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ANNUAL REPORT
UPPER REDWOOD CREEK JUVENILE SALMONID
DOWNSTREAM MIGRATION STUDY, 2000-01
PROJECT 2a5

by

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ABSTRACT

Juvenile anadromous salmonid trapping was conducted in upper Redwood Creek from March 26 – August 4, 2001 to estimate population size of downstream migrating juvenile 0+ chinook salmon, 1+ steelhead trout, and 2+ steelhead trout using stratified mark/recapture methodology. The trap operated 129 nights out of 131 nights possible, and captured 120,692 0+ chinook salmon, 21 1+ chinook salmon, 102,408 0+ steelhead trout, 14,775 1+ steelhead trout, and 1,360 2+ steelhead trout. No juvenile coho salmon were captured. 1+ and 2+ steelhead catches were positively related to the relative gage height of the stream at the trapping site. 0+ chinook salmon and 1+ steelhead trout average fork length and weight by week significantly increased over the course of the study. No significant relationships of fork length and weight with time were found for 2+ steelhead. Trap efficiencies for 0+ chinook salmon, 1+ steelhead trout, and 2+ steelhead trout by week averaged 55.3, 24.0, and 10.9 %, respectively. 0+ chinook salmon trap efficiencies were negatively related to stream gage height. 1+ steelhead and 2+ steelhead trap efficiencies showed positive relations with gage height. Total population estimates with 95% confidence intervals for 0+ chinook salmon, 1+ steelhead trout, and 2+ steelhead trout were 378,063 (335,290 – 420,835), 50,654 (45,571 – 55,736) and 12,668 (9,786 – 15,550), respectively. Peak population out-migration for 0+ chinook salmon, 1+ steelhead trout, and 2+ steelhead trout occurred during May-June, April-May, and April-June, respectively, and followed trends of actual catches. Comparisons are made with downstream migration data collected in 2001 and 2000.

INTRODUCTION

This study is the second consecutive year of juvenile salmonid downstream migration trapping in Upper Redwood Creek, Redwood Valley, Humboldt County, California. The first study year was funded by the Redwood Creek Landowners Association (RCLA), and carried out by Michael Sparkman and Douglas Parkinson (Sparkman 2000). In January 2001, representatives from Redwood Creek Landowners Association approached the California Department of Fish and Game Steelhead Research and Monitoring Program (S-Ramp) to lead and assist the second year of the downstream migration study in Upper Redwood Creek. S-Ramp agreed to lead the study, and plans to work with the RCLA in upper Redwood Creek in future study years.

In the spring of 2001, a scientific committee consisting of federal, state, and private scientists and resource managers formed to (critically) review biological and physical data of Redwood Creek. One of the scientific committee's goals is to bring together information on Redwood Creek from a variety of disciplines and studies in order to increase our understanding of anadromous fisheries population dynamics, and species relations to watershed conditions. Both S-Ramp and the Redwood Creek Scientific committee will look at oceanic conditions when data on juvenile salmonids over multiple years are collected.

Although there is abundant data on Redwood Creek with respect to hydrology, geology, geomorphology, forestry, and wildlife biology, relatively little information exists concerning anadromous salmonids upstream of the estuary. The more recent studies of salmon and steelhead in Redwood Creek include: summer steelhead snorkel (dive) survey counts, estuarine juvenile salmonid research, upper Redwood Cr out-migrant trapping, and beginning this year, out-migrant trapping with a rotary screw trap in lower Redwood Creek. In addition, adult spawning surveys were conducted above and below the upper Redwood Creek rotary screw trap site in 2001. The spawner survey recorded 95 redds above the upper Redwood Creek trap site. Live fish observed were primarily chinook salmon, and one coho salmon.

Site Description

Redwood Creek flows through Trinity and Humboldt Counties 70 miles before reaching the Pacific Ocean (Figure 1). 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 et. al 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 (Brown 1988).

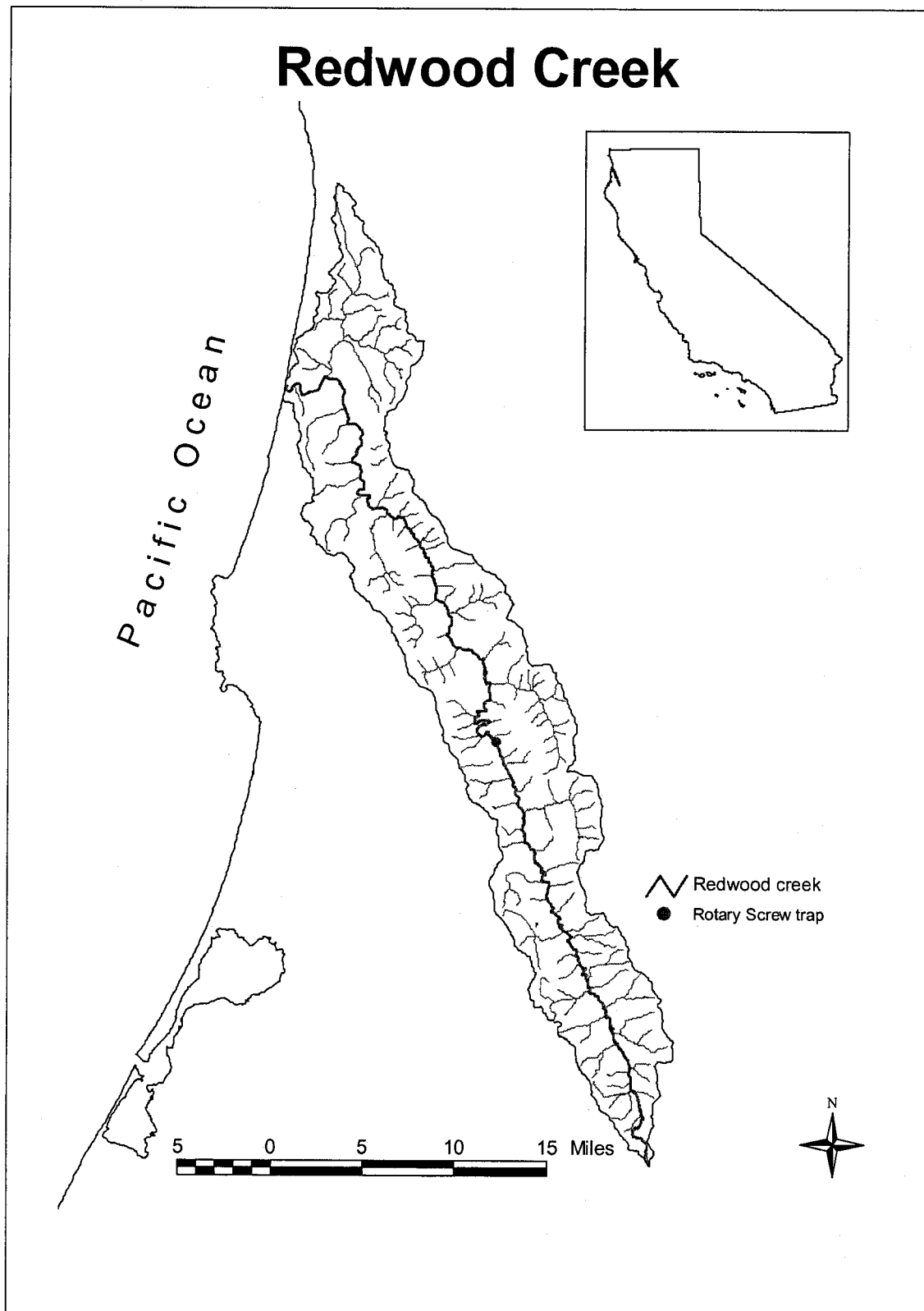


Figure 1. Redwood Creek Watershed, Humboldt County, California (scale is slightly inaccurate due to reproduction process) (pers. comm. Peters 2001).

Geology

The geology of 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).

Average Rainfall

Most of the rainfall in Redwood Creek occurs from October through May. Based upon limited data, the mean annual rainfall is 61.7 inches, and ranges from 49.7 – 77.3 inches (CDWR 1981). Preliminary data show that rainfall in water year 2001 (October 2000 – September 2001) was 29.64 inches, with 6.64 inches falling within the trapping period (CDWR 2001).

Discharge

A USGS gaging station (#11481500) is located about 6.4 miles upstream of the trap site on Redwood Creek. Stream flow records cover the periods of 1953 – 1958, 1972 – 1993, and 1997 – 2001, (USGS 2001) to total 30 years. Following the pattern of rainfall, most of the high flows occur in the months of November through May, and typically peak in February (USGS 2001; see Flow Events in text). Low flows usually occur from July through October. Using all years' data, mean monthly discharge is 234 cfs, and ranges from 8 – 565 cfs (USGS 2001). Preliminary data for water year 2001 show that the mean monthly discharge was 77 cfs, and ranged from 3 – 241 cfs. The average monthly flow during the trapping season was about 72 cfs, and ranged from 4 – 175 cfs (USGS 2001).

Overstory

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

Redwood Cr History

Redwood Creek watershed has experienced extensive logging of Redwood and other commercial tree species. In conjunction with associated road building, geology types, and flood events in 1955, 1964, and 1975, 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 Federal 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

The purpose of this project was to describe juvenile salmonid downstream migration in upper Redwood Creek, and to determine out-migrant population sizes for wild 1+ (between 1 and 2 years old) steelhead, 2+ (between 2 and 3 years old) steelhead, and 0+

(young of year) chinook salmon. An additional goal is to document the presence or absence of juvenile coho salmon. 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 1+ steelhead, 2+ steelhead, and 0+ chinook salmon.
- 4) Record fork length (mm) and weight (g) of captured fish.
- 5) Collect and handle fish in a manner that minimizes mortality.
- 6) Statistically analyze data for significance and trends.
- 7) Compare data between study years.

METHODS AND MATERIALS

Trap Operations

A modified E.G. Solutions (5 foot diameter cone) rotary screw trap was placed in upper Redwood Creek (RM 33) on March 26, 2001 at the same location as the previous study year (i.e. downstream of a moderately high gradient riffle). Modifications to the trap involved using the larger pontoons normally equipped with the 8 foot cone so that a larger livebox could be added. The debris wheel of the E.G. solutions livebox was cut out, and aluminum was added to the livebox to increase the length two-fold. A perforated plate was then used to close the downstream end where the debris wheel once was located. Perforated plates with 2 mm holes were placed in the sides (2, 56 x 31 cm) and bottom (1, 89 x 41 cm) of the livebox to dissipate livebox water velocities. The modifications to the livebox decreased livebox velocities, allowed for less fish crowding during peak catches, and enabled the trap to continue trapping under higher flows as compared to the stock model.

The rotary screw trap operated continually (24hrs/day, 7 days a week) in the thalweg of the stream from March 26 through July 11, 2001, except for 1 day when the stream flow was too low and the cone had to be raised (see flow events). Memorial Day was also observed and the cone was raised the previous night. Unlike last year's study, lower flows occurred much earlier this year. Beginning on April 14, 2001 screen meshed weir panels were used in conjunction with a rock weir upstream of the trap to funnel water and fish into the area of the cone. After May 21, screened weirs were replaced with plywood weirs to increase flow. On June 11, 2001 plastic drop cloths were used to line the weirs to further increase flow. On June 13th, the plywood weirs were positioned at an angle between the two rotary screw trap pontoons to increase cone revolutions. On July 11, 2001 the rotary screw trap was no longer functional (due to the low flows and corresponding low cone revolutions), and a pipe trap was set. A rock weir about 20 meters upstream of the trap was built to direct flow into an 8-inch pipe. A McBain ramp was fastened to the downstream end of the pipe to dissipate excess water. The rotary

screw trap was then set facing downstream so that the McBain ramp would dump the contents into the large rotary screw trap livebox. A perforated plate was then placed near the cone end of the rotary screw trap livebox to prevent fish from entering the cone and escaping into the stream.

The system worked very well, and enabled trapping to the time when out-migration was at the tail end of catch distributions (August 4, 2001). Throughout the trapping season, efforts were continually made to maximize trap efficiencies and trap catches, and to minimize trap mortalities.

The livebox was emptied at 08:00 every morning by 2 - 4 technicians. All fish were graded by size and placed in 5 g buckets for delivery to 32 g perforated plastic holding cans located on the margin of the river. Young of year (0+) juveniles were separated from 1+ and 2+ juveniles to decrease predation of 0+ fish in the 5 g and 32 g containers. 1+ and 2+ fish were kept together.

Two holding cans were used to hold portions of 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 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. Hand held temperature gages were used to keep the water about 2 °C cooler than the stream water.

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 trout (0+ SH). A 350 mm measuring board (± 1 mm) and an Ohaus Scout II digital scale (± 0.1 g) were used in the study. Fork lengths (mm) were taken every day of trap collection, and fork length frequencies of 0+ and older steelhead were used to determine age-length relationships at varying times throughout the trapping period. 0+ chinook and 1+ steelhead weights (g) were taken 2-3 times per week, and 2+ steelhead weights were taken almost every day of trap operation, due to expected low sample sizes. Individuals were weighed in a tared plastic pan (containing water) on the electronic scale. The scale was calibrated every day prior to data collection.

Developmental Stages

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 with 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 biometric data was collected, fish were recovered in buckets of continuously aerated fresh water. Young of year fish were kept in separate recovery buckets from age 1+ and older fish to decrease predation, or injury. Crushed ice was used in the recovery buckets to reduce water temperatures during June-August.

After recovery, 0+ juvenile salmonids were transported 157 meters downstream of the trap into edge-water of a riffle. 0+ juveniles were placed into a circular rock weir with a downstream facing escape exit, which served as a final recovery and release station. The low velocity, pool like habitat allowed more time for recovery and stream re-orientation. In addition, we were able to monitor any immediate negative effects associated with handling and water temperature acclimation.

1+ and 2+ steelhead were released 160 meters downstream of the trap into the edge of the main riffle current. The older juvenile fish were generally much more alert than young of year fish, and could handle the stronger current (i.e. could swim wherever they wanted to). There was no concern of fish predation due to their size, and avian predators were not seen at the release location.

Population Estimates

The number of fish captured by the trap represented 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 three times a week for 0+ chinook salmon and 1+ steelhead, and five times a week 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. If a marked fish was captured out of the week strata it was clipped and released, the number originally marked for that particular strata was reduced by the number caught out of the strata. For example, if 100 fish were clipped and released for the week's population estimate and 2 were recaptured the following week (e.g. out of strata captures), the number originally marked would be reduced to 98. The rationale is that for each week we are attempting to

estimate the number of out-migrants passing the trap. If an efficiency trail fish is caught out of strata, then that fish did not pass the trap with the previous week's group that we are estimating.

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. Chi-square (or Fisher's Exact Test) was used to determine if trap efficiencies of pooled weeks differed from one-another. If not different ($p > 0.05$), pooling was allowed (Carlson et al. 1998).

The pooling procedure tends to smooth out inflation of population size due to low recapture probability. Week and bi-weekly estimates were 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 and bi-week variances), and used to calculate 95% CI for the final total population estimate (Carlson et al. 1998). If the pooling process did not appreciably reduce the estimate or confidence intervals (e.g. 5 %), pooling was not used, so that estimate resolution on a week basis would not be lost. Additional population estimate models (e.g. Peterson, Darr) were also used for comparison.

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 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 upstream of the trap after the livebox was emptied.

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 accounted for.
- 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 due to size 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. This 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.

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 the 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. We assumed probability of capture for marked and unmarked smolts was the same. In general, we feel the rotary screw trap location and use of weirs decreased the likelihood of marked fish purposely avoiding the trap.

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. Based upon last year's results of five separate handling and clipping mortality tests (Sparkman 2000), we only ran two 24 hr period tests for 1+ steelhead. Every efficiency fish was held in a live car in the stream for a period of 1 – 2 hr prior to upstream release to document any immediate mortality due to fin clipping, and handling.

Assumption 5: Each member of the field crew was specifically trained in 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 fewer 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. 0 - 4) and considered negligible when compared to the numbers originally released and recaptured in the previous week. The 2+ SH efficiency fish showed 'straggling' more so

than 0+ chinook salmon and 1+ steelhead trout. Of a total of 126 marked 2+ SH recaptures, 91.3% were captured in the correct strata. Recaptures in strata 2, 3, and 4 represented 3.6, 2.2, and 2.9 % of total recaptures. Marked fish of one week were not counted for the population estimate of the following week, unless the two week's data were pooled.

Similar to many out-migration studies, an important assumption for efficiency fish is that they continue migrating downstream of the release point, and pass the trapping site. If the marked fish do not travel past the trap site, then population estimates will be positively biased and too high. Based upon the generally high number of recaptures, we assume this assumption to be met. We were able to use an additional experiment to determine if 1+ and 2+ steelhead released downstream of the trap migrated back upstream of the trap site. If these fish then migrated downstream past the trap, a portion would be caught with the trap. The study could show if a sample of 1+ and 2+ steelhead were truly migrating past the trap site.

Additional Experiments

We marked 374 1+ steelhead and eight 2+ steelhead with a plastic elastomer over the course of the study to determine if any trapping efforts in the lower part of the watershed would catch these fish. The fish were released 160 m downstream of the upper Redwood Creek trap site. The marks were generally stratified by color each week, and injected into the left or right side of the lower jaw. If these specially marked fish were caught in sufficient numbers at the lower mainstem trapping site, downstream travel time could be determined.

Delayed mortality experiments were conducted on fin clipped 1+ steelhead on April 15 and 27, 2001. Fifty fin clipped fish were held in mesh cages in the stream for a period of 24 hours during each test.

Physical Data Collection

A staff gage with increments in the hundredths of a foot was used to gage the relative stream surface elevation at the trap site from March 27 – July 11, 2001. The staff gage was read every morning prior to biometric data collection. On July 11, 2001 the staff gage was very low (0.01) due to low stream flows, and a second gage was installed. The second staff gage was read every morning to the nearest millimeter.

Continual stream temperatures were recorded with an Optic StowAway Temp Probe (Onset computer corporation, 470 MacArthur Blvd. Bourne, MA 02532) placed near the rotary screw trap. The probe was deployed from April 7 – August 4, 2001, and recorded stream temperature (°C) every hour. Data was later downloaded into Microsoft Access to determine daily mean, maximum, and minimum water temperatures.

Data of fraction of the moon illumination at midnight was gathered from the Astronomy Applications Department, US Naval Observatory, Washington, DC 20392-5420.

Statistical Analyses

Numbers Cruncher Statistical System Software (NCSS) (Hintze 1998) was used for descriptive statistics, ANOVA, correlation, and linear regression/ANOVA output. Gage height relationships were tested with the first staff gage and rotary screw trap information. 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), and for differences in size of each species among study years. 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 $\text{Log}(x+1)$, 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 (α) 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
Correlation	Average week fork length 0+ KS	Week number
Correlation	Average week fork length 0+ SH	Week number
Correlation	Average week fork length 1+ SH	Week number
Correlation	Average week fork length 2+ SH	Week number
Correlation	Average week weight of 0+ KS	Week number
Correlation	Average week weight of 1+ SH	Week number
Correlation	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
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 rotary screw trap operated from 3/26/01 – 7/11/01, and trapped 105 nights out of a possible 107. The pipe trap operated from 7/12/01 – 8/04/01, and trapped 24 nights out of a possible 24. Using both traps, trapping occurred 129 out of 131 nights possible.

Species Captured

Species captured in the 2001 study year included: juvenile chinook salmon (*Oncorhynchus tshawytscha*), juvenile steelhead trout (*O. mykiss*), cutthroat trout (*O. clarki clarki*), sculpin (*Cottus* spp.), sucker (*Catostomidae* family), juvenile and adult Pacific Lamprey (*Entosphenus tridentatus*), an unidentified lamprey that might be river lamprey (*Lampetra ayres*), and stickleback (*Gasterosteus aculeatus*). No juvenile coho salmon (*O. kisutch*) were captured. Of special importance in this year's study was the capture of 1+ juvenile chinook salmon. Total trap catches of juvenile salmonids for study year 2001 are given in Figure 2, and for all species and both study years, Table 2.

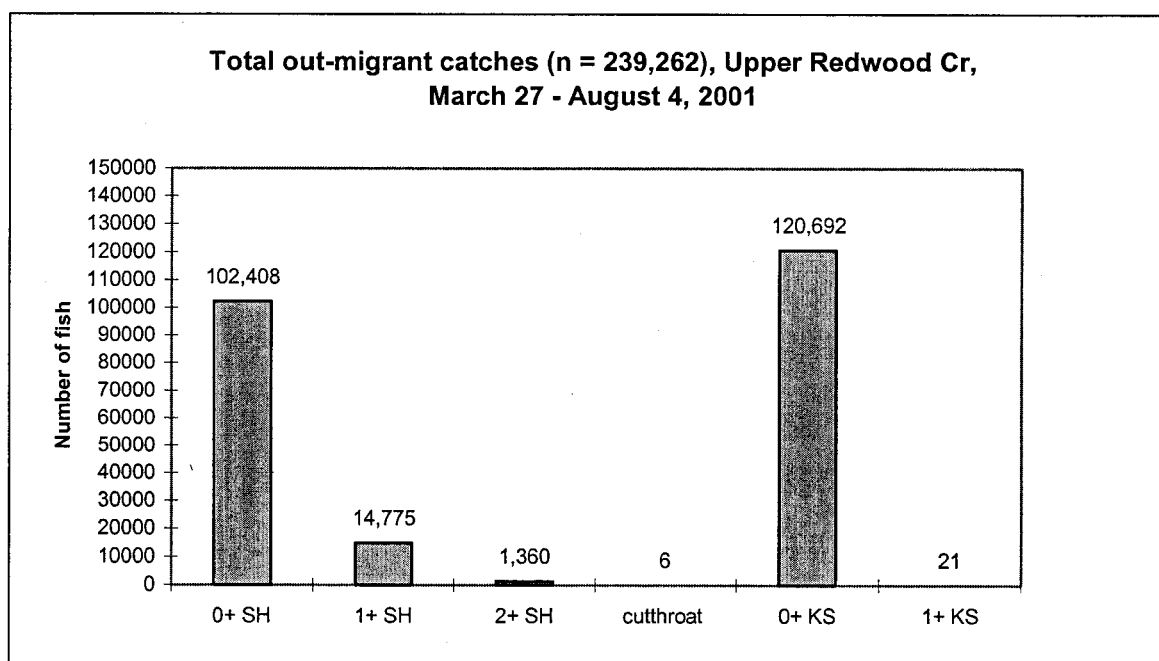


Figure 2. Total catch of juvenile salmonids from March 27 to August 4, 2001 in Upper Redwood Creek, Redwood Valley, Humboldt County, California.

Catches of 0+ SH and 2+ SH were considerably higher in 2001 as compared to study year 2000 (Table 2). 0+ chinook salmon and 1+ steelhead trout catches in 2001 were similar to catches in 2000. Juvenile coho salmon were not captured in 2001 and 2000. An unidentified lamprey was captured in 2001 that was not captured the previous year. The lamprey was not a brook lamprey.

Table 2. Trap catches of various species in study years 2001 and 2000.

Species Captured	Study Year	
	2001	2000
0+ Steelhead Trout	102,408	55,126
1+ Steelhead Trout	14,775	12,263
2+ Steelhead Trout	1,360	736
Adult Steelhead	3	6
0+ Chinook Salmon	120,692	123,633
1+ Chinook Salmon	21	0
Coho Salmon	0	0
Cutthroat Trout	6	2
Prickly Sculpin	8	3
Coast Range Sculpin	67	145
Sucker	7	3
3-Spined Stickleback	85	144
Adult Pacific Lamprey	5	16
Juvenile Pacific Lamprey	1,103	597
Possible River Lamprey	16	0
Pacific Giant Salamander	28	30

Peak Captures

Catches of 0+ KS, 0+ SH, 1+ SH, and 2+ SH were variable over time, with apparent multiple peak catch distributions.

0+ Chinook Salmon

0+ chinook salmon were first caught later this year compared to last year. The first catch occurred on 4/19/01, 24 days after trap placement, whereas in year 2000, 0+ chinook were first captured on 4/5/00, the day following trap placement. Peak 0+ chinook salmon catches occurred during May and June (Figure 3). Catches in May and June 2001 accounted for 96.5 % of the total 0+ chinook catch, as compared to 81 % in study year 2000. May and June are important months for 0+ chinook salmon out-migration in upper Redwood Creek. The highest daily 0+ chinook salmon peak captures in 2001 occurred on May 13 (n = 3,993), May 15 (n = 4,682), May 24 (n = 6,204), June 9 (n = 3,374), and June 10 (n = 3,359), whereas peak catches in 2000 occurred on May 27 (n = 4,232), June 7 (n = 3,832), and June 21 (n = 5,457). Peak catches in 2001 represented 17.9 % of the total catch compared to 10.4 % in 2000. The pattern of catches show that the trapping period encompassed downstream migration (Figure 3). Zero catch days to the left of the distribution are times when fry have not yet emerged from redds, or have not moved downstream (Figure 3). Very low catches on the right tail of the distribution show that downstream migration substantially decreased to values near zero. The daily captures

expressed as a percentage of the total catch ranged from 0.0 – 5.1 %, and suggest that nights missed trapping ($n = 2$) did not influence the total catch to any large degree.

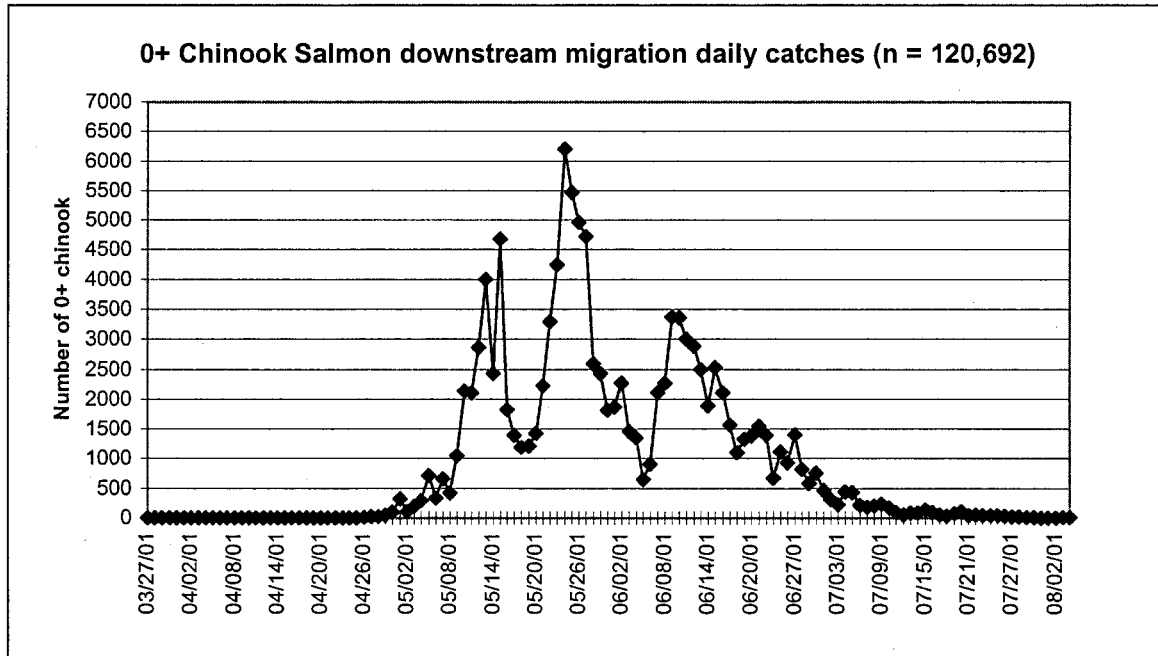


Figure 3. Temporal pattern of 0+ KS catches, upper Redwood Creek, Humboldt Co., California, 2001.

0+ chinook salmon catches by week peaked earlier this year compared to last year (Figure 4). Each peak in 2001 was about one week earlier than in 2000. Differences in catch by week may be attributable to time of adult spawning, and reduced stream habitat capacity in 2001 due to low stream flows. Differences were not due to trap efficiencies, or stream temperatures.

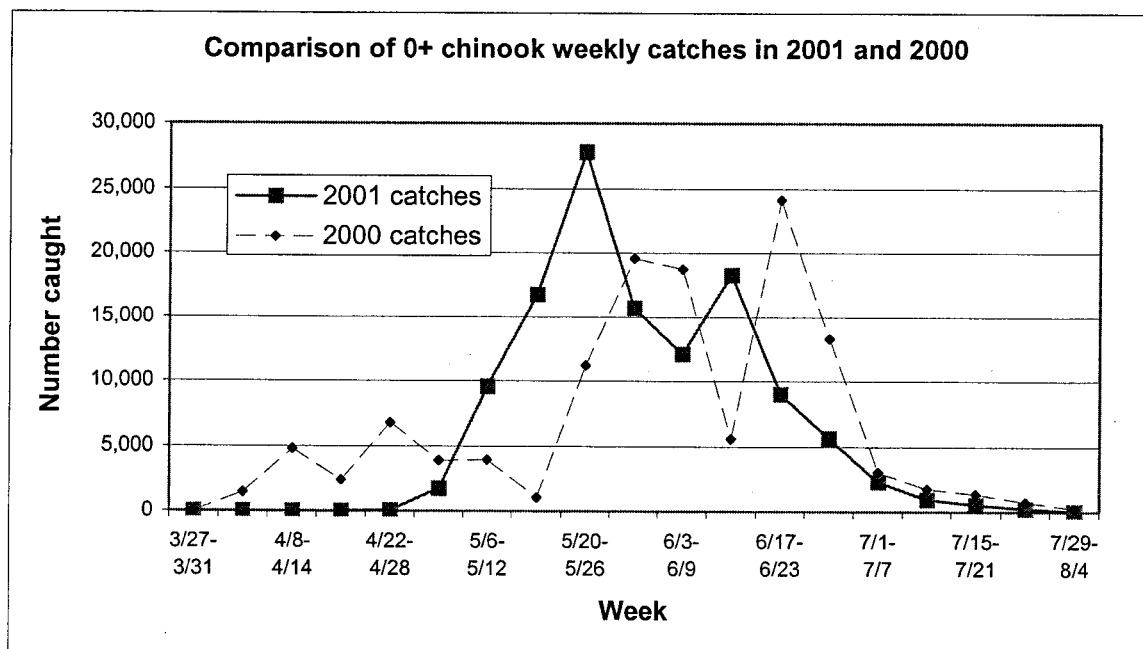


Figure 4. 0+ chinook salmon captures by week, study years 2001 and 2000.

1+ Chinook Salmon

One year old chinook salmon ($n = 21$) were captured from 3/27/01 – 5/05/01. Fork lengths (mm) were originally used to differentiate 1+ from 0+ chinook salmon at the trap site. In the laboratory, scale analyses confirmed annuli present on the larger chinook salmon juveniles. After 5/05/01, all chinook salmon captured were young of year, and lacked annuli typical of 1+ chinook salmon.

0+ Steelhead

0+ steelhead were first caught later this year compared to last year. The first catch occurred on 5/02/01 ($n = 1$), 37 days after trap placement. Last year, 0+ steelhead were first captured on 4/7/00 ($n = 1$), three days after trap placement. Peak 0+ steelhead trout catches in 2001 occurred during May and June (Figure 5), and accounted for 84.7% of the total catch. Peak catches in 2000 occurred in June and July, and accounted for 87.5 % of the total catch. May, June, and July were important months for 0+ steelhead out-migration or stream redistribution. The highest daily 0+ steelhead peak captures in 2001 occurred on May 13 ($n = 2,296$), May 27 ($n = 4,457$), June 9 ($n = 2,436$), and June 27 ($n = 6,993$), whereas peak catches in 2000 occurred on June 5 ($n = 846$), June 21 ($n = 1,449$), June 28 ($n = 2,439$), July 2 ($n = 2,282$), and July 5 ($n = 1,938$). Peak catches in 2001 represented 15.8 % of the total catch compared to 16.2 % in 2000. The pattern of catches show that the trapping period encompassed the majority of downstream migration or stream redistribution (Figure 5). Zero catch days to the left of the catch distribution correspond to times when fry have not emerged from redds, or moved downstream (Figure 5). The daily captures expressed as a percentage of the total catch ranged from 0.0 – 6.8 %, and suggest that nights missed trapping ($n = 2$) did not influence the total catch to any large degree.

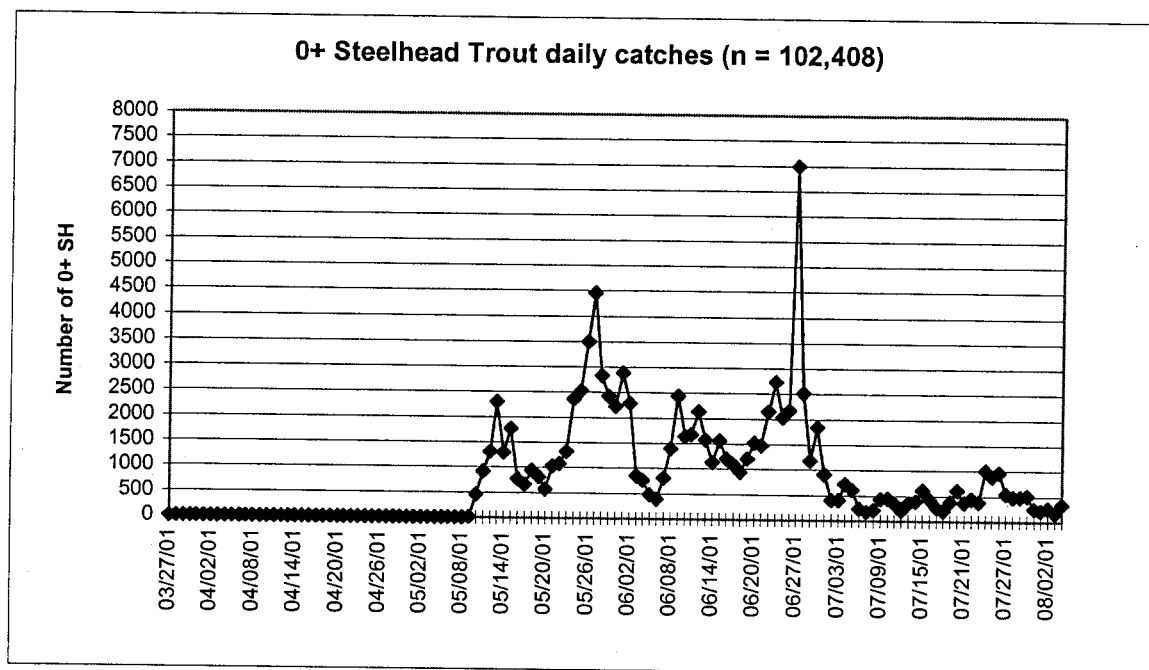


Figure 5. Temporal pattern of 0+ SH catches, upper Redwood Cr, Humboldt Co., Ca.

0+ steelhead trout catches by week peaked earlier this year compared to last year (Figure 6). Peak captures in 2001 occurred 5/27 – 6/02 and 6/24 – 6/30, and for study year 2000, 6/3 – 6/9 and 6/24 – 6/30. Differences in catch by week may be attributable to time of adult steelhead spawning, unknown trap efficiencies, and relatively lower flows in 2001. Lower flows and corresponding reduction in habitat space were probably the most influential factors.

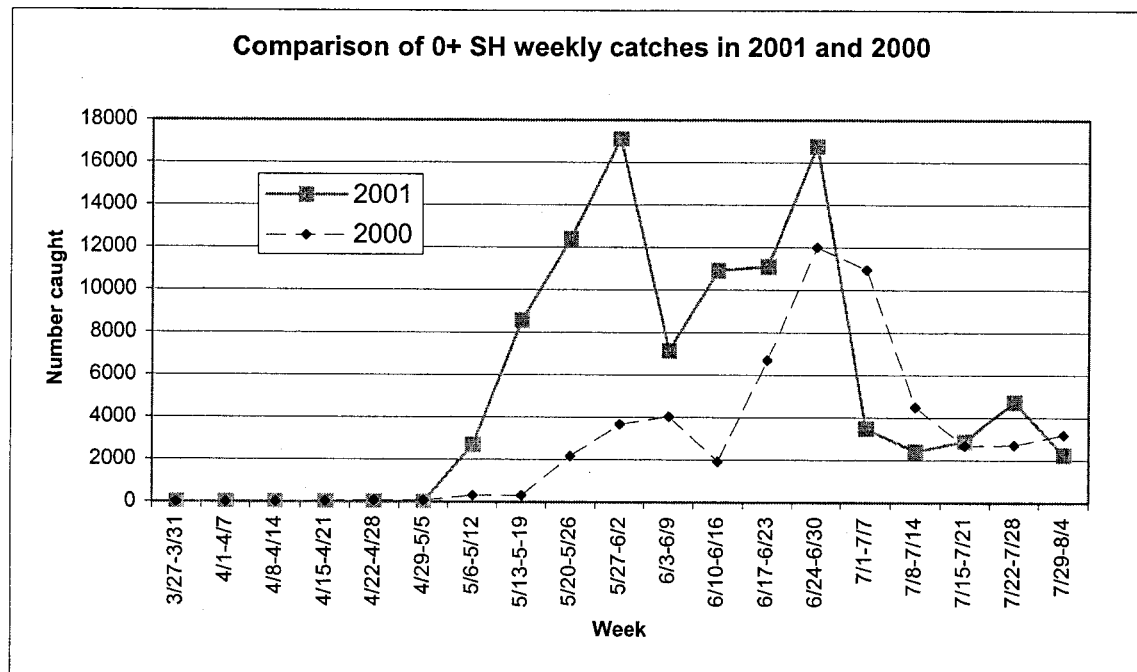


Figure 6. 0+ steelhead captures by week, study years 2001 and 2000.

1+ Steelhead

Peak 1+ steelhead trout catches occurred during March, April, and May 2001 (Figure 7). The months of April and May accounted for 79.7 % of the total 1+ steelhead catch in 2001, and 77 % in study year 2000. April and May were important months for 1+ steelhead downstream migration. The highest daily peak catches in 2001 occurred on 3/27 ($n = 407$), 4/7 ($n = 439$), 4/18 ($n = 618$), 4/25 ($n = 598$), and 5/16 ($n = 710$), whereas peak catches in 2000 occurred on 4/13 ($n = 234$), 4/28 ($n = 408$), 5/3 ($n = 465$), 5/10 ($n = 544$), and 6/4 ($n = 224$). Peak catches in 2001 represented 18.8 % of the total catch compared to 15.3 % in 2000. The pattern of catches show that the trapping period encompassed most of downstream migration. It is unknown how many 1+ steelhead out-migrated prior to trap placement. The relatively high catch the day after trap placement suggests 1+ steelhead were out-migrating prior to the trapping period. The daily captures within the trapping period expressed as a percentage of total 1+ steelhead catch, ranged from 0.0 – 4.8 %, and suggests that nights missed trapping ($n = 2$) did not influence the total catch to any large degree.

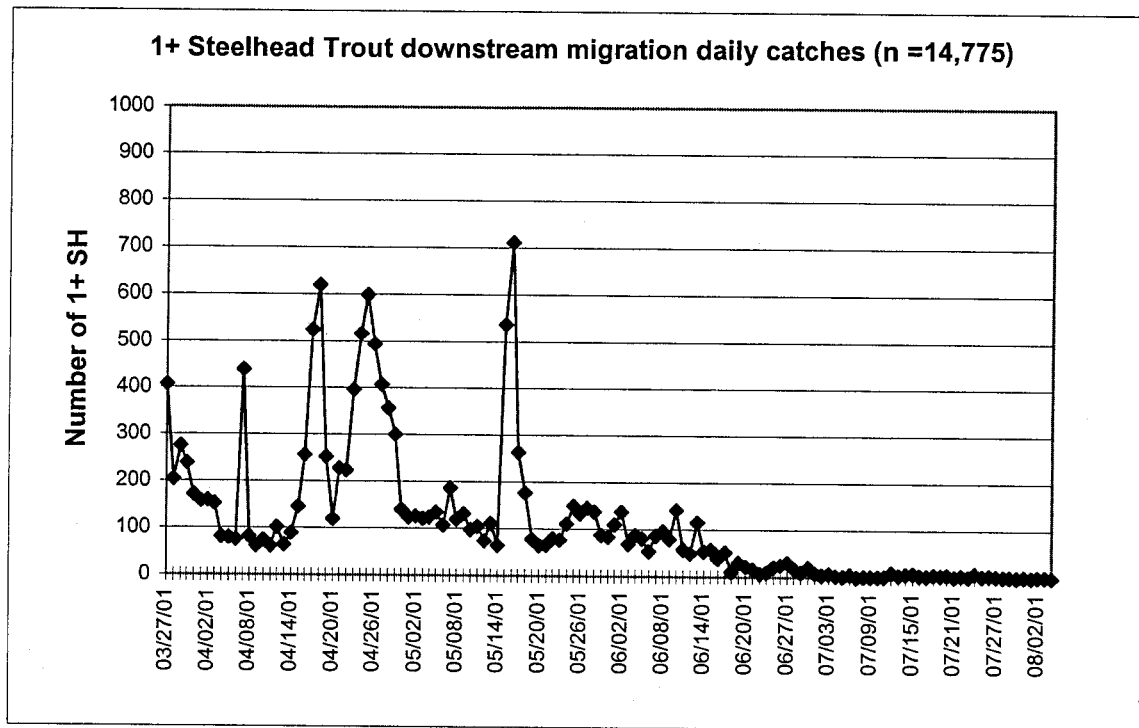


Figure 7. Temporal pattern of 1+SH catches, upper Redwood Cr, Humboldt Co., Ca.

1+ steelhead catches by week peaked earlier this year compared to last year (Figure 8). The two peaks in 2001 were 1 week earlier than in study year 2000. Catches by week in 2001 also show that the trapping period probably covered most of 1+ SH out-migration (e.g. the biggest peak occurred 5 weeks after trap placement). Differences in catch by week among 2001 and 2000 are probably related to lower flows in 2001, with a corresponding reduction in habitat space. Trap efficiencies of week 5 for both study years show that 2001 was less than 2000, therefore, the peak catch at week 5 in 2001 was not due to increased trap efficiency as compared to study year 2000.

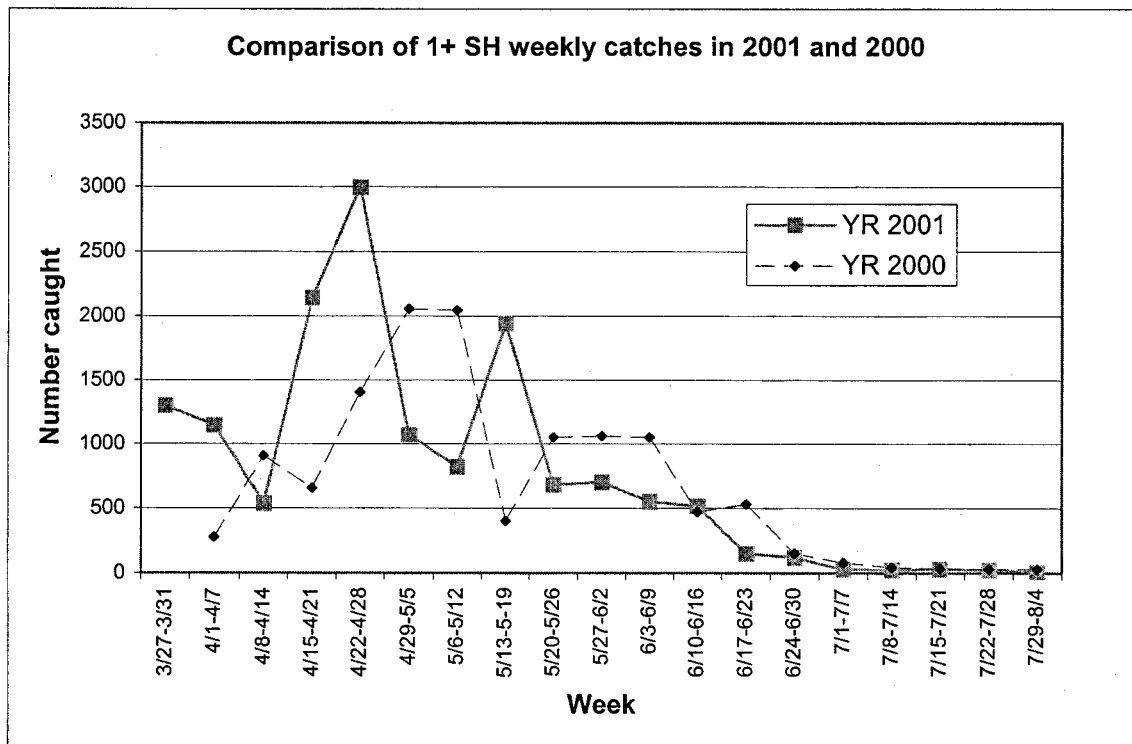


Figure 8. 1+ SH captures by week, study years 2001 and 2000.

2+ Steelhead

Peak 2+ steelhead catches occurred during March, April, May, and July 2001 (Figure 9). The months of April and May accounted for 64.3 % of the 2+ steelhead total catch in 2001, and 81 % in study year 2000. Although April and May appear to be important months for 2+ steelhead out-migration, data in 2001 show that March and July were also periods of increased out-migration. 2+ steelhead daily catches were very variable over time. The highest daily peak catches in 2001 occurred on 3/27 ($n = 45$), 4/7 ($n = 45$), 4/18 ($n = 36$), 5/7 ($n = 28$), 5/16 ($n = 28$), and 7/18 ($n = 22$). The dates of 3/27, 4/7, 4/18, and 5/16 also corresponded to peak 1+ steelhead out-migration in 2001. Peak 2+ SH catches in 2000 occurred on 4/6 ($n = 35$), 4/13 ($n = 26$), 5/3 ($n = 24$), and 5/10 ($n = 19$). Peak 2+ steelhead catches in 2001 represented 15.0 % of the total catch compared to 17.7 % in 2000. The relatively high catch the day after trap placement suggests that an unknown number of 2+ steelhead were out-migrating prior to trap installation date. The daily captures within the trapping period expressed as a percentage of total 2+ steelhead catch, ranged from 0.0 – 3.3 %, and suggests that nights missed trapping ($n = 2$) did not influence the total catch to any large degree.

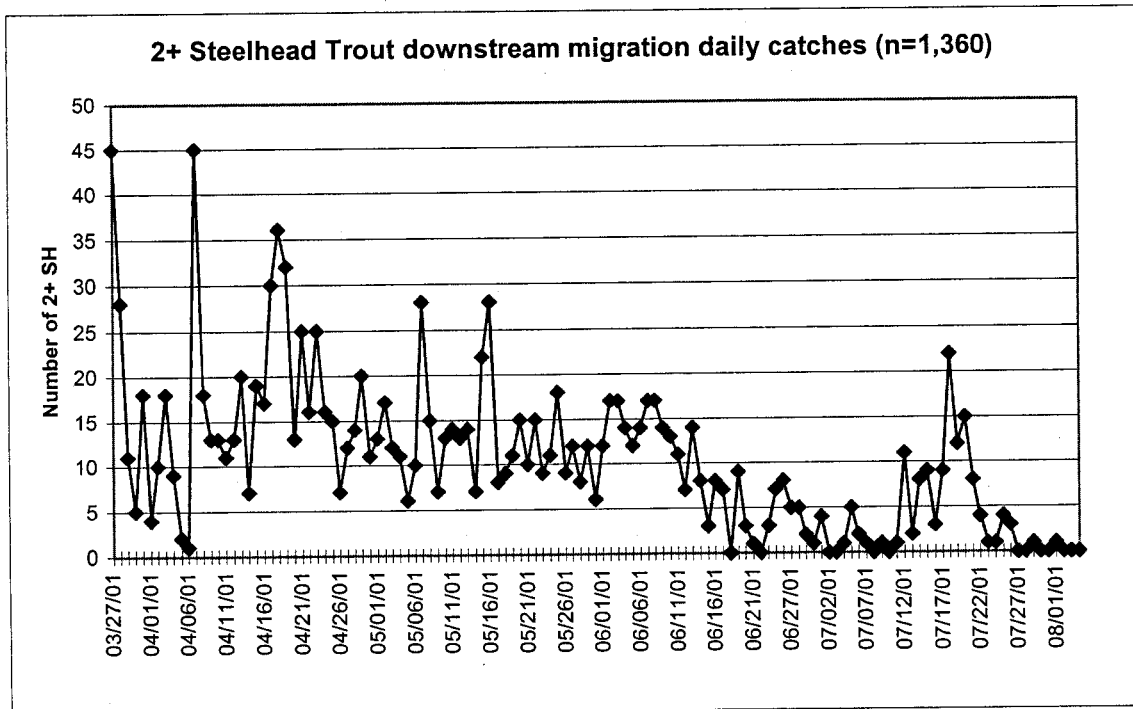


Figure 9. Temporal pattern of 2+ SH catches, upper Redwood Cr, Humboldt Co., Ca.

2+ steelhead out-migration in 2001 was noticeably higher, and more spread out over time than in year 2000. Catches by week among years also peaked at different times (Figure 10). The first peak in 2001 occurred one week after the first peak in 2000. The second and third peak in 2001 happened when at the same time last year, 2+ steelhead numbers were noticeably decreasing. The second peak in 2000 occurred 5 weeks before the second peak in 2001. Catches by week also show that the month of June was important for 2+ steelhead outmigration in 2001 (Figure 10), which does not show up as readily in daily captures (Figure 9). Unlike 1+ SH, 2+ steelhead catches by week suggest that low flows and reduction in habitat space might not have been as important for timing of out-migration, except for the week of 7/15 – 7/21 when very low flows might have caused a pulse of 2+ fish to out-migrate. However, the 2+ steelhead in 2001 may have resided farther upstream of the trap site this year as compared to last year. The increased travel time to the trap site could explain these differences. Trap efficiency data for both years was similar (see 2+ SH trap efficiencies).

It is difficult to determine if the trapping period covered the majority of 2+ SH out-migration because the catch distribution is missing the left side of the expected normal bell shaped curve. Although an unknown number of 2+ were assuredly out-migrating prior to trap placement, the peak catch by week occurred on the 4th week of trap operation. This does suggest that we might have encompassed the majority of 2+ steelhead out-migration.

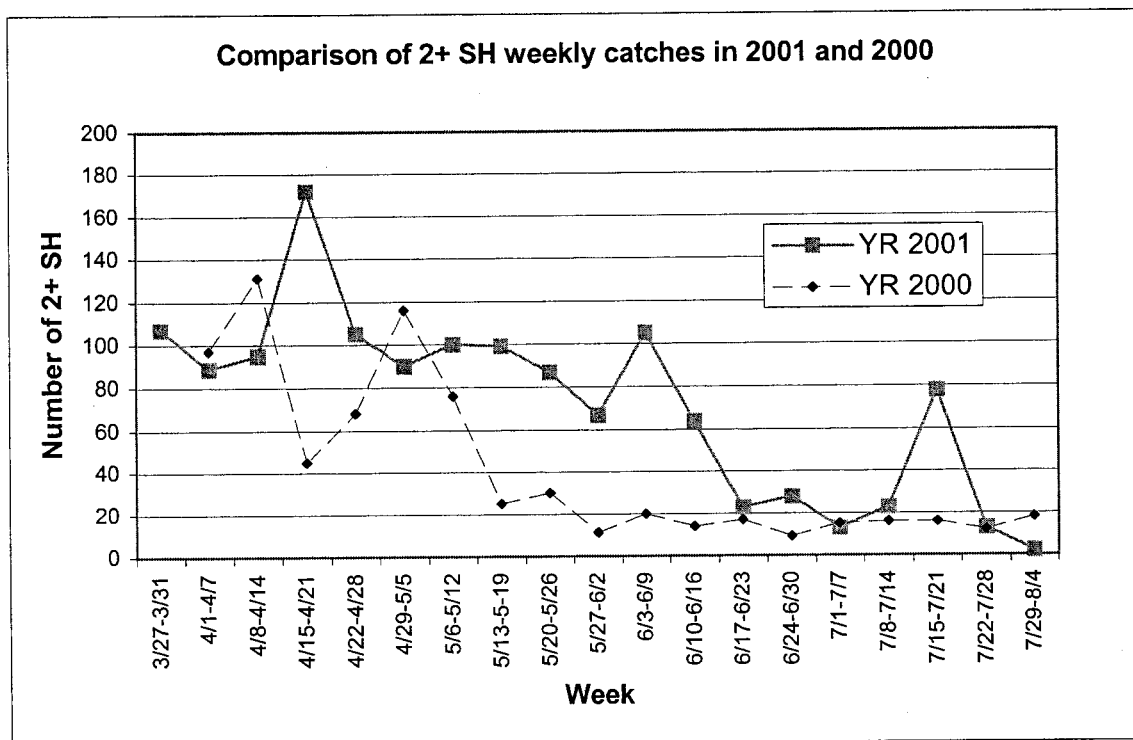


Figure 10. 2+ SH captures by week, study years 2001 and 2000.

Flow Events

Stream discharge in water year 2000-01 (October 2000 – September 2001) was considerably less than the historic average (Figure 11). Peak discharge in water year 2000-2001 was one month later (March) than the historic peak (February).

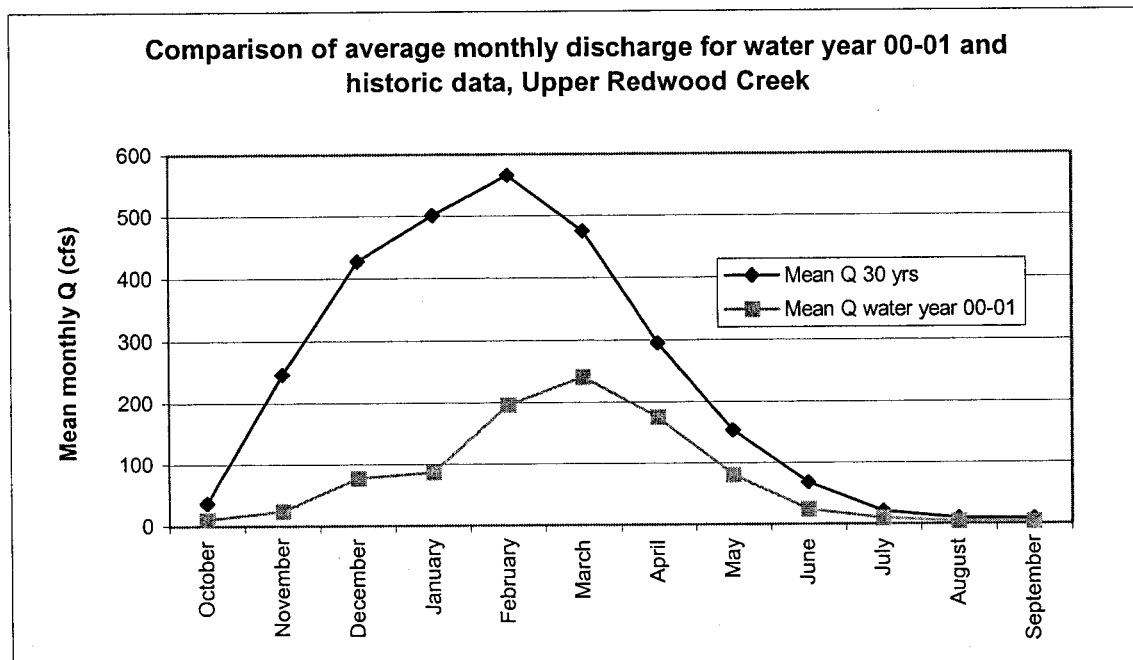


Figure 11. Average monthly discharge in upper Redwood Creek (USGS 2001).

The staff gage used for data analyses operated from 3/27 – 7/10, 2001 (Figure 12). Flows in study year 2001 were much less than in 2000. The relatively smaller high flow events in 2001 occurred on 3/28, 4/7, 4/21, and 5/15. The largest daily increases in gage height in 2001 were 0.56, 0.34, and 0.72 ft, as compared to 1.14 and 0.60 ft. in 2000.

Throughout all flow events in 2001, the trap was positioned in the middle of the thalweg, unlike year 2000 when the trap was at least partially re-positioned out of the thalweg five times due to high flows. The low flows in 2001 required trapping adjustments on a weekly, and at times, daily basis (eg. increase weir paneling, increasing cone clearance with streambed).

A regression of the daily gage height (ft) on cone revolutions per second determined a significant positive relationship ($p = 0.0000001$, $R^2 = 0.89$; power = 1.0). Factors not taken into consideration in the regression model include positioning the trap upstream into the faster water, and weir modifications.

From 6/19 to 6/23, the stream dropped a total of 3.12 inches. The significant drop in gage height (0.14 ft or 1.7 inches) on 6/23/01 was due to the final filling stages of Chezum Dam, located about 5.6 miles upstream of the trap site. By the following day, the dam had filled to capacity, and the spillway allowed more water to return to the stream. The stream rose 2.64 inches on 6/24/01. Figure 13 shows the change in gage height (ft) more readily than Figure 12. The drop in stream flow on 6/23 due to filling Chezum Dam caused the rotary screw trap to stop spinning. The cone was raised, and the very low catch was released without counting or measurements. The change in stream flow was very apparent, and potentially alarming. Aside from losing a day trapping, the abrupt change in stream flow could have stranded fish in dewatered stream habitats. Additionally, the large increase the following day (e.g. 2.64 in.) would have spelled disaster had we installed a fyke net trap the previous day.

The second staff gage recorded gage height (mm) from 7/12 – 8/4, 2001. Gage height was very stable, and gradually dropped from a reading of 433 (7/12) to 385 mm (8/4).

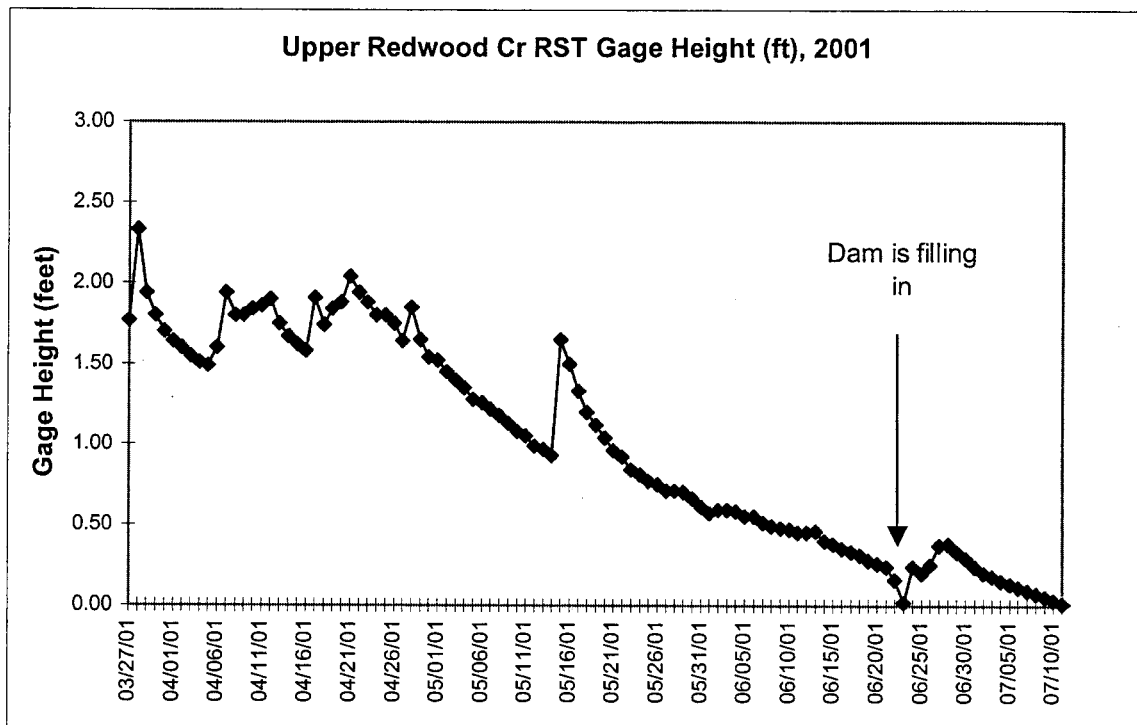


Figure 12. Staff gage at RST site, upper Redwood Creek, Humboldt Co., California.

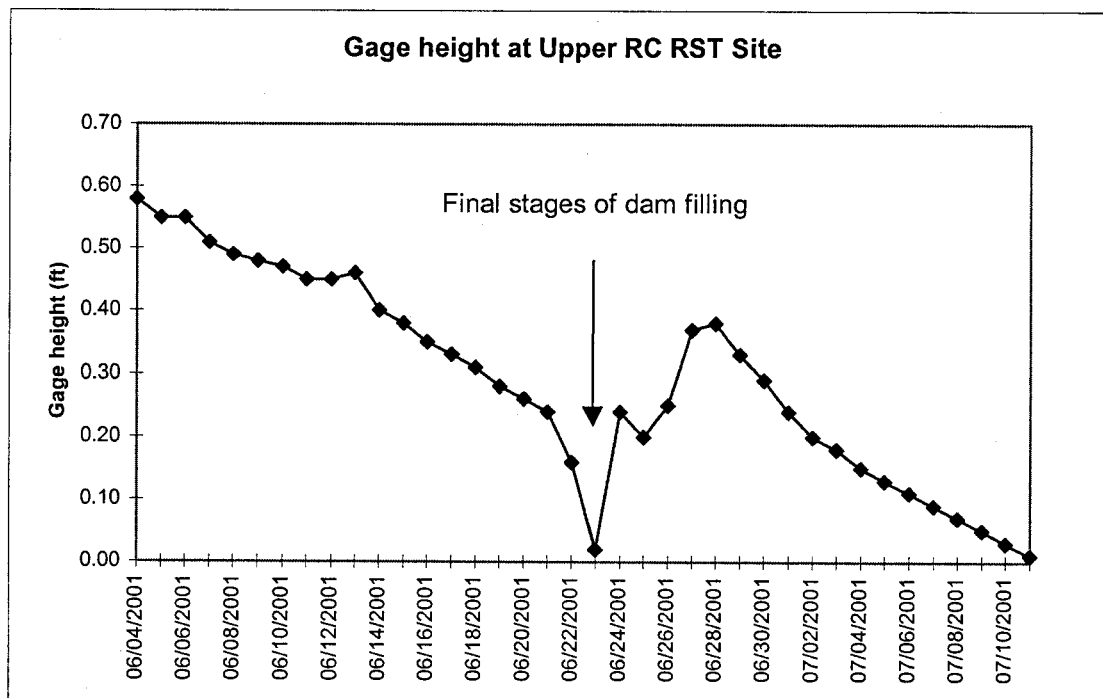


Figure 13. Gage height (ft) during Chezum Dam final filling period.

Linear Relations of Catch with Staff Gage Height

Linear regression of daily gage height (ft) on daily catches for all salmonids (log (x+1) transformation) showed a significant negative relationship ($p = 0.0000001$, $R^2 = 0.41$; power = 1.0). In study year 2000, no significant relationship was found. Using average gage height by week and total species catch by week, regression determined a significant negative relationship present ($p = 0.01$, $R^2 = 0.39$, power = 76). The results of these tests are biased to some degree by the catches of 0+ KS and 0+ SH that typically out-migrate at later times than 1+ and 2+ SH.

Regression of daily gage height (ft) on 0+ chinook daily catches showed no significant linear relationship ($p > 0.05$, $R^2 = 0.002$; power = 0.07), similar to results in study year 2000. Only one 0+ chinook peak in 2001 was on the same day as a gage height peak, and the remaining peak catches occurred during the descending limb of the stream surface elevation graph. The regression of average gage height (ft) by week on 0+ chinook salmon catches by week also showed no significant relationship ($p > 0.05$; $R^2 = 0.01$; power = 0.06).

Regression for 0+ SH daily catches (log (x+1) transformation) showed a significant yet weak negative relation with daily gage height ($p = 0.00004$, $R^2 = 0.22$; power = 0.99), similar to that found in 2000. The majority of 0+ SH catches in 2001 catches occurred on the falling limb of the water surface elevation graph.

Regression of 1+ SH catches (log (x+1) transformation) showed a significant positive relation ($p = 0.0000001$, $R^2 = 0.59$; power = 1.0). The relationship was similar to study year 2000, however, the R^2 was much higher in 2001 (e.g. 0.59 vs 0.34). Two of the five 1+ SH peaks in 2001 were associated with peak gage height (ft). The regression of average gage height (ft) by week on 1+ SH catches by week in 2001 also showed a significant positive relationship ($p = 0.0019$, $R^2 = 0.54$; power = 0.95).

2+ SH daily catch and gage height (ft) violated regression assumptions even when data was transformed with log (x+1), however, one of the 6 peak catches did correspond to a peak in gage height (ft). In study year 2000, 2+ SH daily catches were positively related to gage height ($p < 0.05$). In 2001, average gage height (ft) by week and weekly 2+ SH catches passed regression assumption tests. The regression of average gage height by week (ft) on catch by week was significant and positive ($p = 0.0006$, $R^2 = 0.61$; 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. 0+ chinook salmon catches generally decreased with a full moon, and increased with a new moon. Peak catches of 0+ chinook (i.e. > 4,000) occurred at moon illumination factors less than 0.51. The largest peak catch of 6,204 was at a moon illumination factor of 0.02 (new moon).

phase). Results in 2001 differed from 2000. In 2000, 0+ chinook catches decreased with a new and full moon, with peak catches occurring during a moon illumination of 0.30 – 0.84. 0+ SH catches in 2001 also decreased with a full moon, and increased with the new moon. The largest 0+ SH peak catch occurred during a moon illumination of 0.41. 0+ SH catches greater than 3,000 by day occurred at moon illumination fractions of 0.13 – 0.41. Results for 0+ SH were somewhat similar for both study years, except in 2000 peak 0+ SH catches did not occur at moon illumination fractions greater than 0.17. 1+ SH catches in 2001 were low during full moon illumination, except for one peak catch of 439 that occurred at a moon illumination of 0.99. The majority of higher 1+ SH catches were below a moon illumination fraction of 0.50, with the largest peak catch ($n = 710$) occurring at 0.42. Aside from a peak catch at 0.99 in 2001, results in 2001 and 2000 were similar. 2+ steelhead were the most variable of all salmonids with respect to catches and moon illumination. High catches in 2001 occurred at full and new moon phases with no clear pattern. A dip in catches was apparent at a moon illumination of 0.60 – 0.67. Results in 2001 and 2000 were similar.

Stream Temperatures

The average daily (24 hr period) stream temperatures from 4/7/01 – 8/4/01 was 16.26 °C (95% CI 15.47 – 17.05), and ranged from 7.14 – 22.94 °C (Figure 14). The average daily stream temperature (°C) exceeded 20 °C for 30 days out of 120 d (25%) of record. Relations of the average stream temperature °C and gage height (ft) were significantly negative ($p = 0.0000001$, $R^2 = 0.87$; power = 1.0). Gage height (ft) explained 87 % of the variation in average stream temperatures (°C). The maximum and minimum daily temperatures ranged from 7.71 – 28.9 °C, and 5.69 – 19.31 °C (Figure 14). Maximum temperatures (°C) occurred in the mid to late afternoon, well after the trapped fish were processed and released. The average stream temperature in 2000 was 15.88 °C. Using data for the same dates in both study years (i.e. truncating the 2001 data to match 2000 data), Kruskal-Wallis One Way Anova on Ranks determined median stream temperatures in 2001 (18.6 °C) were significantly greater than in study year 2000 (15.5 °C) ($p = 0.000003$).

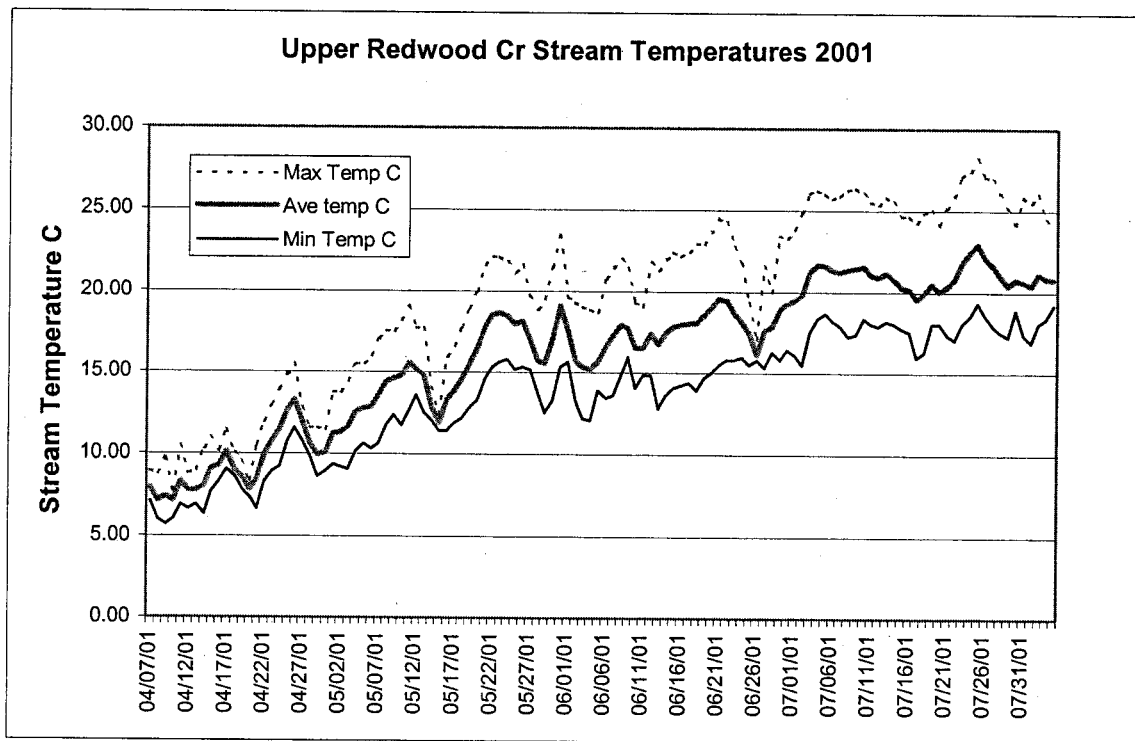


Figure 14. Upper Redwood Cr stream temperature ($^{\circ}\text{C}$), 2001.

Linear Relations of Catch with Average Stream Temperature

Linear regression of average stream temperature ($^{\circ}\text{C}$) on catches for all salmonids combined showed no significant relationship present ($p > 0.05$), unlike in 2000 where a significant positive relationship was found ($p < 0.05$). Using the average stream temperature ($^{\circ}\text{C}$) and catches by week in 2001, no significant relationship was present ($p > 0.05$). Regression for 0+ KS also showed no significant relationship using daily or week data ($p > 0.05$). In 2000, 0+ KS showed a weak, yet positive significant relation ($p < 0.05$). Daily data for 0+ SH in 2001 violated regression normality tests, and results were unreliable. The average stream temperature ($^{\circ}\text{C}$) and catch of 0+ SH by week did not fail test assumptions, and showed no significant relationship present ($p > 0.05$). In 2000, daily catches of 0+ SH and average stream temperatures showed a highly significant positive relationship ($p < 0.05$). Regression of average stream temperature ($^{\circ}\text{C}$) and catch by day for 1+ SH showed a highly significant negative relationship ($p = 0.0000001$, $R^2 = 0.37$; power = 1.0), similar to study year 2000. Using YR 2001 average stream temperatures ($^{\circ}\text{C}$) and 1+ SH catches by week, similar results were found ($p = 0.001$, $R^2 = 0.51$; power = 0.96). Daily data for 2+ SH showed significant negative relations with average stream temperatures ($^{\circ}\text{C}$) and catch ($p = 0.0000001$, $R^2 = 0.47$; power = 1.0). In study year 2000, no such relationship was found ($p > 0.05$). Using YR 2001 data by week, 2+ SH catches and average stream temperatures ($^{\circ}\text{C}$) were significantly negative ($p = 0.00008$, $R^2 = 0.65$; power = 1.0).

Fork Lengths/Weights

Data in 2001 was tested for significant relationships with time (week) using linear correlation. Single factor ANOVA was used to determine if significant variation in average fork length (mm) and weight (g) existed between years. The average fork lengths (mm) by week of out-migrating 0+ chinook salmon and 0+ steelhead trout over both study years are shown in Figure 15. The lack of data in some weeks is due to 1) differences in trap placement time among study years, 2) no catches occurred, or 3) sample size was too low to generate an average.

Correlation of week on average 0+ chinook fork length (mm) in 2001 showed a highly significant positive relationship ($p = 0.0000001$, $r = 0.98$; power = 1.0), similar to the test in 2000. Chinook salmon were larger over the course of the trapping period. 0+ KS average week fork lengths (mm) in 2000 (mean = 55.2 mm) were greater than in 2001 (51.9 mm), however, differences were not significant ($p > 0.05$). The difference in average fork length (mm) from week 5 to week 19 for 0+ KS was + 24.7 mm in 2001, compared to + 30.2 in study year 2000 (wk 2 – 19).

The correlation test for 0+ SH showed a highly significant positive relationship of fork length (mm) with time ($p = 0.000007$, $r = 0.90$; power = 1.0), similar to data in 2000. As expected from the graph below, ANOVA found no significant differences in 0+ SH average week fork length (mm) (YR2000 = 38.5 mm; 2001 = 40.0 mm) among years ($p > 0.05$). The difference in average fork length (mm) from week 6 to week 19 for 0+ SH in 2001 was + 13.6 (mm), compared to + 21.1 mm (wk 3 – 19) in 2000.

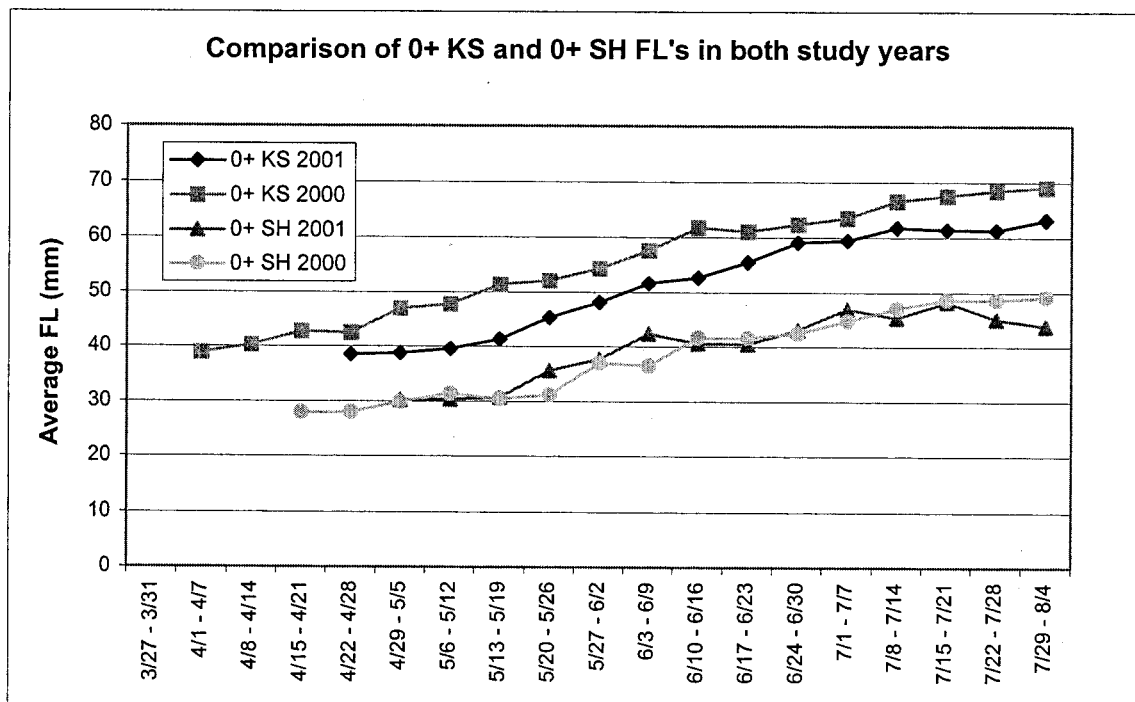


Figure 15. Comparison of 0+ KS and 0+ SH fork lengths (mm) among study years.

Correlation of week on average fork length (mm) for 1+ steelhead in 2001 showed a significant positive relationship ($p = 0.006$, $r = 0.61$; power = 1.0), similar to the test in 2000, except that r was much higher in 2000 (0.97). As expected from the graph below (Figure 16), ANOVA found no significant differences in 1+ SH average week fork lengths (mm) (YR 2000 = 95.9 mm; 2001 = 92.3 mm) among study years ($p > 0.05$). The difference in average fork length (mm) from week 1 to week 19 was + 11.8 mm in 2001, compared to + 28.6 in study year 2000 (wk 2 – 19).

The correlation test for 2+ SH determined no significant relationship of average fork lengths (mm) with time ($p > 0.05$), similar to results in 2000 ($p > 0.05$). Average week fork lengths in 2001 (mean = 149.8 mm) were significantly less than in 2000 (mean = 159.05 mm) ($p = 0.003$, power = 0.87) (Figure 16). The difference in average fork length (mm) from week 1 to week 18 was negative (–) 3.0 mm in 2001, compared to (–) 13.8 mm in study year 2000 (wk 2 – 19).

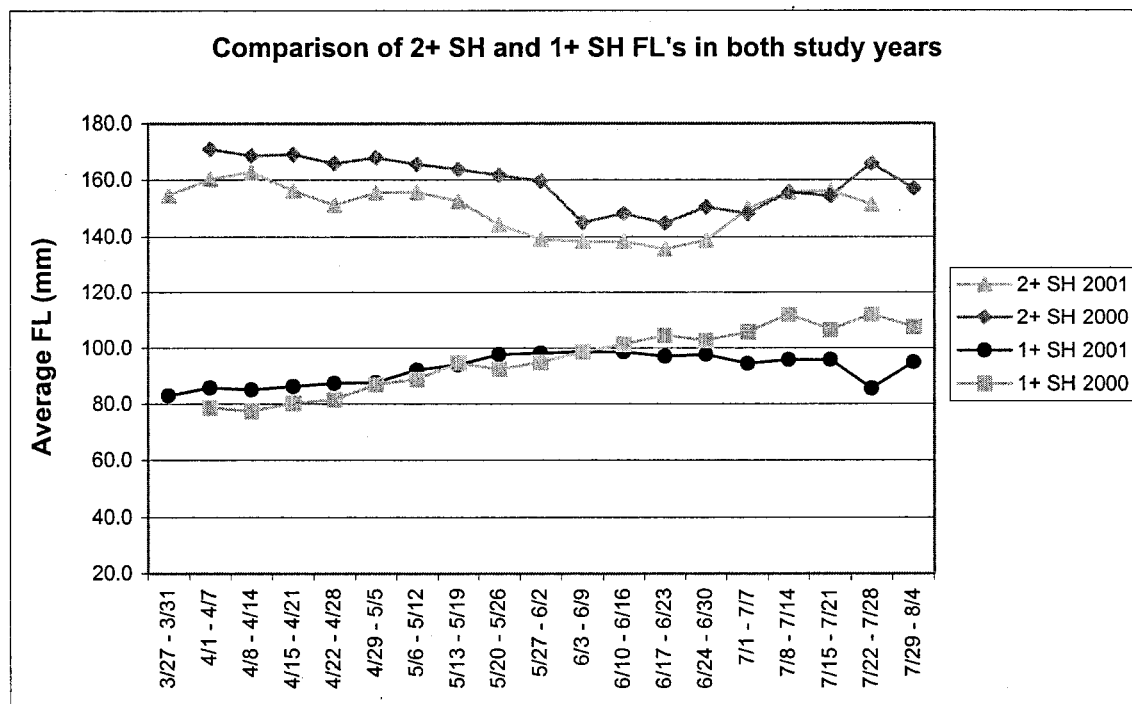


Figure 16. Comparison of 2+ SH and 1+ SH fork lengths (mm) among study years.

Correlation of week number on average weight (g) for 0+ chinook in 2001 showed a highly significant positive relationship ($p = 0.0000001$, $r = 0.98$; power = 1.0), similar to data collected in 2000 (Figure 17). 0+ KS average week weights (g) in 2000 (mean = 2.07 g) were greater than in 2001 (mean = 1.73 g), however, differences were not significant ($p > 0.05$). The difference in average weight (g) from week 6 to week 19 for 0+ KS in 2001 was + 2.14 g, compared to + 2.8 g in study year 2000 (wk 2 – 19).

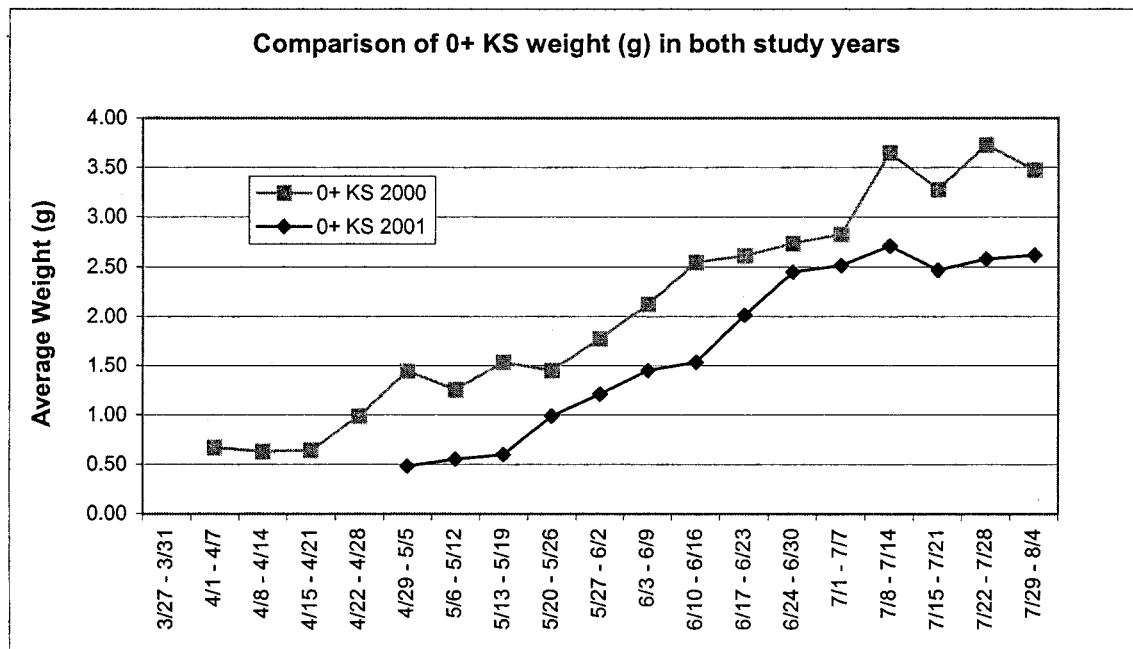


Figure 17. 0+ Chinook salmon average weights (g) in both study years.

Correlation of week number on average weight (g) for 1+ steelhead in 2001 showed a significant positive relationship ($p = 0.004$, $r = 0.62$; power = 0.88), similar to 2000, except r was much higher in 2000 (0.92) (Figure 18). There were no significant differences in median week weight (g) among study years (K-W $p > 0.05$; YR2000 median = 10.02, YR2001 median = 10.00). The difference in average weight (g) from week 1 to week 19 was + 4.27 g in 2001, compared to + 8.07 in study year 2000 (wk 2 – 19).

The correlation test for 2+ SH determined no significant relationship of average weight (g) with time ($p > 0.05$), similar to results in 2000 ($p > 0.05$). Average week weights (g) in 2001 (mean = 38.68 g) were significantly less than in 2000 (mean = 43.86 g) (ANOVA $p = 0.01$, power = 0.73). The difference in average weight (g) from week 1 to week 18 was positive (+) 0.35 (g) in 2001, compared to negative (–) 11.62 g in study year 2000 (wk 2 – 19) (Figure 18).

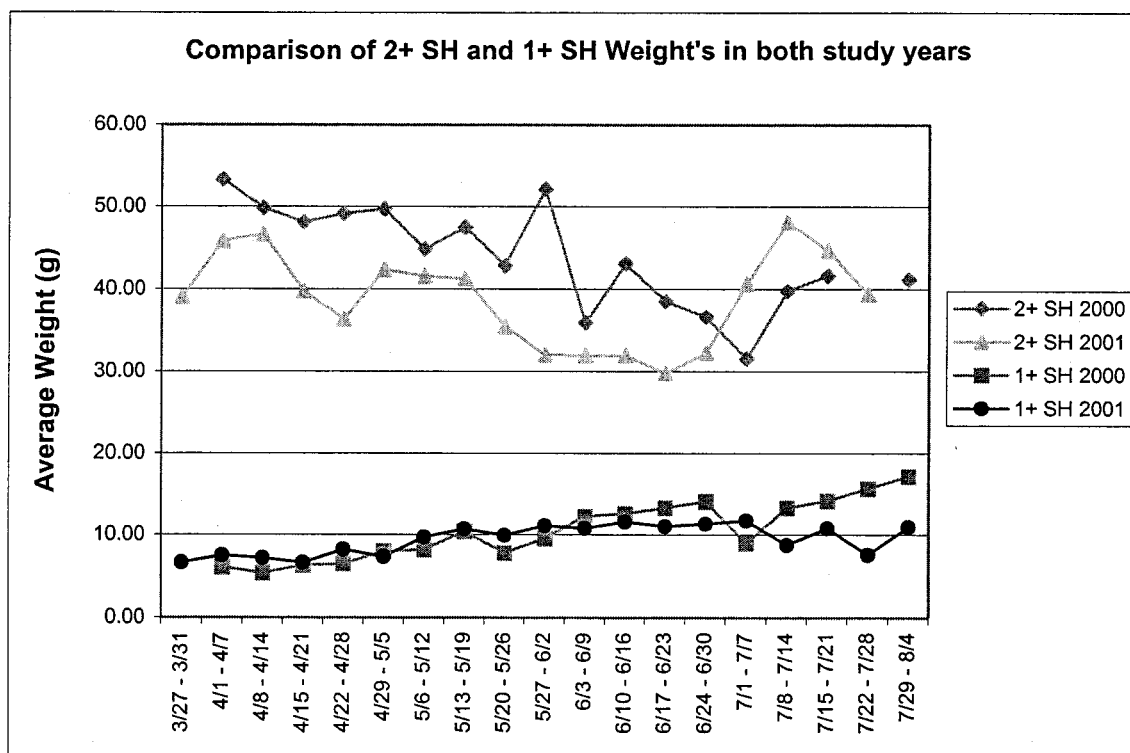


Figure 18. 2+ steelhead and 1+ steelhead average weights (g) in both study years.

Length/Weight Relationships

Length/weight curves for 0+ chinook salmon ($n = 778$), 1+ steelhead ($n = 908$), and 2+ steelhead ($n = 1,225$) are given in figures 19, 20, and 21.

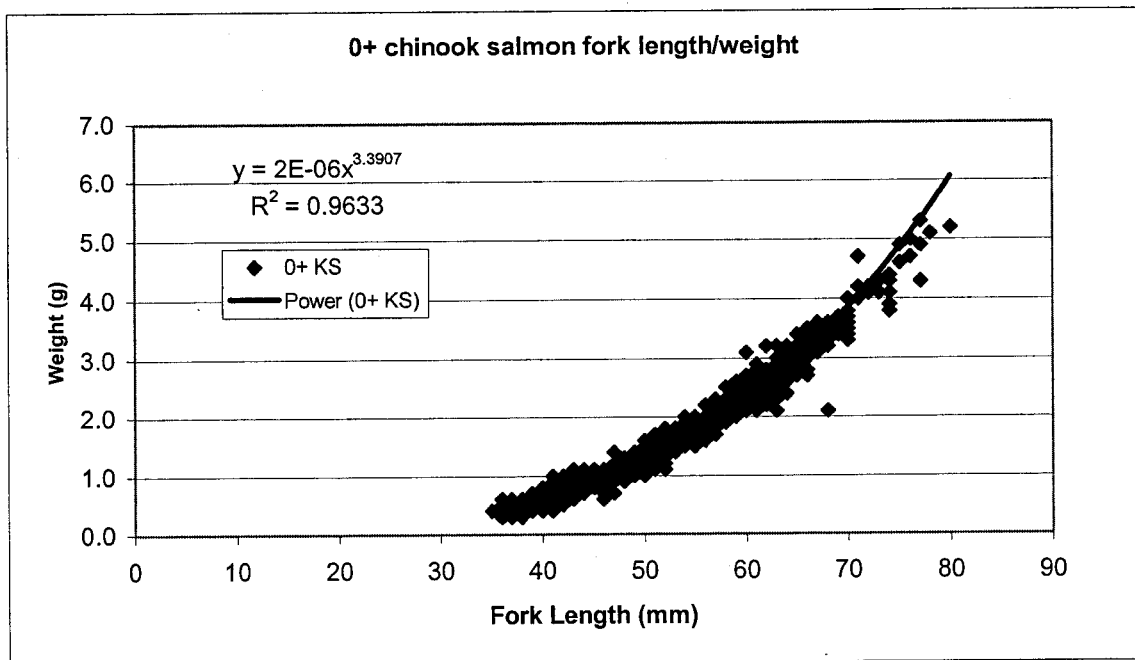


Figure 19. 0+ Chinook salmon fork length/weight relationship, 2001.

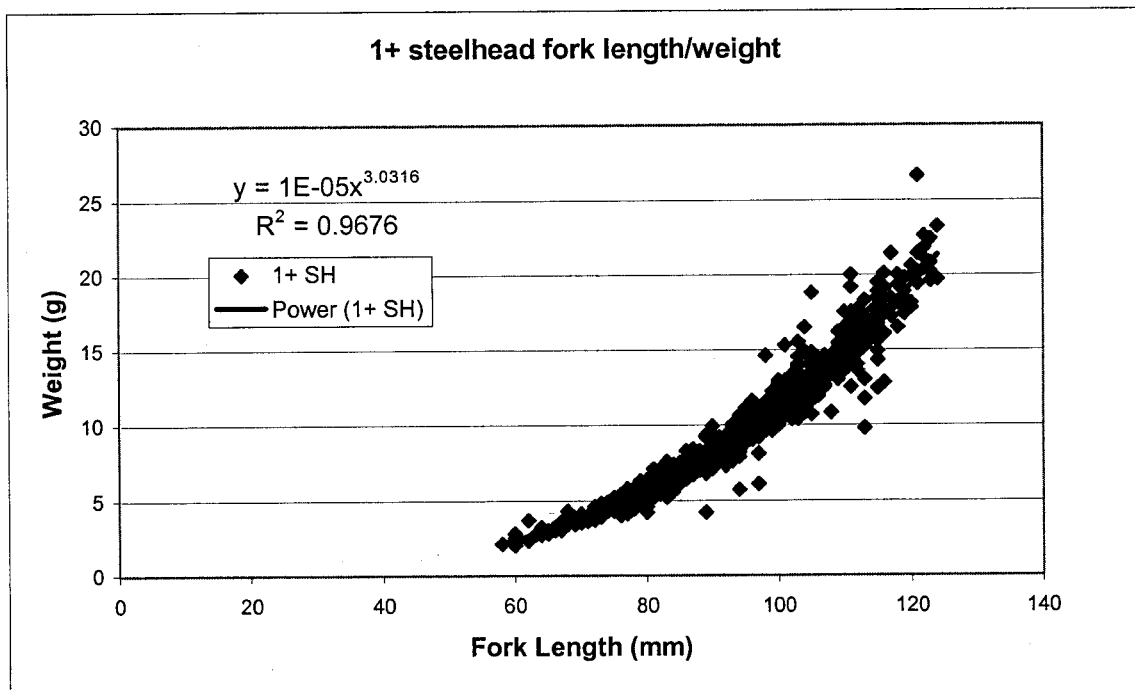


Figure 20. 1+ Steelhead fork length/weight relationship, 2001.

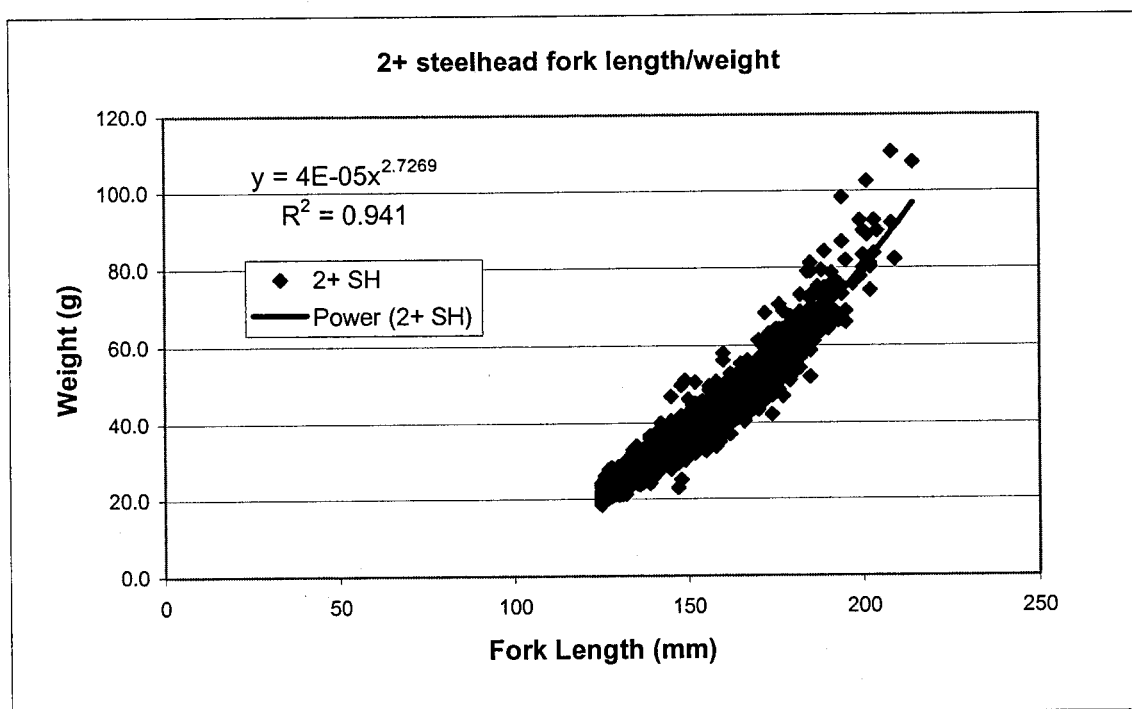


Figure 21. 2+ SH fork length/weight relationship, 2001.

Fork Length and Weight

0+ Chinook Salmon

A total of 2,719 fork length (mm) and 778 weight (g) measurements were taken for 0+ chinook salmon in 2001 (Appendix 1, Table 10; Appendix 2 Table 11). Overall, fork lengths (mm) ranged from 34 – 81 mm, and averaged 51.9 mm (95% CI 51.5 – 52.2 mm, SEM = 0.2 mm, mode = 38 mm). The average FL (mm) in 2001 (mean = 51.9 mm) was less than in 2000 (mean = 55.5 mm, 95%CI 55.1 – 55.9, SEM = 0.2 mm). The mode in FL (mm) in 2001 (38 mm) was less than the mode in 2000 (40 mm). Weights (g) in 2001 ranged from 0.3 – 5.3 g, and averaged 1.73 g (95% CI 1.66 – 1.80; SEM = 0.04). Similar to FL (mm) data, the average weight in 2001 (mean = 1.73 g) was less than in 2000 (mean = 2.03 g, 95% CI 1.95 – 2.10; SEM 0.04 mm).

1+ Chinook Salmon

Seventeen fork length (mm) and 13 weight (g) measurements were taken for 1+ chinook salmon juveniles (n = 21) (Table 3). Using all measurements, fork length (mm) and weight (g) averaged 104.4 mm and 13.38 g.

Table 3. 1+ Chinook salmon average fork length (mm) and weight (g), 2001.

	1+ Chinook Salmon						
	MIN	MAX	95% LCL	95% UCL	Average	SEM	n =
FL (mm)	86	133	98.5	110.3	104.4	2.8	17
WT (g)	6.6	28.6	9.79	16.98	13.38	1.7	13

0+ Steelhead Trout

A total of 1,136 fork length (mm) measurements were taken for 0+ Steelhead Trout in 2001 (Appendix 3, Table 12). Overall, fork lengths (mm) ranged from 25 – 69 mm, and averaged 39.0 mm (95% CI 38.5 – 39.5 mm, SEM = 0.3 mm, mode = 44 mm). The average FL (mm) in 2001 (mean = 39.0 mm) was less than in 2000 (mean = 40.9 mm, 95%CI 40.5 – 41.2, SEM = 0.2 mm). The mode in FL (mm) in 2001 (44 mm) was greater than the mode in 2000 (30 mm).

1+ Steelhead Trout

A total of 2,761 fork length (mm) and 908 weight (g) measurements were taken for 1+ Steelhead Trout in 2001 (Appendix 4, Table 13; Appendix 5 Table 14). Overall, fork lengths (mm) ranged from 55 – 124 mm, and averaged 91.9 mm (95% CI 91.4 – 92.4 mm, SEM = 0.3 mm, mode = 90 mm). The average FL (mm) in 2001 (mean = 91.9 mm) was slightly less than in 2000 (mean = 92.4 mm, 95%CI 91.8 – 93.0, SEM = 0.3 mm). The mode in FL (mm) in 2001 (90 mm) was similar to the mode in 2000 (90 and 92 mm). Weights (g) in 2001 ranged from 2.0 – 26.6 g, and averaged 9.27 g (95% CI 8.98 – 9.54; SEM = 0.14). The average weight in 2001 (mean = 9.27 g) was greater than in 2000 (mean = 8.29 g, 95% CI 8.05 – 8.54; SEM 0.13 mm).

2+ Steelhead Trout

A total of 1,316 fork length (mm) and 1,225 weight (g) measurements were taken for 2+ steelhead trout in 2001 (Appendix 6, Table 15; Appendix 7 Table 16). Overall, fork lengths (mm) ranged from 125 – 218 mm, and averaged 151.2 mm (95% CI 150.1 – 152.3 mm, SEM = 0.5 mm, mode = 130 mm). The average FL (mm) in 2001 (mean = 151.2 mm) was less than in 2000 (mean = 164.4 mm, 95%CI 163.2 – 165.5, SEM = 0.6 mm). The mode in FL (mm) in 2001 (130 mm) was much less than the mode in 2000 (170 mm). Weights (g) in 2001 ranged from 18.6 – 110.1 g, and averaged 39.17 g (95% CI 38.33 – 40.01; SEM = 0.43 g). The average weight in 2001 (mean = 39.17 g) was less than in 2000 (mean = 49.12 g, 95% CI 47.93 – 50.32; SEM 0.61 mm).

A single factor ANOVA showed significant variation among 1+ and 2+ steelhead fork lengths ($p = 0.0000001$; power = 1.00), and supports fork length cutoffs used to separate 1+ and 2+ steelhead throughout the trapping period.

Developmental Stages

1+ and 2+ steelhead developmental stages in 2001 show that few were in a parr stage (Table 4). Differences in developmental stages among study years could be “real” (e.g. differing degrees of smoltification) or due to variability among observers. The most difficult stages to separate are pre-smolt and smolt. The combined percentage of pre-smolt and smolt in 2001 for 1+ steelhead and 2+ steelhead was 99.0 and 99.8%, respectively. On a weekly basis, there was no apparent relationship in 2001 for either species at age of combined pre-smolt and smolt designations on trap catches.

Table 4. Developmental stage for captured 1+ and 2+ steelhead for both study years.

Species	Developmental Stage (percentage)					
	2001			2000		
	Parr	Pre-smolt	Smolt	Parr	Pre-smolt	Smolt
1+ SH	1.0	84.0	15.0	19.0	59.0	22.0
2+ SH	0.2	37.0	62.8	0.3	13.6	86.1

Trapping Efficiencies

0+ Chinook salmon

The number of upstream released fin clipped 0+ chinook salmon totaled 4,109 and ranged from 27 – 400 per 7 d week with an average of 296 per week. Trap efficiencies increased over time, and correlation analysis determined a statistically significant positive correlation with week ($r = 0.86$, $p = 0.000046$, power = 0.9998), similar to that in study year 2000 ($r = 0.84$, $p = 0.000016$, power = 0.9999). Weekly trapping efficiencies in 2001 (mean = 55.3%, range = 3.2 – 96.3%) were greater than in study year 2000 (mean = 31.3%, range = 5.8 – 56.3%). Overall trap efficiency for 0+ chinook salmon in 2001 was 52.0%. Weekly trap efficiencies were negatively related to the week's average gage height ($p = 0.0008$, $R^2 = 0.77$, power = 0.99), similar to study year 2000 ($p = 0.00036$, $R^2 = 0.58$, power = 0.99). Gage height (ft) explained 77 % of the variation in weekly trap efficiencies for 0+ chinook salmon in 2001.

1+ Steelhead trout

The number of upstream released fin clipped 1+ steelhead trout totaled 1,920 and ranged from 4 – 168 per 7 d week with an average of 101 per week. Trap efficiencies decreased over time, and correlation analysis determined a statistically significant negative correlation with week ($r = 0.68$, $p = 0.00001$, power = 0.9998), similar to that in study year 2000 ($r = 0.48$, $p = 0.042$, power = 0.55). Weekly trapping efficiencies in 2001 (mean = 24.0%, range = 0.0 – 46.3%) were greater than in study year 2000 (mean = 16.9% range = 5.3 – 42.0%). Overall trap efficiency for 1+ steelhead in 2001 was 29.9%. Weekly trap efficiencies were positively related to the week's average gage height ($p = 0.0000001$, $R^2 = 0.88$, power = 1.00), similar to study year 2000 ($p = 0.035$, $R^2 = 0.26$,

power = 0.58). Gage height (ft) explained 88% of the variation in weekly trap efficiencies for 1+ steelhead in 2001. Gage height relationships were stronger in 2001 probably because the high flow events were less than in 2000.

2+ Steelhead trout

The number of upstream released fin clipped 2+ steelhead trout totaled 1,091 and ranged from 0 – 140 per 7 d week with an average of 57 per week. Trap efficiencies for 2+ SH were more variable than 0+ KS and 1+ SH, and no significant correlation with week was detected ($p > 0.05$, $r = 0.0039$, power = 0.06), similar to study year 2000 ($p > 0.05$). Weekly trapping efficiencies (without pooling) in 2001 (mean = 10.9%, range = 0.0 – 20.7%) were very similar to study year 2000 (mean = 11.7% range = 0.0 – 25.8%). Overall trap efficiency for 2+ steelhead in 2001 was 12.6%. Weekly trap efficiencies were positively related to the week's average gage height ($p = 0.01$, $R^2 = 0.38$, power = 0.74), unlike study year 2000 when no significant relationship was present ($p > 0.05$). Gage height (ft) explained 38 % of the variation in weekly trap efficiencies for 2+ steelhead in 2001

Population Estimates

0+ Chinook salmon

No weekly trap efficiencies were pooled with other weeks for 0+ chinook salmon population estimates. Comparisons of population model estimates for 2001 data show Carlson et al. (1998), Peterson (Ricker 1987), and Darr (personnel com. Bjorkstedt) gave similar results (Table 5).

Table 5. Model comparison for 0+ chinook salmon population estimate, 2001.

Model	0+ Chinook salmon
Carlson et al. 1998	378,063 $\pm$ 11.3%
Peterson (Ricker 1975)	380,915 $\pm$ 11.9%
Darr (Bjorkstedt)	373,823 $\pm$ 9.8%

The total 0+ chinook salmon Carlson et al. (1998) population estimate over the course of the trapping period in 2001 equaled 378,063 (95% CI 335,290 – 420,835), compared to 427,542 (95% CI 390,096 – 464,988) in 2000. In 2001, May and June accounted for 98.2 % of the total population estimate, compared to 63.0 % in 2000. In 2000, April was also an important month for downstream migration (e.g. 32.8 %). 0+ chinook salmon population estimates in 2001 varied over time, with peak out-migration corresponding to 5/6 – 5/12 ($n = 83,278$) and 5/20 – 5/26 ($n = 67,745$). A smaller peak occurred 6/10 – 6/16 ($n = 25,514$) (Appendix 8, Table 13). The pattern of downstream migration at the population level varied among study years (Figure 22). In 2001, downstream migration did not begin until 4/22 – 4/28, whereas in 2000 downstream migration was ongoing from time of trap installation (4/5). In addition to having fewer but larger peaks in 2001, population out-migration was more compressed in 2001 than in 2000. This could be due to decreased stream flows, and less available space for rearing in 2001, or differences in

time of adult spawning between study years, among other factors. Both population lines show that downstream migration tapered off from 7/1 onward.

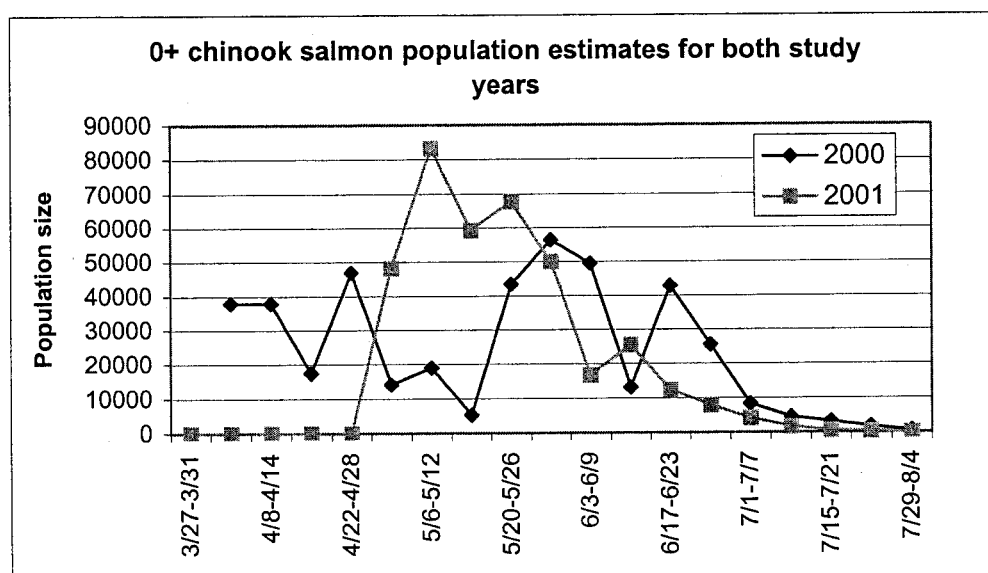


Figure 22. 0+ chinook salmon population estimates, 2000 and 2001.

1+ Steelhead trout

No weekly trap efficiencies were pooled with other weeks for 1+ steelhead trout population estimates. Comparisons of population model estimates for 2001 data show Carlson et al. (1998), Peterson (Ricker 1987), and Darr (personnel com. Bjorkstedt) gave similar results (Table 6).

Table 6. Model comparison for 1+ steelhead trout population estimate, 2001.

Model	1+ Steelhead Trout
Carlson et al. 1998	50,654 ± 10.0 %
Peterson (Ricker 1975)	52,116 ± 10.8 %
Darr (Bjorkstedt)	51,221 ± 10.8 %

The total 1+ steelhead trout Carlson et al. (1998) population estimate over the course of the trapping period in 2001 equaled 50,654 (95% CI 45,571 – 55,736), compared to 68,328 (95% CI 59,055 – 77,601) in 2000. In 2001, April and May accounted for 74.9 % of the total population estimate, compared to 68.0 % in 2000. In 2000, June was also an important month for downstream migration (e.g. 29.0 %). 1+ steelhead population estimates in 2001 varied over time, with peak out-migration corresponding to 4/22 – 4/28 ($n = 7,663$) and 5/27 – 6/2 ($n = 6,446$). A smaller peak occurred 6/10 – 6/16 ($n = 3,941$) (Appendix 9, Table 15). The pattern of downstream migration at the population level varied among study years (Figure 23). The number of peaks was similar, yet in 2000 one peak was much higher than other peaks (5/6 – 5/12). Additionally, in 2000, population downstream migration appeared to occur over a slightly longer time period, and consisted

of more individuals. Population out-migration for both years tended to substantially decrease from 7/1 to the end of the trapping period.

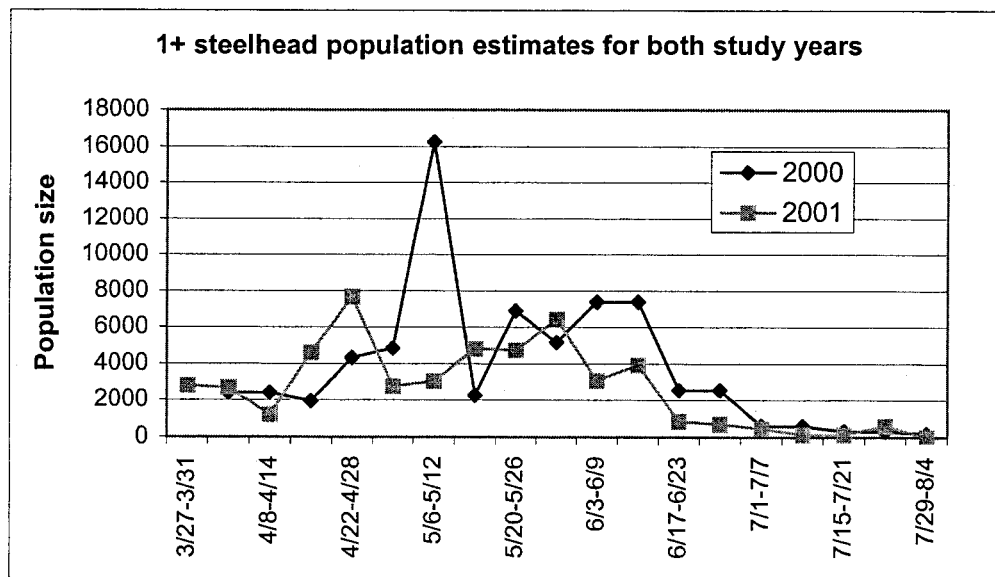


Figure 23. 1+ steelhead trout population estimates, 2000 and 2001.

2+ Steelhead trout

A Fisher exact test (and chi-square) determined weeks 8 and 9 trap efficiency data could be pooled ($p > 0.05$), in addition to weeks 1-2, 10-11, 12-14, and 18-19 ($p > 0.05$). Only weeks 8 and 9 were pooled because pooling reduced the total population estimate by about 2,000 fish, and the 95% confidence interval by 5.4 %. Pooling other weeks did little to change the estimate or confidence interval, and by not pooling, population estimate resolution on a weekly basis was increased. Comparison of population model estimates for 2001 data show that Carlson et al. (1998) and Peterson (Ricker 1987) were similar, and much lower than Darr (pers. comm. Bjorkstedt) (Table 7).

Table 7. Model comparison for 2+ steelhead trout population estimate, 2001.

Model	2+ Steelhead Trout
Carlson et al. 1998	12,668 $\pm$ 22.7 %
Peterson (Ricker 1975)	13,570 $\pm$ 21.1 %
Darr (Bjorkstedt)	20,211 $\pm$ 60.5 %

Differences in Darr from Carlson et al. (1998) are primarily due to how Darr deals with fish captured out of the 'correct' strata. The total 2+ steelhead trout Carlson et al. (1998) population estimate over the course of the trapping period in 2001 equaled 12,668 (95% CI 9,786 – 15,550), compared to 4,739 (95% CI 3,669 – 5,808) in 2000. Population out-migration in 2001 was about 2.7 times greater than in 2000. The Carlson et al. (1998) un-

pooled population estimate for 2001 equaled 14,068 (95% CI 10,066 – 18,069). In 2001, April and May accounted for 66.8 % of the total population estimate, compared to 76.2 % in 2000. In 2001, June was also an important month for 2+ SH downstream migration (e.g. 23.0 %).

2+ steelhead population estimates in 2001 varied over time, with peaks in out-migration corresponding to 4/1 – 4/7 ($n = 1,068$), 4/15 – 4/21 ($n = 1,338$), 5/27 – 6/2 ($n = 1,575$), and 6/10 – 6/16 ($n = 1,280$). A smaller peak occurred 7/15 – 7/21 ($n = 354$) (Appendix 10, Table 17). The pattern of downstream migration at the population level varied among study years (Figure 24). In 2001, 2+ steelhead population out-migration peaked more often than in 2000, and was consistently higher. Out-migration in 2000 generally decreased to numbers less than 200 per week from 6/3 to the end of the trapping period, whereas in 2001, population estimates below 200 per week occurred from 7/1 onward, excluding week 7/15 – 7/21.

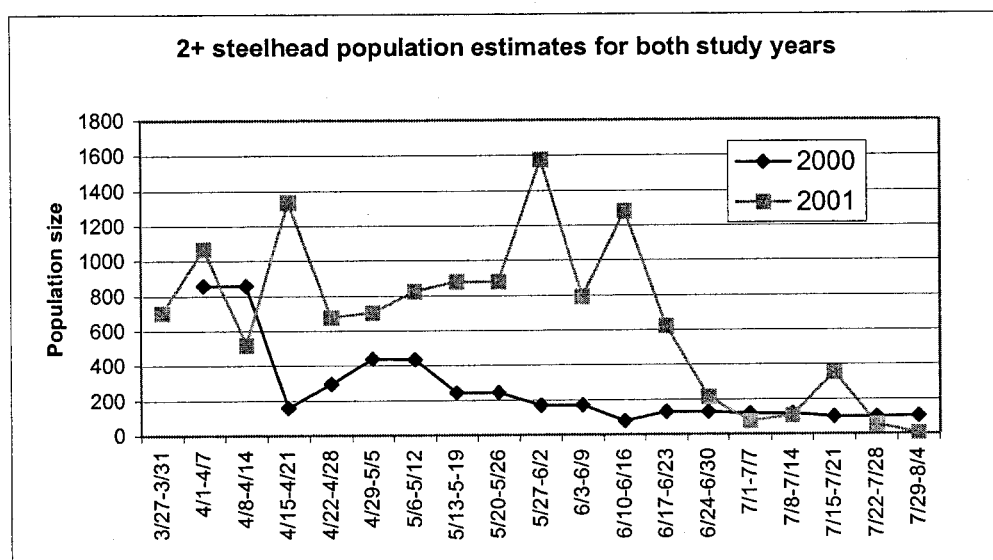


Figure 24. 2+ steelhead trout population estimates, 2000 and 2001.

Additional Experiments

None of the 374 1+ steelhead and 8 2+ steelhead injected with elastomere in the lower jaw were recaptured by the upper Redwood Creek trap, suggesting that these fish continued migrating downstream of the downstream release point. The lower Redwood Creek rotary screw trap caught zero elastomere marked fish, (and only a few of the fin clipped chinook salmon), therefore 1+ and 2+ steelhead travel time from the upper trap to the lower trap could not be estimated.

Zero fin clipped efficiency fish died in the holding containers prior to upstream release. Two separate fin clip and handling mortality studies showed zero 1+ steelhead died in a 24 hr period (Table 8).

Table 8. 1+ steelhead fin clip delayed mortality study, 2001.

Date	Age/Species	Number fin clipped	Mortalities/total	% Mortality
4/15 – 4/16	1+ steelhead	50	0/50	0
4/27 – 4/28	1+ steelhead	50	0/50	0

Trapping Mortality

The mortality of fish that were captured in the trap and handled was closely monitored over the course of the trapping period. Mortality by species at age ranged from 0.00 to 0.91 %, and using all species was 0.68 % of the total juvenile salmonid catches (Table 9). Significant days of mortality occurred on 4/21/01 and 5/11/01. On 4/21, a log was found stuck in the cone that stopped the cone from spinning; seventy-five 1+ steelhead were killed in the cone. On 5/11, a technician overcrowded a holding container, and killed 710 0+ chinook salmon. Every attempt was made to insure this mistake would not happen again, and from thereon, trap and handling mortalities were once again low.

Table 9. Trapping mortality for juvenile salmonids, 2001.

Age/Species	Number captured	Number of mortalities	Percent mortality
0+ steelhead	102,408	450	0.44 %
1+ steelhead	14,775	83	0.56 %
2+ steelhead	1,360	5	0.37 %
0+ chinook	120,692	1,093	0.91 %
1+ chinook	21	0	0.00 %
Cutthroat trout	6	0	0.00 %
Total:	239,262	1,631	0.68 %

DISCUSSION AND RECOMMENDATIONS

This was the second consecutive year of a study designed to quantify the numbers of out-migrating juvenile salmonids in upper 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. Unfortunately, there are no historic records enumerating juvenile salmonid out-migration, and only anecdotal information concerning adult population sizes. As mentioned in the 2000 report (Sparkman 2000), this study needs to be continued over multiple consecutive years to assess status and population trends of anadromous salmonids within upper Redwood Creek. Information drawn from two years of data collection and analyses can be significant and informative, however, inferences about the watershed and species relations at large are limited to only the time period covered in the studies. 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.

0+ Chinook Salmon

The data show that upper Redwood Creek has had a relatively large number of downstream migrating 0+ chinook salmon in both study years. Catches in 2001 ($n = 120,692$) and 2000 ($n = 123,633$) were very close to one another, and suggest biologic stability. The period of out-migration between years was different. In 2001 out-migration started later, and was more compressed than the previous year, with peak catches by week occurring 1 week earlier than study year 2000. The difference in the temporal distribution of peak catches in 2001 was probably influenced by lower stream flows, and hence, reduced habitat capacity. Based upon trap catches, peak out-migration occurred in May and June for both study years, and show that these months are critical for downstream migration.

The length (mm) and weight (g) of 0+ chinook salmon significantly increased over the course of time within each study year ($p < 0.05$). On average, increases in length (mm) and weight (g) over time were less in 2001 compared to 2000, however, the increase in size over time for both study years suggests rearing conditions for 0+ chinook salmon were adequate for growth to occur. Although 0+ chinook salmon average fork length (mm) and weight (g) in 2001 was less than 2000, differences were not significant. 0+ Chinook salmon were, using season averages, 3.3 mm and 0.34 grams less than in 2000. It is probable that the decrease in habitat space in 2001 might account for a portion of the size differences. In general, a greater amount of water or flow leads to a greater amount of physical space, with a greater amount of food availability. Additionally, a greater amount of space allows for greater growth, holding the number of fish constant.

0+ Chinook Salmon Population Size

Trap efficiencies for 0+ chinook salmon were higher in 2001 than 2000 due to lower stream flow in 2001. A significant negative relationship was found with gage height and

trap efficiencies for both study years ($p < 0.05$). The coefficient of determination (R^2) of gage height on trap efficiencies for 2001 and 2000 data was 0.77 and 0.58, respectively. The trap in 2001 was also fished in the thalweg of the stream throughout the trapping season, unlike year 2000. All three population estimate models in 2001 gave estimates numerically close to one-another. The Carlson et al. (1998) method determined 378,063 ($\pm 11.3\%$) 0+ chinook salmon out-migrated in 2001. Population out-migration in 2001 was about 88 % of the 2000 estimate of 427,542 ($\pm 8.8\%$). Subtracting trap mortalities from the total population estimate, we determined that 376,970 0+ chinook salmon out-migrated from upper Redwood Creek in 2001 to later contribute to the adult population.

Although the population estimate in 2001 was lower than 2000, the estimates are close enough to suggest population stability within the study period. Differences in estimates among years could be due to: 1) variation in the number of adults spawning upstream of the trap, 2) variation in redd survival, and 3) variation in stream survival. Redd survival conditions in 2001 were expected to be higher than other years because of a very mild winter and spring (i.e. no large flows with increased sediment deposition or infiltration into redds). Redd counts in 2001 ($n = 95$) were not used to estimate survival from egg deposition to out-migrant population estimate for the following reasons: 1) redd surveys were not designed to cover all areas upstream of the trap where chinook salmon could spawn, 2) high use or multiple redd locations can make redd enumeration difficult, and 2) fecundity relationships for Redwood Creek chinook salmon are unknown (yet presumed to be similar to Prairie Creek, a tributary to Redwood Creek). The total 2001 0+ chinook salmon population estimate divided by 37 stream miles (Brown 1988) equaled 10,218 fish/mile, compared to 11,555 fish/mile in 2000. Using watershed area above the trap site (65,000 acres), fish per acre in 2001 equaled 5.8, and for year 2000, equaled 6.6.

Similar to catch distributions over time, population out-migration by week varied among study years. Population out-migration in 2001 experienced higher peaks, and was more compressed over time compared to 2000. In 2001 and 2000, May and June accounted for 98.2 and 63.0 % of the total population estimate; May and June are critical months for 0+ chinook salmon downstream migration. In a relatively higher water year (e.g. study year 2000), April was also a time of increased out-migration. Both study years' population estimates by week show that downstream migration tapered off from July 1 onward.

1+ Chinook Salmon

Twenty-one yearling chinook salmon were caught in 2001 from time of trap installation (3/27/01) through 5/5/01. It is unknown how many were in the upper Redwood Creek system because peak emigration could have occurred before trapping commenced. Fork lengths (mm) were originally used to separate the 1+ chinook from 0+ chinook when 0+ were moving downstream. Fork length (mm) differences were readily apparent (1+ range 86 to 133 mm) compared to 0+ chinook (range 34 to 45) during the same capture periods. Annuli in scales were positively identified in the larger stream type chinook salmon. The 1+ stream life history pattern may be important for increased ocean survival, and general species diversity. Although in coastal streams the 1+ chinook salmon juvenile life history appears relatively rare, the U.S. Fish and Wildlife Service reported 1+ chinook salmon

catches ($n = 100$) in Little River, Humboldt County, California in 1994 (Shaw and Jackson 1994).

0+ Steelhead Trout

Almost twice as many 0+ steelhead trout were captured in 2001 ($n = 102,408$) compared to catches in 2000 ($n = 55,126$). Large numbers of 0+ steelhead trout were also observed in stream margins upstream of the trap site. The first catch of young of year steelhead downstream migration or stream re-distribution occurred much later (5/02/01) in 2001, compared to 2000 (4/07/00). Periods of increased downstream migration in 2001 occurred in May and June, which accounted for 84.7 % of the total capture. The catches in May 2001 accounted for 34.8 % of the total catch, or 35,605 fish. In 2000, a higher flow year compared to 2001, increased downstream migration occurred in June and July (87.5 %). Increases in year to year catches may be attributable to: 1) increase in adult steelhead spawning above trap site, 2) good redd gravel conditions, 3) reduced carrying capacity of stream habitat due to lower flows and possibly increased temperatures or 4) some combination of factors 1, 2, and 3. The large numbers of 0+ steelhead trout redistributing in a downstream manner May through July suggest over-summer densities of 0+ steelhead would be inaccurate with respect to how many fish were produced in a given locale. In conjunction with hydrology and the life history of re-distribution, numbers encountered during June, July, and August would not include those that have migrated downstream. The over-summer densities would simply be a measure of habitat carrying capacity at that time and place. To project from the density of fish captured in small tributaries to adults that produced them could have serious flaws because of these accounting errors. To project forward (i.e. from 0+ steelhead densities to adult steelhead) would be tenuous at best because of high mortality often associated with young of year fish. Additionally, the lack of including 0+ steelhead that out-migrated prior to sampling would once again be an accounting error.

1+ Steelhead Trout

Data show a relatively large number of 1+ steelhead out-migrated from Upper Redwood Creek in both study years. Catches in 2001 ($n = 14,775$) were greater than in 2000 ($n = 12,263$), and the numbers are considered close enough to suggest stability within the study period. Daily catches were positively related to stream gage height (ft) in both study years ($p < 0.05$), and indicates more 1+ steelhead moved downstream during higher flow events. April and May were months of greater downstream migration for both years, and accounted for about 78 % of the total catch. Catch distributions show that 1+ steelhead were out-migrating prior to trap placement, however, peak catches (by day and week) occurred well after trap placement, and suggests the bulk of downstream migration was probably within the trapping period. Dependent upon water year, it is recommended to initiate trapping in February, or early March.

Data of fork length and weight showed significant increases over time for both study years ($p < 0.05$). Increases in length (mm) and weight (g) by week over the course of the trapping period were less in 2001 (+11.8 mm; 4.27 g) than in 2000 (+ 28.6 mm; 8.07 g). The decrease in growth of 1+ steelhead in 2001 compared to 2000 may be attributable to

lower flows in 2001. Although 1+ steelhead average weekly fork lengths (mm) and weights (g) in 2001 were less than study year 2000, differences were not significant ($p > 0.05$).

1+ Steelhead Trout Population Size

Trap efficiencies for 1+ steelhead were higher in 2001 than 2000 probably because of lessened high flow events in 2001. There appears to be an upper and lower limit of gage height and 'good' trap efficiencies for 1+ steelhead. A significant positive relationship was found with gage height (ft) and trap efficiencies for both study years ($p < 0.05$; 2001 $R^2 = 0.88$, 2000 $R^2 = 0.26$). All three population estimate models gave similar values. The Carlson et al. (1998) method determined 50,654 1+ steelhead migrated downstream during 2001, which was about 74 % of the 2000 estimate. Subtracting trap mortalities from the total population estimate, we determined 50,571 1+ steelhead out-migrated from upper Redwood Creek in 2001 to later contribute to the adult steelhead population. The total 2001 1+ steelhead population estimate divided by 37 stream miles of accessible habitat (Brown 1988) equaled 1,367 fish/mile, compared to 1,846 fish/mile in 2000. Using watershed area upstream of the trap site (e.g. 65,000 acres), fish per acre in 2001 equaled 0.78, and for year 2000, equaled 1.05.

The graphical lines of population out-migration by week suggest the trapping period covered the majority of downstream migration. Population downstream migration in 2001 was slightly more compressed than in 2000, and experienced smaller peaks. Similar to catch distributions, the months of April and May were very important times for population migration, and accounted for 75 (2001) and 68 % (2000) of the population estimates. In a higher water year (2000) June was also an important time of population out-migration (e.g. 29 %). Both years' population estimates by week showed downstream migration tapered off by July 1. The large numbers of 1+ steelhead emigrating in April and May ($n = 37,936$) indicate over-summer density studies would not include this number of fish. Similar to 0+ steelhead, exclusion of migrating 1+ fish would become an accounting error with respect to general abundance.

Although the population estimate in 2001 was less than in 2000, estimates are close enough to suggest population stability within the study period. Differences among years could be due to a variety of factors such as: 1) number of adults that produced the cohorts, 2) survival from egg to emergent fry, 3) over-summer survival, and 4) over winter survival. The life history components (i.e. 1 – 4) at this time can not be separated to determine which factor, or combination of factors were responsible for the population sizes estimated. Such data simply does not exist for upper Redwood Creek, nor for the ESU that Redwood Creek steelhead belong to. Clearly, studies in addition to juvenile out-migration trapping over consecutive years would be required to address factors 1 – 4, in order to increase our understanding of juvenile steelhead population dynamics. In addition, adult steelhead scale analyses are recommended to determine the freshwater age of returning adults. Current scale readings of adults in other streams are showing successfully returning adult steelhead spent two or more years in fresh water prior to ocean entry (Ricker 2001, study 1a1; pers. comm. Greg Bryant). Further

recommendations include marking a larger number of 1+ steelhead with elastomere to determine if any are caught the next season as two-year-old fish.

2+ Steelhead

The number of 2+ steelhead may very well be the most important group of juvenile steelhead that contributes to future adult populations. We can expect higher survival from smolt to adult, than 1+ or 0+ to adult, and the number of 2+ steelhead smolts should be the most biologically significant life history juvenile stage with respect to predicting adult steelhead returns. Additionally, 2+ steelhead status and trends should give a better indication of watershed and stream health because these fish have had to overcome the numerous components to stream survival.

In both study years, 2+ steelhead catches in the beginning of the trapping period were relatively high, and indicate that an unknown number were out-migrating prior to the beginning of the trapping period. Dependent upon stream flows, installing and operating the trap in February or early March is highly recommended for a more complete (potentially) estimate. Based upon weekly catch and population estimates, this appeared to be more apparent in the 2000 data set compared to 2001.

Data show a relatively large number of 2+ steelhead out-migrated from upper Redwood Creek in both study years. Catches in 2001 ($n = 1,360$) were considerably higher than 2000 ($n = 736$), and suggest an upward trend. Catches were positively related to stream gage height (ft) in both study years ($p < 0.05$), and indicated more 2+ steelhead migrated downstream during higher flow events. The months of April and May accounted for 64.3 % of the catch in 2001, and 81 % in 2000. In 2001, March, June, and July were also important months. Unlike 0+ chinook salmon and 1+ steelhead trout, 2+ steelhead out-migration was more spread out over time in 2001 compared to 2000. Lower stream flows and reduced habitat space in 2001 might not have been as important for determining the period of out-migration, except for week 7/15 – 7/21, when a small peak of 2+ steelhead out-migrated.

Fork length (mm) and weight (g) data showed no significant increase or decrease over time in both study years ($p > 0.05$). Differences in length (mm) and weight (g) among the first and last week of trapping were less in 2001 (- 3.0 mm; + 0.35 g) than 2000 (-13.8; - 11.62 g). However, the average weekly fork length (mm) and weight (g) in 2001 was significantly less than in 2000 ($p < 0.05$).

2+ Steelhead Trout Population Estimates

2+ steelhead trap efficiencies were nearly the same for both study years, and were markedly lower than efficiencies for 1+ steelhead and 0+ chinook salmon. In 2001, trap efficiencies were positively related to gage height (ft) ($p < 0.05$), and in 2000 no such relationship was found ($p > 0.05$). All three population estimate models did not give similar values. Peterson (Ricker 1975) and Carlson et al (1998) were expected to be close to one-another because the computational procedure is similar. Darr (pers comm. Bjorkstedt) gave an estimate that was much higher, and with much wider confidence

intervals than Carlson et al (1998) or Peterson (Ricker 1975). The 'correct' model to use is debatable, and difficult to determine. On a purely statistical standpoint Darr (pers comm. Bjorkstedt) may offer greater advantages, however, the method has not been peer reviewed, nor truly field tested (e.g. use of counting weir to calibrate an upstream trap's estimate). Methods of Carlson et al (1998) and Peterson (Ricker 1975) should also undergo critical review for use with 2+ steelhead. The higher Darr estimate is likely due to the 12 stragglers (or 8.7% of total recaptures) caught out of the correct strata. Biologically, it seems unreasonable that 12 fish could account for 7,486 fish when trap efficiencies were above a 10 % average: errors in the field (e.g. fin clipping, recording correct clip) are potentially possible. Additionally, it seems unlikely that 20,000 2+ steelhead could migrate past the trap with only 1,360 captured, especially when one considers the lower flow regime and earlier use of trap weirs in 2001. Future efforts should address the assumption of all marked fish passing the trap site after release. Electrofishing areas upstream of the trap 1-3 day (over the course of trapping) after a 2+ steelhead efficiency test should show if a substantial amount of fish are not moving downstream within the discrete (week) capture period. The expanded amount of stragglers determined by Darr could then be explicitly tested. By far the 'best' test for models would be to use a permanent counting weir below a rotary screw trap.

The Carlson et al (1998) population estimate for 2+ steelhead in 2001 ($n = 12,668$) was 2.7 times larger than the estimate for 2000. Subtracting trap mortalities from the population estimate, we determined 12,633 2+ steelhead out-migrated from upper Redwood Creek to later contribute to the adult steelhead population. The total 2001 2+ SH population estimate divided by 37 stream miles of accessible habitat (Brown 1988) equaled 342 fish/mile, compared to 128 fish/mile in 2000. Using watershed area upstream of the trap site (e.g. 65,000 acres), fish per acre in 2001 equaled 0.2, and for 2000 equaled 0.07.

Population out-migration in 2001 was more spread out, peaked more often, and was consistently higher than in 2000. Similar to catch distributions, April and May were very important times for population out-migration, and accounted for 66.8 (2001) and 76 % (2000) of the total population estimate. In a lower water year (e.g. 2001) June (23.0 %) was also important. Both year's population estimates by week showed downstream migration tapered off from 6/24 onward, except for a small peak ($n = 354$) of 2+ steelhead that emigrated from 7/15 – 7/21 in study year 2001.

Coho Salmon

Although one adult coho salmon was observed in the spawning surveys in 2001 (which suggests more might be present), no juvenile coho salmon were captured in both study years. It is highly improbable that the trapping effort would not catch any juveniles if present above the trap site. Historic records of coho salmon in areas above the trap site are anecdotal; however, do warrant mentioning. Bill Chezum (long time resident in Redwood Valley, per comm. 2001) 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 during their spawning run, and around the time of the 1954 flood event, the coho seemingly disappeared. Marlin Stover (pers comm. 2000) who is also a long time resident in Redwood Valley, collaborates Bill Chezum's observations of adult coho in upper Redwood Creek.

Cutthroat Trout

A low number of cutthroat trout were captured in both study years. An unknown number of cutthroat trout will residualize in the stream for varying years, and not out-migrate to the estuary and ocean. The low trap catches may not necessarily reflect a low population size in upper Redwood Creek.

Operation of Chezum Dam

Chezum dam serves multiple purposes: 1) source of water for fire fighting, 2) place for the local community to meet and swim, and 3) area of cold water refugia for juvenile and adult salmonids (pers comm. Chezum 2001). The dam does have a spillway to allow both adults and juveniles passage. According to Chezum, he originally built the dam to offer cold-water refugia for salmon and steelhead because of massive fish kills he eye-witnessed during summer low flow months (pers comm. Chezum 2001). Operating and filling the dam in June is a time when 0+ chinook salmon and 0+ steelhead trout downstream migration is considerable, however, data in 2001 show that catches were apparently not affected by dam operation, excluding the day when the trap did not work due to a much reduced flow. Stream temperatures also did not appear to be affected by dam operation. Stream flow in 2001 was substantially reduced due to the filling stages, and efforts should be made to minimize the vertical and horizontal drop in stream flow during dam filling. At a time of already low flows, a decrease of 1.7 to 3.1 inches in stream height could strand fish in side channels and alcoves. Recommendations include a more gradual decrease in stream flow during all filling stages, and to employ continual temperature monitors in the spillway and stream below the dam site to insure the spilled water will not thermally pollute upper Redwood Creek.

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APPENDIX 1

Table 10. 0+ Chinook Salmon Fork Length (mm) in 2001.

Week	0+ Chinook Salmon Fork Length (mm)						n =
	MIN	MAX	Average		FL	SEM	
			95%LCL	95%UCL			
03/27 - 03/31	-	-	-	-	-	-	-
04/01 - 04/07	-	-	-	-	-	-	-
04/08 - 04/14	-	-	-	-	-	-	-
04/15 - 04/21	34	34	-	-	-	-	1
04/22 - 04/28	34	44	37.9	39.2	38.5	0.3	59
04/29 - 05/05	34	45	38.4	38.9	38.7	0.1	210
05/06 - 05/12	36	51	39.2	39.8	39.5	0.2	180
05/13 - 05/19	36	53	40.9	41.7	41.3	0.2	210
05/20 - 05/26	37	63	44.8	45.9	45.3	0.3	210
05/27 - 06/02	38	70	47.4	48.8	48.1	0.4	180
06/03 - 06/09	40	71	50.8	52.4	51.6	0.4	210
06/10 - 06/16	42	66	51.9	53.3	52.6	0.4	210
06/17 - 06/23	44	77	54.6	56.3	55.5	0.4	210
06/24 - 06/30	40	78	58.0	60.1	59.1	0.5	180
07/01 - 07/07	46	76	58.5	60.3	59.4	0.4	210
07/08 - 07/14	47	81	60.9	62.4	61.7	0.4	210
07/15 - 07/21	48	80	60.6	62.1	61.4	0.4	209
07/22 - 07/28	47	80	60.5	62.2	61.3	0.4	185
07/29 - 08/04	43	80	60.7	65.7	63.2	1.3	45
Total (all)	34	81	51.5	52.2	51.9	0.2	2719

APPENDIX 2

Table 11. 0+ Chinook Salmon Weight (g) in 2001.

Week	0+ Chinook Salmon Weight (g)						n =
	MIN	MAX	Average		WT	SEM	
			95%LCL	95%UCL			
03/27 - 03/31	-	-	-	-	-	-	-
04/01 - 04/07	-	-	-	-	-	-	-
04/08 - 04/14	-	-	-	-	-	-	-
04/15 - 04/21	-	-	-	-	-	-	-
04/22 - 04/28	-	-	-	-	-	-	-
04/29 - 05/05	0.3	0.8	0.45	0.51	0.48	0.01	60
05/06 - 05/12	0.4	1.2	0.48	0.61	0.55	0.03	30
05/13 - 05/19	0.3	1.5	0.55	0.65	0.60	0.03	60
05/20 - 05/26	0.5	2.4	0.90	1.08	0.99	0.05	60
05/27 - 06/02	0.5	3.3	1.09	1.32	1.21	0.06	60
06/03 - 06/09	0.6	3.4	1.30	1.60	1.45	0.08	60
06/10 - 06/16	0.8	3.2	1.38	1.68	1.53	0.07	60
06/17 - 06/23	1.0	5.3	1.82	2.21	2.02	0.10	60
06/24 - 06/30	1.1	4.4	2.24	2.66	2.45	0.10	60
07/01 - 07/07	1.1	5.0	2.30	2.73	2.51	0.11	60
07/08 - 07/14	1.2	5.1	2.49	2.93	2.71	0.11	60
07/15 - 07/21	1.2	4.1	2.30	2.63	2.47	0.08	60
07/22 - 07/28	1.1	5.2	2.40	2.76	2.58	0.09	78
07/29 - 08/04	1.3	4.7	1.86	3.38	2.62	0.34	10
Total (all)	0.3	5.3	1.66	1.80	1.73	0.04	778

APPENDIX 3

Table 12. 0+ Steelhead Trout Fork Length (mm) in 2001.

Week	0+ Steelhead Trout Fork Length (mm)						n =
	MIN	MAX	Average		FL	SEM	
			95%LCL	95%UCL			
03/27 - 03/31	-	-	-	-	-	-	-
04/01 - 04/07	-	-	-	-	-	-	-
04/08 - 04/14	-	-	-	-	-	-	-
04/15 - 04/21	-	-	-	-	-	-	-
04/22 - 04/28	-	-	-	-	-	-	-
04/29 - 05/05	29	31	29.2	31.2	30.2	0.4	5
05/06 - 05/12	28	36	30.0	30.6	30.3	0.1	81
05/13 - 05/19	27	41	30.2	31.0	30.6	0.2	150
05/20 - 05/26	27	51	34.8	36.3	35.6	0.4	210
05/27 - 06/02	25	51	36.0	39.3	37.7	0.8	60
06/03 - 06/09	33	55	41.2	43.4	42.3	0.5	90
06/10 - 06/16	27	57	39.2	41.9	40.6	0.7	90
06/17 - 06/23	26	66	38.5	42.4	40.5	1.0	90
06/24 - 06/30	26	65	40.2	45.7	43.0	1.4	60
07/01 - 07/07	32	66	45.3	48.5	46.9	0.8	60
07/08 - 07/14	28	69	43.3	47.2	45.3	1.0	60
07/15 - 07/21	32	69	46.1	50.2	48.2	1.0	60
07/22 - 07/28	29	66	42.7	47.3	45.0	1.1	60
07/29 - 08/04	31	64	42.1	45.6	43.8	0.9	60
Total (all)	25	69	38.5	39.5	39.0	0.3	1136

APPENDIX 4

Table 13. 1+ Steelhead Fork Length (mm) in 2001.

Week	1+ Steelhead Fork Length (mm)						n =
	MIN	MAX	Average		FL	SEM	
			95%LCL	95%UCL			
03/27 - 03/31	58	120	81.1	85.0	83.0	1.0	151
04/01 - 04/07	59	121	84.0	87.4	85.7	0.9	209
04/08 - 04/14	62	120	83.3	86.6	85.0	0.8	210
04/15 - 04/21	61	123	84.5	87.9	86.2	0.8	210
04/22 - 04/28	64	119	85.6	88.7	87.2	0.8	210
04/29 - 05/05	55	120	85.9	89.2	87.5	0.8	180
05/06 - 05/12	62	123	90.2	93.8	92.0	0.9	210
05/13 - 05/19	66	124	92.3	95.6	94.0	0.8	210
05/20 - 05/26	72	124	95.8	99.4	97.6	0.9	210
05/27 - 06/02	71	123	96.3	99.7	98.0	0.9	180
06/03 - 06/09	60	124	96.8	100.2	98.5	0.9	209
06/10 - 06/16	73	122	97.0	100.1	98.6	0.8	210
06/17 - 06/23	70	123	94.7	99.2	97.0	1.1	124
06/24 - 06/30	70	123	95.0	100.4	97.7	1.4	121
07/01 - 07/07	70	124	88.5	100.5	94.5	2.9	30
07/08 - 07/14	71	123	89.2	102.5	95.8	3.2	26
07/15 - 07/21	76	123	90.1	101.6	95.8	2.8	32
07/22 - 07/28	75	122	80.1	90.6	85.4	2.5	25
07/29 - 08/04	75	115	61.1	128.4	94.8	10.6	4
Total (all)	55	124	91.4	92.4	91.9	0.3	2761

APPENDIX 5

Table 14. 1+ Steelhead Trout Weight (g) in 2001.

Week	1+ Steelhead Trout Weight (g)						n =
	MIN	MAX	Average		WT	SEM	
			95%LCL	95%UCL			
03/27 - 03/31	2.0	20.0	5.80	7.53	6.66	0.43	61
04/01 - 04/07	2.8	15.4	6.65	8.40	7.52	0.44	59
04/08 - 04/14	2.7	18.8	6.29	8.19	7.24	0.47	60
04/15 - 04/21	2.8	16.4	5.96	7.37	6.67	0.35	60
04/22 - 04/28	3.4	17.4	7.24	9.24	8.24	0.50	60
04/29 - 05/05	3.6	13.7	6.76	7.96	7.36	0.30	60
05/06 - 05/12	3.7	22.4	8.77	10.65	9.71	0.47	90
05/13 - 05/19	4.2	26.6	9.41	11.99	10.70	0.64	60
05/20 - 05/26	4.0	21.4	8.94	10.89	9.91	0.48	60
05/27 - 06/02	6.0	17.7	10.36	11.91	11.13	0.38	60
06/03 - 06/09	2.3	21.8	9.71	11.91	10.81	0.55	60
06/10 - 06/16	5.0	19.1	10.50	12.64	11.57	0.53	60
06/17 - 06/23	5.3	19.6	9.69	12.40	11.04	0.67	36
06/24 - 06/30	3.9	20.8	9.78	12.92	11.35	0.77	34
07/01 - 07/07	3.5	23.2	9.24	14.25	11.74	1.20	21
07/08 - 07/14	3.9	17.8	2.88	14.69	8.78	2.30	6
07/15 - 07/21	4.4	20.6	8.87	12.80	10.83	0.96	32
07/22 - 07/28	4.6	21.1	5.85	9.34	7.60	0.85	25
07/29 - 08/04	5.0	18.4	0.00	22.00	10.93	3.48	4
Total (all)	2.0	26.6	8.98	9.54	9.27	0.14	908

APPENDIX 6

TABLE 15. 2+ Steelhead Fork Length (mm) in 2001

Week	2+ Steelhead Fork Length (mm)						n =
	MIN	MAX	Average		FL	SEM	
			95% LCL	95% UCL			
03/27 - 03/31	125	218	149.8	159.2	154.5	2.4	90
04/01 - 04/07	125	214	155.1	165.6	160.3	2.6	74
04/08 - 04/14	125	203	158.8	166.8	162.8	2.0	95
04/15 - 04/21	125	209	152.9	159.3	156.1	1.6	160
04/22 - 04/28	125	187	147.7	154.7	151.2	1.8	105
04/29 - 05/05	125	190	151.3	159.4	155.4	2.0	89
05/06 - 05/12	125	190	152.0	159.7	155.8	1.9	100
05/13 - 05/19	125	190	149.0	156.1	152.5	1.8	99
05/20 - 05/26	125	186	141.0	147.9	144.4	1.7	87
05/27 - 06/02	125	175	136.1	141.9	139.0	1.4	67
06/03 - 06/09	125	188	136.0	140.8	138.4	1.2	105
06/10 - 06/16	125	201	134.5	142.1	138.3	1.9	64
06/17 - 06/23	125	164	131.2	140.1	135.6	2.1	24
06/24 - 06/30	125	172	133.7	143.8	138.7	2.5	28
07/01 - 07/07	125	177	138.8	161.5	150.1	5.2	13
07/08 - 07/14	125	194	146.8	164.8	155.8	4.3	23
07/15 - 07/21	125	208	151.6	160.5	156.1	2.2	78
07/22 - 07/28	125	187	139.3	163.8	151.5	5.6	13
07/29 - 08/04	125	160	153.1	165.8	159.5	0.1	2
Total (all)	125	218	150.1	152.3	151.2	0.5	1316

APPENDIX 7

Table 16. 2+ Steelhead Trout Weight (g), 2001.

Week	2+ Steelhead Weight (g)						n =
	MIN	MAX	Average		WT	SEM	
			95% LCL	95% UCL			
03/27 - 03/31	20.5	83.2	34.84	43.26	39.05	2.10	51
04/01 - 04/07	21.2	107.4	41.40	50.29	45.85	2.23	74
04/08 - 04/14	19.8	83.8	43.42	49.74	46.58	1.59	95
04/15 - 04/21	19.3	88.6	37.48	42.14	39.81	1.18	160
04/22 - 04/28	18.6	69.2	34.00	38.67	36.33	1.18	105
04/29 - 05/05	21.6	73.6	39.12	45.59	42.36	1.62	75
05/06 - 05/12	20.4	74.5	38.49	44.69	41.59	1.56	87
05/13 - 05/19	22.2	79.0	38.71	43.82	41.26	1.29	99
05/20 - 05/26	21.0	68.7	32.60	38.30	35.45	1.43	76
05/27 - 06/02	22.0	60.8	29.92	34.10	32.01	1.04	67
06/03 - 06/09	21.0	73.5	29.86	34.10	31.99	1.07	91
06/10 - 06/16	20.9	102.4	28.37	35.47	31.92	1.78	64
06/17 - 06/23	21.8	50.9	26.51	32.99	29.75	1.56	24
06/24 - 06/30	19.6	68.3	27.86	36.65	32.25	2.14	28
07/01 - 07/07	21.6	64.2	31.53	49.78	40.65	4.19	13
07/08 - 07/14	21.7	98.2	39.17	57.04	48.11	4.31	23
07/15 - 07/21	23.0	110.1	40.59	48.75	44.67	2.05	78
07/22 - 07/28	23.1	69.2	30.20	48.60	39.40	4.20	13
07/29 - 08/04	35.0	36.7	25.05	48.65	35.85	0.85	2
Total (all)	18.6	110.1	38.33	40.01	39.17	0.43	1225

APPENDIX 8

Table 17. 0+ Chinook salmon population estimates, 2001 (using Carlson et al. 1998).

Week	Week No.	u_h	m_h	M_h	Population Estimate			$V(U_h)$
					U_h	95% LCL	95% UCL	
3/27 - 3/31	1	0	0	0	0	0	0	0.00
4/1 - 4/7	2	0	0	0	0	0	0	0.00
4/8 - 4/14	3	0	0	0	0	0	0	0.00
4/15 - 4/21*	4	1	0	0	1	0	0	0.00
4/22 - 4/28	5	60	0	0	60	0	0	0.00
4/29 - 5/5	6	1,765	6	190	48,159	15,339	80,980	280,397,121.22
5/6 - 5/12	7	9,577	45	399	83,278	60,826	105,730	131,216,879.44
5/13 - 5/19	8	16,717	109	389	59,269	49,896	68,643	22,870,693.12
5/20 - 5/26	9	27,828	121	296	67,745	58,535	76,955	22,081,752.21
5/27 - 6/2**	10	15,690	92	296	50,107	41,687	58,527	18,454,631.01
6/3 - 6/9	11	12,111	289	399	16,705	15,686	17,723	270,022.78
6/10 - 6/16	12	18,261	286	400	25,514	23,931	27,098	652,701.46
6/17 - 6/23	13	8,989	290	400	12,387	11,631	13,143	148,808.45
6/24 - 6/30**	14	5,627	210	297	7,947	7,358	8,536	90,235.15
7/1 - 7/7	15	2,284	215	396	4,198	3,803	4,592	40,526.39
7/8 - 7/14	16	932	185	338	1,699	1,520	1,878	8,353.75
7/15 - 7/21***	17	549	156	179	629	590	669	412.02
7/22 - 7/28***	18	256	83	103	317	283	351	301.86
7/29 - 8/4***	19	45	26	27	47	43	51	4.44
Total:		120,692			378,063	335,290	420,835	476,232,443.30

* Denotes 1 night's catch when cone was stopped due to branch.

** Denotes 1 night of no trapping.

*** Denotes pipe trap in use.

APPENDIX 9

Table 18. 1+ steelhead population estimates, 2001 (using Carlson et al. 1998).

Week	wk #	u_h	m_h	M_h	Population size			
					U_h	95% LCL	95% UCL	$V(U_h)$
3/27 - 3/31	1	1298	46	100	2789	2202	3377	89799.76
4/1 - 4/7	2	1143	63	150	2697	2185	3208	68073.24
4/8 - 4/14	3	536	68	153	1196	975	1417	12736.90
4/15 - 4/21*	4	2143	68	147	4597	3797	5396	166302.92
4/22 - 4/28	5	2994	58	150	7663	6134	9191	607978.33
4/29 - 5/5	6	1068	57	149	2762	2195	3329	83614.33
5/6 - 5/12	7	819	39	147	3030	2219	3842	171418.90
5/13 - 5/19	8	1940	59	148	4818	3869	5766	234301.82
5/20 - 5/26	9	680	20	145	4728	2872	6584	896661.51
5/27 - 6/2**	10	702	10	100	6446	2976	9915	3133458.22
6/3 - 6/9	11	552	26	150	3087	2026	4148	293177.55
6/10 - 6/16	12	513	21	168	3941	2407	5475	612494.21
6/17 - 6/23	13	148	11	68	851	414	1288	49750.77
6/24 - 6/30**	14	122	8	50	691	288	1094	42263.51
7/1 - 7/7	15	30	1	30	465	30	991	71920.00
7/8 - 7/14	16	26	0	4	130	26	294	7020.00
7/15 - 7/21***	17	32	4	23	154	36	271	3599.36
7/22 - 7/28***	18	25	0	23	600	25	1430	179400.00
7/29 - 8/4***	19	4	1	4	10	4	21	30.00
Total:		14775			50654	45571	55736	6724001.33

* Denotes 1 night's catch when cone was stopped due to branch.

** Denotes 1 night of no trapping.

*** Denotes pipe trap in use.

APPENDIX 10

Table 19. 2+ steelhead population estimates (using Carlson et al. 1998).

Week	Week #	u_h	m_h	M_h	Population Estimate			$V(U_h)$
					U_h	95% LCL	95% UCL	
3/27 - 3/31	1	107	6	45	703	240	1166	55824.52
4/1 - 4/7	2	89	4	59	1068	227	1909	184052.00
4/8 - 4/14	3	95	23	130	519	313	724	11004.32
4/15 - 4/21*	4	172	17	139	1338	748	1928	90671.60
4/22 - 4/28	5	105	12	83	678	332	1025	31231.60
4/29 - 5/5	6	90	10	85	704	310	1097	40379.13
5/6 - 5/12	7	100	7	65	825	300	1350	71775.00
5/13 - 5/26	8-9	186	14	141	1761	913	2609	187283.09
5/27 - 6/2**	10	67	1	46	1575	67	3344	814803.75
6/3 - 6/9	11	105	10	82	792	353	1231	50129.26
6/10 - 6/16	12	64	2	59	1280	29	2531	407360.00
6/17 - 6/23	13	23	0	26	621	23	1484	193752.00
6/24 - 6/30**	14	28	2	22	215	8	421	11091.11
7/1 - 7/7	15	13	1	10	72	13	150	1608.75
7/8 - 7/14	16	23	2	13	107	8	206	2558.11
7/15 - 7/21***	17	78	12	58	354	177	531	8142.00
7/22 - 7/28***	18	13	3	16	55	7	104	610.51
7/29 - 8/4***	19	2	0	0	2	2	2	0.00
Total:		1360			12,668	9,786	15,550	2162276.75

* Denotes 1 night's catch when cone was stopped due to branch.

** Denotes 1 night of no trapping.

*** Denotes pipe trap in use.