salmon population emigration by study year (number of individuals in parentheses).

Study Year	Date of peak in weekly out-migration (number in parentheses)
2000	5/28 - 6/03 (56,457)
2001	5/07 - 5/13 (79,848)
2002	6/04 - 6/10 (63,093)
2003	6/11 - 6/17 (316)
2004	4/09 - 4/15 (165,782)
2005	4/23 - 4/29 (9,059)
2006	6/18 - 6/24 (4,287)
2007	6/04 - 6/10 (12,564)
2008	6/04 - 6/10 (15,451)
2009	5/28 - 6/03 (19,289)
2010	7/02 - 7/08 (16,654)

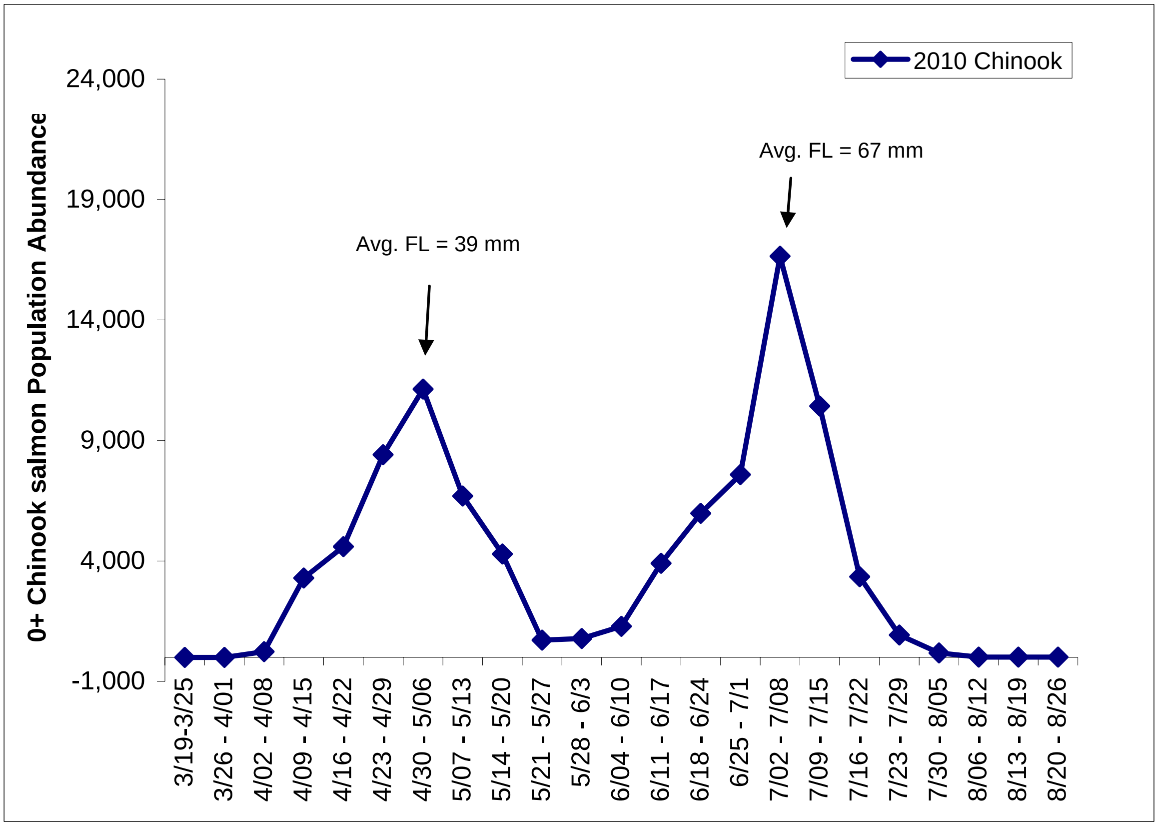

Figure 5. 0+ Chinook salmon population emigration by week in YR 2010, upper Redwood Creek, Humboldt County, CA.

1+ Steelhead Trout

The population estimate (or production) of 1+ steelhead trout emigrating from upper Redwood Creek in YR 2010 equaled 28,323 with a 95% CI of 24,546 – 32,101. Population estimate error (or uncertainty) equaled $\pm$ 13.3% or 3,777 individuals. Population emigration in YR 2010 was 17% less than emigration in YR 2009 (N = 34,035), and 24% less than the previous ten year average (Nav_{10} = 37,255). The average population abundance over 11 years equaled 36,433 (SD = 12,671). The standard error of the mean equaled 3,821 individuals.

On average, there were about 2,343 less individuals each study year (Figure 6). Correlation of time (study year) on yearly population estimates showed a significant negative relationship (p = 0.04, r = 0.61, power = 0.55) (Figure 6). The test of population abundance with time and whether or not a flood type flow occurred the previous winter violated test assumptions, and results were not valid (NCSS 98).

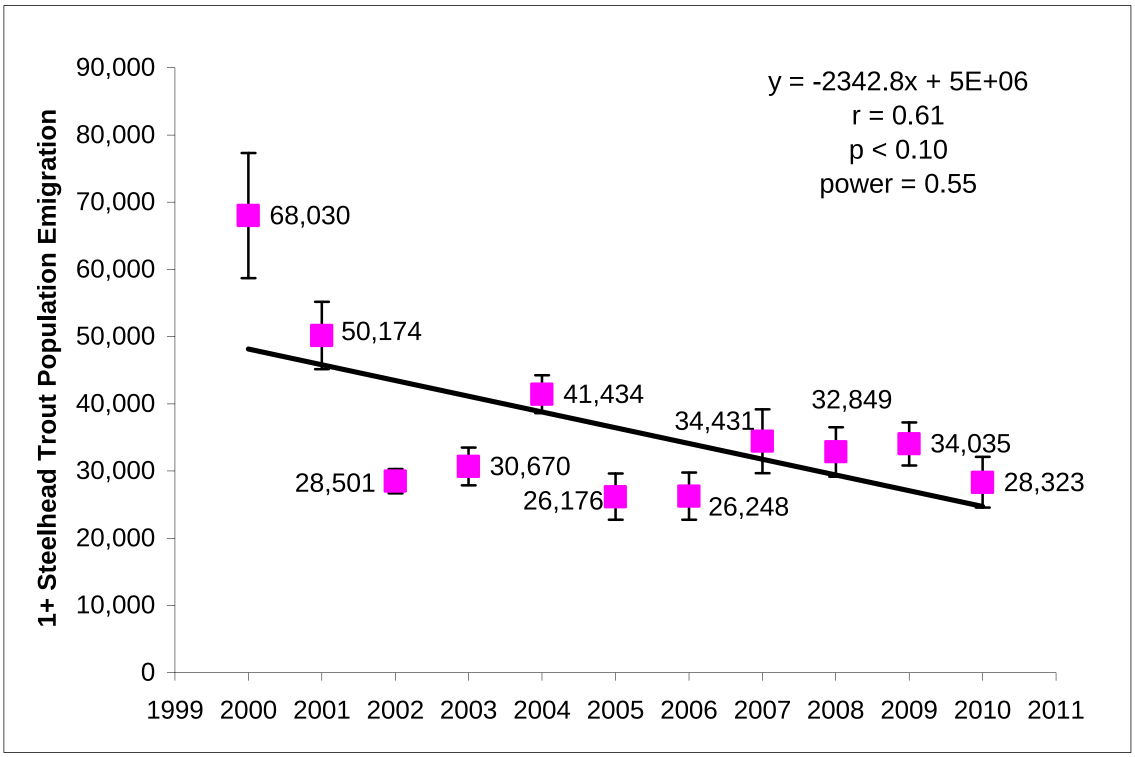

Figure 6. 1+ steelhead trout population estimates (error bars are 95% confidence interval) in eleven consecutive years. Numeric values next to box represent number of individuals. Line of best fit is a regression line, with corresponding equation, correlation value (r), p value, and power of the statistical test.

1+ steelhead trout monthly population emigration in YR 2010 was less than monthly emigration for the previous ten year average, except for the months of April and July

(Figure 7). Emigration peaked in April in YR 2010 (N = 11,435 or 40% of total) and May for the previous ten year average (N = 17,096 or 46% of total) (Figure 7). In YR 2010, the two most important months were April and May (N = 19,481 or 69% of total), compared to May and June (N = 26,286 or 71% of total) for the previous ten year average (Figure 7).

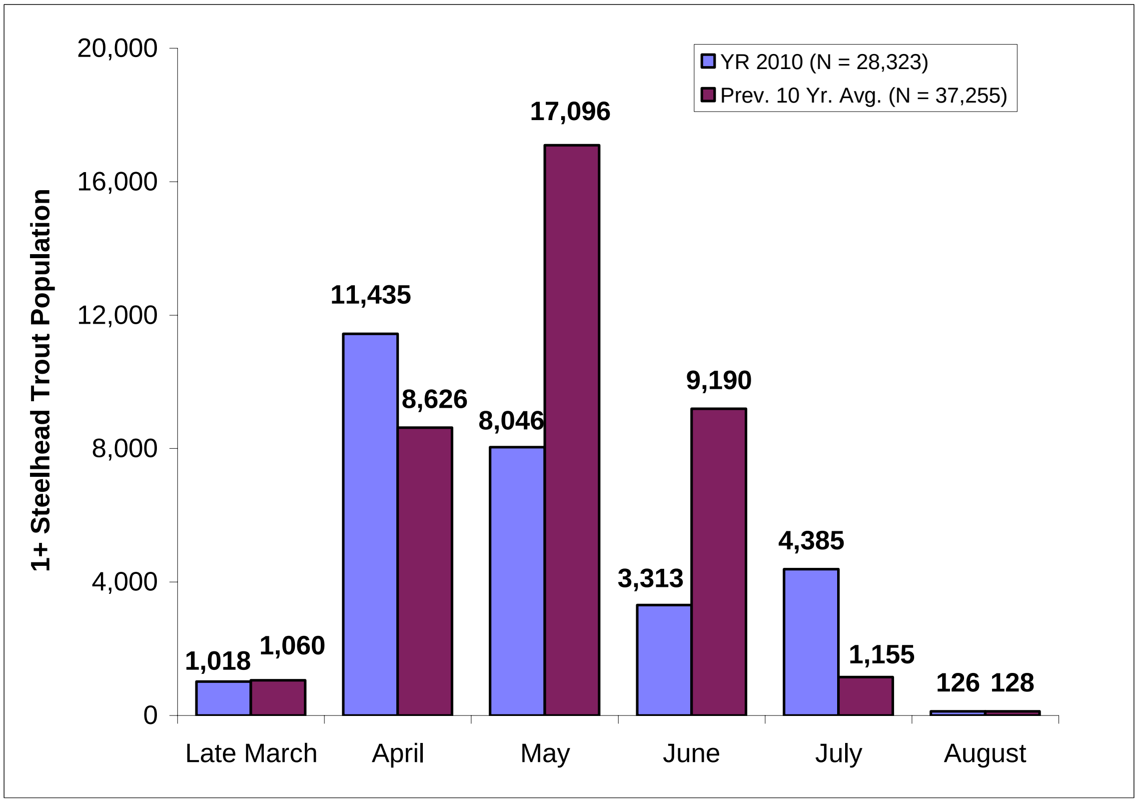

Figure 7. Comparison of 1+ steelhead trout population emigration by month in YR 2010 with the previous ten year average, upper Redwood Creek, Humboldt County, CA. Numeric values above columns represent number of individuals.

The peak in 1+ steelhead trout weekly emigration in YR 2010 occurred in April (Table 4). The largest weekly peak occurred in YR 2000 (N = 16,244), and the smallest occurred in YR 2006 (N = 4,062) (Table 13).

Table 4. Date of peak weekly 1+ steelhead trout population emigration by study year (number of individuals in parentheses).

Study Year	Date of peak in weekly out-migration (number in parentheses)
2000	5/07 – 5/13 (16,244)
2001	4/23 – 4/29 (6,963)
2002	5/14 – 5/20 (4,180)
2003	5/14 – 5/20 (4,483)
2004	5/14 – 5/20 (6,659)
2005	4/23 – 4/29 (4,834)
2006	5/21 – 5/27 (4,062)
2007	5/07 – 5/13 (6,777)
2008	5/28 – 6/03 (6,342)
2009	4/30 – 5/06 (4,971)
2010	4/16 – 4/22 (5,476)

2+ Steelhead Trout

The population estimate (or production) of 2+ steelhead trout emigrating from upper Redwood Creek in YR 2010 equaled 3,015 with a 95% CI of 2,311 – 3,719 (Figure 8). Population estimate error (or uncertainty) equaled ± 23.4% or 704 individuals. Population emigration in YR 2010 was 1.6 times greater than emigration in YR 2009 (N = 1,913), and 34% less than the previous ten year average (Nav_{10} = 4,590). The average population abundance over 11 years equaled 4,447 (SD = 3,208). The standard error of the mean equaled 967 individuals.

On average, there were about 607 less individuals each study year (Figure 8). Correlation of time (study year) on yearly population estimates showed a significant negative relationship (n = 11, p = 0.04, r = 0.63, power = 0.58) (Figure 8). The best model describing population trends (transformed in this test) over time included study year and whether or not a flood type flow occurred during the winter (Correlation, p = 0.02, adj. r = 0.71, slope is negative for both variables, power = 0.43).

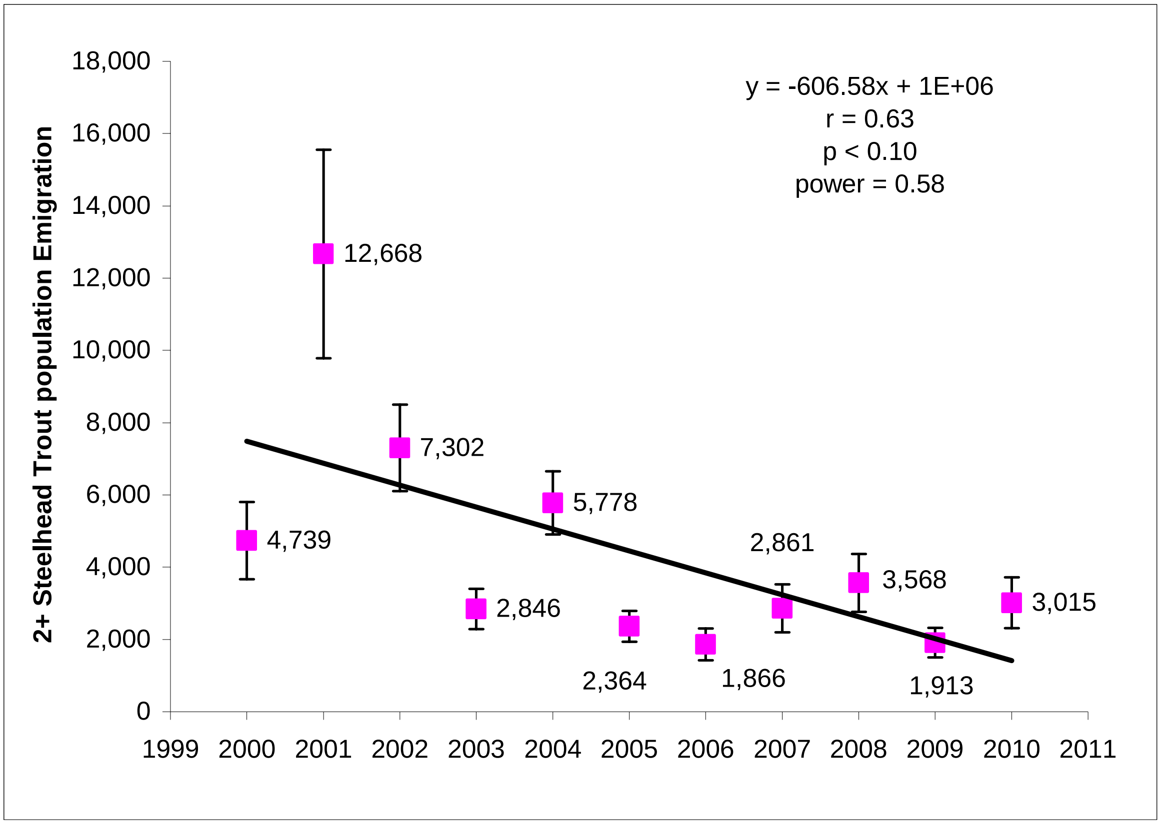

Figure 8. 2+ steelhead trout population estimates (error bars are 95% confidence interval) in eleven consecutive years. Numeric values next to box represent number of individuals. Line of best fit is a regression line, with corresponding equation, correlation value (r), p value, and power of the statistical test.

2+ steelhead trout monthly population emigration in YR 2010 was less than monthly emigration for the previous ten year average, with exception to the months of July and August (Figure 9). Emigration peaked in July in YR 2010 (N = 1068 or 35% of total) compared to May for the previous ten year average (N = 1,520 or 33% of total) (Figure 9). In YR 2010, 2,014 individuals (or 70% of total) emigrated in April and July, compared to 3,024 (or 66% of total) migrants that emigrated in April and May for the previous ten year average.

The peak in 2+ steelhead trout weekly emigration in YR 2010 occurred in July, unlike previous study years (Table 5). The largest weekly peak occurred in YR 2001 (N = 1,463), and the smallest peak occurred in YR 2009 (N = 341) (Table 5).

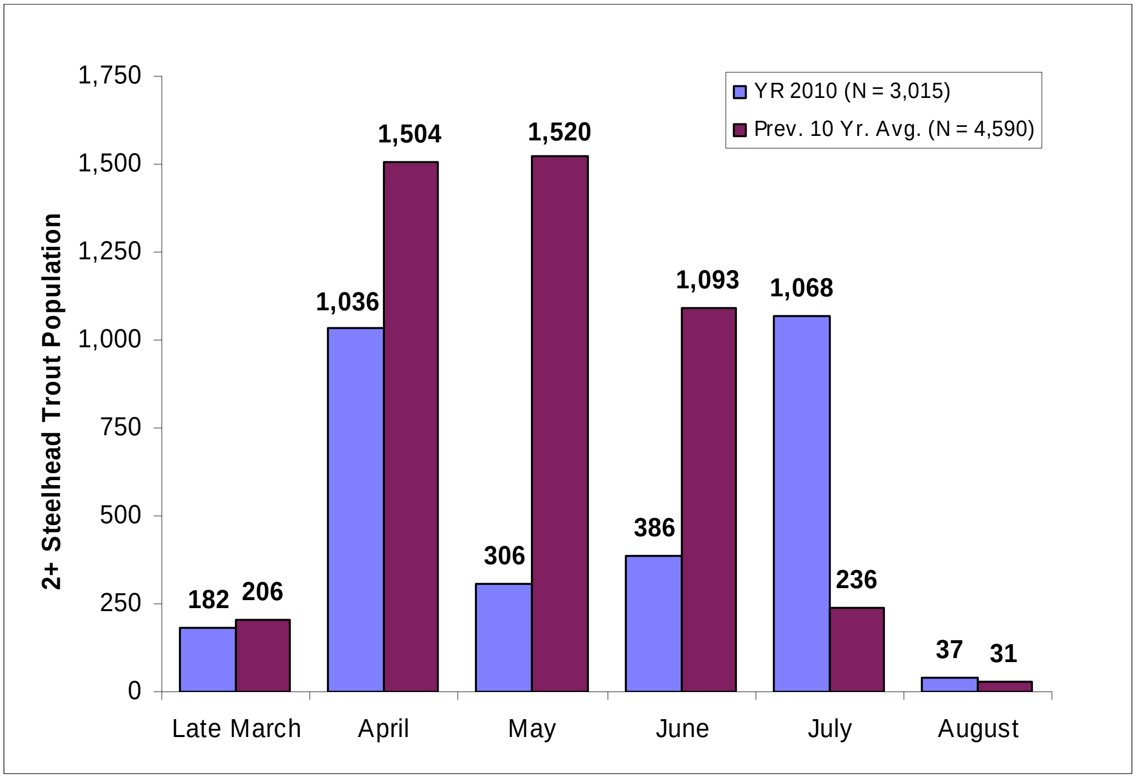

Figure 9. Comparison of 2+ steelhead trout population emigration by month in YR 2010 with the previous ten year average, upper Redwood Creek, Humboldt County, CA. Numeric values above columns represent number of individuals.

Table 5. Date of peak weekly 2+ steelhead trout population emigration by study year (number of individuals in parentheses).

Study Year	Date of peak in weekly out-migration (number in parentheses)
2000	4/09 - 4/15 (1,094)
2001	5/28 - 6/03 (1,463)
2002	4/23 - 4/29 (1,061)
2003	5/14 - 5/20 (363)
2004	5/14 - 5/20 (645)
2005	4/16 - 4/22 (380)
2006	4/30 - 5/06 (365)
2007	6/04 - 6/10 (384)
2008	5/28 - 6/03 (871)
2009	4/23 - 4/29 (341)
2010	7/09 - 7/15 (398)

Age Composition of Juvenile Steelhead Trout

The following percentages represent maximum values for 1+ and 2+ steelhead trout because their population estimates were compared to catches of 0+ steelhead trout (ie the actual catches of 0+ steelhead trout are less than expected 0+ steelhead trout population out-migration). Far more 0+ and 1+ steelhead trout migrated downstream than 2+ steelhead trout (Table 6). Using catch and population data, the ratio of 0+ steelhead trout to 1+ steelhead trout to 2+ steelhead trout in YR 2010 equaled 11:9:1 compared to 17:8:1 for the ratio of the previous ten year average. The ratio of 1+ steelhead trout to 2+ steelhead trout was 9:1 in YR 2010, 17:1 in YR 2009, and 8:1 for the ratio of the previous ten year average.

Table 6. Comparison of 0+ steelhead trout, 1+ steelhead trout, and 2+ steelhead trout percent composition of total juvenile steelhead trout downstream migration in YR 2010 with the previous ten year average, upper Redwood Creek, Humboldt County, CA.

	Percent composition of total juvenile steelhead trout out-migration		
Study Year	0+ steelhead*	1+ steelhead	2+ steelhead
2010	52.4	43.0	4.6
Prev. 10 Yr. Avg.	62.8	33.6	3.6
All years combined	63.4	32.7	3.9

* Uses actual catches instead of population estimate.

Fork Lengths and Weights

0+ Chinook Salmon

We measured (FL mm) 3,092 and weighed (g) 1,873 0+ Chinook salmon in YR 2010 (Table 7). Average FL in YR 2010 was slightly less than the previous ten year average, and average Wt in YR 2010 was slightly greater than the previous ten year average (Table 7).

Table 7. 0+ Chinook salmon population estimates and average fork length (mm) and weight (g) for study YRS 2000 - 2010, upper Redwood Creek, Humblodt County, CA.

	0+ Chinook Salmon						
		Fork Length (mm)			Weight (g)		
Study Year	(N)*	n	Avg.	SEM**	n	Avg.	SEM**
2000	427,542	3,661	55.5	0.2	913	2.03	0.04
2001	378,063	2,719	51.9	0.2	778	1.73	0.04
2002	518,189	3,517	52.4	0.2	1,545	1.70	0.03
2003	987	573	67.3	0.3	499	3.43	0.05
2004	629,847	3,571	50.8	0.2	1,593	1.61	0.03
2005	39,614	2,489	60.4	0.3	1,751	3.09	0.05
2006	26,093	2,123	55.5	0.3	1,684	2.07	0.04
2007	68,283	2,811	51.6	0.2	2,127	1.55	0.03
2008	115,427	2,937	48.0	0.2	2,001	1.32	0.02
2009	144,490	3,140	52.1	0.2	1,838	1.88	0.03
Avg 00-09			54.6	1.8		2.04	0.22
2010	90,485	3,092	53.5	0.2	1,873	2.11	0.04

* "N" denotes emigrant population size; "n" denotes sample size for FL and Wt. ** Standard error of mean. ***Average for FL and Wt does not include YR 2003.

1+ Chinook Salmon

We measured (FL mm) and weighed (g) 11 1+ Chinook salmon in YR 2010 (Table 8). Average FL and Wt in YR 2010 were greater than the previous ten year average (Table 8).

Table 8. 1+ Chinook salmon trap catches and fork length (mm) and weight (g) for study years 2000 – 2010, upper Redwood Creek, Humboldt County, CA.

	1+ Chinook Salmon						
	Catch or	Fork Length (mm)			Weight (g)		
Study Year	(Pop.*)	n	Avg.	SEM**	n	Avg.	SEM**
2000	-	-	-	-	-	-	-
2001	21	17	104.4	2.8	13	13.38	1.65
2002	18	17	108.5	3.9	17	16.62	1.96
2003	29	29	123.4	1.7	29	22.34	0.90
2004	-	-	-	-	-	-	-
2005	-	-	-	-	-	-	-
2006	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	-
2008	9	9	118.2	1.8	9	18.19	0.78
2009	21*	14	106.8	3.3	14	13.92	1.34
5 Yr. Avg.			112.3	3.6		16.89	1.62
2010	-	11	115.9	4.0	11	18.63	1.97

* Denotes population abundance. ** Denotes Standard Error of the Mean.

0+ Steelhead Trout

We measured (FL mm) 3,617 0+ steelhead trout in YR 2010 (Table 9). Average FL in YR 2010 was greater than the previous ten year average (Table 9).

Table 9. 0+ steelhead trout total catch and average fork length (mm) for study years 2000 - 2010, upper Redwood Creek, Humboldt County, CA.

	0+ Steelhead Trout						
		Fork Length (mm)			Weight (g)		
Study Year	(Catch)	n	Avg.	SEM*	n	Avg.	SEM*
2000	55,126	2,669	40.9	0.2	-	-	-
2001	102,408	1,136	39.0	0.3	-	-	-
2002	124,426	3,228	38.7	0.2	-	-	-
2003	102,954	3,338	38.5	0.2	-	-	-
2004	128,885	3,615	37.5	0.2	-	-	-
2005	41,671	3,661	42.3	0.2	-	-	-
2006	48,759	2,670	35.9	0.2			
2007	68,573	2,672	37.0	0.2			
2008	57,805	2,076	33.1	0.1	-	-	-
2009	32,585	2,931	37.0	0.2			
						-	
10 Yr. Avg.			38.0	0.8			
2010	34,475	3,617	39.9	0.2			

* Standard error of mean.

1+ Steelhead Trout

We measured (FL mm) 2,656 and weighed (g) 1,535 1+ steelhead trout in YR 2010 (Table 10). Average FL in YR 2010 was the same as for the previous ten year average, and average Wt in YR 2010 was slightly greater than the previous ten year average (Table 10).

Table 10. 1+ steelhead trout population estimates and average fork length (mm) and weight (g) for study years 2000 - 2010, upper Redwood Creek, Humboldt County, CA.

	1+ Steelhead Trout						
		Fork Length (mm)			Weight (g)		
Study Year	(N)*	n	Avg.	SEM**	n	Avg.	SEM**
2000	68,030	2,721	92.4	0.2	1,455	8.29	0.09
2001	50,174	2,761	91.9	0.3	908	9.27	0.11
2002	28,501	3,049	86.7	0.3	1,356	7.79	0.14
2003	30,670	3,064	84.8	0.3	1,633	7.14	0.09
2004	41,434	3,191	85.7	0.3	1,441	7.57	0.10
2005	26,176	2,473	88.1	0.2	1,592	8.02	0.09
2006	26,248	1,961	85.7	0.3	1,683	7.48	0.09
2007	34,431	2,414	85.4	0.3	1,954	7.41	0.09
2008	32,849	2,362	85.3	0.3	1,759	7.21	0.09
2009	34,035	2,717	83.1	0.3	1,627	7.05	0.09
10 Yr. Avg.			86.9	1.0		7.72	0.21
2010	28,323	2,656	86.9	0.3	1,535	7.86	0.10

* "N" denotes emigrant population size; "n" denotes sample size for FL and Wt.
** Standard error of mean.

2+ Steelhead Trout

We measured (FL mm) 488 and weighed (g) 468 2+ steelhead trout in YR 2010 (Table 11). Average FL and Wt in YR 2010 were less than the previous ten year average (Table 11).

Table 11. 2+ steelhead trout population estimates and average fork length (mm) and weight (g) for study years 2000 - 2010, upper Redwood Creek, Humboldt County, CA.

	2+ Steelhead Trout						
		Fork Length (mm)			Weight (g)		
Study Year	(N)*	n	Avg.	SEM**	n	Avg.	SEM**
2000	4,739	710	164.4	0.6	480	49.12	0.61
2001	12,668	1,316	151.2	0.5	1,225	39.17	0.43
2002	7,302	1,528	147.5	0.6	1,463	37.87	0.51
2003	2,846	625	144.0	0.9	583	35.15	0.71
2004	5,778	1,277	144.1	0.7	1,244	35.44	0.47
2005	2,364	594	150.5	0.2	592	39.90	0.91
2006	1,866	396	159.8	1.4	391	44.86	1.06
2007	2,861	517	146.7	1.1	490	35.40	0.75
2008	3,568	624	139.9	0.8	613	32.29	0.61
2009	1,913	450	142.8	1.0	425	33.09	0.77
10 Yr. Avg.			149.1	2.4		38.23	1.67
2010	3,015	488	144.7	1.0	468	33.94	0.72

* "N" denotes emigrant population size; "n" denotes sample size for FL and Wt.
** Standard error of mean.

0+ Coho and 1+ Coho Salmon

No juvenile coho salmon fork lengths and weights were taken because none were captured in YR 2010.

Developmental Stages

There was an obvious non-random distribution of parr, pre-smolt, and smolt designations (developmental stages) for 1+ and 2+ steelhead trout captured in YR 2010 and for the previous ten year average (Table 12). A totally random distribution would equal 33.3% for each designation (parr, pre-smolt, smolt). The majority of 1+ and 2+ steelhead trout were classified as smolts (Table 12).

Table 12. Developmental stages of captured 1+ and 2+ steelhead trout in YR 2010 and the previous ten year average, upper 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
2010	< 0.1	13.2	86.8	0.0	0.0	100.0
10 Yr Avg.*	2.2	41.9	55.9	0.0	13.0	87.0

* Study years 2000 – 2009.

1+ Chinook Salmon

All 1+ Chinook salmon captured in YR 2010 were classified as smolts.

Trapping Mortality

The mortality of fish that were captured in the traps and subsequently handled was closely monitored over the course of the trapping period. The trap mortality (which includes handling mortality) for a given age/species in YR 2010 ranged from 0.00 – 0.45%, and using all data, was 0.34% of the total captured and handled (Table 13). This level of trap mortality is very low, and considered negligible.

Juvenile salmonid trapping mortality in YR 2010 (0.34%) was less than mortality for the previous ten year average (0.39%) (Table 14).

Table 13. Trapping mortality for juvenile salmonids captured in YR 2010, upper Redwood Creek, Humboldt County, CA.

	Trap Mortality in YR 2010		
Age/spp.	No. captured	No. of mortalities	Percent mortality
0+ Chinook	24,146	57	0.24
1+ Chinook	11	0	0.00
0+ Steelhead	34,475	154	0.45
1+ Steelhead	4,045	5	0.12
2+ Steelhead	491	0	0.00
0+ Coho	0	N/A	N/A
1+ Coho	0	N/A	N/A
Cutthroat trout	13	0	0.00
0+ Pink	0	N/A	0.00
Overall:	63,181	216	0.34

Table 14. Comparison of trapping mortality of juvenile salmonids in yen consecutive study years, upper Redwood Creek, Humboldt County, CA.

	Trap Mortality		
Study Year	No. captured	No. of mortalities	Percent mortality
2000	191,761	934	0.49
2001	239,262	1,631	0.68
2002	361,433	1,480	0.41
2003	111,514	362	0.32
2004	352,860	1,192	0.34
2005	56,544	368	0.65
2006	57,193	128	0.22
2007	89,965	199	0.22
2008	100,905	200	0.20
2009	91,204	387	0.42
Average* (2000-09)			0.40

* Previous ten year average.

Stream Temperatures

The average daily (24 hr period) stream temperature from 3/24/10 – 8/26/10 was 13.5 ^{o}C (or 56.3 ^{o}F) (95% CI = 12.7 – 14.2 ^{o}C), with daily averages ranging from 6.6 – 21.2 ^{o}C (43.9 – 70.2 ^{o}F). Average stream temperature from 3/24/10 – 8/05/10 (truncated) equaled 12.5 ^{o}C (Table 15).

Table 15. Average daily stream temperature (^{o}C) (standard error of mean in parentheses) with minimum and maximum recorded stream temperature during the trapping period in YR 2010 and previous nine years, upper Redwood Creek, Humboldt County, CA.

	Stream Temperature					
	Celsius			Fahrenheit		
Study Year	Avg.	Min.	Max.	Avg.	Min.	Max.
2001	16.3 (0.40)	5.7	28.2	61.3 (0.72)	42.3	82.8
2002	15.8 (0.39)	6.7	27.5	60.4 (0.71)	44.1	81.5
2003**	14.5 (0.46)	6.1	28.4	58.1 (0.82)	43.0	83.1
2004	15.8 (0.39)	6.7	28.8	60.4 (0.71)	44.1	83.8
2005**	13.5 (0.38)	6.2	25.8	56.4 (0.68)	43.2	78.4
2006**	14.9 (0.45)	5.7	29.5	58.8 (0.82)	42.3	85.1
2007	14.4 (0.39)	5.7	25.5	57.9 (0.70)	42.3	77.9
2008	13.0 (0.43)	4.4	25.2	55.4 (0.77)	39.8	77.3
2009	14.9 (0.41)	5.8	27.8	58.8 (0.74)	42.4	82.0
9 Yr. Avg.*	14.8 (0.36)	4.4	29.5	58.6 (0.64)	39.8	85.1
2010**	12.5 (0.38)	5.8	24.4	54.5 (0.68)	42.4	75.9

* YR 2000 excluded due to incomplete coverage during trapping period.
** Data truncated to 8/5 for equal comparison among study years.

The minimum stream temperature in YR 2010 was 5.8 ^{o}C (42.4 ^{o}F) and occurred on 4/05/10; the maximum stream temperature was 24.4 ^{o}C (82.0 ^{o}F) and occurred on 7/25/10 (Figure 10).

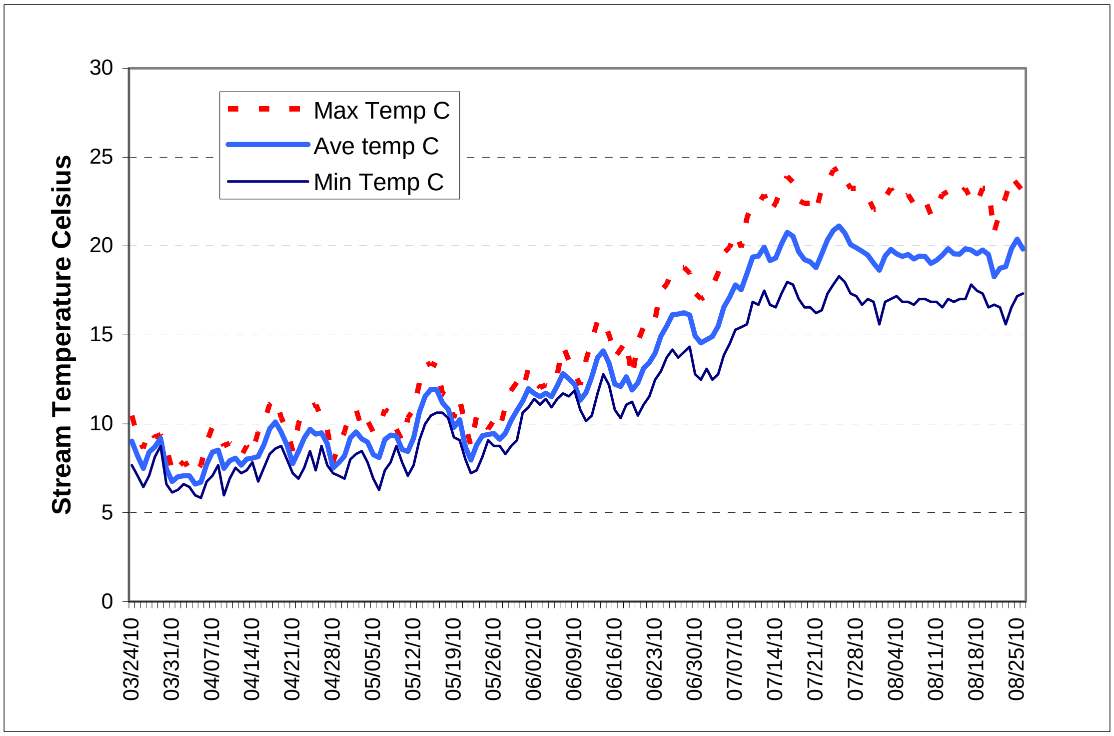

Figure 10. Average, minimum, and maximum stream temperature (Celsius) at the trap site, upper Redwood Creek, Humboldt County, CA., 2010.

DISCUSSION

The main goal of our downstream migration study in upper Redwood Creek is to estimate and monitor the production of Chinook salmon, steelhead trout, and coho salmon (if present) in a reliable, long-term manner. Redwood Creek is a difficult, if not impossible stream to monitor for adult salmon and steelhead populations on a long term basis using traditional techniques (weirs and spawning ground surveys) due to adult run timing, precipitation, hydrology, water depth, and stream turbidity. However, "quantifying juvenile anadromous salmonid populations as they migrate seaward is the most direct assessment of stock performance in freshwater" (Seiler et al. 2004). 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 eleventh consecutive year of trapping in upper Redwood Creek occurred during an above water year with respect to rainfall amounts in Redwood Valley, and below average stream discharge measured at the O'Kane gaging station. However, stream discharge during the majority of the trapping season (April – July) in YR 2010 (261 cfs) was much higher than the historic average (136 cfs). The environmental conditions for downstream migrant trapping in YR 2010 were much more difficult to operate the trap in compared to previous study years. The estimates for catch and subsequent expansions to the population level, based on the nine missed trapping days, were negligible for each species at age; the greatest impact on a population estimate was estimated at 5.6% (1+ steelhead trout), and the adjusted point value easily fell within the 95% confidence interval of the un-adjusted point value. The uncertainty or error in the population estimate for a given species at age ranged from 8 – 23%. Thus, this season's trapping resulted in very good estimates of wild Chinook salmon and steelhead trout smolt emigration (production) from areas upstream of the trapping site.

0+ Chinook Salmon

0+ Chinook salmon (ocean-type) emigrating from upper Redwood Creek were the most numerous migrant captured by the smolt trap for five out of eleven years. Relatively low catches occurred in YRS 2003, 2005 - 2010; and the total catch in YR 2010 was 67% less than the average catch of the previous ten years (Avg. = 74,014).

The population of 0+ Chinook salmon emigrating from upper Redwood Creek was variable over the eleven consecutive years of study; production was greater than 350,000 individuals for the first three years, less than 1,000 in the fourth year (cohort failure), and the fifth year experienced the greatest peak of 630,000. Production in YRS 2005 – 2007, and YR 2010 was less than 70,000, and in YR 2008 and YR 2009 production was greater than 100,000 individuals. The reduction in population emigration in YR 2010 could be due to: 1) change in adult spawner distribution in the watershed, 2) simple decrease in the total number of spawners upstream of the trap site, or 3) a combination of factors 1 and 2. Flood type flows were ruled out because none occurred during spawning and egg development for the YR 2010 cohort. The most plausible reason for the decrease in YR 2010 was a simple decrease in the number of returning adults. The eleven year trend in population abundance over time showed a significant, negative decline. The addition of flood type flows as a dummy variable in the trend regression decreased the p value, increased the r value, and increased the power of the test. Thus, the best model describing the trend of 0+ Chinook salmon over time included study year (-) and whether or not there was a flood type flow (-) during the spawning season for a given cohort.

0+ Chinook salmon monthly population emigration in YR 2010 was reduced from the previous ten year average, with the biggest monthly reduction occurring in April (79% or 69,080 individuals). The majority of juvenile Chinook salmon in YR 2010 migrated downstream during May and July (60% of total emigration), which contrasted the pattern for the previous ten year average (April and May were the two most important months).

The average size (FL, Wt) of 0+ Chinook salmon emigrants in YR 2010 was close in value to the previous nine years.

1+ Chinook Salmon

1+ juvenile Chinook salmon (stream-type) in Redwood Creek represent the third juvenile Chinook salmon life history, and appear to be in very low abundance. Yearly catches ranged from 0 – 29 individuals, and in YRS 2000, 2004 - 2007 zero were captured. The majority of the 1+ Chinook salmon were captured in April and May in YR 2010. The total number of 1+ Chinook salmon juveniles captured over eleven study years equaled 103 individuals, or 0.01% of the total juvenile Chinook salmon catch. Stream-type Chinook salmon are easily differentiated from ocean-type by size at time of downstream migration. For example, the average FL in April 2010 was 116 mm for 1+ Chinook salmon and 39 mm for 0+ Chinook juveniles.

When present, 1+ Chinook salmon from upper Redwood Creek are more likely to be progeny of fall/winter-run Chinook salmon adults than from spring-run adults (stream-type) because few if any spring-run Chinook salmon are observed during spring and summer snorkel surveys in Redwood Creek (David Anderson, pers. comm. 2004). For example, in 23^{+} 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) (David Anderson, pers. comm. 2005). Additionally, stream flows during late spring/summer months can become so low that adult upstream passage into upper Redwood Creek can become problematic. High average stream temperatures (eg > 20 °C) and maximum stream temperatures (24+ °C or 75 °F) may also prevent any adult spring-run Chinook salmon migration into upper Redwood Creek, or inhibit their ability to over-summer in pools. Thus, a spring run of Chinook salmon adults is probably not responsible for the production of yearling Chinook salmon juveniles in Redwood Creek. Bendock (1995) also found both stream-type and ocean-type juvenile Chinook salmon in an Alaskan stream which only has one adult Chinook salmon race; and Connor et al. (2005) reported that fall Chinook salmon in the Snake River produced juveniles exhibiting an ocean-type or stream-type juvenile life history. 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 report 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 for Redwood Creek, is whether the one year old life history for juvenile Chinook salmon was more prevalent prior to the changes in the watershed associated with land use activities, flood events, and geomorphic processes. Perhaps with an increase in habitat quality we may see more 1+ Chinook salmon.

The 1+ Chinook salmon life history pattern in upper Redwood Creek may be important for increased ocean survival of Chinook salmon juveniles, and general species diversity (Don Chapman pers. comm. 2003, Sparkman 2010).

0+ Steelhead Trout

Considerable numbers of young-of-year steelhead trout migrate downstream from upper Redwood Creek during spring and summer months; over eleven consecutive study years we captured 797,667 individuals. 0+ steelhead trout were the most numerous juvenile salmonid captured in the trap for six out of eleven years, and were the most numerous age class migrant for juvenile steelhead trout in nine of the eleven current study years. In YR 2010, the ratio of 0+ steelhead trout catches to 1+ and 2+ steelhead trout at the population level was 11:9:1. Clearly, stream habitat upstream of the trap site is important for adult steelhead trout reproduction.

For the first time in our data set, linear regression detected a significant, negative trend over time with addition of data in YR 2010. The catch in YR 2010 was about 55% less than the previous ten year average. The monthly pattern (data not given) in downstream migration in YR 2010 was very unlike previous study years in that the majority of captures occurred in July. This most likely reflected the above average water year and cooler stream temperatures.

The overall decrease we observed over years could be due to a variety of factors: 1) changes in the number of adult steelhead spawning upstream of the trap site, 2) change in redd gravel conditions, 3) change in carrying capacity of stream habitat upstream of trap site, 4) decrease in the percentage of the total population that passively or actively migrates downstream, or 5) some combination of factors 1 - 4. The potential variable of trapping efficiency among study years would not account for the general decrease we observed in YR 2010 because the trap was operated in the same manner as in other study years (time of placement, use of weir panels, etc).

Average FL for 0+ steelhead trout in YR 2010 was greater than the average for the previous ten years by about 2 mm FL.

I doubt that a large majority of the 0+ steelhead population that out-migrates prior to late summer low-flow periods can be viewed as surplus or lost production, which will not augment future adult steelhead populations. Meehan and Bjornn (1991) state that some steelhead populations normally out-migrate soon after emergence from redds to occupy other rearing areas, and I believe we observe this in Redwood Creek as well. Our experiments of marked 0+ steelhead trout released at the upper trap and recaptured 29 miles downstream in YRS 2006 and 2007 offered direct evidence that 0+ steelhead trout may travel considerable distances in search of suitable rearing areas. In streams that are temperature impaired (many if not most in Humboldt County, CA are, including Redwood Creek; see CWA List, 2002), out-migration prior to times when streams or sections of streams reach high (or maximum) temperatures (July/August) or dry up can be viewed as an advantageous life history strategy.

1+ Steelhead Trout

Fairly large numbers of 1+ steelhead trout emigrate from upper Redwood Creek during the spring/summer emigration period. Population emigration from YRS 2000 – 2009 ranged from 26,176 – 68,030 and averaged 37,255 individuals. Population emigration in YR 2010 (N = 28,323) was 24% less than the previous ten year average. The population of 1+ steelhead trout declined over the eleven study years; linear correlation detected a significant negative trend in 1+ steelhead trout population abundance over time ($p < 0.10$), which indicated that fewer 1+ steelhead trout were emigrating each year compared to previous years.

1+ steelhead trout monthly population emigration in YR 2010 was less than emigration for the previous ten year average except for the months of April and July. The majority of juveniles in YR 2010 migrated downstream during April and May (69% of total emigration), which contrasted the pattern for the previous ten year average when May and June were the two most important months. The peak in weekly migration occurred 4/16 – 4/22, which was earlier than previous study years.

The average size (FL, Wt) of 1+ steelhead trout close in value to the average of the previous ten years.

Each study year the population of 1+ steelhead trout emigrating from upper Redwood Creek was far larger than 2+ steelhead trout population emigration. The ratio of 1+ to 2+ steelhead trout in YRS 2000 - 2009 ranged from 4:1 to 14:1 and averaged 10:1; in YR 2009 the ratio was 9:1. 1+ steelhead trout downstream migration is not unique to Redwood Creek, and other downstream migration studies have routinely documented 1+ steelhead trout emigration (USFWS 2001; Ward et al. 2002; Ward et al. 2003; Johnson 2004; Bill Chesney pers. comm. 2006, among many others). Based upon studies in other streams, the number of returning adult steelhead trout that went to the ocean as one-year-old smolts is relatively low, and usually less than 23% (Pautzke and Meigs 1941; Maher and Larkin 1955; Busby et al. 1996, McCubbing 2002; McCubbing and Ward 2003). Based upon a limited number of scale samples (n = 10) from adult steelhead trout in Redwood Creek, 30% of the adults entered the ocean as one-year-old juveniles. More recently, data collected from adults in YR 2007/2008 showed that 50% of the adults had entered the ocean as a one year old smolt, and in YR 2008/09 the percentage equaled 40%. CDFG AFRAMP is currently collecting scale samples from adult steelhead to increase sample size (author, in progress). The percentage of adult steelhead trout that smolt and enter the ocean at age-1, and the reason(s) for the relative large number of 1+ steelhead trout emigrating from upper Redwood Creek and from the basin of Redwood Creek warrants further investigation. I 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. In addition, stream flow during summer months is very low, which decreases the amount of space available for rearing. Over-summer conditions, particularly in mid to late July, could be limiting the production of older age classes (2+ steelhead trout) in upper Redwood Creek.

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). For example, Pautzke and Meigs (1941) reported that 84% of returning adult steelhead 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, and McCubbing (2002) reported 92% of steelhead adults in a British Columbia stream had spent two or more years as juveniles in freshwater. If this applies to steelhead trout in Redwood Creek, 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 smolt is that it is the least numerous juvenile steelhead trout that emigrates from upper Redwood Creek. For example, in YR 2010 the ratio of 0+ steelhead trout to 2+ steelhead trout equaled 11:1, and the ratio of 1+ steelhead trout to 2+ steelhead trout equaled 9:1.

2+ steelhead trout population emigration during 2000 – 2009 ranged from 1,866 – 12,668, and averaged 4,447 individuals. Population emigration in YR 2010 (N = 3,015) was 34% less than the average emigration over the previous ten years. The pattern or trend in population size over the eleven study years was significantly negative. Thus, the 2+ steelhead trout populations are decreasing over time. This significant, negative trend was first detected in YR 2007 (n = 8 years of data), and has been significantly negative ($p < 0.10$) ever since. The addition of flood type flows as a dummy variable in the trend regression decreased the p value, increased the r value, and increased the power of the test. Thus, the best model describing the trend of 2+ steelhead trout over time included study year (-) and whether or not there was a flood type flow (-) during the winter for a given cohort prior to migrating downstream in spring/summer months. One possible explanation is that during winter flood type flows there may be less suitable habitat (alcoves, backwaters, side channels, etc.) available for rearing and survival.

2+ steelhead trout monthly population emigration in YR 2010 was less than emigration for the previous ten year average except for the month of July. The majority of juveniles in YR 2010 migrated downstream during April and July (70% of total emigration), which contrasted the pattern for the previous ten year average when April and May were the two most important months. The peak in weekly migration in YR 2010 occurred in July, which was much later than peaks in previous study years. This late peak was most likely attributable to the higher discharge and cooler stream temperatures which occurred in YR 2010. Usually, greater numbers of 2+ steelhead trout emigrated earlier in the trapping season when stream discharge was greater (due to increases in discharge) and stream temperatures were cooler compared to later in the season (Sparkman 2010).

The average size (FL, Wt) of 2+ steelhead trout was less than values for the previous ten year average, however these differences are unlikely to be biologically meaningful because the smolts could grow as they migrate downstream and reside in the estuary.

Although there seems to be 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 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 smolt to adult survival for upper Redwood Creek 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 relates to future adults (and watershed conditions) is hard to dismiss or invalidate. With respect to younger juvenile stages (0+ and 1+), the 2+ steelhead smolt is the best candidate for assessing steelhead status, trends, and abundance when information on adult steelhead trout is unavailable or un-attainable. 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 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. 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.

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 (CDFG 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 Redwood Creek at RM 3.7. Pink salmon were observed spawning in the Garcia River in 1937, and the Russian River in 1955 (CDFG 1995). More recently, adult pink salmon were seen spawning in 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).

I know of no historic records or anecdotal information documenting pink salmon presence in Redwood Creek prior to our downstream migration trapping efforts. The pink salmon in Redwood Creek are in very low numbers, and prior to study year 2005, were only captured in even numbered years (e.g. YR 2000, YR 2002, and YR 2004). The total catch over ten study years equaled 22, with the greatest catch (n = 8) occurring in YR 2004. The two individuals caught in YR 2005 may indicate that pink salmon are now spawning upstream of the trap site in even and odd numbered years; however, no pink salmon were captured in YRS 2006 and 2007. In YR 2008 we captured four individuals, and in YRS 2009 and 2010 we captured zero individuals.

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 exists about adult salmon in Redwood Creek. According to the Habitat Conservation Planning Branch (HCPB) of CDFG, pink salmon are considered to be “probably extinct” in California (CDFG 1995). However, the HCPB does state that “more efforts need to be conducted to prove (or disprove) that reproducing populations exist anywhere in California” (CDFG 1995). Based upon our trapping data from upper Redwood Creek, it appears that pink salmon are occasionally present and reproducing, albeit in low numbers.

Coho Salmon

One of the greatest discoveries in YR 2007 was the capture of six young-of-year coho salmon for the first time in eight consecutive years of study. Prior to YR 2007, we captured, observed, and counted 1.37 million juveniles without a single juvenile coho salmon observation. In previous reports I mentioned that we should occasionally see at least a small number of juvenile coho salmon from adults that strayed upstream from downstream tributaries or mainstem reaches. In YR 2008, the greatest discovery was the capture of seven 1+ coho salmon and 32 0+ coho salmon. The capture of 1+ coho salmon was the first time in nine consecutive years, and indicates that freshwater conditions were sufficient enough to allow some of 0+ coho salmon in YR 2007 to successfully survive the summer and winter periods. Coho salmon are still considered to be a rare occurrence in upper Redwood Cr in recent times, and in YR 2010 we did not capture any juvenile coho salmon.

Coho salmon were historically present in areas upstream of the trap site based upon observations by Marlin Stover and Bill Chezum (long time residents in Redwood Valley, pers. comm. 2000 and 2001). I talked with both Marlin and Bill about coho salmon distribution in upper Redwood Creek. Bill Chezum (pers. comm. 2001, he has since passed away) observed schools of adult coho salmon in areas upstream of the current trap site while growing up in Redwood Valley. He particularly mentioned seeing coho in the 1940’s and early 1950’s. Every year he watched the fish swim past him in schools during their spawning run, and around the time of the 1955 flood event, the coho seemingly disappeared. Marlin Stover (pers. comm. 2000), who is also a long time resident in Redwood Valley, corroborates Bill Chezum’s observations of adult coho in upper Redwood Creek. Minor Creek, a tributary to Redwood Creek upstream of the trap site, supposedly supported runs of coho salmon. Lacks Creek, a tributary to Redwood Creek downstream of the trap site by about 9 miles, currently supports coho salmon (Bill Jong, pers. comm. 2003; CDFG 1953); and Prairie Creek (tributary to Redwood Creek at about

RM 3.7) supports a fairly stable population of coho salmon. Prior to our catches in YR 2007, the most recent citing of juvenile coho salmon upstream of the trap site occurred in 1997 (Tom Weseloh, pers. comm. 2003).

The next important observation for juvenile coho salmon in upper Redwood Creek will be whether they can persist over time, which will be evidenced by trap captures. Optimistically, we may be documenting the return of coho salmon populations in upper Redwood Creek. We plan on taking genetic samples from juveniles, if present, to determine how many adults were responsible for the juveniles we captured using mitochondrial DNA analysis techniques.

Cutthroat Trout

A low number of cutthroat trout were captured in all ten previous study years (< 9 individuals each year, total = 38), and only 13 individuals were captured in YR 2010. All cutthroat trout that were captured were in a smolt stage. 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 may not necessarily reflect a low population size in upper Redwood Creek. However, if there were large numbers present, we would probably catch much more than we do, as they re-distribute or migrate downstream. For example, juvenile salmonid trapping efforts in Prairie Creek consistently capture hundreds of cutthroat trout during spring/early summer as they migrate downstream (Roelofs and Klatte 1996; Roelofs and Sparkman 1999, Walt Duffy, pers. comm. 2010).

We did not consider any of the young-of-year steelhead trout to be progeny of cutthroat trout because few aged 1 and older cutthroat trout were captured in any given year (average 5 per year). Upper Redwood Creek has far more older juvenile steelhead trout (1+ and 2+) than cutthroat trout as evidenced by trap catches. In the eleven study years, the ratio of 1+ and 2+ steelhead trout combined catches to cutthroat trout catches each year ranged from 349:1 to 7,881:1, and using data from all years (pooled) equaled 2,035:1. The ratio in YR 2010 was 349:1. Ratios would be even higher if juvenile steelhead trout population data were used instead of catch data. It seems very unlikely that low numbers of cutthroat trout could produce a significant portion of the juvenile trout captures. Therefore, we considered the percentage of 0+ cutthroat trout included in the 0+ steelhead trout catch to be low and negligible.

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 usually more abundant on coastal cutthroat trout as well. Kennedy et al. (2009) reported that field misclassifications of smolts as steelhead or cutthroat trout were low, with values of 1% for steelhead trout and 2% for 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, or having a combination of cutthroat trout and steelhead trout characters (Kennedy et al. 2009). We have observed less than four individuals in the eleven study years that could have been hybrid juveniles. Thus, out of 103,782 1+ and 2+ steelhead trout catches, only 0.004% appeared to show hybrid characteristics. Based upon visual identification, the number of potential hybrids (age 1 and greater) is extremely rare in upper Redwood Creek.

Stream Temperatures

Similar to past study years, average daily stream temperature in YR 2010: 1) significantly increased over the study period, 2) was negatively related to stream discharge, and 3) was negatively related to stream gage height. The average daily stream temperature (truncated) (12.5 ^{o}C) during the trapping period in YR 2010 was the lowest of record, most likely due to the increased stream discharge during the trapping period compared to previous study years.

The maximum stream temperature occurred in late July which was normally when the stream temperatures reached maximum values in past study years. However, the maximum in YR 2010 (24.4 °C) was much lower than previous study years due to increased discharge in YR 2010 compared to previous years. In past years, most of the migration was over by the time stream temperatures reached maximum values in late July. In general, emigration prior to times when streams or sections of streams reach high or maximum temperatures (July/August) can be viewed as an advantageous life history strategy, and one that juvenile salmonids in upper Redwood Creek may employ.

RECOMMENDATIONS

This study is one of the few studies that is designed to document smolt abundance and population trends of the California Coastal Chinook salmon ESU, Southern Oregon/Northern California Coasts Coho salmon ESU, Northern California Steelhead Trout ESU, and Southern Oregon/California Coasts Coastal Cutthroat Trout ESU over a relatively long time period. With respect to the Chinook salmon ESU, this study might be the only one that provides population data for a relatively large stream.

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.

2. Cover multiple cohort life cycles over time.

3. Collect baseline data for future comparisons.

4. Collect data on juvenile salmonid life histories in upper Redwood Creek, which will increase our understanding of juvenile salmonids (smolts).

5. Detect changes in population abundance which can be used to assess the status and trends of Chinook salmon, steelhead trout, and coho salmon in upper Redwood Creek.

6. Detect any fish response (population, fish size, age class composition, etc) to stream and watershed conditions, and restoration activities in the upper basin.

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

This study, when combined with juvenile salmonid monitoring in the lower basin (lower trap at RM 4, estuarine studies) will also help determine potential bottlenecks to anadromous salmonid production in Redwood Creek.

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