Redwood Creek Rotary Screw Trap Downstream Migration Study
Redwood Valley, Humboldt County, California
April 4 - August 5, 2000

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1/16/01

Acknowledgements

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Abstract

A rotary screw trap was deployed in Redwood Creek, Humboldt County, California from April 4 - August 5, 2000 to estimate population size of downstream migrating juvenile 0+ chinook salmon, 1+ coho salmon, 1+ steelhead trout, and 2+ steelhead trout using stratified mark/recapture methodology. The trap operated 121 nights out of a possible 123 nights, and captured 123,633 0+ chinook salmon, 55,126 0+ steelhead trout, 12,263 1+ steelhead trout, and 736 2+ steelhead trout. No juvenile coho salmon were captured. Catches of 1+ and 2+ steelhead were positively related to the relative gage height of the stream at the trapping site. Average fork length and weight by week for 0+ chinook salmon and 1+ steelhead significantly increased over the course of the study, and significantly decreased for 2+ steelhead. Trap efficiencies for 0+ chinook salmon, 1+ steelhead trout, and 2+ steelhead trout by week averaged 0.31, 0.17, and 0.12, respectively. 0+ chinook salmon trap efficiencies were negatively related to gage height, and 1+ steelhead efficiencies showed positive relations. 2+ steelhead trap efficiencies were not linearly related to gage height. Total population estimates with 95% confidence intervals for 0+ chinook salmon, 1+ steelhead, and 2+ steelhead were 427,542 (390,096 - 464,988), 68,328 (59,055 -77,601), and 4,739 (3,669 - 5,808), respectively. Peak population estimates for 0+ chinook salmon, 1+ steelhead trout, and 2+ steelhead trout occurred during April-June, May-June, and April-May, respectively, and followed trends of actual catches.

Introduction

Site description:
Redwood Creek flows through Trinity and Humboldt Counties before reaching the Pacific Ocean. Headwaters originating at an elevation of about 4,000 ft flow north to northwest to the Pacific Ocean, near 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 1995). The study area entails approximately 65,000 acres of upper Redwood Creek watershed, with about 37 stream miles of accessible salmon and steelhead habitat.

Geology: The geology of Redwood Cr basin has been well-studied and mapped (Cashman et al. 1995). According to the authors,

> " 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).

Average rainfall: Most of the rainfall in Redwood Creek occurs from October through May. The mean annual rainfall is 61.7 inches, and ranges from 49.66 - 77.27 inches (CDWR 1981). Preliminary data show that rainfall in water year 1999 (1999/00) was 57.6 inches, with 5.6 inches falling within the trapping period (USGS 2000).

Discharge: A USGS gaging station (# 11481500) is located on Redwood Creek, and has records of stream flow for years 1953 - 1958, 1972 - 1993, and 1997 to September 1999 (USGS 2000). Following the pattern of rainfall, most of the high flows occur in the months of November through May, and typically peak in February (USGS 2000). Using all years' data, the mean monthly discharge is 239 cfs, and ranges from 44.2 - 423 cfs (USGS 2000).

Overstory: The overstory of Redwood Creek is predominately 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*.), manzanita (*Arctostaphylos patula*), brachen fern (*Pteridium aquilinum*), blackcap raspberry (*Rubus spp*.), and elderberry (*Sambucus spp*.), among other species.

Redwood Cr History: Redwood Creek watershed has historically experienced extensive logging of Redwood and other commercial tree species. In conjunction with associated road building, geology types, and flood events in 1955 and 1964, large amounts of sediments were delivered into the stream channel with a resultant loss of stream habitat complexity such as filling in of pools and flattening out of the stream channel. Currently, Redwood Creek within the study area appears to be experiencing channel incision in flood gravel deposits, scouring of pools to increase depth, riparian growth, and input of woody debris, which collectively increase stream complexity.

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. Chinook salmon of Redwood Creek belong to the California Coastal Chinook Salmon Evolutionarily Significant Unit (ESU), and are listed as "threatened" under the Endangered Species Act (NOAA 1999). The definition of threatened as used by 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 belong to the Southern Oregon/Northern California Coasts ESU and are classified as "threatened" (NMFS 1997). Steelhead trout fall within the Northern California Steelhead ESU, and are also listed as a "threatened" species (NOAA 2000). Coastal cutthroat trout of Redwood Creek fall within the Southern Oregon/California Coasts Coastal Cutthroat Trout ESU, and were determined "not warranted" for ESA listing (NOAA 1999). Despite ESU classification of Redwood Creek anadromous salmonid populations, relatively little data exists concerning abundance and population sizes, particularly for juvenile life history stages.

Purpose:
At the request of the Redwood Creek Landowners Association, Douglas Parkinson and Associates performed a study designed to determine various aspects of outmigrating salmon and steelhead populations in upper Redwood Creek drainage basin. Specific study objectives were as follows:

1. Determine the temporal pattern and species composition of downstream migrating juvenile salmonids.
2. Enumerate species out-migration.
3. Determine population estimates for downstream migrating 0+ chinook salmon, 1+ steelhead trout, and 2+ steelhead trout using mark/recapture techniques.
4. Record fork lengths (mm) and weights (g) of captured fish.
5. Collect and handle fish in a manner that minimizes mortality.

Methods and Materials

Trap Operations
An E.G. Solutions (5 foot diameter cone) rotary screw trap was placed in Redwood Creek at the head of a pool downstream of a moderately high gradient riffle on Barnum Timber land on April 4, 2000. The trap was positioned in the main current of the stream alongside a bedrock outcropping on the left side of the river (looking downstream). The trap operated continually (24hrs/day, 7 days a week) from April 4th through August 5th, except for relatively infrequent periods of high flow. During the two periods of high flow that caused the cone of the trap to spin too fast (e.g. > 28 revolutions/3 minutes), the trap cone was raised to stop trapping, or the trap was re-positioned into slower currents to continue trapping. When flows decreased, the trap was placed back into the original main current location. Weir panels and rock weirs were installed upstream of the trap to funnel water and fish into the area of the cone. During the latter part of the season, plastic drop cloths were used to line the weirs to further increase flow and catches. Efforts were continually made to maximize trap catches, and minimize trap mortalities with respect to high flows and debris amounts.

Moderate to high flows and/or wind can cause substantial amounts of debris collection that can increase mortality of trapped fish. When trapping under higher flows, the livebox was checked every 1-2 hours dependent upon the amount of debris in the livebox. During normal flow, the livebox was emptied of debris every afternoon or night prior to the next morning's catch.

The livebox was emptied at 08:00 every morning by 2-3 technicians. All fish were graded by size and placed in 5 gallon buckets for delivery to 32 gallon perforated plastic holding cans located on the margin of the river. Young of year (0+) juveniles were separated from 1+ (between 1 and 2 years old) and 2+ (between 2 and 3 years old) juveniles to decrease predation of 0+ fish in the 5 g buckets and holding cans. 1+ and 2+ fish were kept together. Two holding cans were used to hold the contents of the livebox, and random samples of each species were then netted from the holding cans and transported to the streamside station in 5 g buckets for enumeration and biometric data collection. During the months of June, July, and August when stream and air temperatures increased, crushed ice was used to cool the water in the buckets holding fish, and worked well, as evidenced by the increased vigor in the fish.

Fork Lengths/Weights: Fish were anesthetized with MS-222 prior to data collection in 5 g buckets. Biometric data collection included 30 measurements of fork length (mm) and wet weight (g) for random samples of 0+ chinook salmon (0+ KS), 1+ steelhead trout (1+ SH), and 2+ steelhead trout (2+ SH). Only fork lengths were taken for 0+ steelhead (0+ SH). A 350 mm measuring board (± 1 mm) and an Ohaus 600 sz digital scale (± 0.1 g) were used in the study. Fork lengths were taken every day of trap collection, and weights were taken 2-3 times per week, excluding 0+ steelhead. Fork length frequencies of 1+ and older steelhead were used to determine age-length relationships at varying times throughout the trapping period. Weights were taken by placing individuals into a tared plastic pan (containing water) on the electronic scale.

Developmental Stages were visually determined for all 1+ and 2+ steelhead that were captured. The purpose of designating parr, pre-smolt, and smolt was to provide a week and season index for the downstream migrating populations. Parr designated fish that had obvious parr marks present and no silvering of scales. Pre-smolt designated individuals that had less obvious parr marks, and were in the process of becoming silver colored smolts. Pre-smolt was considered in between parr and smolt. Smolt designated fish that were very silver in coloration (i.e. smoltification), had no parr marks present, and had blackish colored caudal fins.

After measurements were collected, the fish were recovered in buckets of continuously aerated fresh water. Crushed ice was also used in the recovery buckets to reduce water temperatures during June-August. Young of year fish were kept in separate recovery buckets from age 1+ and older fish to decrease predation, or injury. After recovery, the 0+ juveniles were transported 60 meters downstream of the trap to a holding cage in the stream margin, which served as a final recovery and release station. Concerns regarding temperature differences between bucket and stream water, and possible predation of 0+ fish by larger stream dwelling 1+ and 2+ juveniles at release, justified using a holding cage at the release site. By leaving the fish at the downstream release site from 15 - 45 minutes, we were able to monitor any immediate negative effects associated with water temperature acclimation. Care was taken to use as little ice as necessary, and we found that only a few fish ($n = 4$) died in the release cage. The meshed cage might have increased post measurement and release survival by allowing for a more complete stream orientation and acclimation period. Released fry were generally more alert, and were able to hide or swim away from larger juvenile fish. 1+ and 2+ steelhead were released 157 meters downstream of the trapping site into edge-water of a riffle. We did not use a release cage because all released fish appeared very alert and mobile. Additionally, there was no concern of predation due to their size. The older juvenile fish were released farther downstream of the trap than 0+ fish to decrease any likelihood of re-catching a released fish.

Population Estimates: The number of fish captured by the trap represents only a portion of the total fish moving 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 mark-recapture methodology described by Carlson et al. (1998). The approximately unbiased estimate equation for a 1 site study was used to determine total population size (U_h) in a given capture and trapping efficiency period (h). Variance was computed, and the value was used to calculate 95% confidence intervals (CI) for each weekly population estimate. The weekly population estimate (U_h) does not include marked releases, and any short term handling mortality was subtracted (Carlson et al. 1998). Trap efficiency trials were conducted 3 times a week for 0+ chinook salmon, 3 times a week for 1+ steelhead, and every day for 2+ steelhead. Data was combined and run through the equation to determine the weekly estimate. Fin clips were used to identify trap efficiency trial fish. Clips were stratified by week such that marked fish of one group (or week) would not be included in the following week(s) calculations. Clip types for 1+ and 2+ steelhead were kept on differing time schedules to later aid in identifying the correct age group of the recaptured fish; if there was any doubt or question, we would re-measure the fish, and count it for the appropriate age group. If a week's trapping efficiency for a particular species at age was less than 10%, that week's data was pooled with the previous or following week's data to determine a bi-weekly estimate of total population size. This procedure tended to smooth out any inflation of population size due to low recapture probability. Week and bi-weekly estimates were then summed to determine the total out-migrant population estimate for the entire trapping period. Variance for the estimate was determined in a similar way (i.e. adding weekly variances), and used to calculate 95% CI for the final total population estimate (Carlson et al. 1998).

Trap efficiency trial fish were given partial fin clips while under anesthesia, and later recovered in aerated 5 g buckets. 0+ chinook salmon were given upper or lower caudal fin clips, 1+ steelhead were given vertical upper, horizontal upper, or lower caudal fin clips, and 2+ steelhead were given the same fin clips as 1+ SH, in addition to right or left pectoral partial fin clips. Once recovered, the fish were placed in mesh cages in the stream for 1 - 2 hrs to test for short term delayed mortality (Carlson et al 1998). Fin clipped 0+ chinook salmon were released 260 m upstream of the trap, and clipped 1+ and 2+ steelhead were released 160 m upstream of the trap. All fin clipped fish were released in the day after the trap was emptied, and recovered the following day(s).

The number of upstream released fin clipped 0+ chinook salmon totaled 8,056, ranged from 100 to 606 per 7 day week, and averaged 471 per week. The number of 1+ steelhead used in the trials totaled 1,965, ranged from 27 to 207 per 7 day week, and averaged 114 per week. The number of 2+ steelhead totaled 579, ranged from 8 to 101 per 7 day week with an average of 33 per week.

Assumptions of Mark/Recapture

The following assumptions apply to the Carlson et al (1998) population estimates:

1) The population remains closed, and mortality observed during marking, capturing, and handling is censored.
2) All smolts have the same probability of being marked, or of being examined for marks.
3) Probability of capture is constant.
4) Marks are not lost between release and recovery, and survival of marked fish is tested.
5) All marked smolts are reported on recapture.
6) All marked smolts released are either recovered or pass by the downstream capture site.

We attempted to satisfy or test the requirements of the mark-recapture assumptions using the following rationale, or experiments:

Assumption 1: We considered the population to be closed and assumed juvenile fish from watersheds other than Redwood Cr do not swim into the Redwood Cr basin; fish captured in Redwood Creek originated from Redwood Creek. Additionally, mortality was censored throughout the trapping season.

Assumption 2: By using randomly drawn individuals for marking this assumption was met. Fish used in marking were of varying sizes for each species and age class, and hence, possible variability in recapture was accounted for. We assumed that marked fish randomly mixed with the unmarked population because upstream release distances for marked fish were greater than 100 m. The distance of upstream release was considered adequate for mixing. Additionally, the daily numbers of unmarked fish captured were much higher than marked fish recaptured. For example, on any given day we might catch 1,000 0+ chinook salmon, with up to 60 being marked fish. We attempted to use a second trap upstream of the rotary screw trap to catch and mark fish to test if efficiencies of marked fish from the second trap captured by the rotary screw trap, differed from efficiencies of rotary screw trap recaptured and released fish. Such an experiment would have shown if the rotary screw trap efficiency fish had learned to avoid the rotary screw trap. The experiment failed because the second trap was placed at a time downstream migration was tapering off, and we did not catch any sufficient numbers of fish. Based upon rotary efficiencies, it appeared that this might be a concern with the 2+ steelhead juveniles. In general, we feel that the rotary screw trap location and the use of weirs decreased the likelihood of marked fish purposely avoiding the trap.

Assumption 3: Although this assumption was not tested explicitly, methods of using multiple groups of marked fish per week to determine a weekly population estimate should provide a population estimate that takes into account variable flows and capture probabilities within a given week. Carlson et al (1998) suggest that by using more than 1 sample to estimate a weekly population size, the assumption is less restrictive.

Assumption 4: Partial fin clips were used because they are relatively long lasting, easy to apply, and do not harm the fish if correctly applied. We performed 5 separate handling and clipping mortality tests for 0+ chinook salmon to determine short term survival of marked fish. Samples of marked fish (n = 25 - 75) were held in live cars (cages) in the stream for a period of 1-2 d and mortality was monitored. One short term mortality experiment was performed on 50 marked 1+ steelhead that were held in a similar cage for a period of 1 d (24 hrs).

Assumption 5: Each member of the field crew was specifically trained in applying and identifying partial fin clips used for each species at age. All fish captured by the rotary screw trap were anesthetized with MS-222 and individually observed for fin clips. We found that we did not have to totally anesthetize the fish to observe clips, which decreased processing time.

Assumption 6: Using stratified marks by week allowed for discriminating groups of marked fish on a weekly basis. The majority of recaptures occurred 1 d after release, with few captured on the second day of release. Although marked fish of one week were occasionally captured the following week, the numbers were relatively low (e.g. 1 - 3) and considered negligible when compared to the numbers originally released and recaptured in the previous week. Marked fish of one week were not counted for the population estimate of the following week, unless the two week's data were pooled.

Additional Experiments:
We performed four experiments with 0+ chinook salmon to determine if the downstream released fish were moving upstream and recaptured by the rotary screw trap. Experiments were conducted on 5/30/00, 8/2/00, 8/3/00, and 8/4/00 during relatively low flow periods. The chinook salmon were given different clips than those used in the efficiency trials. Sample sizes for the four experiments ranged from 21-50 individuals.

One experiment was conducted on 0+ chinook salmon and 0+ steelhead trout to determine if MS-222 and handling caused any delayed mortality. Random samples of anesthetized fish were placed in separate live cages, and survival monitored for a period of 1 d (24 hrs). Sample size for the chinook salmon was 75, and for 0+ steelhead 20.

Physical Data Collection:
A staff gage with increments in 10ths of a foot was used to gauge the relative stream surface elevation at the trap site. The staff gage was placed on April 11, and read every morning to the nearest 1/10 of a

foot. A Hobo temperature data logger (Hobo Inc., Pocasse, MA) was used from 5/11/00 - 7/09/00 to determine average stream temperature at the trap site. Data of fraction of the Moon illumination at midnight was gathered from the Astronomy Applications Department, US Naval Observatory, Washington, DC 20392-5420.

Statistical Analysis: Numbers Cruncher Statistical System software (Hintze 1998) was used for descriptive statistics, ANOVA, correlation, and linear regression/anova output. Descriptive statistics were used to characterize the mean fork length (mm) and weight (g) of each species at age on a weekly and season basis. ANOVA was used to test if two populations of data were present with respect to 1+ and 2+ SH fork lengths (mm). Linear regressions or correlations were used to test for significant relations of biological data with physical data (Table 1). If data violated tests of assumptions, data was transformed with Log (x+1), where x = the independent variable. When transformations did not work for ANOVA, non-parametric equivalents were used. Power is defined as the ability of the test to detect differences that truly exist, or put another way, the probability of correctly rejecting the null hypothesis when it is false (Zar 1999). The level of significance (Alpha) for all tests was set at 0.05.

Table 1. Linear regressions and correlations used in the study.

Test	Dependent Variable (y)	Independent Variable (x)
Regression	Daily catches of salmonids	Daily staff gage reading
Regression	Daily catches of 0+ KS	Daily staff gage reading
Regression	Daily catches of 0+ SH	Daily staff gage reading
Regression	Daily catches of 1+ SH	Daily staff gage reading
Regression	Daily catches of 2+ SH	Daily staff gage reading
Regression	Daily catches of salmonids	Lunar phase
Regression	Daily catches of 0+ KS	Lunar phase
Regression	Daily catches of 0+ KS	Lunar phase
Regression	Daily catches of 1+SH	Lunar phase
Regression	Daily catches of 2+ SH	Lunar phase
Regression	Average week fork length 0+ KS	Week number
Regression	Average week fork length 0+ SH	Week number
Regression	Average week fork length 1+ SH	Week number
Regression	Average week fork length 2+ SH	Week number
Regression	Average week weight of 0+ KS	Week number
Regression	Average week weight of 1+ SH	Week number
Regression	Average week weight of 2+ SH	Week number
Regression	Weekly 0+ KS trap efficiencies	Average of weekly staff gage
Regression	Weekly 1+ SH trap efficiencies	Average of weekly staff gage
Regression	Weekly 2+ SH trap efficiencies	Average of weekly staff gage
Correlation	Weekly 0+ KS trap efficiencies	Week number
Correlation	Weekly 1+ SH trap efficiencies	Week number
Correlation	Weekly 2+ SH trap efficiencies	Week number
Correlation	Weekly population estimate 0+ KS	Wk. catches of 0+ KS
Correlation	Weekly population estimate of 0+ KS	Wk. trap. efficiency for 0+ KS
Correlation	Weekly population estimate 1+ SH	Wk. catches of 1+ SH
Correlation	Weekly population estimate of 1+ SH	Wk. trap. efficiency for 1+ SH
Correlation	Weekly population estimate 2+ SH	Wk. catches of 2+ SH
Correlation	Weekly population estimate of 2+ SH	Wk. trap. efficiency for 2+ SH
Regression	Daily catches of all salmonids	Average daily stream temperature C
Regression	Daily catches of 0+ KS	Average daily stream temperature C
Regression	Daily catches of 0+ SH	Average daily stream temperature C
Regression	Daily catches of 1+ SH	Average daily stream temperature C

Regression	Daily catches of 2+ SH	Average daily stream temperature C

Results

The trap operated over a period of 18 weeks (week 1 consisted of 4 nights), and trapped 121 nights out of a possible 123. The trap operated a total of 123 days (see High Flow Events).

Species Captured

Species captured by the RST included: juvenile chinook salmon (*Oncorhynchus tshawytscha*), juvenile steelhead trout (*O. mykiss*), adult steelhead (*O. mykiss*), cutthroat trout (*O. clarki clarki)*, sculpin (*Cottus* spp.), sucker (*Catostomidae* family), juvenile and adult Pacific Lampreys (*Entosphenus tridentatus*), and stickleback (*Gasterosteus aculeatus)*. No juvenile coho salmon (*O. kisutch*) were captured. Total trap catches of juvenile salmonids are given in Figure 1, and for all species (Table 2).

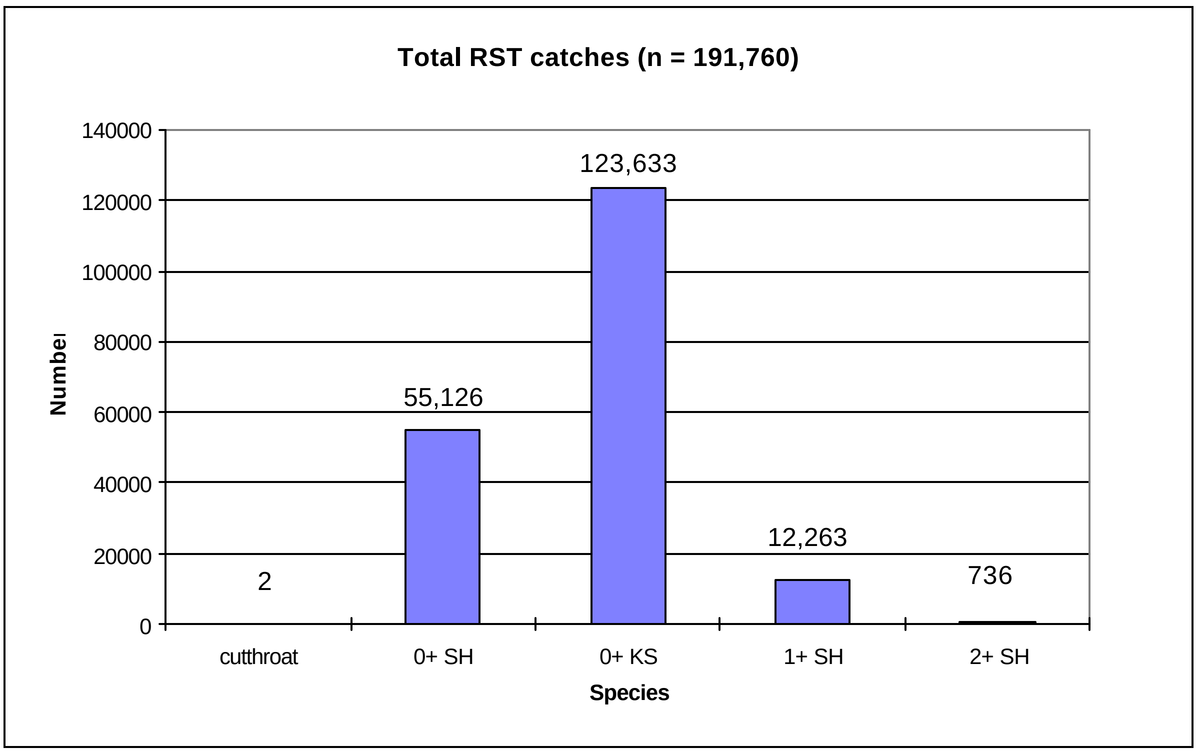

Figure 1. Total Rotary Screw Trap salmonid catches from April 5 through August 5, 2000 in Redwood Creek, Redwood Valley, Humboldt Co., California.

Table 2. Rotary Screw Trap catches of various species, April 5 through August 5, 2000.

Species Captured	Number caught
Cutthroat Trout	2
0+ Steelhead Trout	55,126
1+ Steelhead Trout	12,263
2+ Steelhead Trout	736
Adult Steelhead	6
0+ Chinook Salmon	123,633
Coho salmon	0
Prickly Sculpin	3
Coast Range Sculpin	145
Suckers (spp. unknown)	3
3 Spined Stickleback	144
Adult Pacific Lampreys	16
Juvenile Pacific Lampreys (ammocetes)	597
Pacific Giant Salamanders	30

Peak Captures

The catches of 0+ KS, 0+ SH, 1+ SH, and 2+ SH were variable over time, with apparent multi-modal catch distributions.

Peak 0+ chinook salmon catches occurred during April, May, and June (Figure 2). The highest daily 0+ KS peak captures occurred on May 27 (n = 4,232), June 7 (n = 3,832), and June 21 (n = 5,457). Catches in May and June accounted for 81% of the total catch. The pattern of catches show that the trapping period encompassed the majority of downstream migration. The daily captures expressed as a percentage of the total catch ranged from 0.010 - 4.414%, and suggest that nights missed trapping (n = 2) did not influence the total catch to any large degree.

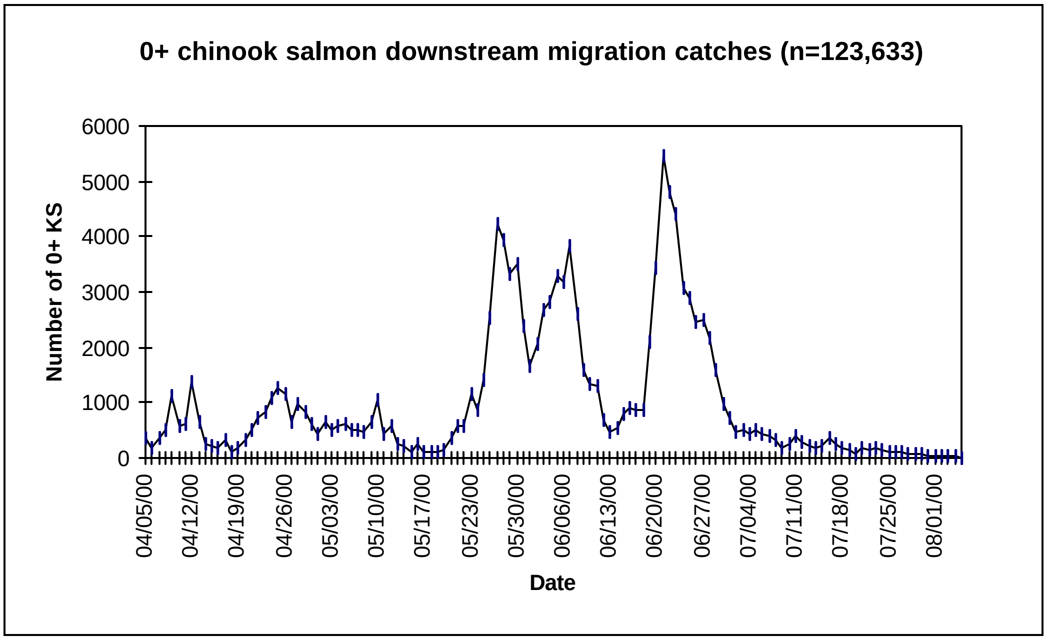

Figure 2. Temporal pattern of 0+ KS catches, Redwood Creek, Humboldt Co., California.

Peak 0+ steelhead trout catches occurred during June and July (Figure 3). The highest daily peak catches occurred on 6/5 (n = 846), 6/21 (n = 1,449), 6/28 (n = 2,439), 7/2 (n = 2,282) and 7/5 (n = 1,938). Catches in June and July accounted for 87.5% of the total catch. Days of zero catches correspond to times when fry have not yet emerged from redds, or are not moving downstream. The pattern of catches show that the trapping period covered the majority of downstream migration, or stream redistribution. The daily captures expressed as a percentage of the total catch ranged from 0.000 - 4.42 %, and suggest that nights missed trapping (n = 2) did not influence the total catch to any large degree.

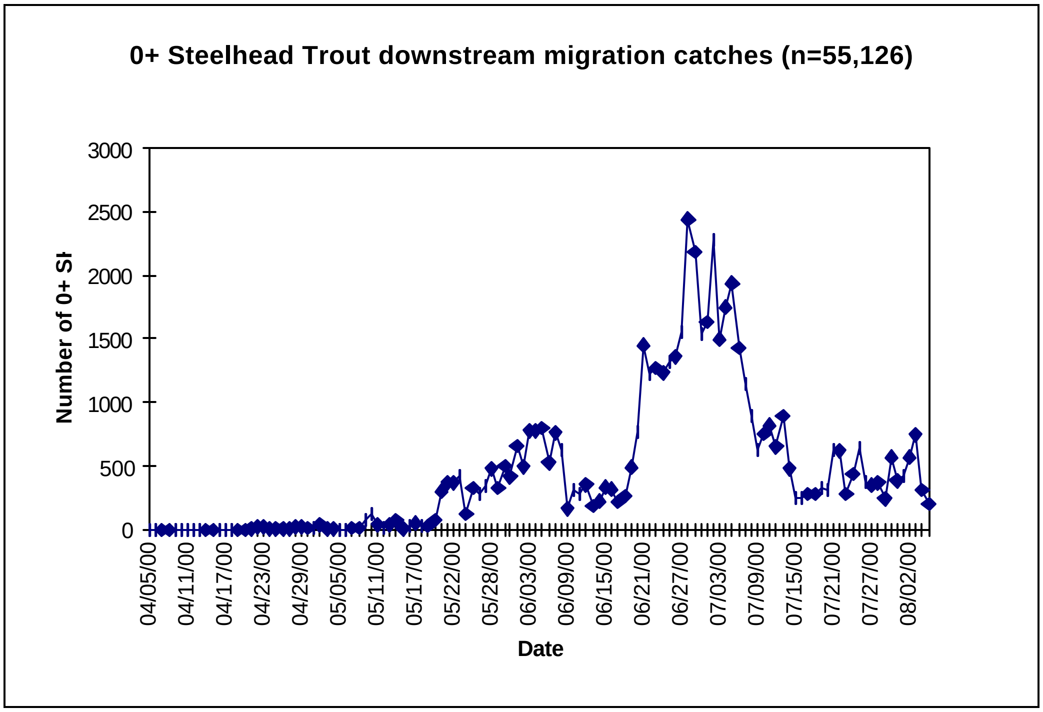

Figure 3. Temporal pattern of 0+ SH catches, Redwood Creek, Humboldt Co., California.

Peak 1+ steelhead trout catches occurred during April, May, and June (Figure 4). The highest daily peak catches occurred on 4/13 (n = 234), 4/28 (n = 408), 5/3 (n = 465), 5/10 (n = 544), and 6/4 (n = 224). Catches in April and May accounted for 77% of the total catch. The pattern of 1+ SH catches over time showed the majority of catches occurred after trap placement, and suggests that we did not miss a significant portion of downstream migrating individuals. The daily captures expressed as a percentage of the total catch ranged from 0.000 - 4.44 %, and suggest that nights missed trapping (n = 2) within the trapping period did not influence the total catch to any large degree.

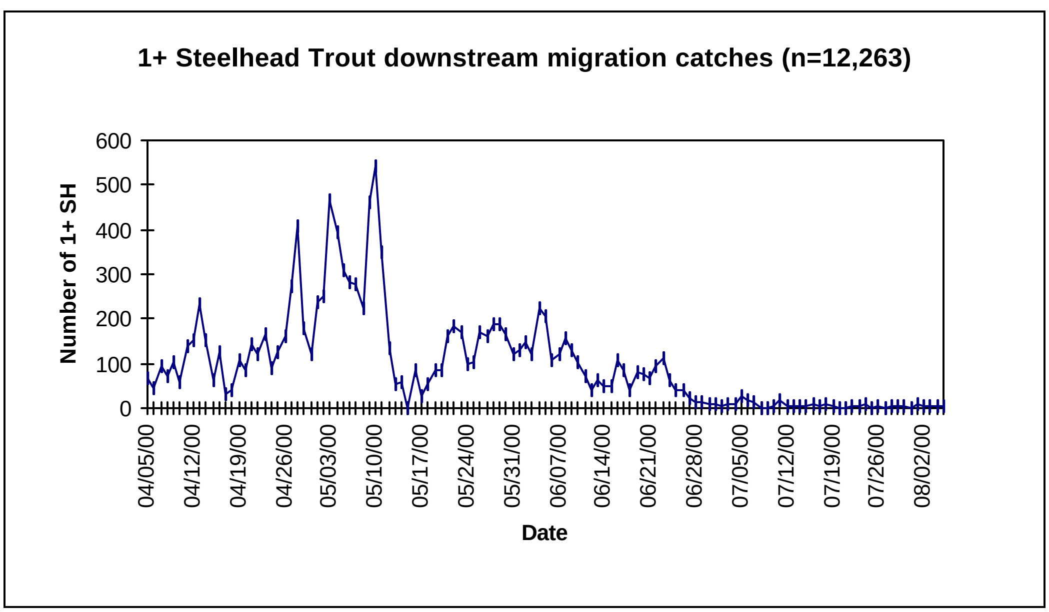

Figure 4. Temporal pattern of 1+ SH catches, Redwood Creek, Humboldt Co., California.

Peak 2+ steelhead trout catches occurred during April and May (Figure 5). The highest daily peak catches occurred on 4/6 (n = 35), 4/13 (n = 26), 4/16 (n = 26), 5/3 (n = 24), and 5/10 (n = 19). Catches in April and May accounted for 81% of the total catch. The pattern of catches showed that most of the 2+ SH were captured early in the trapping season, and suggests that we probably missed a significant portion of downstream migrating individuals due to trap installation date. The daily captures expressed as a percentage of the total catch ranged from 0.000 - 4.76 %, and suggests that nights missed trapping (n = 2) did not influence the total catch to a large degree.

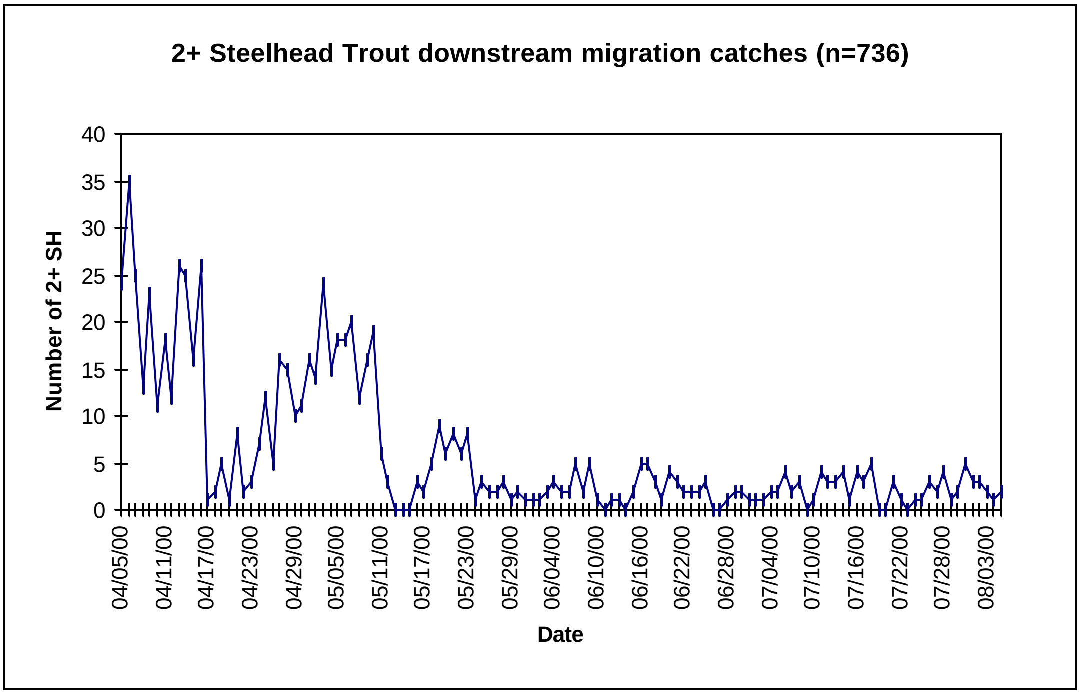

Figure 5. Temporal pattern of 2+ SH catches, Redwood Creek, Humboldt Co., California.

High Flow Events

Periods of high flow occurred on April 17 - 19, April 28, May 10 - 11, and May 15. High flow events are reflected in the stream staff gage readings (Figure 6).

On April 17, high stream discharge and debris loading in the livebox caused water to overflow the livebox, emptying most of the night and early morning's catch. At 5:30 am, any remaining fish (60 0+ KS) were counted and released, and the trap was repositioned out of the main current into slower water. The trap was then operated throughout the high flow during the day by checking the livebox every one-half to one hour, dependent upon debris amounts. The amount of debris in the form of leaves, small branches, etc. was great. During the day, a relatively high number of 0+ KS were captured (272) when compared to the previous three nights' captures of 192, 207, and 264 fry. However, the capture of 1+ and 2+ SH dropped dramatically, probably because of escape from the livebox and repositioning the trap out of the main current. At 1845 the cone was raised and the trap did not operate overnight. On April 18, the cone was lowered at 0600, and trapping was continued. Catches on April 18 reflected day catch only (0+ SH: 0, 0+ KS: 114, 1+ SH: 41, 2+ SH: 2) and at 1830 the trap was left to run overnight. By April 20, the trap was positioned back into the main current.

A smaller high flow event occurred on April 28, and the trap was operated over the course of the runoff event. The catches were high for 0+ KS, 1+ SH, and 2+ SH, with little to no mortality except for the 0+ KS (3.74%). On May 9 the trap was moved partly out of the main current in anticipation of rain and increased runoff. The stream rose more than expected, and on the morning of May 10 we trapped during one of the peak runoffs, and had peak counts (for that time period) for 0+ KS, and 1+ SH. However, the high flows, high rate of trap revolutions, and heavy debris loads caused 6.17% mortality for the 1038 KS captured. The trap was laterally repositioned a few feet out of the main current to decrease revolutions (21 every 3 minutes), and left in operation throughout the day. During the following night (midnight - 1:30 am), debris was emptied from the trap livebox, and the trap was again left running. We continued trapping over the course of the high flow event, and on May 13 the trap was re-positioned back into the full main current. With high flows and threats of continued rain, the trap was re-positioned into calmer water on May 14, and the trap cone was raised. On May 15 at 0600, the trap cone was lowered, and trapping was continued. After checking the contents of the livebox, the trap was re-positioned into the main current. Catches on May 15 were low (0+ SH: 3, 0+ KS: 110, 1+ SH: 1, and 2+ SH: 0), yet showed once again that downstream migration occurred during the day. Thereafter, trapping in the main current continued until the end of the season.

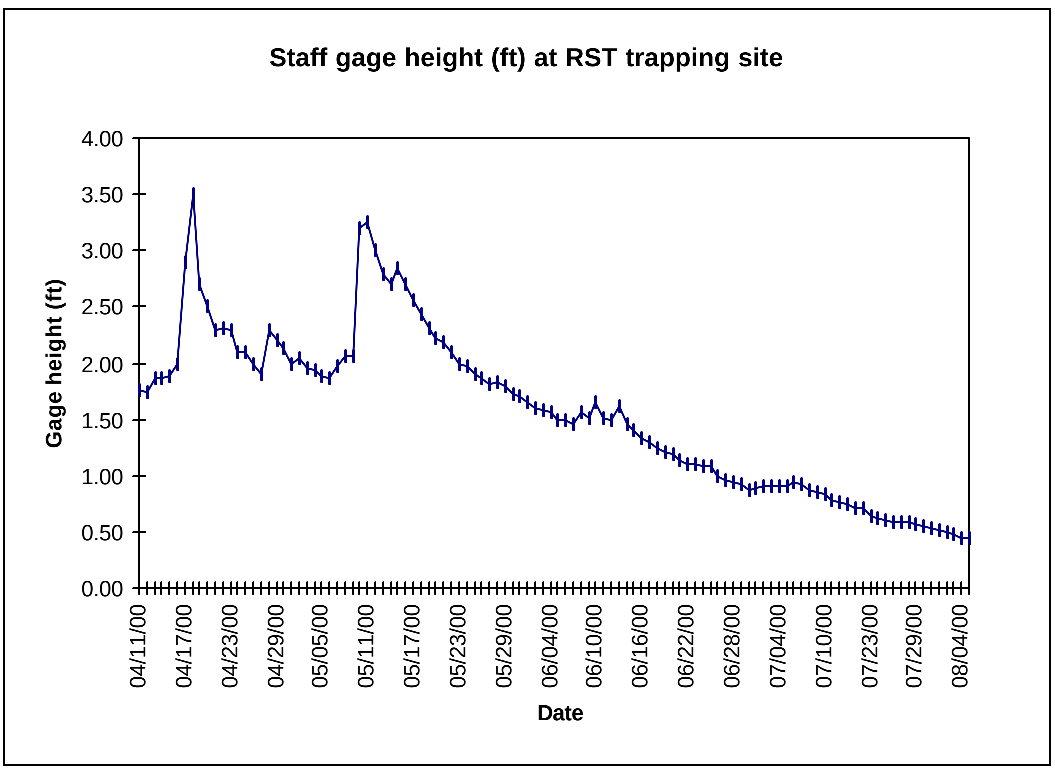

Figure 6. Staff gage at RST site, Redwood Creek, Humboldt Co., California.

Linear Relations of Catch with Staff Gage Height: Linear regression of daily gage height on daily catches for all juvenile salmonids combined showed no significant linear relations ($P > 0.05$; $R^2 = 0.024$). Regression of gage height on 0+ KS catches also showed no significant linear relation ($P > 0.05$; $R^2 = 0.00002$). Regression for 0+ SH catches showed a negative significant relation with gage height ($P = 0.000001$; $R^2 = 0.2640$; power = 0.999). Regression of gage height on 1+ SH catches showed positive relations ($P = 0.0000001$; $R^2 = 0.34$; power = 1.00), as did 2+ SH catches ($P = 0.00009$; $R^2 = 0.124$; power = 0.98).

Linear Relations of Catch with Lunar Phase: Linear regressions of fraction of moonlight on daily catches for all salmonids and each species violated assumptions of normality, and results were not valid. Although statistical relations were not warranted, some generalizations can be made. Catches of 0+ KS generally decreased with a full or new moon phase, and the highest catches occurred during moon illumination fractions of 0.30 - 0.84. 0+ SH catches increased with low moon illumination, and decreased with higher illumination. The peak catches occurred during an illumination fraction of 0.12 - 0.17. 1+ SH catches were generally low during full moon illumination, and the peak catches occurred during a moon illumination of 0.01 - 0.44. The first peak catch of 2+ SH occurred during a moon illumination fraction greater than 0.48, and the second peak was associated with a moon fraction of 0.01.

Stream Temperatures

The average daily (24 hr period) stream temperatures from 5/11/00 - 7/09/00 averaged 15.88 degrees Celsius (95% CI 15.00 - 16.74), and ranged from 8.86 - 21.78 (Figure 7).

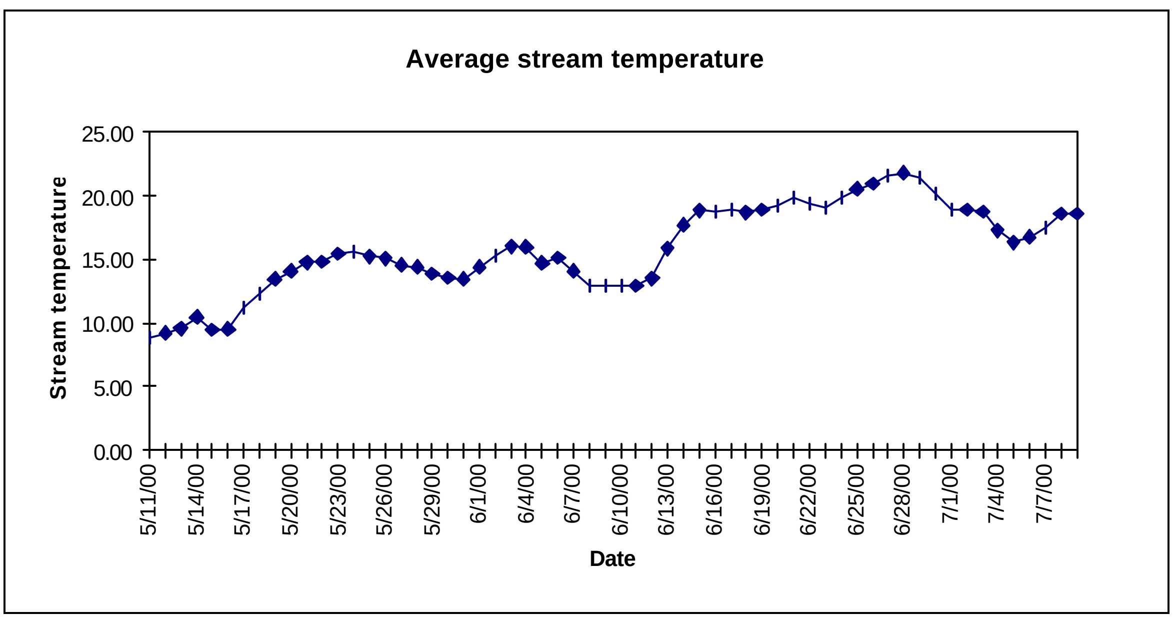

Figure 7. Redwood Creek average stream temperature (Celsius), Humboldt County, California.

Linear Relations of Catch with Average Stream Temperature: Linear regression of average stream temperature C on catches for all juvenile salmonids combined showed a significant positive linear relationship ($P = 0.000076$; $R^2 = 0.238$; power = 0.99). As stream temperatures increased, more juvenile salmonids were caught. Regression for 0+ KS showed a very weak significant positive relationship with stream temperature (P = 0.030; R^2 = 0.08; power = 0.59). Regression for 0+ SH showed a highly significant positive relationship (P = 0.000001; R^2 = 0.52; power = 1.00). Regression for 1+ SH showed a week significant negative relationship (P = 0.0003; R^2 = 0.20; power = 0.97), and regression for 2+ SH showed no significant linear relationship (P > 0.05; R^2 = 0.02).

Fork Length and Weights

The average weekly fork lengths (mm) of out-migrating juvenile chinook salmon and steelhead trout are shown in Figure 8. The data was tested for significant relationships with time (week) using single linear regression. Regression of week number on average length for 0+ chinook salmon showed a highly significant positive relationship (P = 0.000001; R^2 = 0.98; power = 1.000); 0+ SH showed a highly significant positive relationship as well, (P = 0.000001; R^2 = 0.96; power = 1.000), as did 1+ SH (P = 0.000001; R^2 = 0.94; power = 1.000). 0+ and 1+ juveniles were longer as the weeks passed by. 2+ SH showed a significant negative relationship with average fork length and time (P = 0.005; R^2 = 0.40; power = 0.8645). The difference in average fork length from week 1 and week 18 for 0+ KS, 1+ SH, and 2+ SH was positive (+) 30.2, + 28.6, and negative (-) 13.8 mm, respectively. The difference in average fork length from week 3 and week 18 for 0+ SH was + 21.1mm.

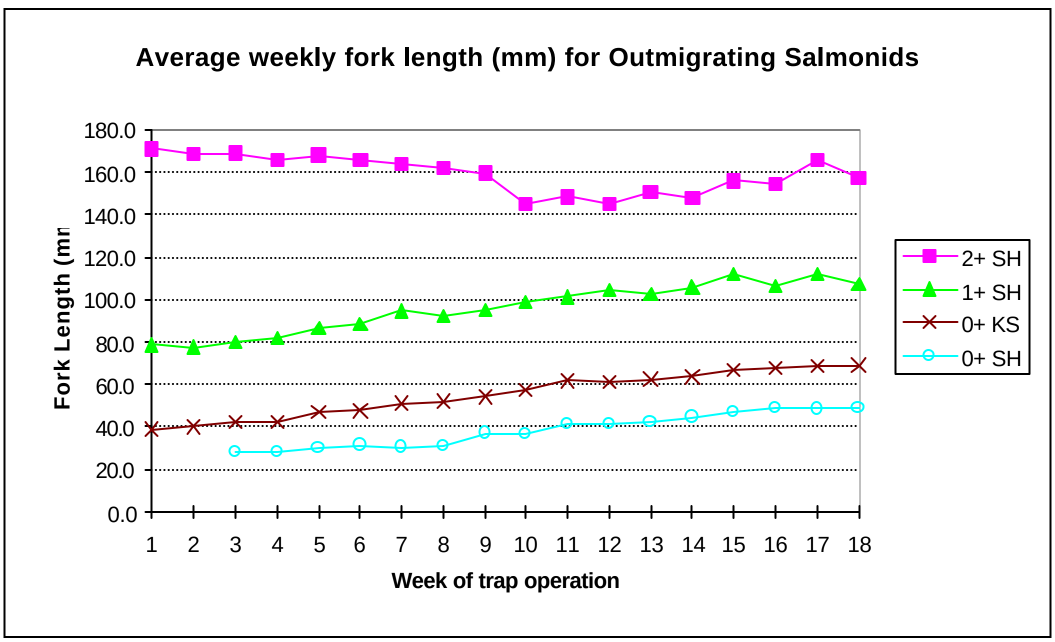

Figure 8. Average weekly fork lengths (mm) for 0+ KS, 1+ SH, and 2+ SH, Redwood Creek, Humboldt Co., California.

The average weight (g) by week showed similar trends (Figure 9). Weight increased for chinook salmon and 1+ steelhead, and decreased for 2+ steelhead. No average was reported for 2+ SH for week 17 due to low sample size (n=1). Change in average weight was highly significant for all three species (P < 0.0005; 0+ KS R^2 = 0.96, 1+ SH R^2 = 0.84, 2+ SH R^2 = 0.56; power 0.98 - 1.00). The difference in average weight from week 1 and week 18 for 0+ KS was + 2.8 g. The difference in average weight from week 1 and week 16 for 1+ SH and 2+ SH was + 8.07, and - 11.62 g, respectively.

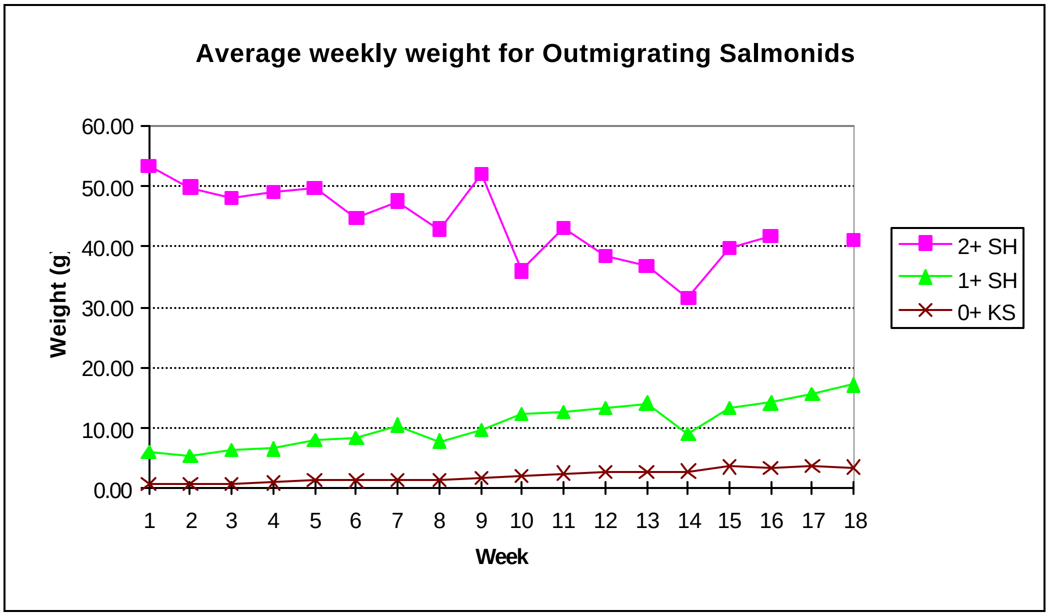

Figure 9. Average weight by week for Out-migrating Salmonids, Redwood Cr, Redwood Valley, California.

A total of 3,661 fork length (mm) and 913 weight measurements were taken for 0+ chinook salmon (Table 3). Overall, 0+ chinook salmon fork lengths (mm) ranged from 36 - 85 mm, averaged 55.5 mm (95% CI 55 - 56 mm), with a standard error of the mean (SEM) of 0.2 mm.
0+ chinook salmon weights (g) ranged from 0.3 - 6.3 g, and averaged 2.03 g (95% CI 2.0 - 2.1 g; SEM = 0.04g).

A total of 2,669 fork length (mm) measurements were taken for 0+ steelhead trout (Table 4). Using all measurements, fork lengths (mm) ranged from 25 - 75 mm, and averaged 40.9 mm (95% CI 40.5 - 41.2 mm; SEM = 0.2 mm).

A total of 2,721 fork length (mm) and 1,455 weight measurements were taken for 1+ SH (Table 5). Overall, 1+ SH fork lengths (mm) ranged from 48 - 138 mm, and averaged 92.4 mm (95% CI 91.8 - 93.0 mm; SEM = 0.3 mm). 1+ SH weights (g) ranged from 1.3 - 30.7 g, and averaged 8.29 g (95% CI 8.05 - 8.54 g; SEM = 0.13 g).

A total of 710 fork length (mm) and 480 weight measurements were taken for 2+ SH (Table 6). Overall, 2+ SH fork lengths (mm) ranged from 136 - 220 mm, and averaged 164.4 mm (95% CI 163.2 - 165.5 mm; SEM = 0.6 mm). 2+ SH weights (g) ranged from 25.1 - 116.0 g, and averaged 49.12 g (95% CI 47.93 - 50.32 g; SEM = 0.61 g).

Table 3. Fork length (mm) and weight (g) of 0+ Chinook salmon downstream migrants.

	0+ KS Fork length (mm)						0+ KS Weight (g)							
Week	MIN	MAX	Average				MIN	MAX	Average				Sample size (n)	
	FL (mm)	FL (mm)	95% LCL	95% UCL	FL (mm)	SEM (mm)	Wt (g)	Wt (g)	95% LCL	95% UCL	Wt (g)	SEM (g)	FL	Wt
4/5 - 4/8	36	48	38	39	38.8	0.2	0.4	1.2	0.6	0.7	0.67	0.03	120	44
4/9 - 4/15	36	56	40	41	40.2	0.2	0.3	1.9	0.6	0.7	0.63	0.04	210	59
4/16 - 4/22	36	58	42	43	42.7	0.3	0.4	1.5	0.5	0.7	0.64	0.05	210	30
4/23 - 4/29	36	64	42	43	42.5	0.4	0.3	1.9	0.9	1.1	0.99	0.06	210	30
4/30 - 5/6	36	68	46	48	46.9	0.5	0.5	3.5	1.2	1.6	1.44	0.10	210	60
5/7 - 5/13	37	65	47	48	47.7	0.4	0.6	2.3	1.1	1.4	1.26	0.06	210	60
5/14 - 5/20	38	70	51	52	51.4	0.4	0.6	3.6	1.4	1.7	1.53	0.08	210	60
5/21 - 5/27	37	69	51	53	52.0	0.4	0.7	3.1	1.3	1.6	1.45	0.07	210	60
5/28 - 6/3	41	79	53	55	54.3	0.4	0.8	4.5	1.6	2.0	1.78	0.10	210	60
6/4 - 6/10	42	82	56	59	57.5	0.6	1.0	5.7	1.9	2.4	2.12	0.12	210	60
6/11 - 6/17	39	85	61	63	61.8	0.6	0.9	5.3	2.3	2.8	2.55	0.15	210	60
6/18 - 6/24	46	84	60	62	61.1	0.5	0.9	5.5	2.3	2.9	2.61	0.14	210	60
6/25 - 7/1	47	82	61	63	62.3	0.5	1.1	5.8	2.5	3.0	2.73	0.12	210	60
7/2 - 7/8	45	82	63	64	63.5	0.4	1.0	6.2	2.6	3.1	2.83	0.12	210	60
7/9 - 7/15	52	81	66	67	66.6	0.4	1.8	5.7	3.4	3.9	3.65	0.14	210	30
7/16 - 7/22	52	83	67	68	67.4	0.4	1.5	6.3	3.1	3.5	3.27	0.10	210	60
7/23 - 7/29	56	85	68	69	68.4	0.4	2.2	5.6	3.4	4.1	3.73	0.16	210	30
7/30 - 8/5	53	83	68	70	69.0	0.4	2.0	4.9	3.2	3.7	3.47	0.70	181	30
Total:	36	85	55	56	55.5	0.2	0.3	6.3	2.0	2.1	2.03	0.04	3661	913

Table 4. Fork length of 0+ Steelhead Trout.

	0+ SH Fork length (mm)						0+ SH Weight (g)							
Week	MIN	MAX	Average				MIN	MAX	Average				Sample size (n)	
	FL (mm)	FL (mm)	95% LCL	95% UCL	FL (mm)	SEM (mm)	Wt (g)	Wt (g)	95% LCL	95% UCL	Wt (g)	SEM (g)	FL	Wt
4/5 - 4/8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4/9 - 4/15	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4/16 - 4/22	27	30	27.6	28.5	28.0	0.2	-	-	-	-	-	-	21	-
4/23 - 4/29	26	31	27.6	28.4	28.0	0.2	-	-	-	-	-	-	44	-
4/30 - 5/6	27	38	29.4	30.2	29.8	0.2	-	-	-	-	-	-	51	-
5/7 - 5/13	26	48	30.4	32.1	31.3	0.4	-	-	-	-	-	-	94	-
5/14 - 5/20	25	40	30.0	30.8	30.4	0.2	-	-	-	-	-	-	149	-
5/21 - 5/27	27	57	30.5	31.7	31.1	0.3	-	-	-	-	-	-	210	-
5/28 - 6/3	27	55	36.1	38.0	37.0	0.5	-	-	-	-	-	-	210	-
6/4 - 6/10	26	61	35.6	37.3	36.5	0.4	-	-	-	-	-	-	210	-
6/11 - 6/17	27	68	40.4	42.8	41.6	0.6	-	-	-	-	-	-	210	-
6/18 - 6/24	29	60	40.8	42.5	41.6	0.4	-	-	-	-	-	-	210	-
6/25 - 7/1	28	65	41.5	43.4	42.4	0.5	-	-	-	-	-	-	210	-
7/2 - 7/8	30	75	43.8	45.6	44.7	0.5	-	-	-	-	-	-	210	-
7/9 - 7/15	35	69	46.1	47.8	47.0	0.4	-	-	-	-	-	-	210	-
7/16 - 7/22	36	72	47.9	49.6	48.7	0.4	-	-	-	-	-	-	210	-
7/23 - 7/29	37	70	47.7	49.3	48.5	0.4	-	-	-	-	-	-	210	-
7/30 - 8/5	36	75	48.4	49.9	49.1	0.4	-	-	-	-	-	-	210	-
Total:	25	75	40.5	41.2	40.9	0.2							2669	

Table 5. Fork length and weight of 1+ Steelhead Trout downstream migrants.

Week	1+ SH Fork length (mm) MIN FL (mm)	MAX FL (mm)	Average 95% LCL	95% UCL	FL (mm)	SEM (mm)	1+ SH Weight (g) MIN Wt (g)	MAX Wt (g)	Average 95% LCL	95% UCL	Wt (g)	SEM (g)	Sample size (n) FL	Wt
4/5 - 4/8	55	129	75.8	81.5	78.7	1.4	1.7	26.4	5.28	6.90	6.08	0.41	108	107
4/9 - 4/15	54	116	75.8	79.3	77.5	0.9	1.7	20.5	5.00	5.82	5.41	0.21	210	206
4/16 - 4/22	48	131	78.3	82.0	80.1	1.0	1.3	27.5	5.83	6.90	6.36	0.27	206	176
4/23 - 4/29	59	116	80.1	83.3	81.7	0.8	2.4	19.2	6.09	6.94	6.51	0.22	210	180
4/30 - 5/6	57	138	85.0	88.7	86.9	0.9	2.2	25.9	7.32	8.69	8.01	0.35	209	150
5/7 - 5/13	65	132	87.0	90.4	88.7	0.9	3.0	21.9	7.40	9.05	8.23	0.41	210	90
5/14 - 5/20	67	132	92.4	96.7	94.6	1.1	3.3	25.2	9.58	11.33	10.46	0.44	178	120
5/21 - 5/27	64	134	90.3	94.1	92.2	1.0	2.6	24.4	7.06	8.63	7.85	0.39	210	88
5/28 - 6/3	69	133	93.2	96.5	94.8	0.8	3.6	23.1	8.82	10.34	9.58	0.38	210	89
6/4 - 6/10	65	131	96.7	100.5	98.6	1.0	3.8	25.3	10.94	13.72	12.33	0.70	210	60
6/11 - 6/17	74	135	99.6	103.1	101.3	0.9	6.5	27.9	11.34	13.92	12.63	0.64	210	60
6/18 - 6/24	70	134	102.8	106.3	104.5	0.9	3.5	27.5	11.90	14.66	13.28	0.69	210	60
6/25 - 7/1	67	135	100.1	105.2	102.7	1.3	4.7	30.7	12.25	15.96	14.11	0.91	126	38
7/2 - 7/8	79	135	102.5	108.9	105.7	1.6	7.3	10.7	-	-	9.00	1.70	79	2
7/9 - 7/15	79	133	108.3	115.9	112.1	1.9	9.1	19.1	9.39	17.24	13.32	1.53	42	6
7/16 - 7/22	78	134	101.7	111.2	106.5	2.3	5.2	23.3	11.29	17.02	14.15	1.33	37	15
7/23 - 7/29	84	135	106.8	117.4	112.1	2.6	12.1	22.7	10.40	20.92	15.66	1.89	27	5
7/30 - 8/5	81	132	101.5	113.2	107.3	2.8	12.5	19.5	7.16	27.10	17.13	2.32	29	3
Total:	48	138	91.8	93.0	92.4	0.3	1.3	30.7	8.05	8.54	8.29	0.13	2721	1455

Table 6. Fork length and weight for 2+ Steelhead Trout downstream migrants.

Week	2+ SH Fork length (mm) MIN FL (mm)	MAX FL (mm)	Average 95% LCL	95% UCL	FL (mm)	SEM (mm)	2+ SH Weight (g) MIN Wt (g)	MAX Wt (g)	Average 95% LCL	95% UCL	Wt (g)	SEM (g)	Sample size (n) FL	Wt
4/5 - 4/8	140	202	167.8	174.0	170.9	1.6	31.9	95.3	50.53	56.04	53.28	1.39	80	80
4/9 - 4/15	137	215	165.8	171.4	168.6	1.4	25.1	101.2	47.46	52.21	49.84	1.20	129	127
4/16 - 4/22	139	201	164.6	173.3	169.0	2.2	29.1	82.5	44.42	51.76	48.09	1.81	44	40
4/23 - 4/29	140	199	162.2	169.3	165.8	1.8	31.5	78.9	46.18	52.03	49.11	1.46	67	64
4/30 - 5/6	140	204	165.6	170.3	168.0	1.2	29.6	103.4	47.07	52.29	49.68	1.31	115	87
5/7 - 5/13	140	199	162.6	168.7	165.7	1.5	32.0	73.6	38.95	50.61	44.78	2.78	72	19
5/14 - 5/20	139	196	157.1	170.4	163.8	3.2	31.7	69.2	40.95	54.05	47.50	3.03	25	14
5/21 - 5/27	138	191	156.4	167.1	161.8	2.6	31.9	62.8	21.02	64.68	42.85	6.86	30	4
5/28 - 6/3	138	186	148.9	170.2	159.5	4.8	35.3	70.4	39.51	64.63	52.07	5.13	11	7
6/4 - 6/10	137	166	141.8	148.2	145.0	1.5	30.6	40.7	32.94	38.91	35.93	1.22	20	7
6/11 - 6/17	137	205	138.0	158.4	148.2	4.7	27.8	110.7	8.27	77.87	43.07	13.53	14	6
6/18 - 6/24	137	164	140.7	148.8	144.8	1.9	27.2	51.2	26.49	50.51	38.50	4.33	17	5
6/25 - 7/1	137	176	141.1	160.0	150.6	4.1	27.9	45.9	27.84	45.52	36.68	3.18	9	5
7/2 - 7/8	138	175	142.4	153.8	148.1	2.7	30.6	33.0	28.42	34.71	31.57	0.73	15	3
7/9 - 7/15	136	184	147.5	164.0	155.8	3.9	29.7	50.8	24.52	55.13	39.83	4.81	16	4
7/16 - 7/22	139	180	147.6	161.1	154.4	3.2	31.4	54.5	29.22	54.10	41.66	4.48	16	5
7/23 - 7/29	137	220	150.9	180.8	165.8	6.8	-	116	-	-	-	-	12	1
7/30 - 8/5	136	188	149.3	164.9	157.1	3.7	31.3	51.1	-	-	41.20	9.90	18	2
Total:	136	220	163.2	165.5	164.4	0.6	25.1	116.0	47.93	50.32	49.12	0.61	710	480

Fork length frequencies using all measurements showed that the mode for 0+ KS was 40 mm (Figure 10), 0+ SH was 30 mm (Figure 11), 1+ SH was 90 and 92 mm (Figure 12), and 2+ SH was 170 mm (Figure 13).

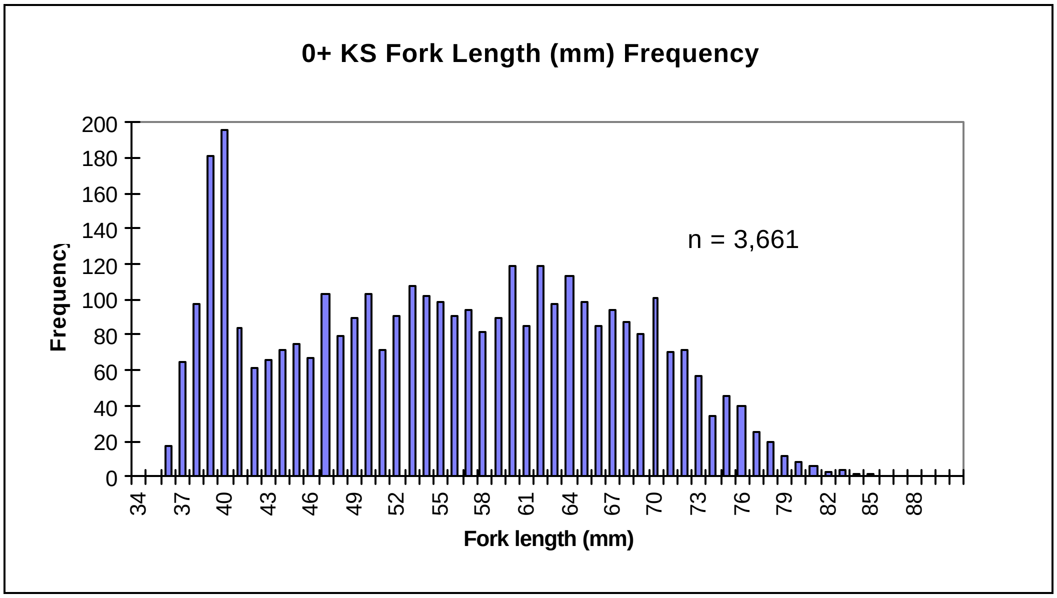

Figure 10. Fork length frequency for 0+ KS captures.

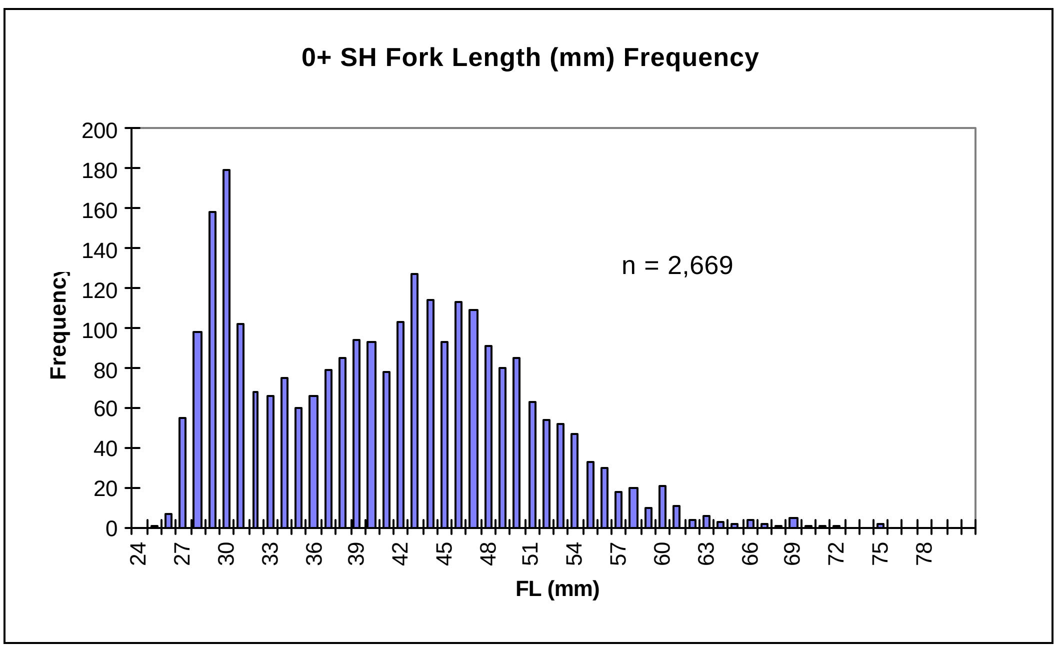

Figure 11. Fork length frequency of 0+ SH captures.

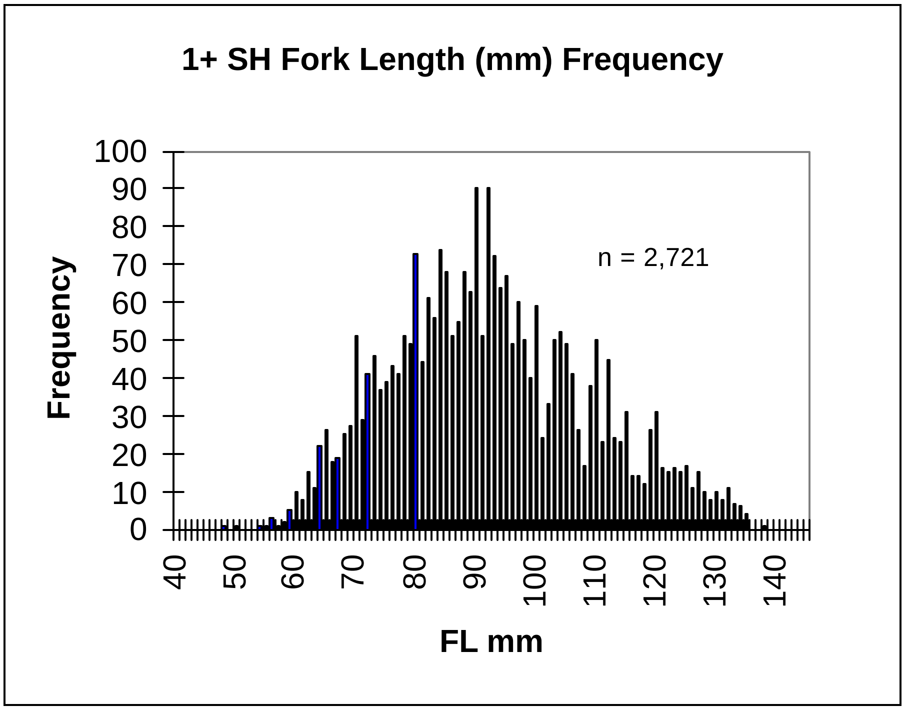

Figure 12. Fork length frequency for 1+ SH.

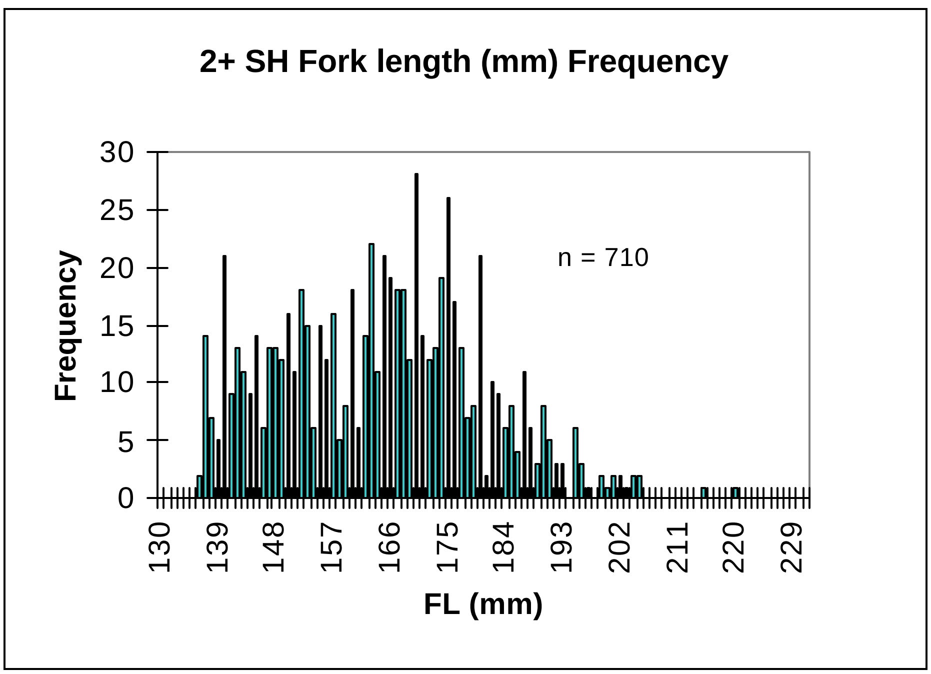

Figure 13. Fork length (mm) frequency for 2+ SH.

Combined 1+ and 2+ steelhead fork lengths show that there are two populations present (Figure 14). A Kruskall Wallace test (non-parametric ANOVA equivalent) determined significant differences among median fork length (mm) for 1+ SH and 2+ SH (P = 0.000009; power = 1.00). The nadir (dip between the two populations) during the trapping season ranged from 136 - 140 by week, and using all measurements was 136 mm.

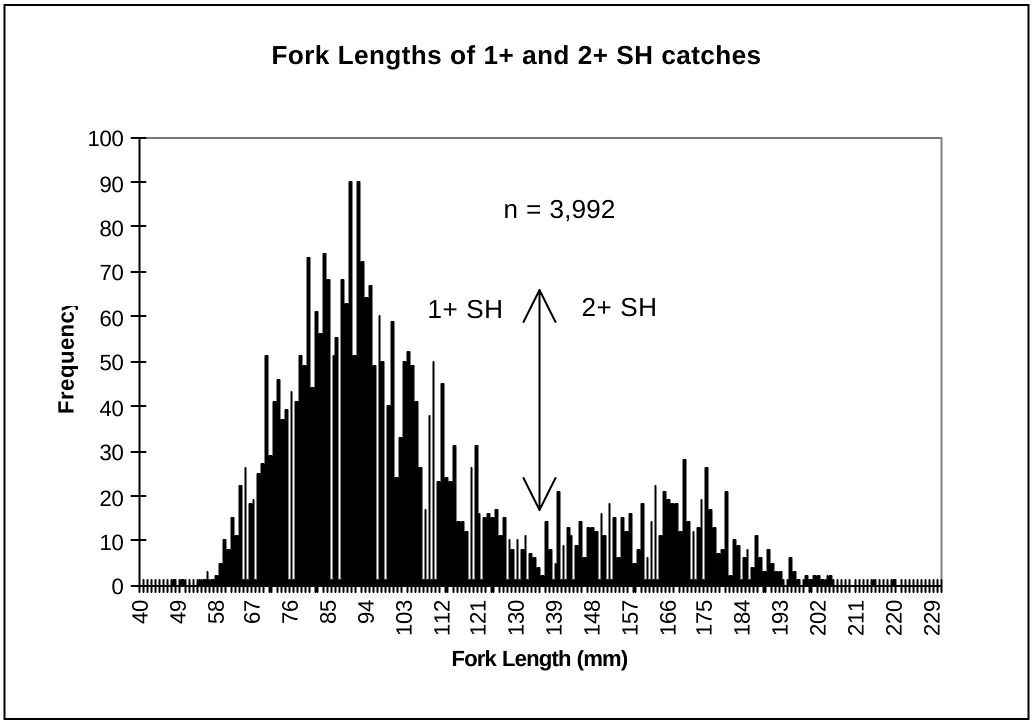

Figure 14. Fork lengths of 1+ SH and 2+ SH

Developmental Stages:

The percentage of 1+ SH pre-smolts and smolts combined by week ranged from 34.3 to 100% (Figure 15). The majority of 1+ SH were in a parr developmental stage until week 5, thereafter the percentage of pre-smolts and smolts was greater than 90%.There was an apparent relationship present with percent pre-smolts and smolts and trap catches for weeks 1 - 5. As catches increased, the percentage of pre-smolt and smolts increased. After week 5, there was no apparent relationship with trap catches. Using all week's data combined, 81% of 1+ SH catches were either pre-smolts or smolts. In general, the high percentage of pre-smolts and smolts suggests that the majority of 1+ steelhead captures will continue migrating to the estuary and the ocean.

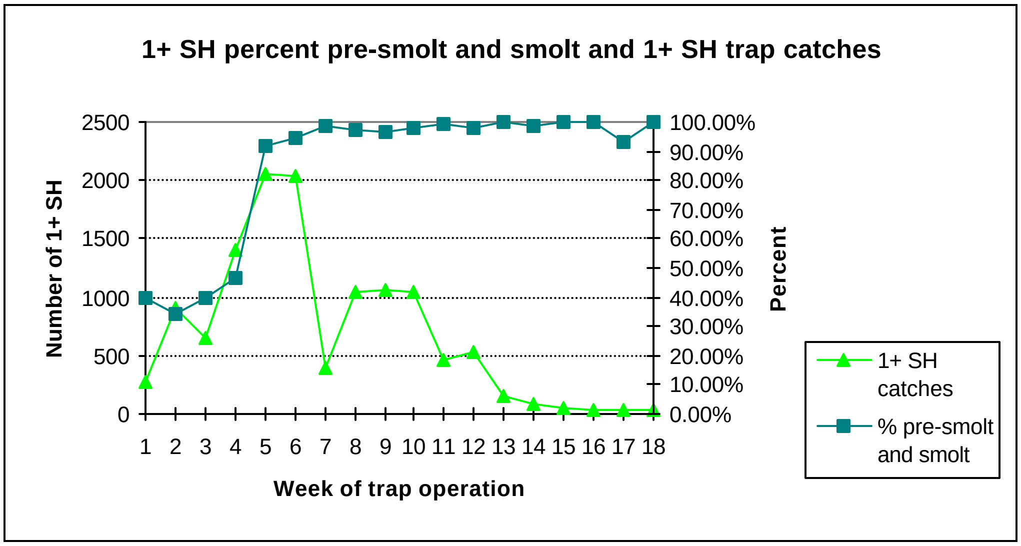

Figure 15. Percent pre-smolt and smolt developmental stage for 1+ SH, and trap catches.

The percentage of 2+ SH pre-smolts and smolts combined by week ranged from 91.7 to 100% (Figure 16). The majority of 2+ SH were in a pre-smolt or smolt developmental stage. No apparent relationship existed between percent pre-smolt and smolt and trap catches by week. Using all weeks, 99.7 % of 2+ SH catches were either pre-smolts or smolts. The very high percentage suggests that the population of 2+ SH will continue migrating to the estuary and ocean.

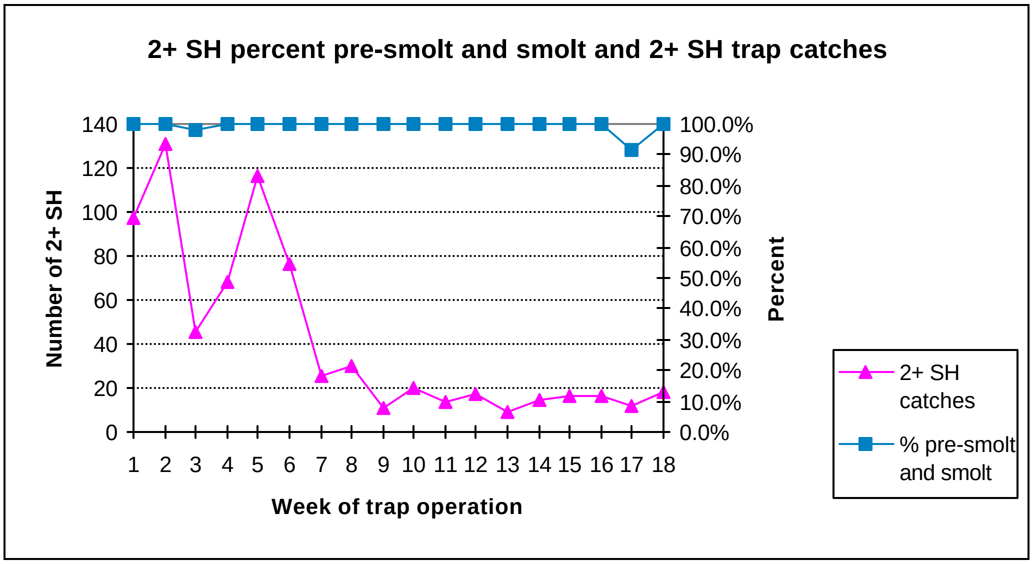

Figure 16. Percent pre-smolt and smolt developmental stage for 2+ SH, and trap catches.

Trapping Efficiencies:

Chinook salmon:

The number of upstream released fin clipped chinook salmon totaled 8,056 and ranged from 100 - 606 per 7 d week with an average of 471. Trap efficiencies for chinook salmon increased over time (Figure 17), and correlation analysis determined a statistically significant positive correlation with week (r =

0.84; P = 0.000016; power = 0.9999). Week trapping efficiencies (without pooling weeks) averaged 0.313, and ranged from 0.058 - 0.563.

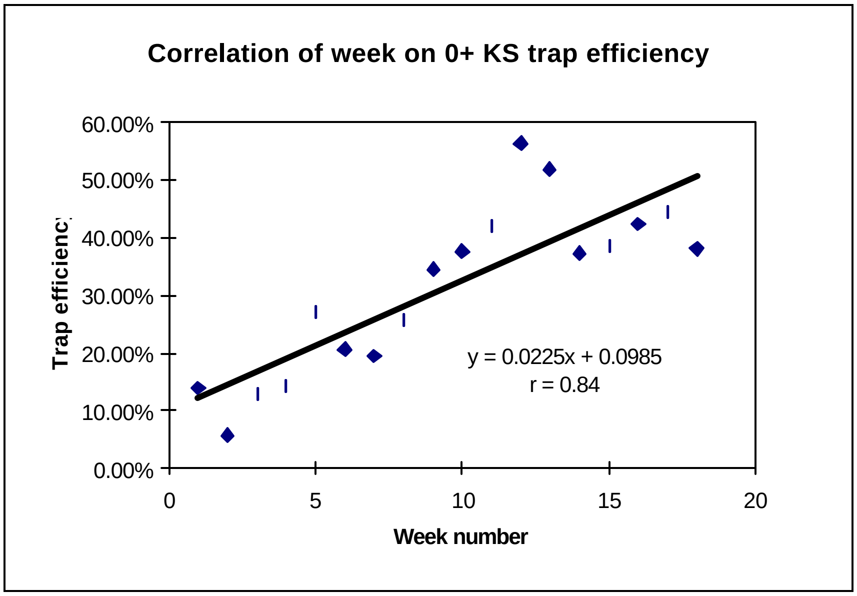

Figure 17. Correlation of week number and 0+ chinook salmon trap efficiencies.

0+ KS trap efficiencies were negatively related to the week's average gage height (Figure 18). Gage height explained 58% of the variation in trap efficiency ($R^2 = 0.58$; P = 0.00036; power = 0.989).

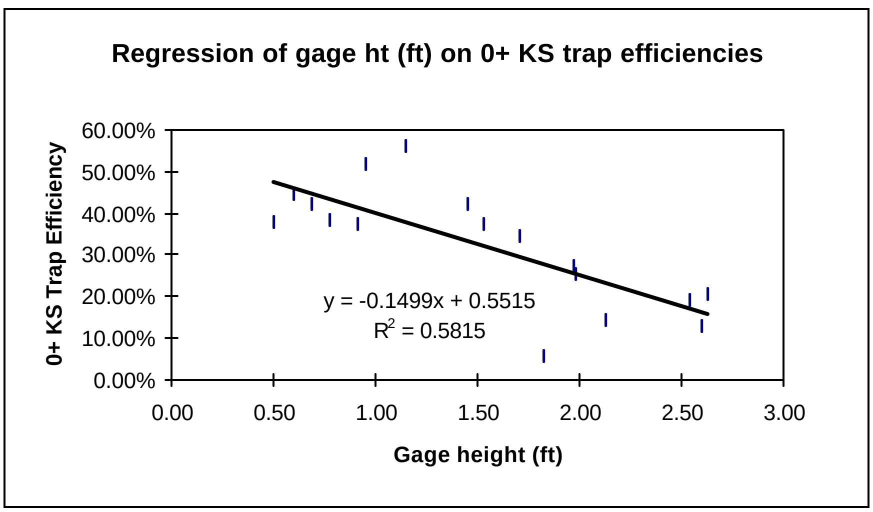

Figure 18. Regression of 0+ KS trap efficiencies and average gage height by week.

1+ Steelhead:

The number of upstream released fin clipped 1+ SH totaled 1,965 and ranged from 27 - 207 per 7 d week with an average of 114. Trap efficiencies for 1+ SH decreased over time (Figure 19), and correlation analysis determined a statistically significant negative correlation with week ($r = 0.48$; $P = 0.042$; power = 0.5476). Week trapping efficiencies (without pooling weeks) averaged 0.169, and ranged from 0.053 - 0.42.

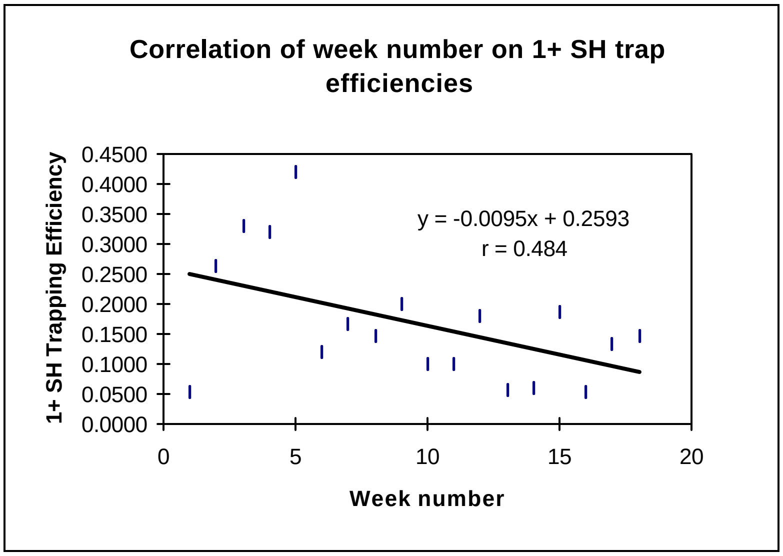

Figure 19. Correlation of week number on 1+ SH trap efficiencies.

1+ SH trap efficiencies were positively related to the week's average gage height (Figure 20). Gage height explained 26% of the variation in trap efficiency ($R^2 = 0.26$; $P = 0.0355$; power = 0.580).

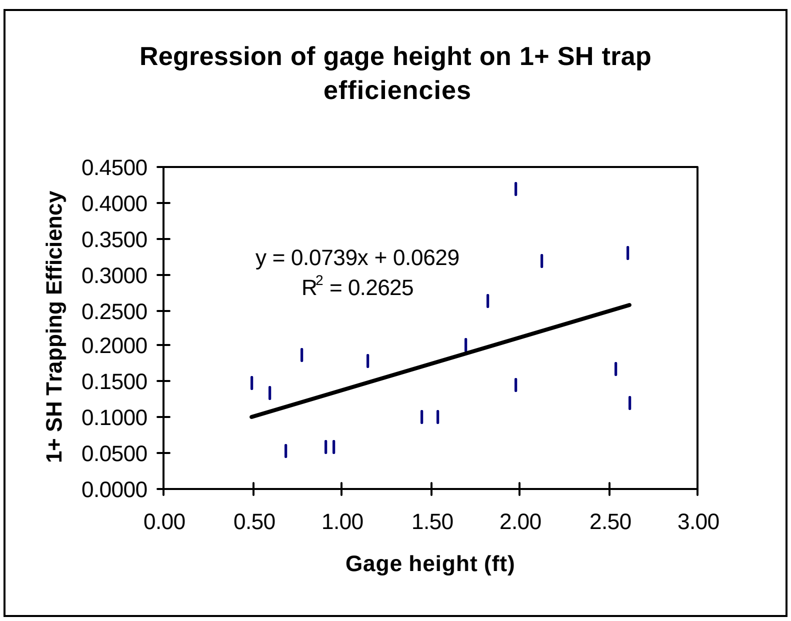

Figure 20. Regression of gage height on 1+SH trap efficiencies.

2+ Steelhead

The number of upstream released fin clipped 2+ SH totaled 579 and ranged from 8 - 101 per 7 d week with an average of 32. Trap efficiencies for 2+ SH were more variable than 0+ KS and 1+ SH, and no significant linear correlation with week was detected (r = 0.244; p > 0.05; power = 0.1576) (Figure 21) Week trapping efficiencies (without pooling weeks) averaged 0.117, and ranged from 0.000 - 0.2581.

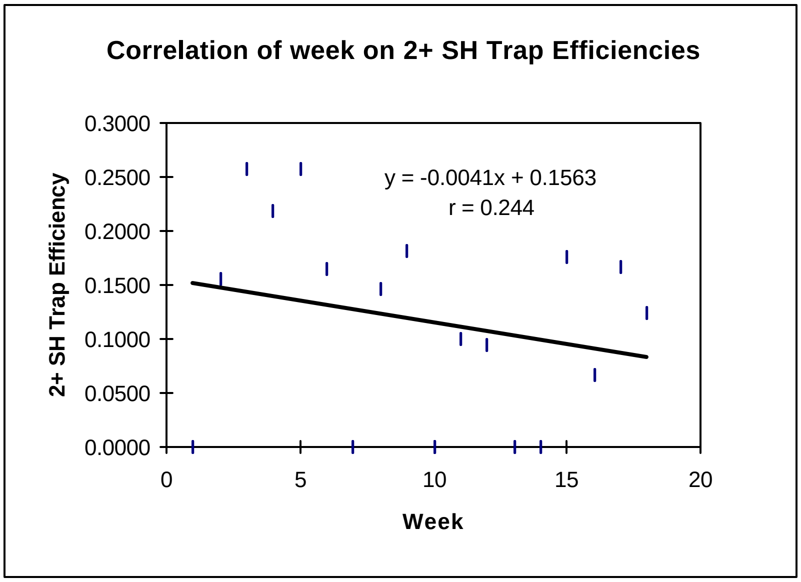

Figure 21. Correlation of week on 2+ SH trap efficiencies.

2+ SH trap efficiencies were not linearly related to average gage height by week (R^2 = 0.1124; p > 0.05; power = 0.2523) (Figure 22).

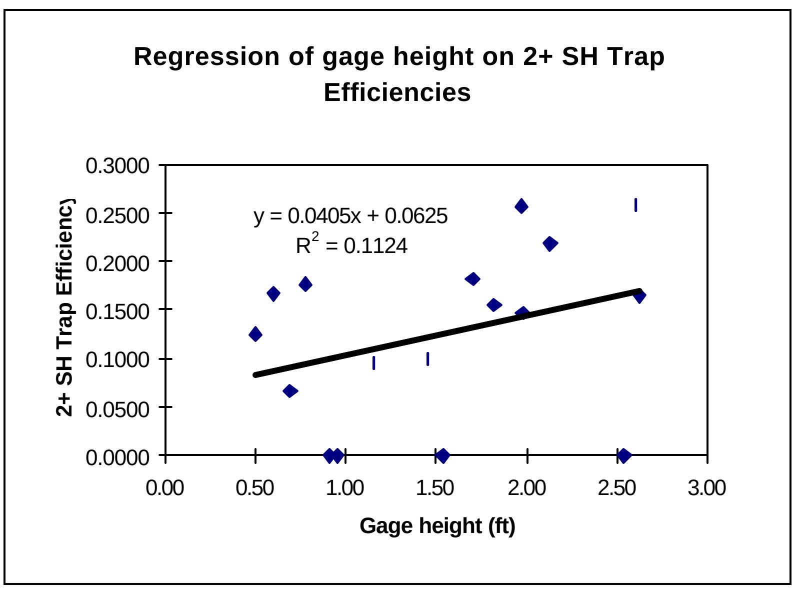

Figure 22. Regression of gage height on 2+ SH trap efficiencies.

Population Estimates:

0+ Chinook salmon:

Data for weeks 1 and 2 (4/5 - 4/22) were pooled to use a bi-weekly trap efficiency for the population estimate (Table 7). Remaining weeks had a trap efficiency greater than 10%, and data was not pooled. Total population estimate of 0+ KS out-migrants over the course of the trapping period equaled 427,542 (95% CI 390,096 - 464,988).

Table 7. 0+ chinook salmon population estimates (Carlson et al. 1998).

					Population Estimate			
Week	Week No.	u_h	m_h	M_h	U_h	95% LCL	95% UCL	$V(U_h)$
4/5 - 4/15	1- 2	6231	16	206	75872	42245	109498	294342090.9
4/16 - 4/22*	3	2369	20	154	17485	10662	24309	12120992.65
4/23 - 4/29	4	6750	78	548	46908	37342	56475	23822477.11
4/30 - 5/6	5	3856	122	449	14107	11957	16258	1203481.234
5/7 - 5/13	6	3923	125	606	18899	15926	21871	2300144.081
5/14 - 5/20*	7	1041	112	578	5334	4409	6259	222668.7548
5/21 - 5/27	8	11173	139	542	43335	37135	49536	10008690.91
5/28 - 6/3	9	19532	209	606	56457	50263	62651	9986102.426
6/4 - 6/10	10	18689	225	598	49534	44418	54650	6812167.662
6/11 - 6/17	11	5548	219	521	13164	11818	14510	471630.1003
6/18 - 6/24	12	24135	338	600	42788	39764	45812	2380398.724
6/25 - 7/1	13	13281	311	600	25583	23595	27571	1029117.309
7/2 - 7/8	14	3053	224	601	8168	7295	9042	198518.1044
7/9 - 7/15	15	1720	232	601	4444	3969	4919	58738.90526
7/16 - 7/22	16	1336	193	456	3147	2789	3506	33475.8618
7/23 - 7/29	17	750	129	290	1679	1447	1910	13967.05362
7/30 - 8/5	18	246	38	100	637	471	804	7216.121302
Total:		123,633	2,730	8,056	**427,542**	390,096	464,988	365,011,877.9

* Notes one night of trap non-operation.

0+ KS population estimates varied over time, with peak out-migration corresponding to 4/5 - 4/15, 4/23 - 4/29, 5/21 - 6/10, and 6/18 - 6/24 (Figure 23). Population estimates followed the trend of actual catches. Correlation analysis of population estimates and actual catches determined a highly significant positive relation (P = 0.000009; r = 0.92; power = 1.00). Data was transformed using log (x+1) to satisfy normality tests of assumptions, and did not change test conclusions. Correlation analysis of population estimates and trap efficiencies showed no significant relationship present (P>0.05). Differences in week or bi-week population estimates represent changes in the number of downstream migrants.

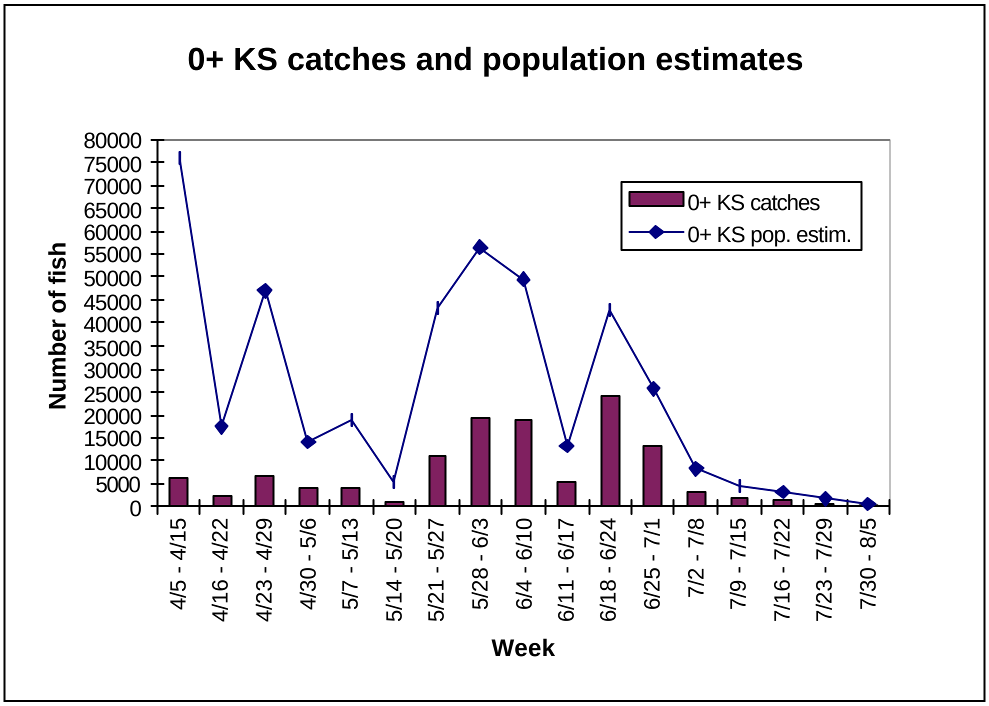

Figure 23. 0+ chinook salmon catches and population estimates.

1+ Steelhead:

Data for weeks 1-2 (4/5 - 4/15), 10-11 (6/4 - 6/17), 12-13 (6/18 - 7/1), 14-15 (7/2 - 7/15), 16-17 (7/16 - 7/29) were pooled to use a bi-weekly trap efficiency for the population estimate (Table 8). Remaining weeks had a trap efficiency greater than 10%, and data was not pooled. Total population estimate of 1+ SH out-migrants over the course of the trapping period equaled 68,328 (95% CI 59,055 - 77,601).

Table 8. 1+ Steelhead population estimates (Carlson et al 1998).

					Population Estimate			
Week	Week #	u_h	m_h	M_h	U_h	95% LCL	95% UCL	$V(U_h)$
4/5 - 4/15	1 - 2	1178	49	202	4783	3619	5946	352387.86
4/16 - 4/22*	3	657	33	100	1952	1412	2492	75930.06
4/23 - 4/29	4	1404	48	150	4327	3324	5329	261726.49
4/30 - 5/6	5	2056	87	207	4860	4077	5643	159638.31
5/7 - 5/13	6	2044	18	150	16244	9557	22932	11641094.11
5/14 - 5/20*	7	402	17	101	2278	1328	3228	234993.68
5/21 - 5/27	8	1048	22	150	6880	4318	9442	1708719.43
5/28 - 6/3	9	1062	30	150	5173	3552	6794	683958.11
6/4 - 6/17	10 - 11	1517	29	291	14765	9793	19737	6435107.91
6/18 - 7/1	12 - 13	677	33	253	5058	3460	6656	664796.60
7/2 - 7/15	14 - 15	122	11	117	1200	552	1847	109231.19
7/16 - 7/29	16 - 17	66	6	67	641	199	1084	50982.31
7/30 - 8/5	18	30	4	27	168	36	300	4508.00
Total:		12,263	387	1,965	**68,328**	59,055	77,601	22,383,074.1

* Notes one night of trap non-operation.

1+ SH population estimates varied over time, with peak out-migration corresponding to 5/7 - 5/13, and 6/4 - 6/17 (Figure 24). Population estimates followed the trend of actual catches. Correlation analysis of population estimates and actual catches determined a significant positive relation ($P = 0.003$; $r = 0.75$; power = 0.933). Correlation analysis of population estimates and trap efficiencies showed no significant relationship present ($P>0.05$). Differences in week or bi-week population estimates represent changes in the weekly number of downstream migrants.

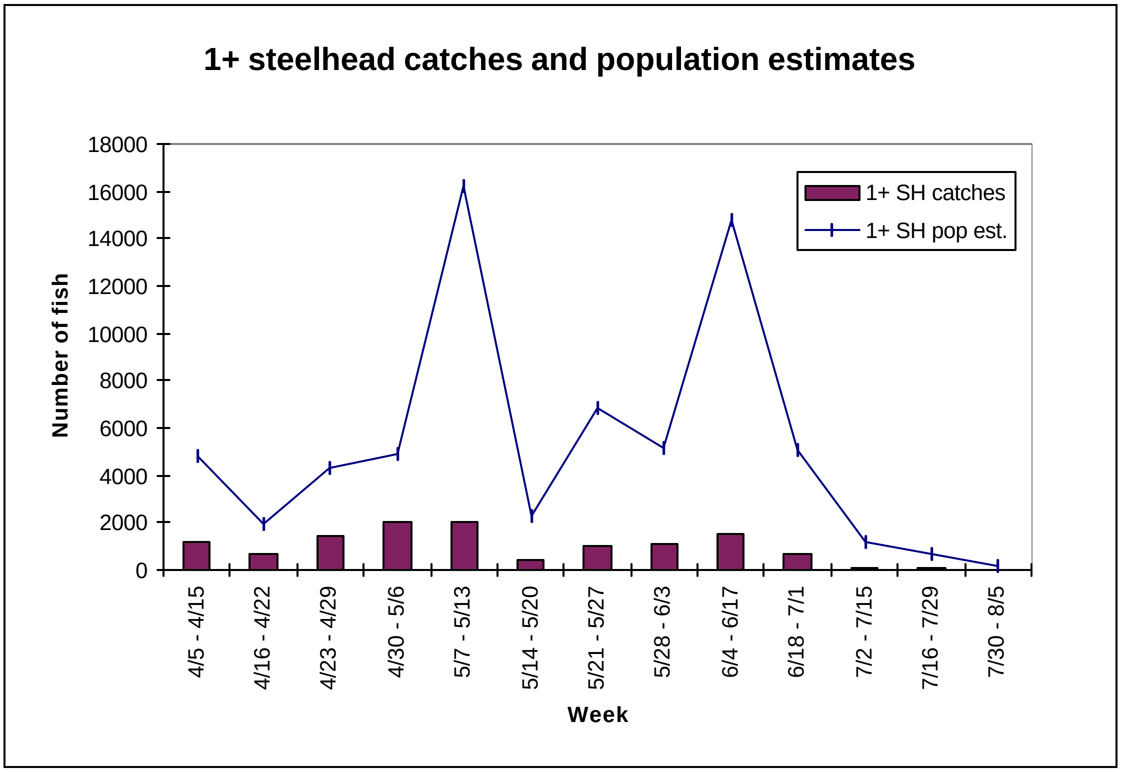

Figure 24. 1+ Steelhead catches and population estimates.

2+ Steelhead:

Data for weeks 1-2 (4/5 - 4/15), 7-8 (5/14 - 5/27), 9-10 (5/28 - 6/10), 12-13 (6/18 - 7/1), 14-15 (7/2 - 7/15), and 16-17 (7/16 - 7/29) were pooled to use a bi-weekly trap efficiency for the population estimate (Table 9). Remaining weeks had a trap efficiency greater than 10%, and data was not pooled. Total population estimate of 2+ SH out-migrants over the course of the trapping period equaled 4,739 (95% CI 3,669 - 5,808).

Table 9. 2+ Steelhead population estimates (Carlson et al. 1998).

Week	Week No.	u_h	m_h	M_h	Population Estimate U_h	95% LCL	95% UCL	$V(U_h)$
4/5 - 4/15	1 - 2	228	14	112	1718	908	2527	170428.86
4/16 - 4/22*	3	45	8	31	160	68	252	2208.00
4/23 - 4/29	4	68	12	55	293	146	440	5605.78
4/30 - 5/6	5	116	26	101	438	284	593	6216.84
5/7 - 5/13	6	76	14	85	436	223	648	11730.30
5/14 - 5/27*	7 - 8	55	5	52	486	129	843	33163.91
5/28 - 6/10	9 - 10	31	2	32	341	7	675	28985.00
6/11 - 6/17	11	14	1	10	77	-7	161	1848.00
6/18 - 7/1	12 - 13	26	2	29	260	5	515	16965.00
7/2 - 7/15	14 - 15	31	3	29	233	31	434	10578.75
7/16 - 7/29	16 - 17	28	3	27	196	26	366	7526.40
7/30 - 8/5	18	18	2	16	102	4	200	2499.00
Total:		736	92	579	**4,739**	3,669	5,808	297,756

* Notes one night of trap non-operation.

2+ SH population estimates varied over time, with peak out-migration corresponding to 4/5 - 4/15. Smaller peaks occurred during 5/14 - 5/27 and 6/18 - 7/1 (Figure 25). Population estimates also followed the trend of actual catches ($P = 0.000005$; $r = 0.94$; power = 1.00). Correlation analysis of population estimates and trap efficiencies showed no significant relationship present ($P>0.05$). Differences in week or bi-week population estimates represent changes in the weekly number of downstream migrants.

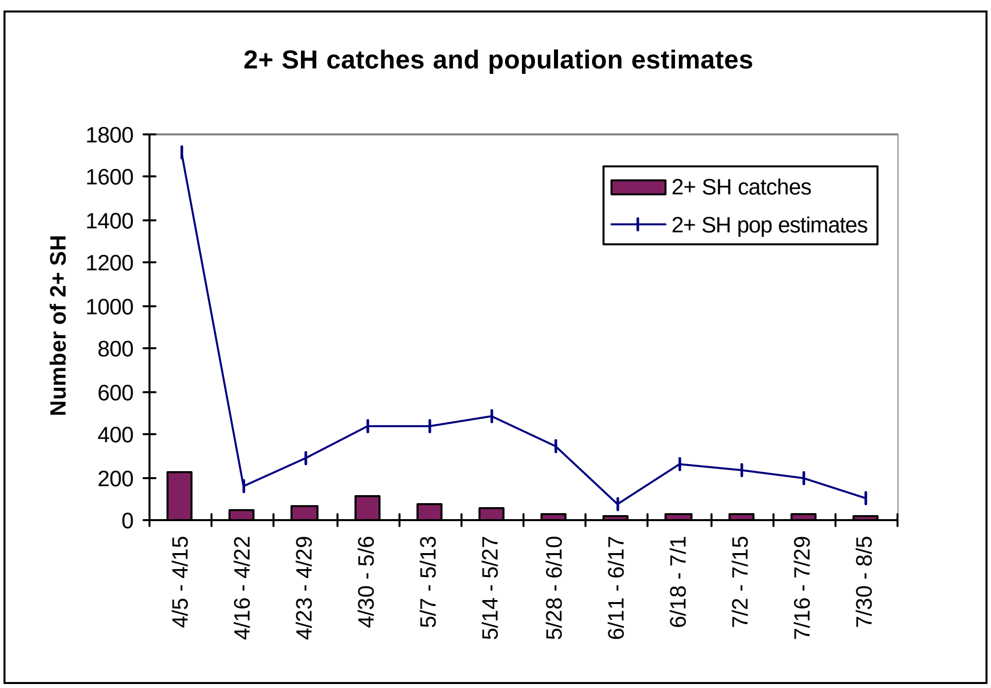

Figure 25. 2+ SH catches and population estimates.

Additional Experiments:
Experiments designed to determine if downstream released 0+ KS were recaptured by the rotary screw trap showed that 2.55% were recaptured (Table 10). The range in recapture was 0.00 - 4.08%. The time period of the tests was generally when the stream was in low flow periods, and is not representative of the entire trapping period. At low flows, it would be easier for downstream released fish to be recaptured. At higher flows, recapture would probably be much less. Results of the experiment were considered negligible.

Table 10. Percent recapture of marked 0+ KS downstream released fish.

Date released	Species	Clip type	Number released	Date of recapture	Number recaptured	Percent recapture
5/30	0+ KS	HUC	50	6/1	1	2.00%
	0+ KS	HUC		6/2	0	0.00%
				none thereafter		
8/2	0+ KS	Hole punch	49	8/3	2	4.08%
	0+ KS	Hole punch		8/4	0	0.00%
				none thereafter		
8/3	0+ KS	R. pectoral	37	8/4	1	2.70%
	0+ KS	R. pectoral		8/5	0	0.00%
8/4	0+ KS	L. Pectoral	21	no recaptures	0	0.00%
Total:			157		4	2.55%

Experiments for 0+ KS and 1+ SH showed that no delayed mortality occurred due to fin clipping or handling (Table 11).

Table 11. Delayed mortality experiments.

Date	Species	Water Temp. Celsius	Partial fin clip: morts/total	Partial fin clip: % mortality	Handled: morts/total	Handled: % mortality
4/21 - 4/22	1+ SH	9 - 11	0/50	0.00%	-	-
7/15 - 7/16	0+ KS	16 - 20	0/75	0.00%	0/75	0.00%
7/27 - 7/29	0+ KS	18 - 21	0/50	0.00%	-	-
7/28 - 7/29	0+ KS	18 - 21	0/25	0.00%	-	-
7/28 - 7/29	0+ SH	19 - 21	-	-	0/20	0.00%
7/29 - 7/30	0+ KS	19 - 21	0/52	0.00%	-	-
8/1 - 8/2	0+ KS	19 - 21	0/35	0.00%	-	-
Total:			0/287	0.00%	0/95	0.00%

Season Trapping Mortality

The mortality of fish that were captured in the trap was closely monitored over the course of the trapping period. Mortality by species at age ranged from 0.00 to 0.57%, and using all species was 0.49% of the total 191,760 juvenile salmonid captures (Table 12).

Table 12. Trapping mortality for juvenile salmonids.

Species	Number captured	Number of mortalities	Percent mortality
0+ KS	123,633	574	0.46%
0+ SH	55,126	316	0.57%
1+ SH	12,263	41	0.33%
2+ SH	736	3	0.41%
Cutthroat	2	0	0.00%
Total:	191,760	934	0.49%

Discussion

This was the first year of a study designed to quantify the numbers of out-migrating juvenile salmonids in Redwood Creek, Humboldt County, California. The few scientific studies of anadromous fish present in the system have focused on aspects besides out-migrant population estimates, and therefore, relatively little is known concerning population sizes and timing of downstream migration.

The next plausible step in assessing the status of anadromous fish populations in Redwood Creek via counts of downstream out-migrants would be to continue the study over multiple years. Information drawn from one year of data collection can be significant and informative, yet inferences about the watershed and species relations at large are limited. Anadromous salmonid populations often fluctuate in numbers by year, dependent upon year class or cohort strength, and environmental conditions (e.g. riverine conditions, El Nino, La Nina, and Pacific Decadal Oscillations), among other factors.

The rotary screw trap functioned very well for describing and quantifying the population of downstream migrants. A large number of juvenile chinook salmon and steelhead trout out-migrated from upper Redwood Creek during the spring of 2000.

Chinook Salmon

The data show that Redwood Creek had a large number of downstream migrating 0+ chinook salmon. Catches of chinook salmon were high until the last week of the trapping season in August (7/30 - 8/5), and averaged 1,005 per day. The total catch of 0+ chinook salmon was 123,633 individuals. Peak out-migration of juvenile chinook salmon in Redwood Creek primarily occurred during April - June, with the months of May and June accounting for 81% of the total catch.

Comparing Redwood Creek 0+ chinook salmon catches with preliminary and unpublished rotary screw trap data (Year 2000) from Blue Creek (Yurok Tribal Fisheries Program 2000), Trinity River (Yurok Tribal Fisheries Program 2000), Shasta River (Chesney 2000) and the Scott River (Chesney 2000) in Northern California, show that Redwood Creek catches were much higher. The rotary screw trap in Blue Creek, Trinity River, Shasta River, and the Scott River captured 7852, 4076, 32409, and 10239 juvenile chinook salmon, respectively. Trap efficiencies and population estimates are currently being determined for these out-migrant studies, and therefore no further comparisons with Redwood Creek data can be made at this time.

0+ chinook salmon population estimates varied over time, and were related more to actual catches than trap efficiencies. Week or bi-week population estimates peaked in April, May, and June, and ranged from 42,788 - 75,872 individuals. The two largest peaks occurred during 4/5 - 4/15 (75,872) and 5/28 - 6/3 (56,457). The total population estimates (for 0+ KS, 1+ SH, 2+ SH) were probably less than what actually out-migrated due to trap down time (2 nights out of 123) and trap re-location in the stream during high flow events. Pooling weeks with low trap efficiencies (i.e. < 10%) appeared to be a good way of reducing the positive biases associated with low trap efficiencies, and produced an estimate that was more realistic and conservative. Additionally, running multiple trap efficiency trials for a week's estimate reduces over-estimation, and encompasses changing flow events. The final estimate of population size for 0+ chinook salmon was also considered accurate because the confidence intervals were narrow. The uncertainty of the population estimate for 0+ KS was ± 37,446 which equals about ± 8.8% of the population estimate of 427,542 individuals. Subtracting trap mortalities from the total population estimate, we determined that 426,968 0+ chinook salmon out-migrated from upper Redwood Creek to later contribute to the adult population.

The Carlson et al (1998) method for stratified population estimates was chosen as an acceptable model to use because population estimates can be determined over discrete time periods (i.e. week or bi-weekly) or over the entire season. Careful analysis of population out-migration over time periods may provide clues as to why more fish are moving downstream at one time than at other times (e.g. changes in rearing habitat, relations with stream discharge, increase in stream temperature, genetics, etc), and may facilitate trend analysis over years. Additionally, the Carlson et al (1998) method does not include recaptures in the captured component "C" of the basic Peterson model of N = MC/R, and produces a more conservative estimate (Carlson et al. 1998).

The following inferences can be made from the population estimate of 0+ chinook salmon: 1) A relatively (considering modern times) large number of returning adult chinook salmon spawned in upper Redwood Creek during 1999/2000, or 2) redd gravel conditions were good, and egg to emergent fry survival was high, or 3) some combination of 1 and 2.

Data of fork length and weight by week for 0+ chinook salmon showed significant increases over time, and on average, fish that out-migrated at a later time (week #18) were 30.2 mm's and 2.8 grams larger than earlier out-migrants. Most chinook salmon emerge out of the redd at sizes of 38 - 42 mm, as shown by Roelofs and Sparkman (1999) in fry emergence studies of Prairie Creek, which is tributary to Redwood Creek. The increase in size over time by captured young of year chinook salmon in Redwood Creek suggests that rearing conditions in Redwood Creek were adequate for growth during Spring/Summer 2000. The rationale is that if rearing conditions were sub-optimal, or that out-migration always immediately followed fry emergence from redds, chinook salmon out-migrants at later times in the trapping season would have fork lengths and weights similar to early out-migrants, holding factors such as trap selectivity by size as negligible to non-existent. This is a reasonable assertion for the captured 0+ chinook salmon because data show the trap captured larger fish as the season progressed (larger fish are generally considered more difficult to catch because of increased swimming abilities), and trap efficiencies increased over time.

0+ Steelhead

A large number (55,126) of young of year steelhead was captured by the rotary screw trap. Large numbers of 0+ steelhead were also observed along the stream margin upstream of the trap location. Catches in Redwood Creek were much higher than for Blue Creek (8,449) and Trinity River (79). The highest catches in Redwood Creek occurred in June and July, and accounted for 87.5% of the total catch.

The following inferences can be made from the capture of 0+ steelhead: 1) a relatively large number of adult steelhead spawned in Redwood Creek during year 2000, or 2) redd gravel conditions were good, and egg to emergent fry survival was probably high, or 3) some combination of 1 and 2.

The typical life history pattern for juvenile steelhead is stream residence 1 - 4 years before ocean entry (Spence et al. 1996). 0+ steelhead out-migration was considered to be stream redistribution, and not migration to the ocean. It is unknown whether 0+ steelhead will find habitat downstream of the trap site and reside there, or move back upstream. Trap efficiencies and out migrant population estimates were not determined for 0+ steelhead because of their small size (which prohibited partial fin clipping), and the high probability of not going to the estuary or ocean during their first year.

Data of average weekly fork length (mm) of 0+ SH showed positive increases over time, and suggests that rearing conditions were adequate for growth. On average, the fork length (mm) of 0+ steelhead that out-migrated during week 18 were 21.1 mm's greater than those out-migrating at week 3. Fork lengths taken during weeks 3 - 6 indicated that two groups or populations of 0+ steelhead may be present. Most fry measured during these times were 28 - 31 mm and some of the fry were 38 - 41 mm. The differences in fork length may be due to different spawning times of summer and winter run steelhead, and hence, differing times of fry emergence from redds. Fish that emerge from earlier redds have more time to grow in the stream as compared to fry emergence from redds formed at a later time.

1+ Steelhead

The majority of larger juvenile steelhead out-migrants captured were 1+ steelhead. Most of the 1+ steelhead captured were in either a pre-smolt or smolt developmental stage, and suggests that they were actively moving downstream to the estuary and ocean. Catches of 1+ steelhead were considered to be high (n = 12,263), and were greater than catches for Blue Creek (1,360) and Trinity River (783). Comparisons with the Shasta and Scott Rivers could not be made because numbers reported included an unknown number of 0+ steelhead. Peak catches (by day) in Redwood Creek ranged from 234 to 544 juveniles. Most of the 1+ steelhead out-migrated in April and May, and those months accounted for 77% of the total catch. Daily catch was positively related to gage height, and indicates that more 1+ steelhead moved downstream during higher flows. Population estimates for 1+ steelhead varied over time, with week and bi-week peaks of 16,244 and 14,765 juveniles in May and June. Peak catches and peak population estimates occurred after 3 weeks of trap operation, and suggests that the bulk of fish migrating downstream were not missed. An unknown number of fish probably migrated downstream during February and March, however, high and often unpredictable flows prevented trap placement at this time. The total population estimate of 1+ steelhead was probably less than what actually out-migrated due to time of trap placement, two missed nights of trapping, and trap re-location into slower currents during higher flow events. Trap revolutions greater than 30/3 minutes prevented running the trap completely in the thalweg during high stream flows because of high flows within the livebox, and increased mortalities of captured fish. If feasible, future work with juvenile downstream migrating steelhead should focus on earlier trap placement, and continual trap operation during high flow events. The total population estimate for 1+ steelhead out-migrants was considered accurate, with relatively narrow 95% confidence intervals. The uncertainty of the population estimate was $\pm$ 9,273 which equals about $\pm$ 13.6% of the population estimate of 68,328 individuals. Subtracting trap mortalities from the total population estimate, we determined that 68,287 1+ steelhead out-migrated from upper Redwood Creek.

Difficulties arise when making inferences from this population estimate to the watershed and species relations for the following reasons: 1) the study covered one year and may or may not be representative of average out-migrant 1+ SH population size in Redwood Creek, 2) no previous data exists in Redwood Creek with which to compare, 3) little to no data exists from other watersheds of similar size in Northern California, and 4) the population estimate for 1+ steelhead reflects the number of parents that produced the cohort, survival from egg to emergent fry, and emergent fry to 1+ steelhead. Survival from emergent fry to 1+ consists of over-summer survival, and over-winter survival. The life history components in #4 can not be separated out to say which factor, or combination of factors were responsible for the population size estimated. Such data simply does not exist for Redwood Creek. However, the total population estimate is considered to be relatively high and a 'good' number. Data suggests that conditions in the upper Redwood Creek watershed were favorable for steelhead survival to age 1+. Multiple and consecutive years trapping would allow for trend analysis, and a greater power in inference concerning the status of juvenile out-migrating 1+ steelhead population sizes in Redwood Creek.

Data of fork length and weight by week for 1+ steelhead showed significant increases over time, and on average, fish that out-migrated at a later time (week 18 for FL, week 16 for Wt) were 28.6 mm's and 8.07 grams larger than earlier out-migrants (week 1). The increase in size over the trapping period suggests adequate habitat conditions for growth during the study period. If conditions were sub-optimal, we would expect later downstream migrating juveniles to be smaller, or near the same size as earlier out-migrants.

2+ Steelhead

A large majority of the 2+ SH were in a pre-smolt and smolt developmental stage and indicates active downstream migration to the estuary and ocean. High catches early in the season suggests that trap placement did not entirely cover the period of downstream migration. Subsequently, catch and population estimates are considered to be underestimates. The number of 2+ SH captured was passable and equaled 736. Catch comparisons with other traps can not be made because most out-migrant studies do not separate 1+ and 2+ steelhead. Peak catches (by day) in Redwood Creek ranged from 24 - 35, with the majority of captures (81%) occurring in April and May. Daily catch was positively related to gage height, and indicates that more 2+ steelhead moved downstream during high flows. Population estimates varied over time with one bi-week peak of 1,718 juveniles in April, and two smaller bi-week peaks of 486 and 260 juveniles in May. The total population estimate was 4,739 $\pm$ 1,070, or $\pm$ 22.6%. Trap efficiencies for 2+ SH were less than efficiencies for other species (e.g. 0+ KS, 1+ SH), as reflected in the increased width of the 95% confidence interval. 2+ steelhead are considered the hardest fish to catch. Subtracting trap mortalities from the total population estimate, we determined that 4,736 2+ steelhead out-migrated from upper Redwood Creek.

In a simplistic sense, the life history pattern of 2+ steelhead is similar to 1+ steelhead with the addition of another year of stream residence. The same difficulties that apply to 1+ steelhead apply to 2+ steelhead with respect to numbers of fish and relations to watershed or species relations at large, with additional over summer and over winter periods for 2+ juveniles. The general lack of data specific to 2+ steelhead precludes inferences about population size.

Data of fork length and weight for 2+ steelhead significantly decreased over time, and may not necessarily indicate poor habitat conditions concerning growth. Trap efficiencies were highly variable, and positively related to gage height. Over the course of the trapping period, gage height generally decreased. It is quite possible that the bigger 2+ steelhead avoided the trap and were not caught.

Cutthroat Trout

In general, we expected to catch more cutthroat trout than we did. The two that were captured were in a smolt condition. Redwood Creek is known to have cutthroat trout, however population estimates have not been conducted where trapping occurred. An unknown percentage of cutthroat trout will residualize for varying years, and not out-migrate to the estuary and ocean, therefore the low catches we observed may not necessarily reflect a low population size in upper Redwood Creek.

Coho Salmon

No juvenile coho salmon were captured, whereas a large number of juvenile chinook salmon and steelhead trout were captured. The trapping period should have encompassed downstream migration of 0+ and 1+ coho salmon. Prairie Creek, tributary to Redwood Creek near the town of Orick, is known to have annual runs of adult coho salmon. For the past 5 years, out-migrant studies in Prairie Creek have captured varying numbers of 0+ and 1+ coho salmon out-migrants (Roelofs and Sparkman 1999). The Southern Oregon/Northern California Coho Salmon ESU are perhaps in greater decline throughout their range than other listed species in Northern California. Data shows that upper Redwood Creek may be missing two juvenile out-migrant year classes.

Trap operations

Perhaps a critical factor to the success of the rotary screw trap was placement below a moderately high gradient riffle. Such locations usually give little room or time for fish to avoid the trap. Benefits include higher trap efficiencies, and narrow population confidence intervals. During the end of the trapping period when low flows were present (i.e. late July to August), a fyke net may be easier to operate than the rotary screw trap.

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